OCEANS OF PROBLEMS FOR THE BLUE PLANET

background reading | oceans unit

EARTH matters
Studies For Our Global Future

***How inappropriate to call our planet Earth when it is quite clearly ocean.* —Arthur C. Clarke**

The ocean. It is where life began on Earth some 3.5 billion years ago. Covering over 70 percent of our planet's surface, it is the world's largest habitat and climate regulator. As humans, we depend on the ocean for food, medicine, minerals, fuel, transportation and global trade. About two-thirds of the world's population live within 60 kilometers of the coast, and almost half of the world's large cities were built in and around the tide-washed river mouths known as estuaries.

For centuries, people have regarded the ocean as an inexhaustible source of resources and a convenient dumping ground that could absorb the residues of human activity with little negative impact. Mounting evidence now shows that human activities – overfishing, pollution, and carbon dioxide (CO_2) emissions – are stressing the ocean's health, leading to the progressive deterioration of marine habitats and species.

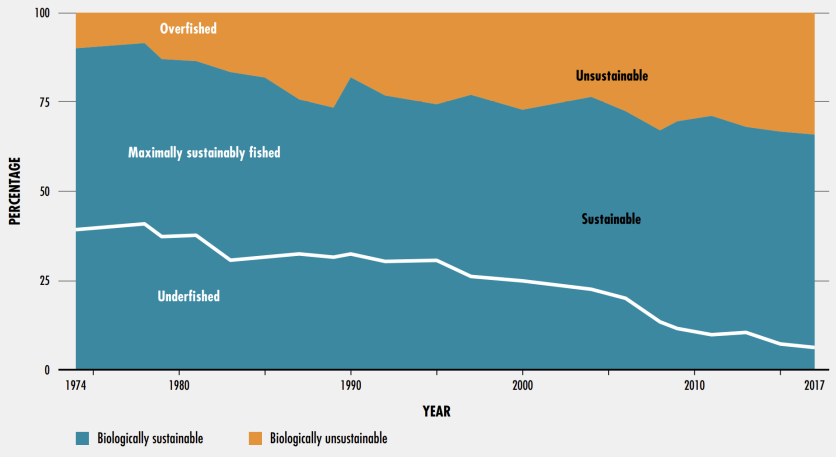
Fishy business

Marine ecologists and ocean conservationists identify **overfishing** as the most immediate threat to ocean **ecosystem** health. Over the past four decades, the world's once-abundant fisheries have been exploited at an unprecedented rate. As the global population has grown, so has the demand for seafood. Since the 1950s, the global fish catch has grown five-fold.[1] This was made possible by larger ships with more powerful engines and refrigeration that allowed vessels to catch and store more fish. Fishing technologies such as sonar, longlines, **fish aggregation devices**, and **bottom trawling** (scraping the ocean floor with nets and heavy steel plates) have contributed to the steep increase in fishing production.

The global fishing fleet has grown 2-3 times larger than it was in 1950.[2] As a result, too many vessels are now competing for increasingly exploited fish stocks. The UN Food and Agriculture Organization (FAO) estimates that about two-thirds of fish stocks are already exploited to their maximum sustainable limit and one-third beyond their limit.[3]

Populations of **top predators**, a key indicator of ecosystem health, are disappearing at an alarming rate. Ninety percent of the large fish that we eat – tuna, swordfish, marlin, cod, halibut, and flounder – have been fished out since large-scale industrial fishing began in the 1950s.[4] Populations of sharks, rays, and skates are also severely threatened due to overfishing. The depletion of these top predator species endanger the structure and functioning of marine ecosystems.

FIGURE 19
GLOBAL TRENDS IN THE STATE OF THE WORLD'S MARINE FISH STOCKS, 1974–2017



SOURCE: FAO.

A deadly catch

While all fishing methods have an impact on the ocean ecosystem, there are some being employed that do great damage to marine life and habitats, including the use of explosives, cyanide fishing (poisoning fish to stun them), and muro-ami nets (nets that catch escaping fish from coral being pounded and crushed with heavy rocks or cement). These **destructive fishing practices** result in direct damage to fisheries habitat or to habitat-structuring organisms, such as coral reefs. The muro-ami technique involves setting bottom nets and then driving reef fish from their hiding places into the nets by pounding on coral reefs with cement blocks.

Many marine animals are inadvertently killed as a result of commercial fishing (bycatch).

Standard fishing practices, too, can have unintentional, yet destructive effects. Many fishermen catch fish other than the ones they target. This **bycatch** is widely recognized as one of the most serious environmental impacts of modern commercial fisheries. The victims of bycatch are varied and many. Different fishing methods kill different species. For instance, nets kill dolphins, porpoises and whales; longline fishing kills birds; and bottom trawling devastates marine ecosystems, including coral reefs.

Farming fish

Fish is a major part of the world's diet, providing 17 percent of the animal protein we consume daily. Per capita fish consumption has grown from 20 pounds per year in 1961 to 45 pounds per year in 2018.[5] With rising affluence in many parts of the world, it is expected that more people will make fish a larger part of their diets. But, as wild fish stocks become depleted, there's a greater chance that the fish on your plate will be farmed. Fish farming, or **aquaculture,** is one of the fastest growing food-producing sectors, now providing half of all the fish we consume. But farming fish is not always a sustainable alternative. If not managed responsibly, aquaculture production can deplete key ecosystems like mangroves and can pollute aquatic environments with chemicals, antibiotics, and invasive species.

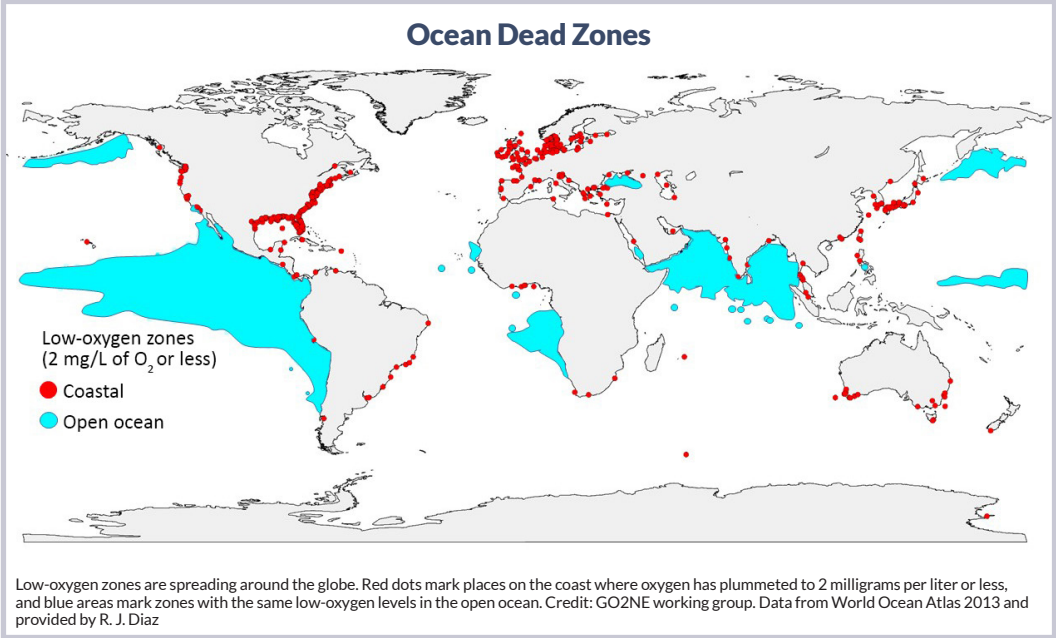
Polluted waters

Most of marine pollution – about 80 percent – comes from land-based activities. One of the biggest sources is **nonpoint source pollution** generated from runoff from farms, ranches, septic tanks, cars, trucks and boats. This runoff includes pesticides, herbicides, chemical fertilizers, detergents, oil, sewage, heavy metals and pharmaceuticals. All of these pollutants pose threats to marine life.

Nitrogen-rich fertilizer that runs off from farms can cause **algal blooms.** These blooms occur when **phytoplankton**, which are tiny microscopic plants, grow quickly in large quantities thanks to the fertilizer. Algal blooms can produce toxins harmful to the environment, block light to organisms in deeper water, clog fish gills, and create **dead zones** by depleting oxygen from the water. Worldwide, scientists have counted 700 such dead zones where no marine life can live.[6]

Considered a waste disposal site for centuries, the ocean contains all sorts of discarded toxic materials. The practice of ocean dumping was rampant until the London Dumping Convention banned it in 1972, with more restrictions added in 1996. However, the toxins already present remain a major challenge.

Sewage, wastewater and chemicals also find their way into the ocean from cruise ships, which in 2019 carried 30 million vacationers on the high seas and into hundreds of coastal ports. The U.S. Environmental Protection Agency (EPA) estimates that a 3,000-person cruise ship generates 150,000 gallons of sewage per week – enough to fill 10 backyard swimming pools.[7] This adds up to more than 1 billion gallons of sewage a year for the industry. The bacteria and nitrogen from the sewage harm marine life and endanger human health. Bathing in polluted waters is linked to 170 million annual cases of gastrointestinal and upper respiratory disease. Eating sewage-contaminated shellfish kills 40,000 people a year and causes about 4 million cases of infectious hepatitis.[8]



Low-oxygen zones are spreading around the globe. Red dots mark places on the coast where oxygen has plummeted to 2 milligrams per liter or less, and blue areas mark zones with the same low-oxygen levels in the open ocean. Credit: GO2NE working group. Data from World Ocean Atlas 2013 and provided by R. J. Diaz

Rivers bring in even more pollutants, including chemicals and heavy metals, along with increasing loads of erosion sediment. A study conducted by the U.S. National Research Council found that roughly 343 million gallons of oil are released into the seas annually. While about half of this is from natural seeps from reservoirs through the ocean floor, the other half is from human activities – runoff from cities and industry, spills from ships and tankers, and leaks from oil rigs.[9] Oil is harmful to marine life, especially marine mammals and birds. It reduces the water repellency on fur and feathers, thus exposing these animals to the elements and endangering their lives.

Swirling garbage patches

The most visible pollution in the oceans is trash, dominated by plastic debris. In 2010, an estimated 5 to 13 million metric tons of plastic waste entered the ocean from both low-income countries with insufficient solid waste infrastructure and high-income countries that generate large amounts of waste.[10]

It's no wonder that plastic makes up the largest share of ocean trash – every decade, global production of plastics doubles and most of it is single-use (think plastic bags and bottles) and isn't recycled. This ocean plastic tends to collect in five large, spiraling currents called gyres. The best known is the Pacific Trash Vortex, often called the

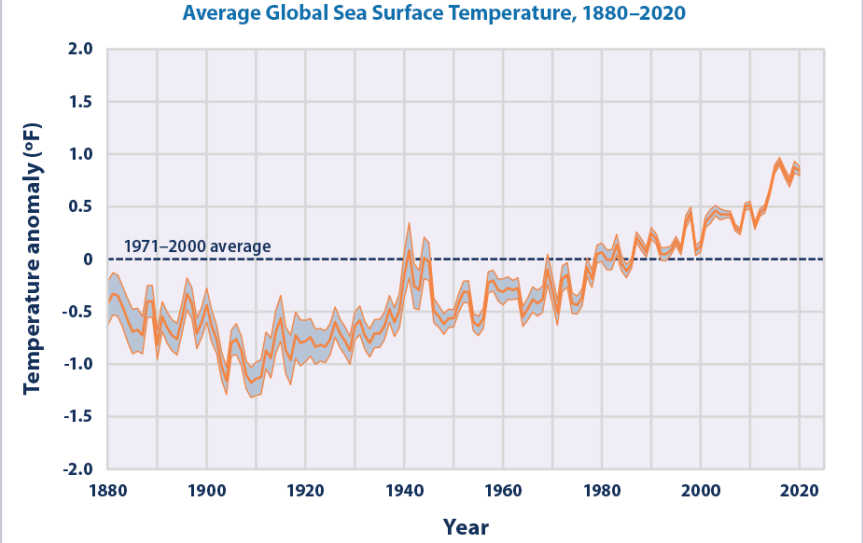
Great Pacific Garbage Patch, estimated to be the size of Texas. Marcus Eriksen, a marine scientist and co-founder of the 5 Gyres Institute, estimates that there are over 5 trillion pieces of plastic debris in the ocean.[11] Only a fraction of that floats on the surface, while the rest – degraded plastic microfibers – litter the deep sea. Plastic decomposes slowly and is often mistaken by marine animals for food. Plastic materials have been found in the stomachs of whales, dolphins, seals, turtles, and sea birds. The highest concentration of plastics is found in a gyre in the North Atlantic, which receives most of its contents from North America and Europe.[12]

Noise pollution

Not only do human activities impact the contents of ocean water. Our activities have raised noise levels in our global seas – doubling in intensity every decade since 1950.[13] Sources of this **anthropogenic** ocean noise include the use of explosives, oceanographic experiments, geophysical research, underwater construction, ship traffic, and intense active sonar and air guns used for seismic surveys for oil. This escalating noise poses significant threat to marine mammals, fish and other ocean wildlife. Marine animals use sound to navigate to find food and mates, avoid predators and communicate with each other. Our noise disturbances can affect their ability to hunt, migrate and reproduce.

Too much CO_2

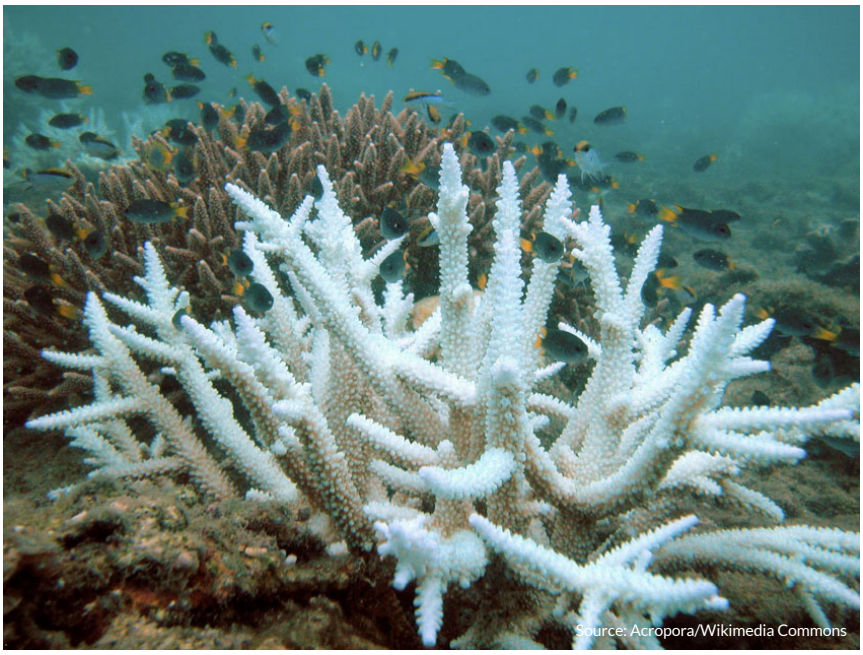
Human activities are also changing the chemical composition of the ocean. The ocean absorbs about 30 percent of the carbon dioxide released into the atmosphere – roughly 22 million tons a day.[14] As levels of atmospheric CO_2 increase, so do levels in the ocean. When CO_2 dissolves in the ocean, carbonic acid is formed, which leads to the higher acidity of seawater, mainly near the surface. This higher acidity inhibits the formation of sea shells and coral skeletons, and affects the ability of certain fish to detect predators. For tens of millions of years, the ocean has maintained a relatively stable acidity level. But in the last 250 years, that acidity has increased 26 percent, affecting the entire world's oceans.[15]



Data source: NOAA (National Oceanic and Atmospheric Administration). 2021. Extended reconstructed sea surface temperature (ERSST.v5). Accessed February 2021.
www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

The ocean also serves as a sink for the Earth's energy. With the rise of **greenhouse gas** emissions, our ocean has been warming. This rise in the ocean's temperature is already affecting ecosystems from polar to tropical regions. The International Union for the Conservation of Nature documents that warming trends are "driving entire groups of species such as plankton, jellyfish, turtles and seabirds up to 10 degrees latitude towards the poles, causing loss of breeding grounds."[16] Not all marine life has the mobility and adaptability to survive in different locations or at different temperatures. Higher ocean temperatures are also associated with more invasive species and the spread of more disease-causing pathogens like cholera.



Bleached branching coral in the foreground, and healthy branching coral behind.

Our fragile reefs

Nowhere are the effects of ocean warming greater than on coral reefs. Warmer water temperatures can result in **coral bleaching**. When water is too warm, corals will expel the algae living in their tissues, turning them completely white. This leaves the coral vulnerable to disease and can lead to large-scale die-off. In 2005, half of the coral reefs in the Caribbean were lost in one year due to a massive bleaching event. In March 2016, an influx of warm water (about 1° Celsius warmer than usual) surrounded Australia's Great Barrier Reef. Air and underwater surveys a month later showed severe bleaching in over 80 percent of the northern reef. By May, continued surveys suggested that as much as half of the corals on the northern section of the reef were already dead.[17] Today, corals are in severe decline worldwide and could be entirely lost by 2050.[18] In addition to ocean warming, the reefs are threatened by damage from other human activities – coastal development, destructive fishing practices, mining, pollution, and tourism.

Coral reefs, along with other tropical marine habitats, support the highest marine biodiversity in the world – more than one million plant and animal species – though they cover less than one percent of the Earth's surface. Reefs also provide a wealth of potential medicines for humans. Coral reef plants and animals are important sources of new medicines being developed to treat cancer, arthritis, human bacterial infections, Alzheimer's, heart disease, viruses and other diseases. If the present rate of coral damage continues unchecked, many of the potential and actual benefits of coral reefs may be lost.

Sea level rise

When water heats up, it expands, causing a rise in sea level. Sea level rise floods coastal communities, erodes shorelines and causes more powerful storm surges. The greatest rates of warming have been occurring in the polar areas. Scientists have documented record melting of glaciers and thinning of sea ice.

In the United States, nearly 40 percent of the 2018 population lived in counties directly on the shoreline where sea level plays a role in flooding, erosion, and hazards from storms.[19] Globally, seven of the world's 10 largest metropolitan areas are near a coast – Tokyo, Mumbai, São Paulo, Lagos, Jakarta, New York, and Karachi.

In urban settings, rising seas threaten infrastructure necessary for local jobs and regional industries. Roads, bridges, subways, water supplies, oil and gas wells, power plants, sewage treatment plants, landfills – virtually all human infrastructure – is at risk from sea level rise. As seas rise, coastal communities have been beset by **nuisance flooding**, flooding that leads to public inconveniences such as road closures. The number of high-tide flooding days in the U.S. doubled from 2000 to 2020. By 2050, such flooding is likely to occur between 25 and 75 days per year, depending on location.[20]

Globally, sea level has been rising at an increasing rate since the 20th century. Analysis of a global network of tide gauge records shows that sea level had been rising at the rate of about 0.6 inches per decade since 1900. Satellite altimeters now indicate that since 1992 the rate of rise has increased to 1.2 inches per decade – a significantly larger rate than at any other time over the last 2,000 years. In the next several decades, continued sea level rise and **land subsidence** will cause an increased frequency of tidal flooding.[21] This rise in sea level is already taking a toll on some island nations and coastal communities. In recent years, several of the Solomon Islands in the Pacific have become submerged. Others are preparing to move entire populations before it's too late.

Coastal living

Even with the looming threats of sea level rise and coastal flooding, populations in coastal communities are expected to grow. Throughout most of the world, coastal zones are overdeveloped, overcrowded and overexploited. Coastal ecosystems – some of which are the most productive and biologically diverse on the planet – support a huge variety of life and serve as nurseries for much of the biodiversity of the entire oceanic system. Coastal zones have the most nutrients of all marine ecosystems, and although they only account for 10 percent of the ocean environment, they are home to over 90 percent of all marine species.

Coastal Wetlands at Parker River National Wildlife Refuge in Newburyport, MA.

Coastal development and associated sprawl destroy and endanger valuable coastal ecosystems such as **wetlands**. In the U.S. coastal watersheds of the Atlantic, Pacific, the Gulf of Mexico and the Great Lakes, wetlands were lost at an average rate of about 80,000 acres per year between 2004 and 2009.[22] Coastal wetlands provide ecosystem services essential to people and the environment, including flood protection, erosion control, wildlife habitat, fish nurseries, water filtration and carbon sequestration (especially salt marshes and mangroves).

The ocean economy

How do you put a value on the ocean? According to a report by the World Wildlife Fund, the value of the goods and services from the ocean, alone, would amount to at least $2.5 trillion a year, ranking it as the world's seventh largest economy.[23] While this estimate includes ocean-based industries such as fishing, shipping and marine biotechnology, it doesn't include all of the ocean's valuable ecosystem services such as regulating climate and producing oxygen. Most of the ocean's value depends on healthy conditions to maintain current output. When we endanger the ocean's health – through overfishing, habitat destruction, pollution and climate change – we threaten the sustainability of this resource. "The oceans are our 'natural capital' – a global savings account from which we keep making only withdrawals," said Brad Ack, World Wildlife Fund's former Senior Vice President for Oceans. "To continue this pattern leads one place: bankruptcy. It is time for significant reinvestment and protection of this global commons."[24]

In need of a sea change

It is hardly an exaggeration to say that the future of humanity depends on the ocean's viability. We exploit ocean resources and pollute its ecosystem at our own peril. The ocean and its coastal watersheds provide us with nourishment, oxygen, livelihoods, and natural wonders that enrich us all. Our future will greatly depend on our ability to restore ocean health and protect marine habitats.

Internationally, we will need to do a better job to stop overfishing our seas, reduce pollution and ocean acidification. The United Nations **2030 Agenda for Sustainable Development** sets 17 goals including one to "conserve and sustainably use the oceans, seas and marine resources for sustainable development" (Goal #14). To address overfishing, international cooperation will be critical to eliminate destructive fishing practices, reduce many fishing subsidies that encourage overharvesting, enforcing laws on the high seas to prevent illegal fishing and expanding marine reserves to protect species. Ocean acidification and warming can only be addressed by forging and honoring commitments to reduce carbon emissions worldwide. Unless we can significantly reduce fossil fuel emissions, ocean organisms will have to adapt to their habitat's changing chemistry or perish. Reducing ocean pollution will need to be attacked on various fronts including enforcing environmental standards to prevent runoff and reducing the manufacturing and use of disposable plastics.

Individual actions will also go a long way to restoring ocean ecosystems. Seemingly small actions can have a large cumulative impact on the health of oceans, such as recycling items so they do not end up as trash in oceans, properly disposing of hazardous materials that could harm ocean wildlife and cleaning up after pets so bacteria and nutrients from their wastes do not contribute to pollution. Even in non-coastal areas, pollutants like pesticides and fertilizers can flow into local streams and eventually end up in the ocean. Making sustainable seafood choices – eating seafood that has been sustainably farmed or wild fish that isn't overexploited – is an important step in reducing incentives for overfishing practices. Individuals can become actively involved in protecting ocean resources by volunteering to help clean up a nearby beach, stream or coral reef, monitoring water quality in local waterways, or helping to educate others about ocean issues.

[1,3,5] Food and Agriculture Organization of the United Nations. (2020). State of the World Fisheries and Aquaculture 2020. Rome, Italy: FAO. Retrieved from https://www.fao.org/state-of-fisheries-aquaculture

[2] Vivas-Eugui, D. and Contreras, C. (2020, December 7). Too large to be missed: how fleet size and harmful subsidies undermine fish stocks sustainability. Article No. 68 [UNCTAD Transport and Trade Facilitation Newsletter N°88 - Fourth Quarter 2020]. Retrieved from https://unctad.org/news/too-large-be-missed-how-fleet-size-and-harmful-subsidies-undermine-fish-stocks-sustainability

[4] *The Science Show with Robyn Williams*. 90% of all big fish have been taken from the oceans. Transcript of guest interview with Daniel Pauly, Professor of Fisheries, University of British Columbia. (2021, February 13). ABC Radio National, Australia. Retrieved from https://www.abc.net.au/radionational/programs/scienceshow/90-of-all-big-fish-have-been-taken-from-the-oceans/13149932

[6] United Nations Department of Economic and Social Affairs. (n.d.). *Goals: 14*. Retrieved October 28, 2021 from https://sdgs.un.org/goals/goal14

[7] Cruise Lines International Association. (2020). *2019 Global Market Report*. Retrieved from https://cruising.org/-/media/research-updates/research/2019-year-end/updated/2019-global-market-report.ashx; Friends of the Earth. (2021). *2021 Cruise Ship Report Card*. Retrieved from https://foe.org/cruise-report-card/

[8] Shuval H. Estimating the global burden of thalassogenic diseases: human infectious diseases caused by wastewater pollution of the marine environment. *J Water Health*. 2003 Jun;1(2):53-64. PMID: 15382734. Retrieved from https://pubmed.ncbi.nlm.nih.gov/15382734/

[9] Transportation Research Board and National Research Council. (2003). Oil in the Sea III: Inputs, Fates, and Effects. The National Academies Press. doi:10.17226/10388.

[10] Law, K.L, Starr, N., Siegler, T.R., Jambeck, J.R., Mallos, N.J., & Leonard, G.H. (2020, October 30). The United States' contribution of plastic waste to land and ocean. *Science Advances*. Vol. 6, No. 44. Retrieved from https://www.science.org/doi/10.1126/sciadv.abd0288

[11] Parker, L. (2015, January 11). Ocean Trash: 5.25 Trillion Pieces and Counting, but Big Questions Remain. *National Geographic*. Retrieved from https://news.nationalgeographic.com/news/2015/01/150109-oceans-plastic-sea-trash-science-marine-debris/

[12] Parker, L. (2014, April 4). Plane Search Shows World's Oceans Are Full of Trash. *National Geographic*. Retrieved from https://www.nationalgeographic.com/science/article/140404-garbage-patch-indian-ocean-debris-malaysian-plane

[13] Jones, N. (2019, April 10). Ocean uproar: saving marine life from a barrage of noise. *Nature*. Retrieved from https://www.nature.com/articles/d41586-019-01098-6

[14] The Ocean Portal Team. (2018, April). *Ocean Acidification*. Smithsonian. Retrieved from https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification

[15] Woods Hole Oceanographic Institution. (n.d.). *Ocean Acidification*. Retrieved October 25, 2021 from https://www.whoi.edu/know-your-ocean/ocean-topics/ocean-chemistry/ocean-acidification/

[16] Laffoley, D. and Baxter, J. M. (2016, September). Explaining ocean warming: causes, scale, effects and consequences. Gland, Switzerland: IUCN. https://doi.org/10.2305/IUCN.CH.2016.08.en

[17] Mooney, C. (2016, October 26). Scientists report 'devastating' coral death at Great Barrier Reef. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2016/10/26/devastating-scientists-report-major-coral-death-at-the-great-barrier-reef/

[18] WWF. (2015, September 15). Living Blue Planet Report: Species, habitats and human well-being. Gland, Switzerland: WWF International. Retrieved from https://www.worldwildlife.org/publications/living-blue-planet-report-2015

[19] NOAA Office for Coastal Management. (n.d.). *Fast Facts: Economics and Demographics*. Retrieved October 25, 2021 from https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html

[20] NOAA Tides & Currents. (2021, July). 2021 State of High Tide Flooding and Annual Outlook. Retrieved from https://tidesandcurrents.noaa.gov/publications/2021_State_of_High_Tide_Flooding_and_Annual_Outlook_Final.pdf

[21] NOAA Climate.gov. (2020, August 14). *Climate Change: Global Sea Level*. Retrieved from https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level

[22] Dahl, T.E. & Stedman, S.M. (2013). Status and Trends of Wetlands in the Coastal Watersheds of the Conterminous United States 2004 to 2009. U.S. Fish and Wildlife Service. Retrieved from https://www.fws.gov/wetlands/documents/status-and-trends-of-wetlands-in-the-coastal-watersheds-of-the-conterminous-us-2004-to-2009.pdf

[23, 24] Vosburgh, K. (2015, April 22). *Ocean wealth valued at US$24 trillion, but declining fast*. WWF. Retrieved from https://www.wwf.mg/en/?244950/Ocean-wealth-valued-at-US24-trillion-but-declining-fast