Plastic Pollution: A Worldwide Oceanic Problem

By Felicia Coleman & D. H. S. Wehle.

From Newfoundland to Australia, biologists studying seabird feeding ecology in the early 1970s started noticing an odd prey item in their subjects' diets: plastic. Their tales were soon joined by similar ones of plastic ingestion and entanglement in plastic debris, in a wide variety of marine organisms including fish off the southern New England coast, sea turtles off Costa Rica and Japan, and whales in the North Atlantic. At the same time, scientists conducting planktonic and benthic surveys in both the Atlantic and Pacific oceans found unprecedented numbers of plastic particles among their samples [Feder et al., 1978; Colton et al., 1974], and members of both Ra expeditions observed plastic pollution while crossing the Atlantic [Heyerdahl, 1971]. Plastic pellets washed ashore in New Zealand in such large quantities that some beaches literally seemed covered with "plastic sand" [Gregory, 1978]. By the close of the decade, a new problem had been added to a growing list of ecological concerns- plastics at sea.

Plastic shows up in the marine environment in two forms: manufactured pieces and raw particles. Those who frequent coastal regions are painfully aware of the prevalence of manufactured plastic litter along the shore. Most of this refuse is generated by transport, fishing, and recreational vessels. In 1975, the US National Academy of Sciences estimated that commercial fishing fleets alone dumped more than 52 million pounds of plastic packaging material into the sea, and probably lost more than 298 million pounds of plastic fishing gear, including nets, lines, and buoys [Merrell, 1980).

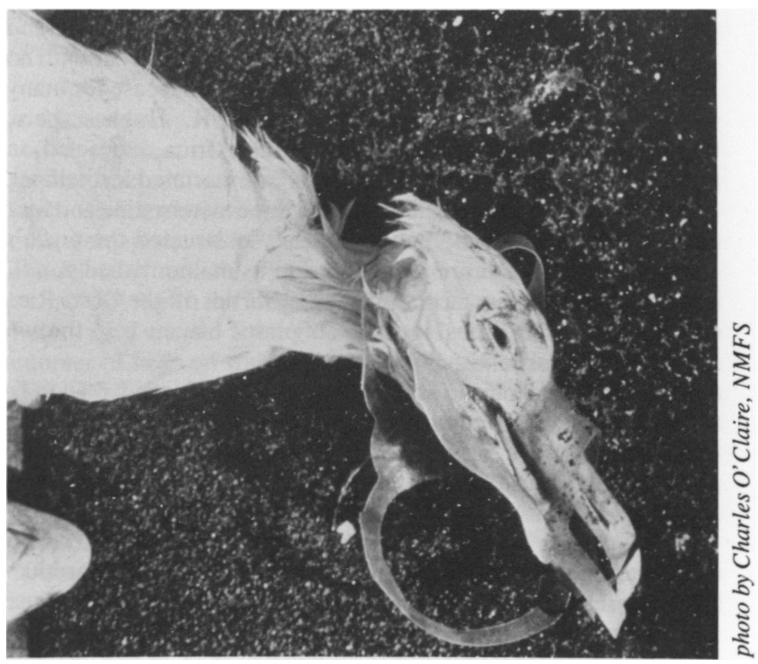

Figure 1. The death of this gull can be attributed to the plastic yoke from a six-pack of drink cans. These yokes are almost invisible in the water, and both divers and surface -water feeders are particularly susceptible to such entanglement.

Raw plastic particles -the spherules, nibs, cylinders, beads, pills, and pellets (each about the size of a wooden match head) from which products are manufactured -enter the ocean via inland waterways and outfalls from plastic manufacturing plants. They are also lost from freighters during loading and unloading, and, upon occasion, are deliberately dumped into the sea.

However it manages to reach the sea, plastic debris is ubiquitous. It has turned up in benthic sediments along the industrialized coast of Great Britain in concentrations of 2,000 pieces per square meter [Morris & Hamilton, 1974]; near Auckland, New Zealand, at densities greater than 100,000 pieces per lineal meter of beach [Gregory, 1978); in the Mediterranean Sea as enormous floating masses [Morris, 1980); and in coastal regions of the United States, Portugal, Colombia, Lebanon, and such remote sites as the Aleutian and Galapagos Islands. Members of the Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP) -- a nationally coordinated program of the US National Marine Fisheries Service (NMFS)-found large quantities of raw plastics in the open ocean, particularly in the Sargasso Sea, an area in which floating debris is known to accumulate; this would indicate that winds and currents play an important role in distributing and concentrating particles in certain oceanographic regions. Given the presence of plastic particles in the marine environment, it was only a matter of time before they turned up in the digestive systems of animals that forage at sea.

One of the earlier known occurrences of plastic ingestion was in 1962 for an adult Leach's storm-petrel collected off Newfound- land [Rothstein, 1973]. In 1966, researchers in the Hawaiian is- lands found plastic in the stomach contents of nestling Laysan albatrosses, indicating that the parents had picked up the plastic as "prey" and fed it to their young [Kenyon & Kridler, 1969].

As the data accumulated, certain patterns emerged: for example, in the Northern Hemisphere, North Pacific and North Atlantic procellariids (particularly shearwaters and fulmars) and North Pacific alcids (particularly auklets and puffins) contained more plastic material than other seabirds in those areas, including phalaropes, gulls, terns [Day, 1980). To date approximately 15 percent of the worlds' 280 species of seabirds are known to ingest plastic.

While seabirds choose from a wide array of plastic objects during foraging (including raw particles, fragments of processed products, detergent bottle caps, and toy soldiers, cars, and animals), marine turtles consistently select only one item -plastic (polyethylene) bags. In the past fifteen years, biologists have found plastic bags in the digestive tracts of four of the seven species of marine turtles: including leatherbacks off the coast of the US, French Guiana, South Africa, and France; hawksbills on the Caribbean coast of Costa Rica; greens in the South China Sea, and in Japanese, Australian, and Central American coastal waters; and olive ridleys in the Pacific coastal waters of Mexico. Polystyrene spherules have been found in the digestive tracts of one species of chaetognath (transparent wormlike animals) and eight species of fish in southern New England waters [Carpenter et al., 1972]. They have also turned up in several species of bottom-dwelling fishes in the Severn Estuary of southwestern Great Britain [Kartar et al., 1976].

Marine mammals are not exempt from participation in the plastic feast. Pygmy sperm whales, rough-toothed dolphins, Cuvier's beaked whale, and West Indian manatees are all involved, eating mostly plastic sheeting or bags. Fishermen report Minke whales eating plastic debris thrown from commercial fishing vessels. Curiously, plastic has not been found in any of the thousands of Alaskan ribbon, bearded, harbor, spotted, ringed or northern fur seal stomachs examined.

The obvious question arising from this mish-mash of data is, why do marine animals eat plastic? Robert H. Day (1980), in the most comprehensive study of plastic ingestion to date, maintains that seabirds, at least in Alaska, eat plastic because they mistake it for natural prey items. For example, in all the parakeet auklets Day examined, most (94%) of the ingested plastic consisted of small, light brown pieces that bore a striking morphological resemblance to the small crustaceans on which the birds typically feed.

Marine turtles also seem to mistake plastic objects for potential food items. For turtles, transparent polyethylene bags apparently evoke the same feeding response as do jellyfish, the major food item of leatherback turtles, and subsidiary prey for greens, hawksbills, loggerheads, and ridleys.

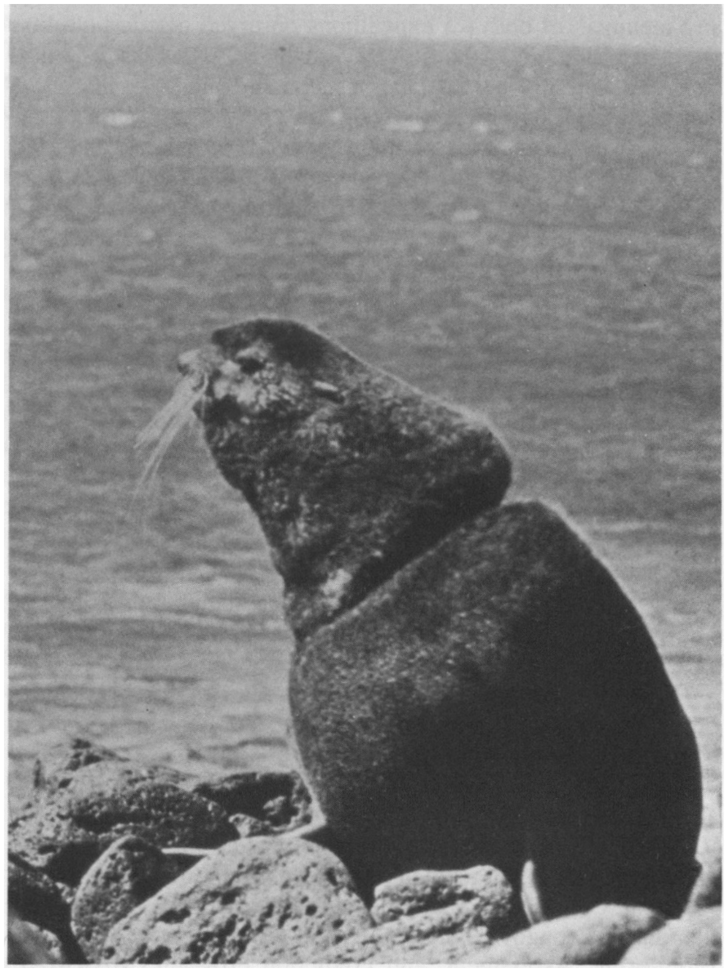

Figure 2. This fur seal is girdled by a discarded plastic band used for strapping closed large boxes or similar containers. The material is water and rot resistant, and this animal has little hope of survival. As it grows, the band will cut deeper and deeper into the flesh, causing increasing pain and a lingering death.

Sea birds, marine turtles, and marine mammals all eat plastic. So what? It could be that plastic ingestion is inconsequential to their health. After all, a cow can retain nails, metal staples, and strands of barbed wire in its stomach for more than a year with no ill effects. This, however, does not appear to be the case for many marine organisms that eat plastic. George R. Hughes (pers. comm.) of the Natal Parks Board, South Africa, extracted an enormous ball of plastic from the gut of an emaciated leatherback turtle; unraveled, the plastic measured three meters wide and four meters long. The plastic ball completely obstructed the turtle 's normal digestion and presumably led to its malnourished condition. Similarly, a mass mortality of green turtles off the Costa Rica is attributed to the turtles' ingestion of plastic banana bags thrown from a dock [Cornelius, 1975].

We know that plastic is virtually indigestible and that individual pieces may accumulate and persist in the gut for extended periods of time. A growing body of evidence indicates that ingested plastic causes a multitude of gastro-intestina1 problems. It may reduce an animal's hunger sensation, and thus inhibit feeding activity; this, in turn, could result in low fat reserves and an in- ability to meet the increased energy demands of either reproduction or migration [Connors & Smith, 1982]. Plastic may cause ulcerations in the stomach and intestinal linings, and is suspected of damaging other anatomical structures, such as the delicate fringe used in prey capture on the bills of prions. Finally, plastic ingestion may contribute to the level of synthetic chemicals in body tissues. Some plastics contain PCBs, a chemical known to cause eggshell thinning, aberrant behavior, and tissue damage; others, such as polystyrene spherules are not made with PCBs, but apparently absorb them from ambient sea water [Carpenter et al., 1972]. Some plasticizers concentrate in fatty tissues; when these highly contaminated tissues are mobilized for energy, toxins may be released in lethal doses.

Publication of data on plastic ingestion is in its infancy. As the problem gains notoriety, it is certain to be revealed as being even more widespread than is now recognized. One indication of this is the occurrence of secondary ingestion, in which plastic consumed by animals feeding at low trophic levels is passed on through them to higher-level consumers. Plastic pellets found in the castings of a predatory South Polar skua in the South Atlantic apparently got there by way of a broad-billed prion eaten by the skua [Bourne & Imber, in press]; plastic pellets found in the Galapagos Islands came from transport vessels in Ecuadorean ports through a food chain involving fi h, blue-footed boobies, and finally, short-eared owls [Anonymous, 1981].

A more obvious effect of plastic pollution is the aesthetic one. Whether we venture deep into the woods, high atop a mountain, or out on the ocean to escape the trappings of civilization, our experience of the natural world is often marred by the discovery of human litter. Even more disturbing is the sight of a young pelican entangled in fishing line and dangling helplessly from its nest, a whale rising to the surface with its flukes enshrouded in netting, or a seal nursing wounds caused by a plastic band cutting into its flesh. Unfortunately, such observations are becoming more and more common, another consequence of plastics at sea.

During the last 20 years, fishing pressure has increased dramatically in all the world's oceans, and with it, the amount of fishing- related debris dumped at sea. With the advent of synthetic fibers after World War II, the type of fishing equipment shifted from the traditional nets of hemp, cotton, or flax (which sank if not buoyed, disintegrated within a relatively short period of time, and which because of the size of their fibers, were largely avoided by diving seabirds and marine mammals) to synthetic monofilament nets, which are more buoyant and longer-lived than their predecessors, and nearly invisible under water, a distinct disadvantage to animal in the net's vicinity.

One result of the change in net materials has been an increase in mortality of air-breathing animals either through incidental capture or entanglement. Incidental catch refers to the capture of non-target animals in actively working fishing nets; entanglement is the capture of any animal in lost or discarded nets. Unlike working nets, which fish for specified periods of time, these free-floating nets, often broken into fragments, fish indefinitely.

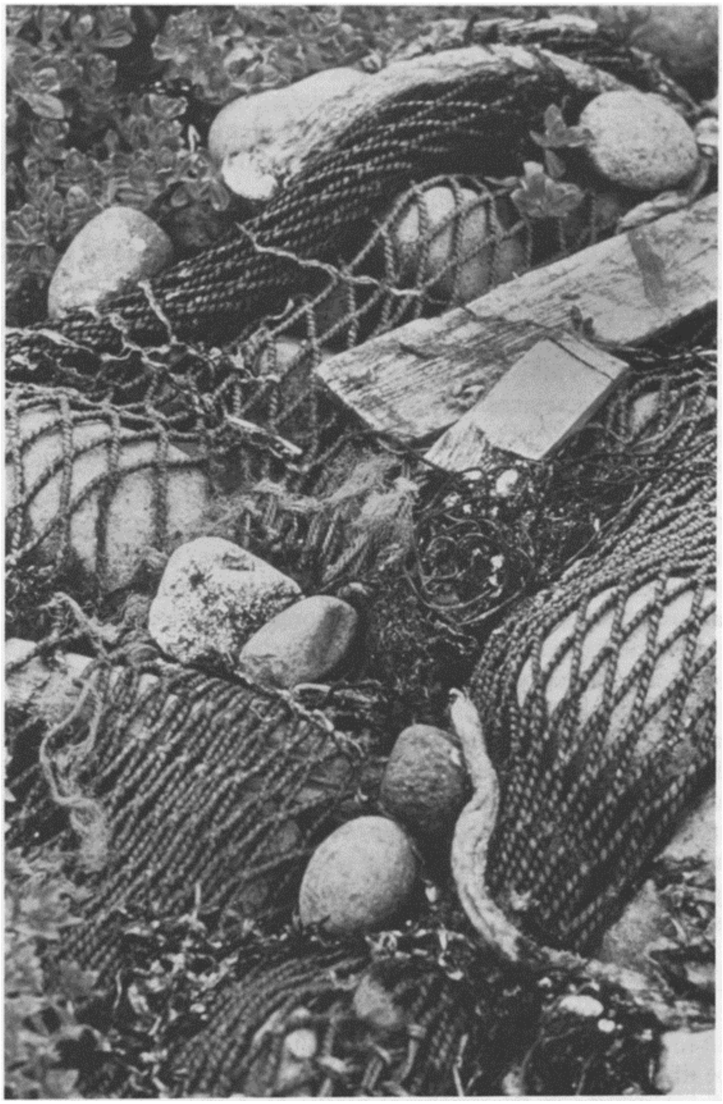

Figure 3. This derelict trawl web net that washed ashore on Amchitka Island is a common site. Free-floating synthetic monofilament nets are also frequently seen, both ashore and floating at sea -- a potential danger to birds and animals wherever they appear.

When washed ashore, they may also threaten land birds and mammals: in the Aleutian Islands, a reindeer became entangled and died in a Japanese gill net that had washed up on the beach. During the heyday (1972-76) of the Danish salmon fishery in the North Atlantic, the incidental catch of thick-billed murres reached three quarters of a million birds a year [Bourne, 1971; Tull et al., 1972]; in 1980, the incidental catch of sea turtles in shrimp trawl nets off the southeastern coast of the United States was around 2,000 animals. Some government officials estimate that about 50,000 northern fur seals currently die in the North Pacific each year as a result of entanglement in fishing gear.

While not fishing-related in the usual commercial sense, there are incidences of capture of cetaceans and sea turtles off the coast of Natal each year. Natal's beaches are important to the economy of the area. A number of shark attacks along those beaches during the height of the resort season proved nearly disastrous to local businesses. In an effort to rectify this, park officials set gillnets offshore to keep sharks from moving in near bathers. While effectively, but not selectively, taking sharks, the nets also caught cetaceans moving inshore to feed on small fish, and turtles coming in to nest [Best & Ross, 1977]. The local officials now find them- selves in an awkward position, faced not only with the problem of shark attack, but with receiving a good deal of bad press relating to the capture of marine mammals. They are working to alleviate the problem through close monitoring of beaches: forbidding swimming and rolling up nets during periods of cetacean and/or turtle migration inshore.

Plastic strapping band, used to secure crates, bundles of net- ting, and other cargo, are another common form of ship-generated debris that is harmful to marine mammals [Merrell, 1980]. Discarded bands are often found girdling pinnipeds (e.g., seals and sea lions), animals that are particularly susceptible to entanglement because of their proclivity for examining floating objects. Sea birds that frequent recreational waters or coastal dumps, such as gulls and terns, are subject to ringing by the plastic yokes used to package six-packs of beer and soft drinks. With the rings caught round their necks, the birds may be strangled when the free end of the yoke snags a protruding object. Pelicans, which plunge-dive to feed, run the risk of diving beak-first into yokes thrown in the water. With a ring firmly wedged around its bill, the bird is unable to feed and may well die of starvation. The problem of plastics at sea is global and its solution will require international cooperation. Historically, the high seas have been considered an international no-man's land. Recently, how- ever, perception of the ocean as a finite and shared resource has caused many nations to express concern for its well-being.

In 1970, the U.S. Congress passed the National Environmental Policy Act, which, among other things, led to the adoption of a number of laws on waste disposal, two of which included pollution by plastics. Having laws on the books, however, does not solve the problem. Small scale refuse disposal on the high seas is difficult to regulate; fishermen who unintentionally lose their nets at sea cannot be held responsible; and illegal large-scale dumping at sea is hard to detect. Granted, laws must be more stringent, but enforcement is really the bigger problem.

On the international level, the United Nation's Conference on the Human Environment, held in Stockholm in 1972, highlighted water pollution and litter in the ocean. The conference, representing 110 nations, defined the need for international policy on marine pollution among coastal and maritime nations. Treaties to implement such a policy soon followed: the 1972 London Convention on the Prevention of Water Pollution by Dumping of Wastes and Other Matter (Ocean Dumping Convention), a part of which specifically prohibits marine dumping of persistent plastic material; and the 1973 London International Convention for the Prevention of Pollution from Ships (Marine Pollution Convention), which is broader in scope, regulating the control of oil pollution, packaged substances, sewage, and garbage [Moore, 1975]. While neither treaty has been adopted by all nations, each represents a start toward global control of marine pollution.

Ironically, the very characteristics that make plastic appropriate for so many uses – its light weight, strength and durability- lead to the majority of problems associated with its occurrence at sea. The longevity of plastics in seawater is not known, but on the beach, particles may last anywhere from 5 to more than 50 years. Given plastic's long life, our handling of plastic polluters, and the projected annual increase in production [Guillet, 1974], one thing is clear-the rate of plastic deposition in the marine environment will remain higher than the rate of its disappearance. In a study of plastic accumulation rate on the beaches of Amchitka Island, Theodore **R.** Merrell, Jr., (NMFS) recorded 550 pounds of plastic litter added to less than a mile of beach in one year [Merrell, 1980]. He also found a 250 percent increase in both the number and weight of plastic items washed ashore over a two-year period.

Outside the realm of laws and treaties, immediate remedies to continued plastic pollution can be generated both within and out- side of the plastics industry. We already have the technology to manufacture biodegradable plastics. In fact, one of the beauties in plastic is its malleability: its properties can be altered and its life expectancy prescribed. Alaska is ahead of the game, in this respect. Alaskan law already requires that plastic six-pack yokes be made of a self-destructing compound. But are the compounds released by degradation more harmful than the intact plastic? This is an important fact to consider.

Another, but perhaps less workable solution (given the logistics and expense involved, and the degree of business and public cooperation required) lies in recyclable plastics. At the very least, all countries should require that the outflow from industrial plants be filtered for plastic particles before it enters the waterways. A recent decline in the uptake of plastic by marine organisms in southwestern England has been attributed, in part, to the efforts of one of the major contaminating plants to filter, collect, and reuse raw particles present in its effluent.

Consumers share with industry the responsibility to reduce plastic pollution. Recreational boaters and commercial fishermen discard plastic refuse that would better be held onboard until they return to port. If six-pack yokes or strapping bands must be dis- carded at sea, the rings should be cut first so that they pose less of a threat to marine animals; other plastic refuse generated on large vessels could be burned in non-atmospheric polluting incinerators or compacted for shore disposal.

The first step in combatting plastic pollution is to alert both industry and the general public to the gravity of the problem and the urgency of doing something about it. Park management is in a unique position in this regard. It is often through the park system that people acquire a reverence for the natural environment, and pick up on ways to illustrate that respect. Education alone won't solve it, but it is a start. Public awareness of the problem, combined with the resolve to correct it, can bring dramatic results.

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Unless otherwise noted, photos are by Dr. Theodore Merrell, National Marine Fishery Service.

Correct Citation: Coleman, FC, and DHS Wehle. 1984. Plastic Pollution: A worldwide Oceanic Problem. Parks 9(1):9-12