Data collected over many decades make it clear that the world in general is getting warmer. The evidence for climate change, and planet warming in particular, is pretty convincing for those willing to take a look at it: melting glaciers; well-documented, temperature-related habitat shifts for a variety of organisms including many plants, birds, and marine animals; and rising sea levels. Of course, daily weather patterns have always been somewhat erratic, especially here in New England, and the actual scientific data indicating that climate change really is occurring and the models predicting rates of change and where those changes may lead are complex and not easily understood by those outside the field. Perhaps more to the point, the idea of global warming is easily ridiculed by New England AM radio hosts whenever we have an unusually cold day. I prefer to call the problem Global Climate Confusion; it seems a pretty good description of what lies ahead. But here is something that is much more straight-forward, and much more difficult to doubt, and far more difficult to ridicule: The world’s oceans are becoming more and more acidic. And, as I will soon make very clear, that rising acidity provides strong evidence for global warming.

The world’s oceans are now at least 25% more acidic than they were at the start of the Industrial Revolution, something that was well underway over 200 years ago. Acidity is not that hard to measure, and people have been making those measurements in oceans all around the world for a great many years, starting in the 1800’s; monitoring has been
especially frequent and precise over the past 65 years. I have yet to hear anyone deny that the ocean has indeed become measurably more acidic during that time. The data are very clear.

So what accounts for this documented increase in ocean acidity? Well here’s a clue: ocean acidity has increased in line with the shift from relatively small numbers of people on the planet making things by hand and traveling by foot, sailing boats, and horses, to a modern industrial lifestyle with lots of power generation, machines, cars, trucks, airplanes, cargo ships, cement manufacturing, and deforestation...and billions more people. The lifestyle benefits of industrialization are many. But one of the consequences is the production of excessive amounts of carbon dioxide (CO₂), which is then released into the earth’s atmosphere, day after day after day.

Over just the past 50 or 60 years, the carbon dioxide concentration in air has risen quite a lot, all around the world. For example, Figure 1 (below) shows data recorded from the Mauna Loa monitoring station in Hawaii over 5 decades, from about 1960 to 2010. The carbon dioxide concentration at the monitoring station in Hawaii has gone from less than 320 parts per million (ppm) in 1960, to nearly 400 ppm today. That’s an increase of about 25%, just in that 50-year period. Pre-industrial levels of CO₂, by the way, were about 280 ppm, about 30% lower than they are today. By the year 2100, CO₂ levels in air are expected to be about double what they are today. The rates of increase that have been documented over the past 6-20 decades are far greater—by several orders of magnitude—than any changes that have occurred on this planet for millions of years.
It’s worth noting here that scientists are a very skeptical group of people; they earn points for themselves by proving others wrong. Hundreds of scientists have looked for alternative explanations for the documented increases in ocean acidity, but have found none. Volcanic activity, for example, is a good source of CO$_2$ input into the atmosphere, but volcanic activity has not increased over at least the past several hundred years. This level of agreement among competing scientists is impressive.

So carbon dioxide concentrations in air have been increasing. About one-third of that excess CO$_2$ in air is being absorbed by the world’s oceans. **When carbon dioxide**
(CO₂) from the air dissolves in water, it forms carbonic acid (H₂CO₃). And that’s where the acidification problem lies. The more CO₂ that the air contains, the more CO₂ the ocean absorbs; the more the ocean absorbs, the more acidic the seawater becomes. Here is a pretty safe prediction: by the year 2100, the world’s oceans will be substantially more acidic than they are now as they continue to absorb more and more carbon dioxide from the air. For chemists in the audience, ocean pH is expected to go from its current average level of about 8.1 down to about 7.7 to 7.9 over the next 80 years or so. That may not seem like much of a change, until you realize that the pH scale is logarithmic: a downward shift from pH 8.0 to pH 7.0 corresponds to a 10-fold increase in acidity.

These well-documented, undisputed increases in ocean acidity—and we’re not talking simply about Boston Harbor, we’re talking about the world’s oceans in general—add indirectly to the evidence for global warming: CO₂ is a major greenhouse gas, making it harder for heat to escape from the Earth’s surface. Thus the increasing acidity of the world’s oceans indirectly confirms the increasing concentrations of CO₂ in the air; and those increasing CO₂ concentrations in the air mean that the continued warming of our planet is an inevitable consequence.

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