Marine Pollution and Debris - Not a new problem

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National Global Change Report

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Sea Level Rise, Ocean Acidification, Other Ocean Changes

(all extremely high, very high, or high confidence unless indicated. Models more like to underestimate than overestimate the amount of long-term change)

- Global mean sea level rise (mainly from volume expansion due to heating and from ice loss): 7-8" since 1900, 3" since 1993; 6" rise by 2050, medium confidence of 18" rise by 2050; 8 ft rise possible by 2100. If all CO2 emissions stopped now, continued rise for hundreds to thousands of years. Future CO2 emission scenarios will have major impact on second half of century. Likely greater rise in U.S. NE and western Gulf of Mexico, less in Pacific NW and Alaska. Models indicate that sea rise is committed, under currently achieved heat change and CO2 emission, to hundreds and even 10,000 years (80-125 ft)
- Tidal flooding has increased 5x-10x since 1960s, and will continue to increase. Extreme flooding associated with coast storms will increase in frequency and intensity, unsure of the magnitude
- Oceans have absorbed 93% of excess heat from greenhouse gas warming since mid-20th c, affected all depths. Under high GG emissions, 4.9^{o} $\pm$1.3^{o}F by 2100. Atlantic Meridional Overturning Circulation will decrease (northward flow of warm salty water in upper layers of the Atlantic, and southward flow of colder water in deep Atlantic).
- Oceans currently absorbing >25% of CO2 causing acidification, with worse higher than lower latitude buffering of acid. Ocean pH is slightly basic-x=8.2, but today it is 8.1, a 25% inc. over two centuries. 7.8 by end of century. The rate of acidification is *unparalleled in the past 66 million y* (med conf). Global ave. surface acidity will increase by 100-150%.
- Deoxygenation has occurred at intermediate depths and many coastal areas; projected to decrease by 3.5% by 2100 relative to preindustrial values.

Marine Ecology

- The open-ocean zone – pelagic zone – has very low ecological productivity, lower than deserts, which results in heightened competition and adaptation.
- Sea biomass is predicted by diversity, climate change, and other human impact. Fish play a significant role in mitigating climate change by maintaining the pH balance of the oceans. They do this by expelling the excess calcium they ingest from drinking sea water, by binding the calcium to bicarbonate, and excreting it as pellets of calcium carbonate ("gut rocks"), which have an alkalizing effect on seawater.
- Diversity: There are 41,415 species on the Int Union for Conservation of Nature Red List, and 16,306 are endangered/threatened with extinction.
- Over-exploitation by fisheries and climate change have resulted in increasing threats of extinction. Most endangered fish are Orange roughy, eel, haddock, halibut, and Atlantic cod. Other endangered sea animals are whales, dolphins, manatees and dugongs, salmon, seabirds, seals, walrus, sea turtle, and sharks, to name a few. There are only 30 vaquita porpoise remaining. Recent marine extinctions or near extinctions: Caribbean Monk seals, white abalone, blue whales, right whales, short-tailed albatross, staghorn and elkhorn coral, and Johnson's seagrass.
- NOAA (Dept. of Commerce), National Marine Fisheries Service manages 137 marine species.
- Actual rates of extinction are not known about sea life because it is difficult to study.

Classification of marine pollution

(Potters G, 2013. Marine Pollution, 5th Ed., Oxford U. Press)

- Physicochemical: 1) Inorganic compounds (NO, NO2, SO2, metal ions), 2) organic (wastewater, nitrogen & phosphorus run-off, petroleum derivatives, 3) sound ("death of a thousand cuts" (Sylvia Earle) from military sonar, oil exploration, industrial shipping – see Ctr for Biological Diversity. Sound waves travel mile in 10s-100s, far exceeds safety levels for humans), 4) light (developed world, Asia, Africa highest % of coastal influence by land light, light fisheries, shipping. Affects sleep-clock activity, maturation, reproductive events, regulates physiology, affects visually guided behaviors of orientation, predation, communication. New field, not yet recognized by MARPOL (Int Conv for Prev of Poll. From Ships) Davies et al, 2014).
- Physical: 1) solid forms (plastic debris, remains of sludge), 2) drifting solids (ashes, heavy metals adhering to dust and particulate matter), 3) gases (like VOC), 4) solutes (nitrogen fertilizers, agricultural run-off, antibiotics, medication, hormones)
- Persistence in environment: 1) biodegradable (mineralized by bacteria or assimilated in the metabolism of organisms will not persist long, 2) dissipate spontaneously and rapidly and become less damaging (heat discharge by power station cooling, acids and bases, cyanides from metallurgical industries), 3) persistent and conservative (not subject to bacterial attack, not dissipated, reactive in plants and animals causing harm (heavy metals, radioactive sources, chlorofluorocarbons, dioxins, pesticides, pollutants that bioaccumulate)).
- 4 main Point/nonpoint sources: 44% from runoff and discharges from land via waterways (industrial, ag, algal blooms, eutrophication, metals on dust/sediment in rivers-40% of watersheds in western US contaminated), 33% through airborne emissions and are atmospheric (dust and greenhouse gases, acidification by CO2), 12% from shipping and accidental spills (engines, garbage incineration, cooling sys, human sewage, bilge, biological contamination and invasives), 10% from dumping garbage and sewage, 1% offshore mining and fossil fuel extraction.

Floating Plastic Debris

- Scientific publications: <20 from 1990-95, 100 from 2000-2005, 230 from 2010-2015
- Still a lack of precise knowledge about the quantity, sources, transport, accumulation, and fate of plastics in the ocean.
- Wind, temperature, waves, and salt break down plastics, but do not biodegrade them – that takes about 450 years.
- Floating plastics accumulate toxic pollutants on their surface during long time in polluted seawater and represent a concentrated source of environmental pollution, or serve as a vector for toxic pollutants that accumulate in food webs.

Sources of Plastics in the Marine Environment

- Over 80% of marine plastic, vast majority is single use items, comes from where people live, play, and work. End up in the streams, lake, groundwater, and ocean.
- Industrial losses of plastic pellets from manufacturing, and from spillage
- In the past 30 years, plastic use has increased 500%. 50% goes to land fill, 3-7% is recycled, and 40% is unaccountable (according to EPA).
- Characteristics
- Plastics are endocrine disrupting chemicals that last for decades. They are increasing the estrogen in waters and in sea life, and causing feminization of male fish and other aquatic life. Not enough studies to know how plastic is changing life.
- In beached whales and other sea animals and birds, there is predictably a great deal of plastic, which will not be digested. Plankton eat plastics. When we eat fish that has eaten plastic, the toxic chemicals are absorbed by the tissue of the fish. Of 485 fish tested, 40% had ingested plastic (Penn State). The plastics affect the organs and behavior of the fish. Nanoplastics can cross the blood brain barrier in fish. Found in shell fish. Also, wildlife **entanglement**, **suffocation**, and **starvation**.
- Penetration in the Env: There are no federal standards for the amount of plastic that a fish can have when sold for food. The EPA and other Int. agreements do not have limits for the amount of plastic than can be released into our waters. Plastic fibers were found in 159 water samples collected from many countries, and U.S. had the worst. Microplastics found in beer in Germany. Microplastics found in salt, and in honey.

Ocean Debris Gyres

North Pacific Gyre, North Atlantic Gyre, South Pacific Gyre, South Atlantic Gyre, Indian Ocean Gyre, the plastic 'patches' are a soup of plastic, found down to the ocean floor, in all oceans.

International laws:

1. Land-based Sources Protocol – to identify main sources of marine pollution in Caribbean area, entered into force in 2010
2. London Protocol 1996 –addresses material that can be dumped (eg-radioactivity, CO2) if no effect on fishing or or navigation
3. MARPOL 1973/78–regulations for prevention of dumping of garbage by ships. , Annex V 1988 –specifies the distances from land for dumping, divides types of debris
4. Regional Seas Programme Conventions and Protocols-1974 UN marine-related policies
5. UNCLOS 1982. UN Convention on the Law of the Sea came into force 1994

These have spurred collective regional action to have a global impact especially for land-based sources. A Regional Seas Programme goals declared in 2013-2016 focus on: 1) coastal area management, 2) ecosystem and biodiversity,3) land-based activities,4) marine litter, 5) sea-based pollution, and 6)small islands.

Microplastics
synthetic organic polymers < 5mm in diameter

- Microfibers are becoming more problematic than large plastics. Those favorite fleeces are made of plastic – often downcycled plastic bottles. Every time they are washed the microfibers come off the clothes (one garment sheds 1900 fibers per wash). They do not break down in the environment, and can't be filtered out. Try to buy more natural materials because they can decompose when they are in the environment.
- Huge amount of small plastics in Lake Huron. Dr. Sherri Mason examined it and found most were very small, including face scrubs and toothpaste. The smallest pieces cannot be removed by water treatment plants. There is a federal ban on microbeads – polyethylene.
- Nerdles – plastic pellets, used for manufacturing of plastic items. Other dangerous chemicals are added to pellets to make the plastic.

“Near permanent contamination of the natural environment”

Roland Geyer et al. from the National Center for Ecological Analysis and Synthesis at U. C. Santa Barbara

- 34 Billion tons of plastic by 2050, which is 100 x the weight of all humans on the planet, and 4 x more than made to date.
- 91% of plastics are not recycled (U.S. < Europe (70%) and China (75%). 79% of all plastics ever produced have been discarded.
- 4% of petroleum used to make plastics.
- Global plastics industry on the verge of massive expansion, driven by 57% increase in oil and shale gas production. Petrochemical industry is predicted to increase plastics exports by 500% by end of next decade.
- 42% of all the plastic ever made are used for packaging, with 1 yr lifespan before being discarded

Ocean Conservancy

Solutions

citizen regional actions are very important

- Do not overfill trash receptacles. Pick up small bits of plastic whenever you can. Municipal drain catchment devices/screens cannot catch the smallest plastics.
- Awareness: What grade would you give your home, school, work place? Plastics are impossible to remove and must be prevented from entering the ecosystem.
- Cut out single use plastics. Refuse, reuse, and recycle.
- Lend a hand. Participate in community cleanups
- Educate others about plastic pollution and solutions
- Ask for alternative sustainable products.
- Nurture habits that limit plastic at home when shopping, eating out, or entertaining.
- Bali, Bangladesh, Rwanda, China, Taiwan, Macedonia, Kenya banned plastic bags.
- Target youth as audience for awareness and behavior change
- Inform local governments.
- Read “My Plastic Life” – how you can deal with plastics in your life.
- Let companies know you are concerned.
- Storm water stenciling – “Dump no waste” and “Drains to Stream”