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HUMANS ARE MAKING OCEANS WARMER, DEEPER, AND LIFE THREATENING

An NPG Forum Paper
by Edwin S. Rubenstein

Without oceans, climate change would be much worse. The oceans directly absorb about a quarter of the CO_2 humans spew into the atmosphere. They also take over 90% of the heat from global warming, acting as a buffer against even greater warming. But the oceans themselves are in trouble from climate change, as the latest report from the UN's Intergovernmental Panel on Climate Change (IPCC) clearly shows.[1]

"The ocean has been acting like a sponge, absorbing heat and carbon dioxide to regulate global temperatures, but it can't keep up," IPCC vice chair Ko Barrett said at a press conference. **"The world's oceans…have been taking the heat of climate change for decades. The consequences for nature and humanity are sweeping and severe."**[2]

"Global warming is really ocean warming," Josh Willis, a NASA oceanographer who had no role in the UN report, adds.[3]

The new report is a follow-up to an earlier UN report, reviewed in our Forum Paper of a few months ago, on how climate change impacts the land.[4] That report assessed the seeming inability of reforestation, renewable energy, and other terrestrial mitigation strategies to curb greenhouse gas emissions.

This report is no more cheerful than that one. In fact, it is even scarier:

It concludes that a potentially disastrous rise in global sea levels is inevitable.

In the "best case" scenario, where humans hold warming to 2.7 degrees Fahrenheit above pre-Industrial Revolution temperatures, sea levels will likely rise between one and two feet by century's end. (This is already over optimistic: most models see temperature rising beyond this level by mid-century.)

But if emissions continue to rise at the high rates actually experienced in recent decades, the IPCC found sea levels would rise from two to over three and a half feet. That's because Earth's most massive ice sheets, on Antarctica and Greenland, **"are projected to lose mass at an increasing rate throughout the 21st century and beyond,"** the study says.[5]

Ten percent of the world's population lives in coastal areas that are less than 33 feet above sea level.

Two thirds of the world's cities with over five million people are located in low-lying areas where catastrophic flooding is deemed likely. Not all of them are poor and remote: Miami has been listed as **"the number-one most vulnerable city worldwide"** in terms of potential damage to property from storm-related flooding and sea-level rise.[6]

Miami's fate, as seen by scientists at Climate Central, a nonprofit organization, is described like this:

"Few other cities in the world have as much to lose from rising sea levels as Miami, and the alarm bells sound ever louder with each successive "king tide" that overwhelms coastal defenses and sends knee-deep seawater coursing through downtown streets.

"Locals consider this the "new normal" in the biggest city of Florida's largest metropolitan area, which would simply cease to exist with a 3C temperature rise. Even at 2C, forecasts show almost the entire bottom third of Florida – the area south of Lake Okeechobee currently home to more than 7 million people - submerged, with grim projections for the rest of the state in a little more than half a century…"[7]

Climate Central's scenarios are based on digital mapping of the Miami metro area's population and land elevation, and temperature projections based on University of Washington emissions modeling and UN warming estimates.[8]

NATIONS FIDDLE AS THE WORLD BURNS

Greta Thunberg, the 16-year-old climate activist, sailed with her father and two skippers across the Atlantic to speak at the UN ocean conference. A day later environmental protests in more than 150 countries dominated the news – the largest outpouring of climate change activism in history.

It was the moment activists had been waiting for.

They are still waiting.

The largest greenhouse gas emitters in the world — China, the United States, and India — offered no new commitments to reduce, or at least mitigate, future emissions. Obsessed with economic growth, and competing among themselves for export markets, the big three see global warming as another cost of doing business. Collectively they account for 58% of global CO_2 emissions.

More than 70 nations promised to deploy more clean energy and retire fossil fuel power plants, and several wealthier ones even pledged international assistance for other countries dealing with the most severe consequences of warming. But these countries together represent just 6.8% of total emissions.[9]

Not one country acknowledges the 900-pound gorilla – population reduction – as the missing link in the fight against global warming.

ARE GLOBAL WARMING DENIERS RIGHT?

(SHORT ANSWER: NO, NO, A THOUSAND TIMES NO!!!)

Facing unthinkable calamities, climate change denial has become a welcome refuge, even among some scientists. Days before the UN ocean conference a group claiming to represent **"more than 500 knowledgeable and experienced scientists and professionals in climate and related fields,"** begged the UN to squelch the report.

"Climate science should be less political, while climate policies should be more scientific," they declared, adding that **'Scientists should openly address the uncertainties and exaggerations in their predictions of global warming…"**[10]

Questioning conventional wisdom is a good thing, especially on a matter as vital to human survival as climate change. But scientists must do more than just question; they must provide evidence to support their skepticism. A study, a data set, an analysis of the historical climate record. Something – anything - to support their position.

Alas, the 500+ signatories come up with… nothing. No study. No data. No analysis. Just unsubstantiated innuendo regarding political bias on the part of the wider scientific community.

(Nota bene: 500 sounds like a lot of scientific brainpower – and it is. But in 2017 15,364 scientists from 184 countries signed a warning to humanity laying out evidence pointing to catastrophic climate change.[11] **Topic for further NPG research**: are the 500 "skeptics" working, directly or indirectly, for the fossil fuel industry?)

In the scientific literature, there is an overwhelming consensus that global surface and ocean temperatures have increased in recent decades and that the trend is caused mainly by human-induced emissions of greenhouse gases.[12] No scientific body of national or international standing disagrees with this view.

Scientific literature (including the IPCC studies) relies on articles that are peer-reviewed, where scientists unaffiliated with the authors appraise the methodology and validity of their findings.

It would be wonderful if we could just stick a thermometer into the ocean, or into the air, and take the temperature of the globe. But temperatures vary with location, with height above sea level, and with depth below the ocean's surface. The Earth is big, and Oceans are deep. Despite many thousands of temperature-measuring buoys, ships, and balloons, there are many areas where little or no data is available.

Differences in global warming estimates among reputable scientific organizations reflect different methodologies used to fill gaps where little or no data exists, and how each group accounts for changes in measurement methods over time.[13]

While top research groups may differ as to the exact *magnitude* of global warming, they unanimously agree on its *existence.* No matter how you adjust the data, the world is getting hotter:

The graphic shows annual growth in global temperature relative to the average temperature for 1981 to 2010, as estimated by four independent organizations: NASA, NOAA, the Hadley Centre for Climate Research (the U.K.'s leading meteorological research agency), and the Japanese Meteorological Agency. Data points run from 1880 to 2018.

The trend is summarized in the *State of the Climate In 2018*, an annual compendium of climate research published by the American Meteorological Society:

"**Another year passes, another warm year. In fact, 2018 was the fourth warmest year after 2016, 2015, and 2017, based on four independently constructed datasets measuring global land and ocean surface temperatures since global records began in the mid-to-late 1800s. Every year since the start of the twenty first century has been warmer than the 1981–2010 global average. The warmth was also observed in the atmosphere, with annual tropospheric temperatures in 2018 [the] third to seventh highest on record, depending on the dataset…**

"**Along with warmer average conditions across the globe, there were more positive, and fewer negative, temperature extremes during 2018 than in nearly all the 68 previous years in the observational record**."[14]

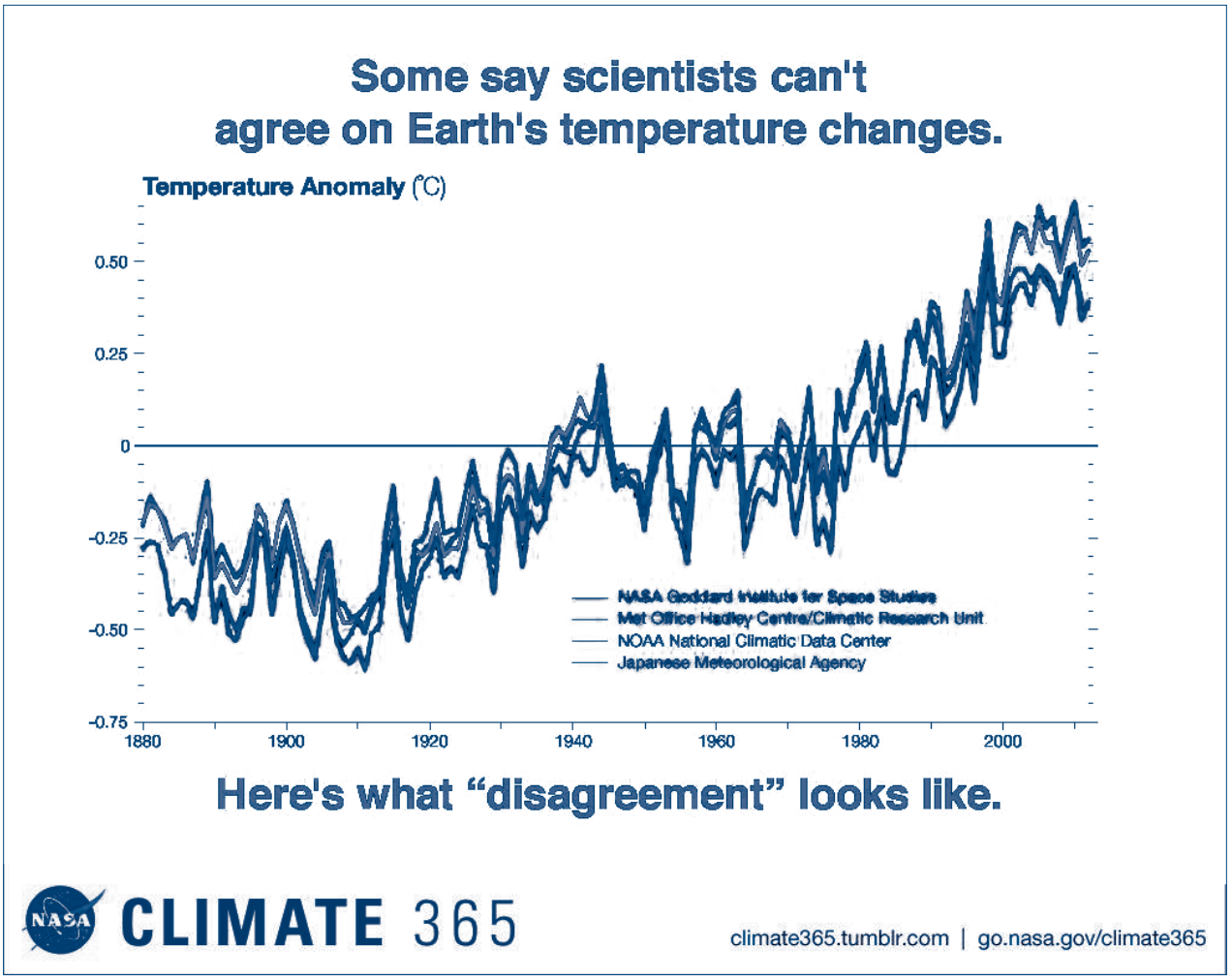
Of course, all four could be wrong. If so, they are more likely to err on the low side. Right now, the concentration of CO_2 in the atmosphere is the highest in more than three million years – and still climbing. The last time levels were this high, the world was 5 degrees Fahrenheit. hotter, and sea levels 32 to 65 feet above where they are.

Climatologists themselves have not processed the magnitude of the change. Their climate models are biased towards normality. Year-to-year upticks in global temps are treated as minor oscillations around an underlying, predictable rise rather than the onset of a cataclysm humans have never experienced.

Self-interest also plays a role. Consensus is safe; being an outlier is dangerous. Projecting an egregiously high temperature rise, if proven wrong, can end a promising career and destroy the reputation of a respected meteorological organization.

The predicable result:

"**For some time now it has been clear that the effects of climate change have been appearing faster than scientists anticipated."**[15]



IT'S NOT TOO LATE…YET

Every day humans emit more than 140 million tons of global warming pollution into the atmosphere, according to the IPCC. The accumulation of greenhouse gases, some of which will envelop the planet for hundreds, perhaps thousands of years, is now trapping as much energy daily as 500,000 Hiroshima-size bombs could release every 24 hours.[16]

More damage and losses are inevitable, no matter what we do. But we still have the ability to avoid truly catastrophic, civilization-ending consequences if we act quickly. The oceans are a good place to start: Nearly three-quarters of the Earth's surface is water, yet oceans absorb only 25% of anthropogenic CO_2.

Science Magazine recently summarized a new report, by the High Level Panel (HLP) for a Sustainable Ocean Economy, on ways to mitigate ocean-related emissions.[17]

We summarize HLP's five-step program for oceans:

Ocean-based Renewables – Tides, winds, and waves represent an enormous, and largely untapped, source of energy. Wind farms already exist, but they are anchored into the ocean seabed close to shore. Advanced technology that can move this infrastructure to deeper water sites (e.g., development of floating offshore wind and solar technologies) present a nearly unlimited source of power. Monitoring and mitigating adverse impacts on marine life and ecosystems will be necessary.

Carbon-free Ocean Shipping – Marine shipping must be able to move 24/7, in sunlight and darkness, in wind and calm. This will require large increases in renewable energy storage capacity in vessels primarily designed to move cargo and passengers. In the short run, substantial CO_2 reductions can be made with hybrid power systems, including combustion engines, and more efficient hull designs. In the longer term, a tax on fossil fuels to close the price gap between low and zero-carbon fuels will be needed. As a practical matter, this goal will likely be achievable only if nations commit to complete decarbonization of their energy systems.

Restoring "Blue-carbon" Ecosystems – Historically, the ocean and terrestrial forests have been regarded as the major carbon sinks. New research finds that coastal systems like mangroves, sea grasses, and salt marshes, are even more effective at removing carbon dioxide from the atmosphere. Although these ecosystems cover less than 0.5% of the seabed, they are responsible for more than 50%, and potentially up to 70%, of all carbon stored in the ocean, leading to the scientific recognition of the term "blue carbon."[18] Restoring these ecosystems is as important to ocean-based mitigation efforts as reforestation is to land-based ones. HLP suggests incorporating blue carbon ecosystems into climate change targets as a means of incentivizing their restoration. Looking further into the future, seaweed holds promise: **"Seaweed products might replace products with a higher CO_2 footprint, thereby avoiding emissions (rather than directly contributing to sequestration) in fields such as food, feed, fertilizers, … biofuels, and bioplastics. The addition of seaweeds to diets of ruminant mammals (particularly sheep and cattle) could play an important role in reducing …methane emissions."**[19]

A Seafood Rich Diet – Fish and other seafood humans eat have a substantially lower carbon footprint per unit of protein than food from cattle, sheep, and terrestrial-based ruminants. So, switching from meat to fish is good for the health of the planet as well as humans personally. But making the switch is easier said than done: Ocean heat waves - which can kill fish, seabirds, and coral reefs - have doubled since the 1980s, and will reduce the ocean catch by one-quarter by the end of the century, according to the UN report. This scenario is not just academic: In 2019 officials in the Gulf of Alaska had to reduce permitted cod catches by 80% to rebuild in the wake of a local heatwave. Toxic algae blooms spawned by global warming forced fisheries to close down from California to British Columbia in 2013 and 2014.[20]

HLP suggests ways to mediate what appears to be a conflict of interest between fishing industry jobs and the climate change effort: **"In the short term, reforming fisheries practices to reduce their carbon emissions while optimizing the amount of fish caught sustainably per fishing effort could have a substantial impact of lowering emissions as well as increasing the catch and income of wild capture fisheries. Encouraging diet shifts to include more sources of sustainable low-carbon protein from the ocean could play an important role with no additional investment in technology required**…"[21] [A modest proposal by this NPG writer: Require food packaging to disclose CO_2 content per serving along-side the already existing info on calories per serving.]

There are limitations. Large scale shifts in food policy and behavior are deemed to be **"daunting"** by HLP. Of the five ocean-related mitigations, dietary shifts yield the least in terms of potential CO_2 reduction.

Seabed Storage – CO_2 can be captured and deliberately injected deep into the ocean seabed, where most of it can be stored and isolated from the atmosphere for centuries. Several techniques for doing this have been proposed, most involving liquid CO_2, which can be transported and pumped into undersea caverns. At 3,000 feet below the ocean surface, high pressure and cold temperatures make liquid CO_2 denser than water, preventing it from rising to the surface, according to researchers

at Harvard and Columbia University.[22] That, at least, is the theory. No large-scale project of this type has actually been completed, and HLP itself admits that "**considerable further investigation**" is needed to address environmental concerns.[23] It might be worth the effort: Deep ocean storage around the U.S. alone could store thousands of years of U.S. CO_2 emissions.[24]

Reality check: The five ocean-based actions, combined, will contribute no more than 21% of the CO_2 reduction needed to meet IPCC's 1.5 degree C warming target for 2050.[25]

The clear implication: more land-based mitigations are desperately needed.

Population reduction, anyone?

OUR PLASTIC FUTURE

Do you remember the sage career advice a parent gave to Dustin Hoffman's character in the 1967 movie the Graduate? It consisted of one word: "Plastics." Back then soda came in metal cans or glass bottles; straws were made of paper; blueberries and strawberries were packaged in cardboard containers. There was no need to query grocery shoppers on their bag preferences.

Bottled water, if available at all, was: a. mainly for health nuts, and b. sold in glass bottles.

If human civilization were to be destroyed and cities wiped off the map, it would be easy for intelligent aliens to figure out when the "Plastic-cene" Era started. From 1950 to today 8.3 billion metric tons of plastic have been produced, with around half of it made since 2004.[26] Three-quarters of the plastic ever made has been thrown away.

Plastic packaging, which is typically used for less than a year, accounts for over half (54%) of plastic thrown away annually. About 12% is incinerated, which is the only way to permanently dispose of it; 9% percent is recycled, which only delays final disposal; and 60% is buried in landfills or scattered elsewhere.

About 10% of all plastic waste ends up in the ocean, most notoriously in the Great Pacific Garbage Patch (AKA, the Pacific Trash Vortex) a vast floating dump of debris in the north Pacific Ocean gathered by prevailing currents from Asia, North and South America. Some of the plastic in the patch has been found to be over 50 years old, and includes items such as "plastic lighters, toothbrushes, water bottles, pens, baby bottles, cell phones, plastic bags, and beads."[27]

Most debris consists of small plastic particles suspended at or just below the surface, avoiding detection by aircraft or satellite. With direct measurement of submerged plastic impossible, the size of the dump (if it were floating on the ocean's surface) is determined by sampling at various depths in various locations. Estimates of its size range from 270,000 sq. miles (about the size of Texas) to more than 5,800,000 sq. miles (about the size of Russia).

The patch is believed to have increased 10-fold each decade since 1945.[28]

SUMMARY

We see shrinking glaciers. We experience floods and super storms. We see the diminished snow cover of iconic mountains like Mt. Kilimanjaro. But the ocean looks about the same now as it did when we were kids at the beach. Its degradation is apparent in changes that most humans do not experience first-hand.

But the science and supporting data in the UN report are clear: Greenhouse gases triggered by human activity are heating the oceans, changing their chemistry, and threatening the lifestyle of hundreds of millions of people living along the coasts.

Because CO_2 is so long-lived in the atmosphere, oceans are locked into a degradation spiral that will last at least until the end of the century. Even if CO_2 emissions are phased out completely in coming decades, the oceans will be in far worse shape in 2100 than they are today.

If greenhouse gases continue piling up unchecked throughout the century, sea levels could keep rising at a relentless pace for hundreds of years, potentially by 17 feet or more by 2300. We would not recognize that world.

Optimists insist we got this: There are plenty of new climate mitigation strategies, plenty of new technologies, and plenty of smart people with expertise in this subject.

And there were plenty of deck chairs on the Titanic also.

Global population reduction may be the last, and best, hope for survival.

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