ANSWERS TO A FISHERMAN'S TESTIMONY ABOUT OCEAN ACIDIFICATION

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In April 2010, a sea-fisherman gave testimony about ocean "acidification" before the US Senate. The list of supposed effects of ocean "acidification" included in the fisherman's testimony seems to have been written for him by climate-extremist lobbyists. His items are in **bold face:** replies are in Roman face.

> **Research shows that CO_2 emissions from burning of fossil fuels and other manmade sources of CO_2 are absorbed into the ocean from the atmosphere. In the ocean, the CO_2 reacts to form carbonic acid. The acid changes the ocean's chemistry.**

CO_2 from whatever source, natural or manmade, is exchanged between the atmosphere and the ocean. Some 30% of all manmade CO_2 emissions can be expected to accumulate in the oceans. However, *the oceans already contain 70 times as much CO_2 as the atmosphere*. If, therefore, we were to double the CO_2 concentration in the atmosphere, an additional partial pressure equivalent to just 30% of today's atmospheric concentration would end up in the oceans – an increase amounting to less than 0.48% of what is already there. That would simply not be enough, on any view, to cause any appreciable "acidification" of the oceans.

> **Ocean acidification is real. It has been documented by researchers all over the world and there is no doubt that the pH of the ocean is dropping, becoming more acidic.**

There is no evidence whatsoever that the oceans have become "more acidic". The oceans are in fact pronouncedly alkaline, and will remain so however much CO_2 we add to the atmosphere. The pH or acid-base index is neutral at a value of 7; acid below 7; alkaline (also known as "base") above 7. The oceans are currently at a pH of 7.9-8.2. No serious scientist suggests that the oceans will become acid: at worst, they will come a little closer to neutrality. To put this in context, ordinary rainwater is acid, with a pH of 5.2.

There is not the slightest danger that the oceans will become acid at all, yet alone as acid as harmless rainwater. The reason is that the oceans run over rocks, which react chemically with seawater to keep it firmly alkaline.

Nor is it at all clear that "the pH of the ocean is dropping". At most, the pH may have fallen by 0.1 acid-base units over the past century, but we do not know for sure because no comprehensive, worldwide measurements have ever been taken by a single research project, and there were certainly far too few measurements a century ago to provide a reliable baseline from which any such conclusion can be drawn.

What is certain is that even a shift of as little as 0.1 acid-base units cannot have been caused by the change in CO_2 concentration, because in the past 250 years we have added only 0.19% to the partial pressure of CO_2 already pre-existing in the oceans. This is too little to make any measurable difference to the acid-base balance of the oceans.

> **Measurements show that the open ocean, on average, is about 30% more acidic today than it was before the Industrial Revolution. In some places, like the West coast, local factors compound that change in seawater. With upwelling or the kind of conditions that produce nutrient-driven hypoxia like we get in the Gulf of Mexico, seawater can become corrosive to some of the fish and shellfish and to the species they eat.**

Unfortunately, there were too few measurements 250 years ago to allow any such conclusion to be drawn. While it is true that a movement of 0.1 acid-base units towards neutrality would increase the partial pressure of hydrogen ions (the pH) in seawater by some 30%, it is by no means certain that such a movement has actually occurred: measurements in the past were simply not frequent enough or adequate enough.

Besides, even if there has been a movement of 0.1 acid-base units towards neutrality, it is blindingly obvious that the minuscule increase of <0.2% in the partial pressure of CO_2 in the oceans for which humankind is responsible cannot have been more than an altogether insignificant contributor.

CO_2 is in fact only the seventh on the list of substances whose partial pressures in seawater might in theory influence its acid-base balance. Therefore, if there has been a small movement towards neutrality in the oceans, some other cause than CO_2 must be looked for.

> **Mixing CO_2 into seawater doesn't just make it more acidic. The carbonic acid from CO_2 changes a lot of the ocean's chemistry. For one thing, it reduces the availability of nutrients in seawater that clams, oysters, crabs, lobsters; corals need to build and maintain their shells and skeletons. They absorb nutrients from the seawater. The increased acidity depletes those nutrients. That makes it harder (and sometimes impossible) for a lot of these shell-builders to survive.**

Since there has been no "increased acidity", the argument that the insignificant additional partial pressure of CO_2 in the oceans that could in theory be attributed to humankind is reducing "the availability of nutrients" is without foundation. Likewise, <0.2% additional CO_2 in the oceans (i.e. less than a one-in-500 increase in the partial pressure of CO_2) is simply not enough to "change a lot of the ocean's chemistry".

Also, additional CO_2, combined with the superabundance of calcium ions in the oceans, tends to facilitate calcification, not to inhibit it.

In most regions, there has been no decline in calcification: in those regions where a decline has been noted, the decline cannot have been caused by the barely-measurable increase in the partial pressure of CO_2, and must have been caused by something else (such as changes in the activity of the 220,000 subsea volcanoes that are known to exist).

> **Even small changes in the ocean's chemistry can disrupt the marine food web and cause trouble for fish higher in feeding order. For fishermen to make a living, we need fish stocks that are abundant and dense enough so we can harvest them efficiently.**

The increase of 0.2% in the partial pressure of CO_2 in the oceans that may have occurred over the past 250 years is very well within natural variability.

In the Neoproterozoic era, for instance, there was 300,000 ppmv CO_2 in the atmosphere, some 773 times today's concentration: yet the early oceanic life that led to today's creatures survived.

In the Cambrian era, 550 million years ago, much of the CO_2 in the oceans had precipitated out by reaction with magnesium and calcium ions to form dolomitic rock (which contains 40% CO_2 from the oceans), and the atmospheric concentration of CO_2 had fallen to 7000 ppmv, or 18 times today's concentration: yet it was at that time that the calcite corals first came into existence.

By the Jurassic era, 175 million years ago, atmospheric CO_2 concentration was still around 6000 ppmv, more than 15 times today's concentration: yet that was when the delicate aragonite corals first came into existence.

Corals have survived for hundreds of millions of years, and it is nonsense to suggest that a barely-detectable increase in the oceanic partial pressure of CO_2 could possibly put them in any way at risk.

As for other calcifying (i.e. shell-building) organisms, they form their shells in an environment in which they topically and biogenically regulate the pH of the water, so that the process of calcification is to a significant extent independent of the pH of the surrounding seawater.

> **Cold water absorbs more CO_2 than warm water. The oceans in high latitude places like Alaska are more acidic than the warmer waters nearer the equator.**

For reasons explained earlier, no oceans anywhere in the world are "acidic". It is of course true, by Henry's Law, that colder oceans will tend to be less alkaline than warmer oceans: however, the official theory is that "global warming" will cause a significant increase in global sea temperatures.

By Henry's Law, the predicted warming of the oceans would cause them to outgas CO_2, compensating at least in part for the (in any event insignificant) increase in the partial pressure of oceanic CO_2 arising from greater atmospheric concentration. This is particularly true in the polar oceans, which have warmed more, on average, than the oceans as a whole.

> **For a lot of species, it looks like they are most vulnerable in early life, especially their larval stages.**

Even if a few species are vulnerable to a small reduction in the alkalinity of the oceans, and even if there has been a reduction in the alkalinity of the oceans, since CO_2 cannot be the cause of the reduction in alkalinity it is not and will not be harmful to the species in question.

> **Even adult shellfish, corals and other calcifiers show slower rates of shell building, diminished reproduction, muscle wastage, and other problems when exposed to acidified seawater.**

Laboratory experiments in which hydrochloric acid is added to seawater to simulate "acidification" of the oceans do indeed cause the effects described: however, the addition of hydrochloric acid (in the absence of balancing stoicheia that are nearly always omitted in such experiments) drives the chemical reaction in the opposite direction to the addition of CO_2.

No laboratory experiment in which as little as 0.2% additional CO_2 is added to seawater has been conducted, because it is obvious to all serious researchers that so little an additional partial pressure would simply make virtually no detectable difference to marine organisms. Laboratory experiments in which >0.5% CO_2 is added to seawater are simply unrealistic, because humankind's activities, even in a century, will not add more than 0.5% to the existing partial pressure of CO_2 in the oceans.

CONCLUSION

The notion that past or foreseeable manmade emissions of CO_2 and consequent increases in CO_2 concentration in the atmosphere will raise the partial pressure of CO_2 in the oceans enough to make any measurable difference to their acid-base balance is without scientific foundation. If there has been a global decline in oceanic pH, the decline has been small, and cannot be attributed chiefly (or, in effect, at all) to manmade CO_2 emissions. Other causes, probably natural, must be looked for.

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