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MARINE DEBRIS IN HAWAII

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INTRODUCTION

The production and use of plastics and other synthetic materials have increased rapidly in recent decades. With this increase, a growing problem has arisen of plastic debris polluting the environment. Because of the aesthetic effect of litter on the terrestial environment, improper disposal of plastics on land has been an issue for some time. Only in recent years, however, have the effects of plastic debris in the marine environment become more vivid (Shomura and Yoshida 1985; Laist 1987). Seabirds and sea turtles can ingest pieces of plastic that block or impede their digestive tracts; marine mammals, seabirds, and fish can become entangled in fragments of trawl webbing or gill net; also, floating rope or webbing can disable vessels by fouling propellers.

With a relatively small human population and no extensive industrial sources of effluent plastic particles, Hawaii is not faced with many of the marine debris problems encountered along continental margins. Also, plastic litter generated in Hawaii may be borne away on oceanic currents rather than remain near shore. Yet because of its midocean location (Fig. 1), Hawaii is recipient of flotsam and debris from perhaps more widespread sources than continental coastlines. Moreover, the same current system which carries debris away from the islands also carries debris from the various fisheries of the North Pacific Ocean toward Hawaii (Pickard 1963). This debris affects the inhabitants and wildlife of Hawaii.

In the main Hawaiian Islands, state and county parks and populous beaches, such as Waikiki, are routinely cleaned of litter and marine debris by local government agencies, but data on such debris items are not collected. In the Northwestern Hawaiian Islands (NWHI), personnel of the National Marine Fisheries Service (NMFS) have since 1982 retrieved, cataloged, and burned nets, webbing, lines, and other debris that could entangle wildlife. Data collected included location, size, and estimated weight of debris. Color, twine diameter, and mesh size were also noted from net or webbing fragments. Except for plastic hoops or rings capable of encircling a seal's muzzle, the cleanup has not included other debris items such as plastics and glass.

TYPES AND SOURCES OF DEBRIS

Although types of debris and beach litter are not regularly noted in the main Hawaiian Islands, results of a single-day beach cleanup in 1984 showed that plastic bags, cups, and utensils predominate in beach litter, with styrofoam cups,fishing lines, and ropes contributing significantly.[1] The probable sources of these items were not noted.

Despite the fact that large plastics and other flotsam not capable of entangling animals are not collected or cataloged in the NWHI, some conclusions are possible based upon many observations of plastics along the beach perimeter of these islands. Land-generated items such as six-pack yokes, styrofoam food and beverage containers, and plastic utensils are seldom seen. Rather, plastic items tend to include beverage crates, buckets, and fish baskets. This debris appears to originate from ships rather than from coastal litter. Also present on the islands are countless, small pieces of plastic resulting from the breakdown of larger plastic items. These pieces and the myriad plastic bottle caps and disposable cigarette lighters probably originate from shore. Fry et al. (1987) note that plastic trash is more abundant in the NWHI than on other remote islands in the central Pacific, and speculate that it is carried by the Kuroshio Extension into the North Pacific gyre. Seabirds that have ingested plastics may also contribute to debris in the NWHI by transporting items to the nesting area to feed their young.

Henderson et al.(1987[2]) have documented the physical characteristics of 632 samples of webbing collected from NWHI locations: 539 (85.3%) were constructed of polyethylene or polypropylene and were considered to have originated from trawl nets; 66 (10.4%) were monofilament gill nets; the remaining 27 (4.1%) were of other materials or unknown origin. Of the trawl net fragments, 17 (3.2%) were assessed to be cod ends of groundfish trawls, based on criteria of at least 6-mm twine diameter combined with stretched mesh size of 80-130 mm. The gill-net samples were assigned to probable source fisheries according to mesh size (Table 1).

It is interesting that, of the two fisheries which are the source of most of the derelict nets found in Hawaii, the trawl fishery contributes most of the material. This is despite the fact that the squid gill-net fishery operates closer to Hawaii, and that according to some estimates (Fredin 1985; Shima 1985) the amount of gill net (both salmon and squid) involved in fishing the North Pacific far exceeds that of trawl net.

A large number of ropes and lines are found in the NWHI, but the amounts have not been quantified. These items undoubtedly originate from ships at sea.

DISTRIBUTION OF DEBRIS ON BEACHES

Henderson et al. (footnote 2) described the distribution of derelict trawl web and gill net on the shores of the NWHI. Netting tends to wash ashore on beaches facing northeast, beaches exposed to the northeasterly trade winds which are predominant most of the year. Certain promontories along islands also accumulate debris as a result of inshore currents. At French Frigate Shoals, a multi-islet atoll, debris accumulates more on Trig, Whale-Skate, and East Islands, the three more permanent and vegetated islands within the atoll. Trig and Whale-Skate Islands are on the windward (northeast) edge of the atoll, whereas East Island is on the leeward (western) perimeter. The uneven distribution of nets presents a particular hazard to Hawaiian monk seals, Monachus schauinslandi, at Lisianski Island and French Frigate Shoals. At Lisianski Island, pups are born predominantly on the east side of the island (Johanos and Henderson 1986; Johanos and Kam 1986), coincident with areas of higher debris accumulation. At French Frigate Shoals, a major pupping site for seals, approximately one-half of all seal pups born in 1983 were born on East and Whale-Skate Islands, two of the islands accumulating the most debris.

ENTANGLEMENT IN MARINE DEBRIS

Debris items may possess openings capable of ensnaring marine animals. Depending on the size of the item, an entangled animal will be either immobilized or able to continue its movements while "wearing" the debris. In the latter instance, eventual death may result as the animal "grows into" the debris item. Animals in Hawaii that are known to become entangled include marine mammals, sea turtles, seabirds, and fish.

Marine Mammals

The Hawaiian monk seal is endemic to Hawaii and is the only pinniped that regularly occurs there. Virtually all marine mammal entanglements in Hawaii have involved monk seals. Thirty-five incidents of monk seal entanglement have been documented in Hawaii through 1984, including eight seals bearing scars indicative of a previous entanglement from which the animal had escaped (Henderson 1985). From 1985 through 1987, 19 monk seals were observed entangled or bearing new scars from recent entanglements (Henderson unpubl. data). Among these incidents were three deaths. One weaned pup died in 1986 after becoming entangled in wire debris at East Island, French Frigate Shoals. In 1987, two seals died after becoming entangled in large fragments of trawl web which previously had washed ashore: A yearling died at Shark Island, French Frigate Shoals, and a pup died at Lisianski Island. The 19 incidents over 3 years represent an increase in entanglement rate since 1984. In 1983-84, eight incidents were noted (Henderson 1985). This increase has occurred despite the fact that beaches in the NWHI are cleaned at least annually of debris that might entangle animals.

One entanglement incident has been reported involving cetaceans in Hawaii. In January 1987, a humpback whale, *Megaptera novaeangliae*, was sighted between Lahaina, Maui, and the Island of Lanai, towing an orange buoy of unknown origin (L. Consiglieri pers. commun.[3]). The animal was sighted only once, and its ultimate fate is unknown. It is possible that the buoy had been towed a long distance; gray whales, *Eschrichtius robutus*, have been documented in Washington, towing nets picked up in California (Beach et al 1985[4]).

Sea Turtles

Twenty-five incidents of sea turtle entanglement through 1984 have been documented, including 20 green turtles, Chelonia mydas; 4 olive ridley turtles, Lepidochelys olivacea; and 1 hawksbill turtle, Eretmochelys imbricata (Balazs 1985). One of the entangled green turtles was a hatchling entrapped while moving toward the sea soon after hatching. The cases of entangled olive ridley turtles are noteworthy in that they comprise most of the documented occurrences of this species in Hawaii. It is likely that the animals became entangled in their normal range to the south of Hawaii and passively drifted north.

Seabirds

The NWHI are a nesting location for approximately 5.4 million seabirds (Fefer et al. 1984), and several species have been observed entangled. An immature masked booby, Sula dactylatra, was found entangled in a scrap of trawl net on Nihoa Island (Conant 1984), and black-footed albatross, Diomedea nigripes; Laysan albatross, D. immutabilis; and sooty terns, Sterna fuscata, have also been observed entangled (S. Fefer pers. commun.[5]). The NWHI are a nesting location for approximately 5.4 million seabirds (Fefer et al. 1984), and several species have been observed entangled.

Fish

Few reports exist of fish becoming entangled in marine debris in Hawaii. An ulua, Caranx sp., was found entangled in a large pile of trawl net which was fouled on an offshore reef at Lisianski Island (Henderson 1984). The author has also observed several dead parrotfish, Scarus sp., entangled in a derelict barrier net on Oahu, and a dead ulua caught by a pile of trawl net on Seal-Kittery Island, Pearl and Hermes Reef. A large mass of trawl and gill net retrieved for the shallow lagoon at Kure Atoll contained skeletal remains of at least four fish, tentatively identified as billfish (family Istiophoridae), tuna (family Scombridae), and barracuda (family Sphryaenidae) (M. Seki pers. commun.[6]).

It is difficult to determine whether fish found in derelict fishing gear were caught while the net was actively fishing or after it was lost. Abandoned barrier nets will continue to catch fish for many years (High 1985).

Passerine Birds

Although this description does not report entanglement, one impact of debris on an endemic passerine bird is noteworthy. Morin (1987) reported deaths in marine debris of the Laysan finch, <u>Telespyza</u> <u>cantans</u>, which is endemic to Laysan Island in the NWHI. During dry summer months, fresh water is scarce on Laysan, causing birds to seek water whenever or wherever available. Certain debris items, such as broken plastic fishing floats or plastic crates, form cisterns for rainwater. In 1986, two Laysan finches drowned in a plastic cooler, having apparently been unable to escape after venturing in to drink the fresh water. The cooler was high on the beach and had evidently been washed ashore for some time. Although this may have been a rare occurrence, the potential exists for loss of more birds under similar circumstances.

INGESTION OF MARINE DEBRIS

Marine debris may be ingested because it resembles the natural food items of certain species or may be ingested during normal feeding on natural food. Plastic spherules resemble fish eggs, and plastic bags or balloons resemble coelenterates. Plastic flotsam also provides a substrate on which flyingfish (family Exocoetidae) lay eggs, and animals feeding on the eggs may also ingest the plastic. Furthermore, some marine animals are opportunistic feeders, eating anything of a suitable size found floating on the ocean surface, including plastics. Potential effects of ingested debris include intestinal blockage, physical debilitation or starvation resulting from a reduced feeding drive due to the presence of debris in the stomach, poisoning from compounds which leach from the plastic, or perforation of the gastrointestinal wall. Animals in Hawaii that are known to ingest plastic or other debris include cetaceans, sea turtles, and seabirds.

Cetaceans

A single occurrence of a cetacean ingesting debris has been noted in Hawaii. A clear plastic trash bag was found in the stomach of an immature male Risso's dolphin, Grampus griseus, which stranded on Maui in February 1988 (E. Nitta pers. commun.[7]). It is not known whether the bag caused or contributed to the death of the animal.

Sea Turtles

Seven cases of ingestion of plastic by sea turtles in Hawaii have been reported through 1984, six of which involved the green turtle and one of which involved the hawksbill turtle (Balazs 1985). The majority of green turtles found to ingest plastic were juveniles. Juvenile turtles live a pelagic existence for perhaps several years after hatching before returning to the nearshore areas to feed on benthic algae. During pelagic existence, their normal diet consists of floating items such as coelenterates, algae, and pelagic mollusks (Carr and Meylan 1980), and turtles are more likely to encounter and ingest debris at this early age (Carr 1987).

Turtles may in some instances be able to pass plastic materials through their gastrointestinal tract and expel them. One young green turtle, which was being maintained in captivity, ingested a plastic bag, part of which was found protruding through the cloaca. Dead turtles have also been found with shreds of plastic bags in the feces in the lower intestine, suggesting that the bags may not always obstruct the digestive tract.

Seabirds

Ingestion of plastics is ubiquitous among seabirds breeding in Hawaii. In a study of plastic ingestion by nestling seabirds at Midway Islands, 14 of 16 species were found to have ingested plastic (P. Sievert pers. commun.[8]). Young birds are more likely to ingest plastic because they are fed regurgitated food by the parent and tend to accumulate indigestible items.

The effects of ingested plastics on young seabirds are unclear. Many hard items, such as pumice, squid beaks, and floating seeds, naturally occur in seabird diets; hence, young birds have evolved means of casting such residue, including plastics. Healthy albatross chicks, for example, naturally regurgitate hard items that have become concentrated in the proventriculus. Chicks debilitated by disease or dehydration, however, may be unable to regurgitate normally and may experience higher mortality, either from the original source of debilitation, the presence of plastics, or a combination of these factors (see footnote 8).

Plastic ingestion may also occur frequently among adult Hawaiian seabirds. Birds which are surface feeders are particularly susceptible (Day et al. 1985); 90% of adult Laysan albatross examined by Fry et al. (1987) had ingested plastic items.

EFFECTS ON HUMANS

The author knows of no reported fouling of propellers or other entanglements with vessels at sea near Hawaii that could be hazardous to human health or safety. Aesthetic degrading of beach areas is probably the most significant impact of debris on a state which depends heavily on tourism for revenue.

Marine flotsam can also have a favorable effect in Hawaii; floating pieces of trawl webbing, often called "cargo net" by local fishermen, may aggregate large fish communities. Fishermen take advantage of this focus for fish and may catch large amounts of tuna and other commercially valuable species in association with floating net fragments.

SUMMARY

Despite, or perhaps because of, its midocean location, Hawaii is affected by the problem of plastic pollution and marine debris in the world's oceans. The remote NWHI daily are recipient of nets and other flotsam in which endangered monk seals, threatened and endangered sea turtles, and protected seabirds may become entangled. Nesting seabirds and foraging juvenile turtles range widely from the islands, ingesting plastic or other items mistaken for food. Within the main islands, derelict nets are both a danger and a boon to fishermen, who risk having their boats become fouled in abandoned webbing, yet who may also catch large amounts of commercially valuable fish associated with the flotsam. The aesthetic effect of marine debris on beaches is difficult to quantify but is certainly evident, particularly along windward beaches.

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FOOTNOTES

[1]City and County of Honolulu, community work day program, press release, October 28, 1987.

[2]Henderson, J. R., S. L. Austin, and M. B. Pillos. 1987. Summary of webbing and net fragments found on Northwestern Hawaiian Islands beaches, 1982-86. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-87-11, 15 p.

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[4]Beach, R. J., A. C. Geiger, S. J. Jeffries, S. D. Treacy, and B. L. Troutman. 1985. Marine mammals and their interactions with fisheries of the Columbia River and adjacent waters, 1982-85. Processed Rep. 85-04, 316 p. Available from Northwest and Alaska Fish. Cent., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way, N.E., Seattle, WA 98115.

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[6]M. Seki, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, 2570 Dole Street, Honolulu, HI 96822-2396, pers. commun. August 1987.

[7]E. Nitta, Western Pacific Program Office, National Marine Fisheries Service, NOAA, 2570 Dole Street, Honolulu, HI 96822-2396, pers. commun. February 1988.

[8]P. Sievert, National Wildlife Health Laboratory, U.S. Fish Wildl. Serv., 6006 Schroeder Road, Madison, WI 53711, pers. commun. August 1987.

Table 1.--Number of gill-net fragments found on beaches of Northwestern Hawaiian Islands in 1982-85, with probable source fishery.

Mesh size (mm)	No.	Probable source fishery
Unknown	5	Unknown
15	1	Soviet saury/anchovy (?)
50-58	4	North American coastal herring
89-109	32	High seas squid
110-115	14	High seas or Asian land-based salmon or high seas squid
119-130	8	High seas salmon
140-160	2	North American coastal salmon

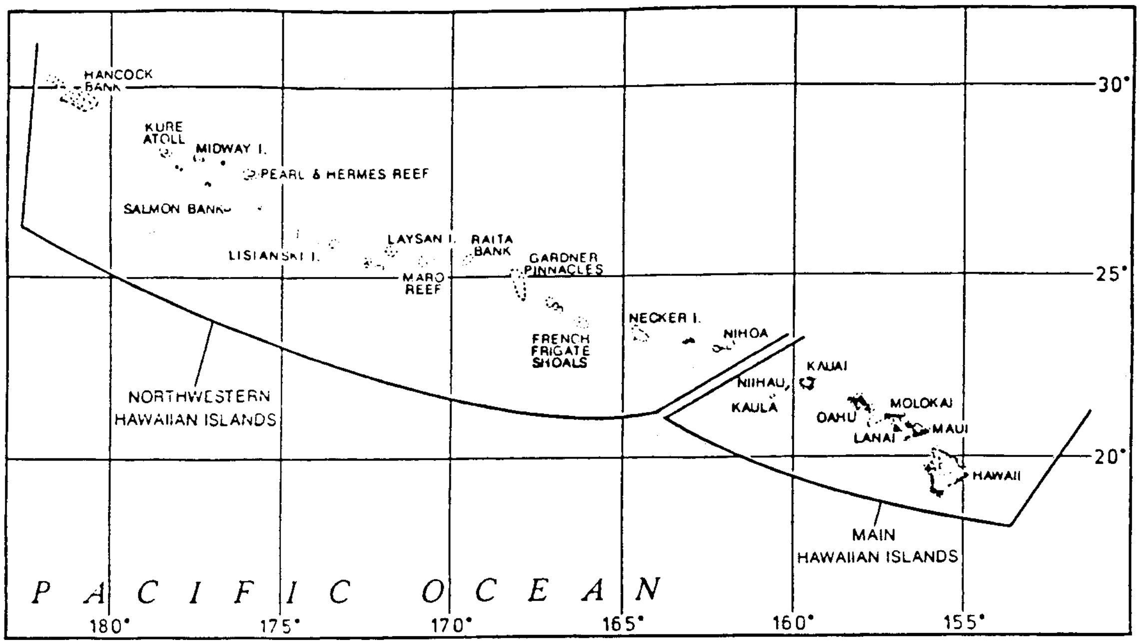

Figure 1.--Hawaiian Archipelago.