Appendix A Contaminants and Debris in the Marine Environment

This appendix describes contaminants in the pelagic environment, their potential economic, ecological and human health and safety effects, and legal instruments for their control.

Chemical Pollutants

Chemical pollutants include such things as petrochemicals, dissolved metals, fertilizers and organic pesticides. Chemical pollutants are most concentrated adjacent to heavily populated areas, industry, intensive agriculture and military activities. Consequently, the adverse impacts of marine pollution are most apparent in the nearshore environment (state and territorial waters) (Green, 1997). The effects of marine pollution are likely to be much less severe in the open ocean pelagic environment (federal and international waters) where water is well-mixed and concentrations of pollutants are diluted.

Nevertheless, at least one category of pollutant, “persistent organic pollutants” (POPs), occurs in water, sediments and air throughout the world, even far from locations of manufacture or use. POPs are carbon-based compounds that tend to resist photochemical, biological and chemical degradation. They are often halogenated and characterized by low water solubility and high lipid solubility, leading, together with their persistence, to bioaccumulation in fatty tissues, including the fat of fish and marine mammals. POPs are also semi-volatile, a property that permits them to vaporize or to be adsorbed onto atmospheric particles and transported around the globe. Primary mechanisms of entry into marine waters are aerial transport and atmospheric deposition, river discharges and agricultural run-off, waste water disposal and marine migratory species. POPs may persist in the environment for years and may bioconcentrate up to ten thousands fold. While direct inputs to the sea have largely ceased, substantial quantities remain in bottom sediments.

Twelve POPs, all chlorine-containing organic compounds, have been chosen as priority pollutants by the United Nations Environment Programme (UNEP) for their impact on human health and the environment. The twelve POPs include many of the first generation organochlorine insecticides (e.g., DDT, aldrin), industrial chemical products (e.g., polychlorinated biphenyls [PCBs]), or by-products such as dioxins and furans. The complete list includes:

- 2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)
- Chlordane
- DDT
- Heptaclor
- Hexachlorobenzene
- Mirex
- Toxaphene (mixtures of polychlorinated camphenes)
- Aldrin
- Dieldrin

- Endrin
- Polychlorinated dibenzo-para-dioxins (other than TCDD)
- Polychlorinated dibenzofurans

Humans are exposed to POPs through the ingestion of food including fish. Effects can include cancer, neurotoxic, behavioral, immune system and reproductive disorders. The mechanism for many of these effects appears to be through disruption of the human endocrine system.

POPs have also been linked to reproductive failure, deformities, and malfunctions in fish and wildlife. POPs may concentrate in the air-water interface where the surface film is rich in amino acids and particles. This may represent an elevated risk to surface living organisms or to birds such as petrels that skim fat off the surface of the sea.

Contaminants from abandoned landfills and debris sites in the MHI and NWHI could possibly work through the island-associated food web (Marine Mammal Commission, 2000). A point source of contaminants (PCBs leaking from discarded generators) has been identified as a potential threat to monk seals, seabirds and sea turtles as well as fisheries around Tern Island, French Frigate Shoals. However, a recent analysis of risks to Hawaiian monk seals based on dietary exposure and contaminant concentrations in blubber and blood indicates that no contaminants are present at concentrations believed to represent a risk to the seals (CH2M Hill, 2000). Nevertheless, there is a possibility that contaminants from the site may become redistributed into the nearshore environment as a result of major storm events. PCB contamination can make some animals lethargic and perhaps more vulnerable to being incidentally caught in fishing gear.

Exposure of marine organisms to petroleum can be chronic or, in the case of a spill, acute. Spills are much more likely in coastal areas than in pelagic environments. Petroleum has the potential to be toxic to seabirds if it is ingested, inhaled or absorbed through the skin, mucous membranes or eyes. Hydrocarbons can also bioaccumulate in zooplankton and fish eaten by seabirds and other wildlife. Any detrimental effects of marine pollution on their forage species would also affect seabirds. Oil contamination affects seabirds directly and immediately by destroying the waterproof nature of their plumage and disrupting thermoregulation and buoyancy. Aside from large, catastrophic spills, the long-term effects of low levels of petroleum exposure are unknown.

Petroleum also has the potential to be toxic to marine mammals if it is inhaled, ingested or absorbed through the skin, mucous membranes or eyes, or if it inhibits feeding by baleen whales. Hydrocarbons can also bioaccumulate in zooplankton and forage species eaten by marine mammals. Any detrimental effects of marine pollution on their prey species would also affect marine mammals. Aside from large, catastrophic spills, the long-term effects of low levels of petroleum exposure are unknown.

Eating ocean fish from uncontaminated marine environments exposes consumers to very low doses of methyl mercury. Not one person of any age in Hawaii or elsewhere has been reported with methyl mercury poisoning from marine fish consumption since the deaths and severe neurological disorders related to industrial pollution of Minimata Bay and the Agano River in Japan during the 1950's and 1960s..

Scientists have established a strong link between air pollution and elevated methyl mercury levels in some freshwater fish species in contaminated lakes. Studies of change in mercury concentrations in open ocean fish and coastal seabirds over the past century using museum specimens as early controls have produced conflicting findings. There was no difference in the mercury concentration of Pacific tuna and swordfish caught between 1878 and 1909 compared to 1972 (Miller et al., 1972). In contrast, a significant increase in mercury was found in some studies of fish-eating seabirds pre-1973 to post-1979 off the Atlantic coast of Europe (Monteiro and Furness, 1997; Thompson et al., 1998). There remains some question about the accuracy of testing museum specimens for heavy metal concentrations, however (Gibbs, et al., 1974; Renaud et al., 1995).

If mercury in Pacific pelagic top predator fish originated wholly or partly from atmospheric pollution, the two- to three-fold increase in atmospheric mercury over the past 150 years should be reflected to a measurable extent in tuna inhabiting the upper layers of the Pacific Ocean. On the basis of constant mercury concentrations in yellowfin tuna caught off Hawaii in 1971 and 1998 – a 27-year span – scientists concluded that mercury levels in tuna are not responding to atmospheric pollution. They hypothesize that methyl mercury is formed in the deep ocean (> 900 m) or in deep ocean bottom sediments. The mixing time between the deep ocean and the surface (where atmospheric mercury is deposited) is too long (hundreds of years) for the dep ocean to have been impacted by human mercury inputs over the past 150 years. Thus, mercury in tuna and presumably in swordfish and other open ocean top predators is coming from a natural, not human source (Kraepiel et al., 2003).

The risk posed by exposure to mercury from ocean fish consumption is currently speculative. Action levels represent the limit at or above which the FDA will take legal action to remove a product from the market. In 1979, the U.S. Food and Drug Administration set a 1.0 ppm action level as the maximum safe limit for total mercury in the edible muscle of fish. In 1984, the FDA switched from enforcing the mercy action level based on total mercury to a methyl mercury limit.

A series of public health advisories regarding methyl mercury in seafood has been issued by several U.S. agencies. These warn pregnant women and women of child-bearing about the potential hazard of high levels of methyl mercury in certain species of fish, including swordfish, to fetuses and newborn children. The developing brain of an unborn child or infant is more sensitive to the harmful effects of methyl mercury than the central nervous system of an older child or adult. The latest advisory, issued jointly by the FDA and EPA in March 2004, also recommends that women who are planning to become pregnant, already pregnant, or feeding a young child should eat no more than 6 oz. of albacore tuna per week. The Hawaii Department of Health recommends that pregnant women, nursing mothers and young children do not eat Pacific blue marlin and limit their consumption of bigeye tuna, yellowfin tuna. Albacore tuna, wahoo and moonfish to once every two weeks and once a week for skipjack tuna. Mahimahi and striped marlin.

The State's advice is based on the EPA's guideline for a daily safe intake of methyl mercury. The EPA's guideline is derived from a study in the Faroe Islands that found statistical correlations between pre-natal methyl mercury exposure and subtle changes in vocabulary test scores of children at age 7 (Steuerwald et al., 2000). Pre-natal exposure was due to the mothers' high consumption of pilot whales, which have much higher concentrations of methyl mercury (also of PCBs and cadmium) than fish. The most sensitive outcome from testing of the Faroese children was divided by an uncertainty factor of 10 to derive the EPA guideline. Thus, there is a considerable margin of safety in this guideline..

The 9-year Seychelle Islands Child Development Study found no detectable health risk to children from pre-natal methyl mercury exposure resulting solely from their mothers' consumption of ocean fish (not whales or sharks) (Myers et al., 2003).. This research is more applicable to Hawaii because of the Seychelle sample's continuous consumption (average 12 meals per week) of ocean fish, including tuna and ono, containing methylmercury concentrations comparable to those in pelagic species consumed by Hawaii and U.S. mainland populations. Based on the findings of this study, the U.S. Department of Health and Human Services (Agency for Toxic Substances and Disease Registry, ATSDR) set a "minimal risk level" of methyl mercury intake that is three times higher than the EPA level (Agency for Toxic Substances and Disease Registry, January 2004). The higher level would protect 99 percent of U.S. women of child-bearing age, according to pharmacokinetic and statistical modeling (Clewell, H.J., P.R. Gentry, A.M. Shipp, et al. 1998; Shipp, A.M., P.R. Gentry, G. Lawrence, et al. 2000).

Marine Debris

Marine debris includes solid waste from many sources, including derelict fishing gear. The majority of marine debris (estimated 80 percent) is thought to originate from land-based sources and the balance (20 percent) is from maritime sources (Faris and Hart, 1995). Marine debris is thought to be primarily (> 90 percent) forms of discarded plastic material (Ribic et al., 1997). Commercial fishing gear is estimated to comprise 5 percent of the total amount of marine debris found in the ocean (O'Hara et al., 1988).

Marine debris can have negative economic, ecological and public health effects. Ecological effects can include habitat destruction through abrasion or smothering, macrofaunal entanglement, ingestion, and, in the case of fishing gear, ghost fishing. It can facilitate alien species introductions. It can be a hazard to navigation and endanger life and property. Aesthetically, marine debris is unsightly and can discourage tourism and coastal recreation.

As a result of oceanic circulation patterns, the Hawaiian Archipelago is the repository for significant amounts of exogenous marine debris, including derelict fishing gear from North Pacific fisheries. The Coral Reef Ecosystem Division (CRED) of the PIFSC conducts a comprehensive multiagency program to assess, monitor and mitigate the effects of marine debris on coral reef ecosystems of the U.S. Pacific Islands. In partnership with the FWS, USCG, the State of Hawaii, and several NGOs, annual surveys to assess derelict fishing gear in the NWHI have been done since 1996. Five sites have been surveyed: French Frigate Shoals, Lisianski Island, Pearl and Hermes, Kure and Midway Atolls. Approximately 330 tons of marine debris have been removed from NWHI reefs during these surveys. Net samples collected from the NWHI between 1998 and 2002 were about 86% trawl/seine nets. These types of fisheries do not exist in Hawaii, and it is presumed that this debris originates in various fisheries in the northern Pacific. Gillnet made up about 8% of the total. Longline gear comprised about 1.4%.

Marine mammals, turtles, sharks, other fishes, lobsters, and crabs have been observed entangled in derelict fishing gear in the NWHI (Donohue, 2003). Plastic materials, including plastic bags, cigarette lighters and chemical light sticks, can be mistaken for forage by some seabirds and sea turtles. The ingested material may cause lethal and sublethal effects by physical blockage of the digestive tract, physical trauma leading to infection and direct toxicity of ingested materials. Marine debris, particularly floating plastic items such as plastic chips and discarded cigarette lighters and chemical light sticks have been found in necropsies of seabirds in the NWHI. The effects of ingested plastic on the growth and survival of Laysan (*Phoebastria immutabilis*) and black-footed (*P. nigripes*) albatross chicks were studied by Sievert and Sileo (1993). They concluded that ingested plastic is not a direct cause of death in albatross chicks, although there was some evidence that plastic may affect survival indirectly during nesting and the period after fledging.

Sea turtles may ingest or become entangled in marine debris, leading to decreased ability to breath, feed, swim or haul out. Anything that causes individuals to lose body conditioning has the potential to increase vulnerability to predators, disease agents and stressors, reducing survivability and reproductive success. Ingested plastic materials and monofilament fishing line from nearshore recreational fishing activities have been identified in necropsies of green turtles in the main Hawaiian Islands (Work, pers. comm., 2000).

Marine debris can have lethal or sublethal effects on marine mammals if ingested or if it entangles them, leading to decreased ability to breath, feed, swim or haul out. Marine debris, particularly derelict fishing gear, presents a serious risk of injury or death to Hawaiian monk seals. Monk seal pups and juveniles are especially attracted to debris. Subsequent interactions can lead to entanglement. Unless they are able to free themselves quickly, entangled seals risk drowning or death later due to injuries inflicted by the debris. In 1998, 18 monk seals were found entangled in marine debris (Marine Mammal Commission, 1999). Of these, five were able to disentangle themselves, 12 were disentangled by field crews and one was found dead in a fishing net caught on the reef at Laysan Island. In 1999, a record 25 monk seals were reported to have been found entangled in marine debris (WPRFMC, 2000e, 2000g, 2000h).

A great diversity of sessile and motile organisms have been reported from freely drifting and shore-cast marine debris. The communities described bear resemblances to those associated with drifting seaweeds. They also include a number of fouling organisms, mostly bryozoans, which have already achieved global distribution through attachment to natural substrates such as wood and turtles. Terrestrial invasive species could also be among the hangers-on and hitch-hikers (this is from Gregory in the APEC proceedings). Substantial aggregations of marine debris may also provide habitats suitable for the larval and juvenile stages of many marine organisms as well as be attractive to adults of larger species, and in many ways resemble FADs. It has also been suggested that matted rafts of marine debris could provide a suitable platform upon which some small aggressive, and habitat-endangering vertebrates, such as mice, rats and mustelids as well as some larger taxa could voyage.

Drifting marine debris is known to aggregate certain species of marine life, including targeted species of tuna and non-targeted species (*mahimahi*, marlins, rainbow runners, etc.). Large schools of fish can be found in association with drifting debris such as logs, refuse and derelict fishing gear. Debris may act to provide shelter for forage species and provide concentrated feeding opportunities for target species. The attractiveness of floating debris to fish in the pelagic environment is the basic principle used in the design and accounts for the effectiveness of artificial fish aggregating devices. FADs are effective in artificially aggregating fish, making them more vulnerable to harvest.

The biological effects of FADs are not well understood. FADs may have positive impacts by aggregating forage species and providing target species with additional feeding opportunities. Potential adverse biological impacts of FADs relate to the increased efficiency of harvesting activities on both target and non-target species, the possible disruption of normal migratory, foraging and aggregation patterns, the potential for introduction of alien marine species as FADs drift across the ocean and impacts associated with the accidental grounding of lost FADs.

Concerns about FADs have heightened following the great increase in the use of drifting FADs by tuna purse seine vessels in the western and eastern Pacific in recent years. Concerns are mostly related to the biological impacts of increasing the efficiency of tuna seining operations that tend to harvest younger, less mature tuna. Of particular concern is the trend towards FAD fishing in the eastern Pacific that has increased the amount of juvenile and adult bigeye tuna caught and processed as canned tuna. The uncertain impacts on the catch of larger, mature bigeye tuna by longline fisheries elsewhere in the Pacific are a great international concern.

FADs used by tuna purse seiners are most commonly floating bamboo rafts with portions of line and seine net suspended in the water column. The suspended netting could entangle marine life in the open ocean. FADs that are intentionally released to drift by tuna purse seiners may be lost or abandoned and might be expected to contribute to the adverse impacts described in the discussion of derelict fishing gear in the coral reef or nearshore environment should the rogue FAD eventually make landfall.

<u>Legal Instruments Controlling Marine Pollution and Debris</u>

Pollution and debris in the marine environment are international problems. International law, as reflected in the provisions of the United Nations Convention on the Law of the Sea (UNCLOS) and elsewhere, sets forth rights and obligations of States and provides the international basis upon which to pursue the protection and sustainable development of the marine and coastal environment and its resources.

Several important international legal instruments have been developed and are in place to control the discharge of marine contaminants and solid wastes including persistent fishing gear and gear fragments into the marine environment. The Convention of the Prevention of Marine Pollution by Dumping of Wastes and other Matter, also known as the London Dumping Convention (LCD), entered into effect in 1975 and is administered under the United Nations by the International Maritime Organization (IMO). This treaty established permitting requirements for the disposal of wastes into the sea and functions as the global instrument to control marine pollution from dumping dredge spoils, sewage sludge and other types of land-based wastes.

MARPOL 73/78, also administered by the IMO, is a U.N. agreement that addresses the operational and unintentional discharge of vessel-derived debris, including certain fishing gear, persistent plastics and other refuse at sea. MARPOL has six annexes covering oil discharge (I), hazardous liquid control (II), hazardous material transport (III), sewage discharge (IV), plastic and garbage disposal (V), and air pollution (VI). The Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 (Public Law 100-220, Title II) is the U.S. legislation that serves to implement MARPOL in U.S. waters. These instruments work together to regulate the input of pollution (including derelict fishing gear) into the world's oceans. MARPOL has emerged as the principal legal basis for regulating the disposal of all plastic materials from ships at sea.

Under MARPOL and the MPPRCA it is illegal for any U.S. vessel to discharge plastics into the ocean (within the EEZ or on the high seas). U.S. vessels are required to have a written waste disposal plan and maintain a detailed waste logbook documenting the handling and disposal of plastics and other wastes. The U.S. Coast Guard monitors vessels for compliance.

The international community has also established a policy for phasing out or limiting the use of POPs. The UN Global Program of Action (GPA) for the Protection of the Marine Environment from Land-based Activities built upon several prior international declarations, conventions and guidelines (1985 Montreal Guidelines on Marine Pollution from Land-based Sources, 1995 Washington Declaration of the Protection of the Marine Environment from Land Based Activities, and others). In particular, the Stockholm Convention requires signatory nations to develop plans to eliminate or reduce their release of POPs to the environment.