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Oceans in Crisis—Human Garbage

Abstract

The level of consciousness that created a problem in the first place is not the level of consciousness whereby the problem can be fixed. Yet, having learned little or nothing from history, our civilization is currently destroying the very environment from which it sprang and on which it relies for continuance. To change anything, we must, through the choices we make, reach beyond where we are, beyond where we feel safe. We must dare to move ahead, even if we do not fully understand where we are going or the price of getting there because we will never have perfect knowledge. And, we must become students of processes and let go our advocacy of positions and embattlements over winning agreement with narrow points of view. True progress toward an ecologically sound land-sea environment and a socially just culture will be initially expensive in both money and effort, but in the end will be progressively benefit all generations. The longer we wait, however, the more disastrous becomes the social-environmental consequences of the current land-sea nexus and the more expensive and difficult become the necessary social changes. No biological shortcuts, technological quick fixes, or political hype can mend what is broken. Dramatic, fundamental change is necessary if we are really concerned with bettering the quality of life-even that of next year. It is not a question of can we or can't we change, but one of will we or won't we change. Change is a choice, a choice of individuals reflected in the collective of society and mirrored in the biophysical land-sea connection of human garbage.

Review Article

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Chris Maser*
Department of Social-Environmental Sustainability, Oregon State University, USA

***Corresponding author:** Chris Maser, Department of Social-Environmental Sustainability, Oregon State University, Corvallis, Oregon, USA,
Email: maserc@peak.org

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Introduction

Nature's life-sustaining marine debris—driftwood

European settlement along the east coast gave birth to greed that drove men across the vast North American continent in a frenzy of conquest and exploitation. The Constitutional Convention of 1787 prepared the way for westward expansion across what is now the United States. By 1812, the overriding emphasis of human endeavors in the Pacific Northwest was focused on the battle for Nature's bounty. But it was in the 1840s, in what are now Oregon and Washington that human manipulation of the environment began to change the forest in ways never before seen. Finally, the eruption of World War II set the technological stage for the systematic alteration, which most often equates to destruction, of the forests, streams, rivers, estuaries and oceans faster and more completely that at any time in history. Logging in what is now the Willamette National Forest, in western Oregon, was first recorded in 1875. During the first three decades of the 20th century, 90% of the timber cut was still readily accessible near rivers and streams below a 4,000-foot elevation. By the 1970s, 65% of the timber cut occurred above a 4,000-foot elevation and the average age and size of trees felled became progressively younger and smaller. And today, to maintain the same volume of wood fiber cut below 4,000 feet in elevation, we're cutting five times the number of acres above the 4,000-foot level. In just 142 years, from the start of Lewis' and Clark's epic travels in 1803 to the end of World War II in 1945, we in the United States have achieved the technological capability of disarranging and disarticulating the basic biological functioning of the world. And today, 70 years since the end of World War II, the demands of human society are causing the rapid, global deforestation. In the process, forests are both physically and ecologically uncoupled from streams, rivers, estuaries and oceans of the world. Today, for example, we are preventing driftwood from even beginning its journey by removing as much wood as possible from the forests as a product for human consumption, lest it remain as an "economic waste." Then, by damming rivers, we are preventing what little driftwood even begins its journey from completing it. We have thus severed the connection of the forest and the sea—to the everlasting detriment of the world's oceans.

To illustrate an infinitesimal aspect of the importance of trees drifting at sea, consider that they are usually heavily populated with plants and animals, including both pelagic and near-shore species, acquired during the tree's transit to the open ocean. In addition to the communities of organisms actually attached to or secreted within the driftwood itself, communities or other organisms form around it. More than a hundred species of invertebrates and some hundred thirty species of fishes are known to congregate on and around different types of floating objects. With respect to these open-ocean communities, wind-induced water movements in the ocean's upper layer are among the most important factors leading to the aggregation and survival of organisms near floating objects. The rapidity with which the associations of fishes form has to due with the Langmuir currents, which are parallel pairs of counter-rotating convection currents driven by surface winds. Langmuir convection currents sweep driftwood, organic detritus and plankton into the long, parallel windrows (often called slicks) of floating debris or lines of foam.

Although some species of organisms may seek shelter or food in connections with pelagic driftwood, for most it is a vehicle bringing them into rich feeding grounds because driftwood, originating at river mouths, travels through biologically rich coastal areas and tends to accumulate in rich parts of the ocean. In this way, driftwood can be used as "stepping stones" in the movements of such fish as tunas because it links them to major features in the circulation of ocean currents along their migration route, as the driftwood, entrained in the current, covers hundreds of miles during its weeks and months at sea. Various hypotheses have been advanced to explain the formation of communities associated of floating objects, particularly fishes. Shade, refuge from predaceous fishes, an abundance of food, or protection from waves may be involved. It is also been suggested that shadows cast by floating trees make zooplankton more visible to predators or that pelagic fishes simply seek shade. Then again, drifting trees may serve as sites for egg attachment, or where pelagic fishes can secure algal and invertebrate food, or where they can clean external parasites off themselves.

In addition, it is thought that small fishes are initially attracted to a floating tree as a point of reference, swimming with it while feeding on the small planktonic organisms in its vicinity. Along with the planktivores come juveniles of carnivorous species. With time, larger, obligate predators arrive and eat the accumulated prey. Thus, within three to five weeks after a tree initially arrives in the open ocean, the combined weight of its associated tunas alone may reach as much as hundred tons. The prey responds by using the floating tree as protection. The predators rapidly deplete the available prey, albeit only temporarily. In their search for food, the predators move away from the tree only to return and use it as a point of reference. In the eastern Pacific, the primary species/groups aggregating around driftwood are small yellow fin tuna (Thunnus albacares) and skipjack tuna (Katuwouvs pelamis), as well as other species of fishes. Small yellowfin and skipjack tuna are also the main species associated with driftwood in other oceans, which indicates its importance in their life histories.

Tunas even time their migration to the Continental Self for spawning to coincide with the onset of monsoon rains. In turn, the resulting floods—carrying new driftwood to the sea—arrive as the young tunas are hatching from their eggs. In the eastern Pacific, for example, it is very likely that the association of juvenile yellowfins with large driftwood is important in determining recruitment success. Skipjack, on the other hand, which spawn only infrequently in the eastern Pacific, also have a strong tendency to associate with large driftwood. In addition, the association of some species with "old" driftwood, that with barnacles and algae attached, may indicate a degree of habitat specificity in the association [1-5]. (If you are interested in a further discussion of the vital role of driftwood in the ocean, see: From the Forest to the Sea: The Ecology of Wood in Streams, Rivers, Estuaries and Oceans [6,7].) In addition to the continual removal of driftwood from its oceanic destination, we are substituting such non-wooden human garbage as: metal, glass, rubber, plastic, oil, bilge, chemical effluents, medical and household wastes and raw human sewage in the oceans of the world [6].

Human Garbage

In 1987, for example, 17 tons of human garbage was cleaned from Oregon beaches. (In 1989, 26 tons of garbage was collected and in 1991, 17.5 tons were collected) Six tons of human garbage was collected from Washington beaches, 75 tons from California beaches, 306.5 tons from Texas beaches, 36.8 tons from the beaches of Hawaii, 200 tons from Louisiana beaches and 40 tons from New Jersey beaches. This garbage came from such sources as recreation and commercial boats; commercial, military and research ships; beach-goers; offshore oil and gas rigs; shore-based solid wastes; manufacturing; and sewage treatment plants [8]. In 2011, the Ocean Conservancy says 598,076 volunteers picked up 9,184,428 pounds of garbage from 20,776 miles of beaches worldwide:

i. 266,997 pieces of clothing, enough to dress every member of the audience at the opening ceremony of the London 2012 Summer Olympics.

ii. Enough cans and bottles to fetch $45,489.15 if recycled.

iii. 940,277 food containers, enough to get takeout for breakfast, lunch and dinner for the next 858 years.

iv. Among the more unusual items were: 195 cell phones, 155 toilet seats and nearly 10,000 fireworks.

The top 10 items collected from beaches worldwide were, in order of abundance:

i. Cigarettes—it is estimated that if all the butts picked up by volunteers over the last 26 years were stacked on top of one another, they would be as tall as 3,613 Empire State Buildings.

ii. Caps and lids

iii. Plastic beverage bottles

iv. Plastic bags

v. Food wrappers and containers

vi. Cups, plates, forks, knives and spoons

vii. Glass beverage bottles

viii. Straws and stirrers

ix. Beverage cans

x. Paper bags [9,10]

Micro-plastics

Beaches and oceans are often littered with white plastic foam, from beer coolers to flotation devices and bumpers used on boats, which are made from what is commonly known as "Styrofoam." The chemical building blocks of the foam (polystyrene) have not only been detected in several areas of the Pacific Ocean but also found to degrade in seawater. Polystyrene foam is a manufactured plastic composed primarily of rings of carbon and hydrogen, called "phenyl groups," attached to long hydrocarbon chains that can break into smaller styrene units, of which the styrene monomer is carcinogenic in mice. Water samples collected off Malaysia, the U.S. Pacific coast and in the northern Pacific Ocean all contained styrene monomers, as well as other components [11]. As it turns out, synthetic polymers (plastics) entered the marine environment in quantities that paralleled their level of production over the last half century. However, in the last two decades of the 20th Century, the rate of deposition exceeded the rate of production and plastics are now one of the most common and persistent pollutants of ocean waters and beaches worldwide. Marine litter is now 60% to 80% plastic, reaching 95% in some areas [12].

Moreover, every time a garment made from polyester or other synthetic fabric goes through a washer it sheds thousands of tiny micro-plastic fibers per garment—micro-plastic bits that are contaminating oceans waters and shores worldwide. In fact, a single garment can produce greater than 1,900 fibers per washing and fleece fabrics shed the most. Now, consider the cumulative effects of laundering worldwide during just one day and you may glean an infinitesimal inkling of a single source of micro-plastics accumulating daily in the global seawater. What makes the micro-plastics so dangerous is their ability to act like a sponge thereby absorbing and concentrating fat-soluble pollutants such as DDT, polychlorinated biphenyls and polycyclic aromatic hydrocarbons (some of which are constituents of crude oil).

In addition to fibers from clothing, degradation of plastics on beaches through weathering results in their surfaces becoming brittle and thus prone to micro-cracking, which yields micro-particles being carried into the seawater by wind or waves. In fact, examination of a single bag of sand from a beach in Hawaii proved to be 90% plastic. When micro-plastics are added to beach sands, they increase the permeability significantly and affect the sands temperature because they both warm more slowly and reach lower maximum temperatures. This change to the dynamics of beach sand has a variety of potential effects, such as influencing the temperature-dependent sex-determination sea turtle eggs. Beyond that, these tiny pieces of plastic not only have the potential to get inside tissues of mussels and other animals but also have the ability to actually move into their cells. As well, micro-plastic lurks invisibly in our oceans, in seemingly clear water, where some of it is indistinguishable in size from algae and thus eaten by Pacific krill, small organisms near the bottom of the marine food web. In some areas, the micro-plastic even outweighs the zooplankton. So it is that pollutants tainting the plastics become available to larger animals and their predators. Because micro-plastics have more surface area than volume, they rapidly absorb toxic pollutants and release them just as quickly to fatty substances inside an animal. This, coupled with their ability to be ingested by a wide range of animals, makes them increasingly dangerous to the world's oceanic ecosystem [13-23].

The great garbage patches

A mass of plastic has been accumulating in the Pacific Ocean for decades in the invisible present, but has increased tenfold each decade since 1945. Somewhere in time it crossed the threshold from the twilight zone of human consciousness into an island of plastic that is now twice the size of Texas and killing everything in its wake. This patch appears to double in area every 10 years. The Great Pacific Garbage Patch is actually comprised of two enormous masses of ever-growing garbage. The Eastern Garbage Patch floats between Hawaii and California. The Western Garbage Patch extends eastward from Japan to the western archipelago of the Hawaiian Islands. A narrow, 6,000-mile-long current called the "Subtropical Convergence Zone" connects the patches.

Once in the open ocean, plastic becomes entrained in the massive clockwise movement of North Pacific Gyre, which is carrying plastic that is over 50 years old. In fact, a piece of plastic found in the stomach of an albatross in 2009 had a serial number that was traced to a World War II seaplane shot down just south of Japan in 1944; it was identified over 60 years later off the West Coast of the United States. The ocean currents and winds of the North Pacific Gyre have essentially become a giant toilet bowl that regularly disgorges untold yards of plastic onto Hawaii's Big Island. Kamilo Beach is often covered in plastic lighters, toothbrushes, water bottles, pens, baby bottles, cell phones, plastic bags and "nurdles"—also known as "pre-production plastic pellets" or "plastic resin pellets," which are typically under 0.20 of an inch in diameter and serve as the feedstock for all disposable plastics. Approximately 60 billion pounds of nurdles are produced annually in the United States. Each year 250 billion pounds of small plastic pellets or nurdles are shipped worldwide and billions are spilled during transfer in and out of railroad cars. Those spilled nurdles end up in gutters and drains and are eventually carried into the ocean. For example, a quarter of billion nurdles washed down the Los Angeles and San Gabriel Rivers into the Pacific Ocean in just three days in 2006. As such, nurdles are a major contributor to marine garbage patches. Waterborne nurdles are either a raw material used in the production of plastic or larger chunks of plastic that have been ground down. So it is no wonder that nurdles were the most common contaminant of the beaches in Orange County, California, where they comprised roughly 98% of the debris collected in 2001. Some nurdles are even washing up on the shores of Antarctica.

Once in the ocean, plastics act like sponges, attracting neuron-toxins (such as mercury and pyrethroids insecticides), carcinogens (such as PCBs, DDT and PBDE—the backbone of flame retardants) and human-made hormones (like progesterone and estrogen), which at high levels induce animals to become hermaphroditic. Japanese scientists found nurdles to contain concentrations of these poisons as high as a million times greater than when the toxins are simply free-floating substances in the water. Therefore, the mass of plastic that has now been documented in the Atlantic Ocean-the Atlantic Garbage Patch can legitimately be likened to toxic, chunky soup. This collection of garbage is floating between Bermuda and Portugal's mid-Atlantic Azores Islands. The highest concentrations of plastic occurs between 22 and 38 degrees northern latitude, an offshore patch equivalent to the area between Cuba and Washington, D.C.

How could something like this come about, you ask?

We-residents of the United States-throw away more than 385,000 cell phones and 143,000 computers every day. The electronic waste is now the fastest-growing stream of garbage. Although most of this electronic waste is shipped overseas to such places as China, where it is dismantled and burned, the process is deleterious to the environment and human health. Nevertheless, a fair amount ends up in garbage dumps, which allows lead and mercury to seep into ground water, where it stays for decades. Some of the electronic waste, however, is winding up at sea. We also discard about 2.75 million plastic water and soda bottles hourly—that's 24 billion a year. And some of these bottles are now in the oceans. In fact, the U.S. produces about 15 billion pounds of plastic each year, but only 1% of it is recycled. As a matter of fact, the average American uses 223 pounds of plastic each year in 2008 and it was projected to rise as high as 326 pounds per annum by 2011. Globally, 100 million tons of plastic are generated each year and at least 10% of that is finding its way into the sea. About a half a trillion plastic bags are manufactured globally each year—and that is a single product. The United Nations Environmental Program now estimates that there are 46,000 floating pieces of plastic for every square mile of ocean. Some of that trash is circulating the globe 95 feet below the seawater's surface.

Plastic is a petroleum product and the most commonly produced resin in North America includes: polyethylene, polypropylene and polystyrene. The long-chain molecules that make up plastic are durable and long lasting. Although sunlight photo-degrades plastic, breaking it into smaller and smaller pieces, in the ocean they may take 500 years to break down. Not a single molecule of plastic is digestible by any known organism. At least 80% of the oceanic plastic originates from the land. But then, thousands of cargo containers also fall overboard in stormy seas each year. In 2002, 33,000 blue-and-white Nike basketball shoes were spilled off the coast of Washington. Currently, there is six times more plastic than plankton floating in the middle of the Pacific and each year a million sea birds and 100,000 sharks, turtles, dolphins and whales die from eating plastic. Moreover, nurdles resemble fish eggs, or roe, which induces both tuna and salmon to eat them indiscriminately. In addition, around 2.5 billion humans eat fish regularly. Plastic and other human-made toxins are polluting the global food chain and it is escalating at an unprecedented rate—in the invisible present. The only way to contend with the marine garbage patches is to slow the amount of plastic flowing from the land into the sea. How can this be done? Well, you purchase organic, cotton shopping bags, use them instead of supermarket plastic bags and make it a habit to return those bags to your car after unpacking your groceries. Re-use your plastic water bottles. If you can refill one bottle for a day, then why not attempt it for a week? Another part of the solution is thermal-conversion landfills, like those of Golden Spirit Enterprises, which will render landfill trash neutral, prevent landfills from contaminating ground water and from haphazardly leaking methane, the potent greenhouse gas, into the atmosphere.

Finally, we must each deliberately reduce the amount of trash we generate and in particular the quantity of disposable plastic that is being discarded carelessly. I say this because plastics are poisoning the oceans of the world in unforeseen ways in the invisible and are thus irreversibly affecting all of its life forms in a never-ending story of degradation—to the impoverishment of the global commons for all generations [24-32].

The plastic island

Not understanding the dynamics of plastics in the marine environment, a Netherlands-based architecture company, WHIM, plans to construct an island from 97 million pounds of plastic floating in the Pacific Ocean's Great Garbage Patch, turning it into a "fully sustainable island with enough space for half a million inhabitants," according to WHIM's Ramon Knoester. Why would anyone want to live there? Situated in the North Pacific Gyre, between Hawaii and San Francisco, "Recycled Island," as it has been dubbed, will provide the convenience of a location where the weather is always nice, Knoester said. Although plastic, the 6,214-square-mile island is supposed to be green in both appearance and environmental impact. Knoester plans to recycle the plastic and construct the island on site. The island is to be powered by wave and solar energy and residents will be able to use seaweed as biofuel and fertilizer. He believes that creating the floating island not only will clear a majority of the plastic out of the Pacific Ocean but also will create new, habitable land and thus counter coastlines being lost to rising sea levels. Moreover, the island's urban design is to resemble a modern-day Venice, with canals winding around plastic buildings. According to Knoester, a lot of people will be curious about the island because it's the first plastic island and the biggest floating island [33].

There are, however, some obvious questions about such an endeavor, a few of which are:

I. How much of the floating plastic is reliably recyclable?

II. If the idea were to clean up the plastic, what would be done with plastic that is too damaged by the sun and saltwater to use?

III. If there is more usable plastic that is needed, what will be done with the rest?

IV. If there is not enough reusable plastic floating in the garbage patch, will more be hauled in to complete the island and, if so, will that not be counter productive from a marine environmental point of view?

V. (5) Can plastic blocks be created that are in fact deterioration proof? (6) Can non-toxic, plastic blocks even be manufactured?

VI. If not, how would life on the island affect the health of potential residents and how would that be determined?

VII. If not, how would seafood obtained in the vicinity of the island affect the resident's health if they consume it?

VIII. How will the continuing accrual of plastic debris in the North Pacific Gyre be dealt with as it collects around the island?

IX. How would the residents be supplied with the modern "necessities?"

X. If supplies had to be shipped in or flown in, would that not greatly increase the pollution sustained by the North Pacific Gyre merely from transportation, which heretofore did not exist?

XI. How would human waste be disposed of?

XII. How would human-generated garbage be disposed of?

XIII. What are the truly clean businesses, environmentally speaking, that could exists on the island and employ people?

XIV. What will prevent the island from disintegrating in a violent storm or series of storms? These questions are pertinent because all systems are open to outside influences.

Tsunami debris

Then there are the natural phenomena that cause anthropogenic pollution to invade the oceans of the world, such as the earthquake that struck Japan in March of 2011—and roughly 5 million tons of debris swept into the ocean by the ensuing tsunami. The devastating tsunami that hit Japan … created lasting images of houses, boats, cars and entire neighborhoods pulled out to sea. [On October 25, 2011,] seven months later, that debris is on a direct collision course with the Pacific coast of the United States. Up to 20 million tons of the debris, all of it potentially toxic is floating across the Pacific Ocean in an area estimated to be twice the size of Texas. [A] Russian training ship, the STS Pallada, following a map of the computer models, hit an extended field of debris in mid-Pacific, close to Midway Island, a US territory about 1,700 miles from Hawaii. The ship's encounter with the 1,000-mile-long mass of tsunami debris came in September, 300 miles ahead of schedule and nearly 2,000 miles from the site of the tsunami in Japan. The Pallada's crew sailed through the debris, surrounded by everything from appliances and televisions to furniture, all of it now headed straight for Hawaii [34].

How about the derelict Japanese fishing boat set adrift by the tsunami?

The Japanese ship, Ryou-Un Maru, floated across the Pacific Ocean after it was ripped from its moorings by the tsunami last March. It is floating roughly 195 miles south of Sitka in the Gulf of Alaska. Japanese Coast Guard spokesman Masahiro Ichijou said the vessel belonged to a fishing company in Hokkaido, Japan's northernmost island. It had been used for squid fishing before being put up for sale because of its advanced age. It has no lights or communication systems. Coast Guard officials decided to sink the ship amid fears that it could disrupt traffic as it drifted through shipping lanes or spill fuel from its 2,000-gallon tank should it run aground [35]. And, this says nothing of all the war material sunk during the various human conflicts over the centuries, or the ships sunk by storms.

As it turns out, the ocean is not only the mother of all waters but also the recipient of centuries of human garbage. For the sake of millions of people who rely on the world's oceans for their subsistence (now and in the future), we must begin to adjust our behavior from that which is self-centered and unconscious of the effects we cause through our thinking and subsequent behavior to that which is other-centered and increasingly conscious of the effects we pass forward through our thinking and subsequent behavior to all generations—beginning now, today.

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