**EFFECT OF PLASTICS ON MARINE WILDLIFE**
*By Gary Antonides*

In our last newsletter, we discussed the magnitude of plastic pollution in our oceans, how it accumulates in certain locations, how it breaks down into microplastics over time, as well as some of the methods of controlling the flow of plastics into our oceans. In this article, we discuss the effects of plastics in our oceans on marine wildlife.

**Large Pieces** -- It is easy to see how larger pieces of plastic can damage wildlife. The photos show three examples. The effects of plastic rings on the turtle and seal are obvious. The corpse of the albatross chick is an example of marine life eating plastics. Midway Atoll is one of the places where plastic debris accumulates. Thousands of bird corpses rest on these beaches, piles of colorful plastic remaining where their stomachs had been. It is estimated that of the 1.5 million Laysan Albatrosses which inhabit Midway, all of them have plastic in their digestive system. For one third of the chicks, the plastic blockage is deadly. Captain Charles Moore, researcher and author of “Plastic Ocean” saw albatrosses and tropical birds circling above a line of trash, and choosing the reds and pinks and browns - anything that looks like shrimp.


Greenpeace reported that a staggering 80 percent of seabird populations observed worldwide have ingested plastics. Research into the stomach contents of dead Fulmars from the Netherlands, between 1982 and 2001, found that 96 percent of the birds had plastic fragments in their stomachs with an average of 23 plastic pieces per bird (Van Franeker and Meijboom, 2003). When plastic ingestion occurs, it blocks the digestive tract, gets lodged in animal’s windpipes cutting airflow and causing suffocation, or fills the stomach, resulting in malnutrition, starvation and often death.

In a 2006 report, *Plastic Debris in the World’s Oceans*, Greenpeace stated that at least 267 different animal species are known to have suffered from entanglement and ingestion of plastic debris. The National Oceanographic and Atmospheric Administration said that plastic debris kills an estimated 100,000 marine mammals annually, and millions of birds and fishes. From 50 to 80 percent of sea turtles found dead are known to have ingested plastic marine debris.

In April 2002 a dead Minke whale washed up on the Normandy coast in France. Its stomach contained 800 kg of plastic bags (GECC, Groupe d’Etude des Cétacés du Cotentin, 2002). In February 2004, a Cuviers Beaked whale (Ziphius cavirostris) was found washed ashore on the west coast of the Isle of Mull, Scotland. The Scottish Agricultural College found that the entrance to the stomach was completely blocked with tightly packed shredded black plastic bin liner bags and fishing twine.

Of the 260 million tons of plastic the world produces each year, about 10 percent ends up in the Ocean, according to a Greenpeace report (Plastic Debris in the World’s Oceans, 2006). Much of it eventually sinks, damaging life on the seabed. The rest floats in open seas, often ending up in gyres, circular motion of currents, forming conglomerations of swirling plastic trash called garbage patches, or ultimately ending up washed ashore on someone’s beach. Plastics travel long distances. Their distribution in the oceans isn’t uniform, yet they are omnipresent from the Polar Regions to the Equator.

The largest pieces of marine debris, mostly miles long discarded fishing nets and lines, take an obvious toll on animals. These derelicts nets, called ghost nets, snare and drown thousands of larger sea creatures per year, such as seals, sea lions, dolphins, sea turtles, sharks, dugongs, crocodiles, seabirds, crabs, and other creatures. These nets restrict movement causing starvation, laceration, infection, and, in animals that need to return to the surface to breathe, suffocation. Derelict fishing gear can also be destructive to coral reefs. Nets and lines become snagged on coral and subsequent wave action causes coral heads to break off. Plastic bags kill coral by covering them, or by blocking sunlight.

Plastic bags are dangerous because they can be mistaken for food and consumed by a wide range of marine species, especially those that consume jellyfish or squid, which look similar. Various governments including those of San Francisco, China, Ireland, Uganda, South Africa, Russia, and Hong Kong have banned plastic bags. In the U.S. measures to ban or curtail the use of plastic bags have met with official resistance. The plastics industry argues that jobs will disappear.

In many areas where marine debris concentrates, so does marine life. This makes simple scooping up of the plastic risky and more harm than good may be caused. Straining ocean waters for plastics would capture the plankton that is the base of the marine food web and responsible for 50 percent of the photosynthesis on Earth. (NOAA). Captain Charles Moore says cleaning up of the oceanic garbage patches "would bankrupt any country and kill wildlife in the nets as it went." However, Doug Woodring, from Project Kaisei, will be producing a documentary for National Geographic testing catch techniques for the plastic, at least for the largest debris.

**Micro- and Nano-Plastics** -- Micro- and nanoplastics are new categories of plastic litter that wastewater treatment facilities in the most developed countries are not yet equipped for. From toothpastes and deodorants to shower gels, eye shadow and sunscreen, numerous products have contained tiny plastic particles for decades.. They deliver active ingredients, exfoliate, regulate viscosity and fulfill numerous other functions. Some products are made up of 90 percent of these tiny plastic grains. They are so small their size is described in micrometers (thousandths of a millimeter). A human hair is around 100 micrometers thick. Some producers even use tinier particles, nanoplastics, which are in the range of millionths of millimeters. How many of these particles reach rivers and streams, and eventually the ocean, is unknown.

The biggest source of microplastics, however, is larger items breaking down. Every piece of plastic in the ocean falls apart with time. Ultraviolet light and the force of the waves degrade fishnets, plastic bags, bottles, and toothbrushes into smaller and smaller pieces. These are likely to dwarf the amount coming from cosmetic products or textiles, a recent study by the Federal Environment Agency of Germany suggests. Little is known about the impacts of micro-plastics on a wide range of smaller organisms, including the effects of chemicals in the plastics. The particles mimic food items for zooplankton and small fish, and to some degree, they will move up the food chain. But there is also damage to the guts of small critters. (http://www.greenfacts.org/en/marine-litter/l-2/3-micro-plastics.htm).
At the Alfred Wegener Institute in Germany, a research team has conducted a study to find out how much plastic escapes wastewater treatment plants. They found that substantial amounts of microplastics get into their rivers, but also that the amounts from different facilities vary greatly. To detect micro- and nanoplastics and hold them back completely in a wastewater treatment plant requires an additional stage of cleaning, which would increase costs to consumers.

Lars Grønbæk is a process engineer working for the Danish wastewater purification company KD, and is a specialist in membranes that can remove tiny particles from water using a principle similar to a coffee filter. His company's membranes are already capable of filtering down to a size of a tenth of a micron, and they could be further refined. But at the moment, only a small fraction of wastewater treatment plants are deploying membrane filters, says Grønbæk. As long as there is no regulation requiring them to do so, this is unlikely to change.

Of course, if we did not use materials that can become a problem for the environment, we would not have to remove them with expensive technologies. Accordingly, in late 2015, President Obama signed the Microbead-Free Waters Act, which bans tiny plastics in cosmetics and other products.

Some emerging economies are growing so fast that their waste management systems can't keep up, and so their contribution to marine debris is enormous. If just five countries — China, Indonesia, Vietnam, Thailand and the Philippines — improved their recycling and waste disposal systems, they could cut global inputs by almost half, according to http://www.oceanconservancy.org/our-work/marine-debris/mckinsey-report-files/full-report-stemming-the.pdf.

Materials can degrade by photodegradation or biodegradation. Plastics are generally a durable material and resistant to natural biodegradation because the microbes that break down other substances do not recognize plastic as food. Yet plastic can be fragmented with the effects of UV, being broken down by light in smaller and smaller debris over time, which is photodegradation. This process continues down to the molecular level, yet photo-degraded plastic remains a polymer. No matter how small the pieces, they are still plastic and are not easily absorbed into or changed by natural processes.

Dr. Richard Thompson of the University of Plymouth, UK has found plastic particles thinner than the diameter of a human hair in filter feeders like mussels, barnacles, and amphipods. The photo degradation of plastic makes matters worse since it is eaten by tinier marine organisms, therefore entering the food chain earlier and ultimately affecting more marine life.

Marine biologist David Barnes of the British Antarctic Survey says plastics can actually change entire ecosystems. He has documented that floating plastic debris acts as rafts for small sea creatures to grow and travel on. This represents a potential threat should an alien species become established.

**Chemical Effects** -- Plastics in the ocean can damage wildlife chemically in two ways. They can leach problematic additives such as bisphenol A, and they also show a tendency to absorb organic pollutants such as DDT from the water around them, acting like pollution sponges, which, as bits of plastic are eaten, results in toxins accumulating up the food chain.

Until recently, it was thought that plastic rubbish is relatively stable chemically and, its principle threat to living creatures came from its ability to choke or strangle animals that either got caught in it or ingested it thinking it was food. However, a 2009 report by Katsuhiko Saido at Nihon University in Chiba, Japan, has found that at least Styrofoam degrades more rapidly than previously thought in the conditions and temperatures of the open ocean, and that as plastics break down in the sea they release toxic substances not found in nature and which could affect the growth and development of marine organisms. They release a range of chemicals, including bisphenol A, which has been implicated in disrupting the hormonal system of animals.

All sea creatures, from the largest to microscopic organisms, are, at times, swallowing the seawater soup instilled with toxic chemicals from plastic decomposition. Humans are eating fish that have eaten other fish, which have eaten toxin-saturated plastics. In essence, we are eating our own trash.

Marine litter used to be primarily organic materials, but is now 60 to 80 percent plastic, according to a report published in October 2008 in *Environmental Research*. In addition, most of these plastic waste items are highly buoyant, allowing them to travel in currents for thousands of miles.

Some common plastics that leach chemicals are: polyvinyl chloride **(called** one of the most hazardous consumer products ever created), polystyrene, and polycarbonate. **These are associated with endocrine disruption, chromosome damage,** adverse effects on red blood cells, the brain, nervous system, sexual function, behavior, liver, kidneys, and stomach, as observed either in humans or in animal studies.

Dioxins are produced during the manufacture of materials containing chlorine, including PVC, as well as other industrial processes. Although emission controls keep much of it from entering the environment, it is still a major pollution problem. Dioxin is the most potent synthetic carcinogen ever tested in laboratory animals. The National Institute of Standards and Technology says it is over 10,000 times more potent in causing cancer than the next highest chemical. http://oceanbites.org/model-suggests-40-of-global-dioxin-emissions-end-up-in-the-oceans/ reports on a model study that indicates that 40% of all dioxin emissions end up in the ocean.

**There are safer plastics. High-density** polyethylene (HDPE), **Low-density polyethylene** (LDPE), and **Polypropylene** (PP) are safer. Biodegradable bio-based plastics, made from resources such as corn or potato starch and sugar cane, are also safer.

The concentration of absorbed chemicals like PCB’s and DDT in plastics can be almost 1 million times greater than the overall concentration of the chemicals in seawater. This makes plastic far more deadly in the ocean than it would be on land. These findings were published in the *Marine Pollution Bulletin*.
PCBs can lead to reproductive disorders, death, and the alteration of hormone levels. They have been linked to the masculinization of female polar bears and spontaneous abortions and declines in seal populations.

**Solutions** -- Nonprofits are addressing plastic pollution, and governments at the local and federal levels, as well as many countries, are passing laws to help solve the problem of plastics in the ocean. They usually involve education and advocate the three “r’s” -- reduce, recycle, and reuse.

**Biodegradable Plastics --** According to the Biodegradable Plastics Society (2005), when these are composted they break down to carbon dioxide and water. Controversy exists though, because it is possible that they do not break down fully and leave non-degradable constituents, some of which may be hazardous. Scientists at the University of Southern Mississippi (USM), with funding from the Naval Sea Systems Command (NAVSEA), are developing a new type of plastic that degrades into nontoxic products in seawater. It is made of polyurethane that has been modified by the incorporation a known degradable polymer used in surgical sutures.

**Microorganisms** -- In 2008 a high school student, Daniel Burd, discovered plastic-consuming microorganisms. He immersed ground plastic in a yeast solution that encourages microbial growth, then isolated the most productive organisms. After six weeks of tweaking and optimizing temperatures, he achieved a 43 percent degradation, an amazing feat -- a non-chemical, fully organic, low cost, nontoxic method for degrading plastic. There have been other bacteria or fungus based solutions developed in Japan, Ireland, and Wisconsin.

A new kind of material, called oxo-biodegradable plastic, does not just fragment, but is subsequently consumed by microorganisms. This process continues until the material has biodegraded to $CO_2$, water, humus, and trace elements. It can be made with the same machinery and workforce as conventional plastic. The time taken to degrade can be programmed to a few months or years and, until it degrades, it has the same characteristics as conventional plastic.

http://news.discovery.com/earth/oceans/plastic-eating-microbes-help-marine-debris-sink-140619.htm reports on a 2014 study that indicates that microscopic creatures may be helping to reduce marine garbage in the ocean surface. Oceanographers at the University of Western Australia found that microscopic creatures appear to be biodegrading the millions of tons of debris floating on waters worldwide. The study documents the biological communities living on tiny particles of microplastics, and records many new types of microbe and invertebrates. While there has been research on microbes eating plastic at landfills, this shows that their marine counterparts could be just as effective on ocean garbage. The actions of the microbes could explain why the amount of plastic floating on the seas has not been expanding as fast as expected.