Corals and Science

Thomas R. Cuba

2023 0101

Along with the advent of Global Warming, came the predictions that the increases in Atmospheric Carbon Dioxide would dissolve into the ocean and depress the pH. In what was never recognized as a contradiction, the atmosphere in 1980 was substantially cleaner than it was prior to the passing of the Clean Air Act in or around 1973 and the emission controls that went along with it. In another apparent contradiction, actual atmospheric data tended to indicate that atmospheric carbon dioxide had increased and that oceanic pH levels had become depressed, despite the reduced emissions. The magnitude of these changes seemed to vary almost daily and there were numerous discussions regarding the driving forces. After the industrial emissions were virtually eliminated, automobiles became the focal point of the theorists, which was also an apparent contradiction because automobile emissions had been reduced dramatically as well.

Nonetheless, coral reef scientists did document changes in the reef communities. Populations of epilithic macro-algae were increasing. Coral diseases, especially Black Band disease, were increasing. Along with these changes were the observations of coral bleaching. As usual, though, everything was complicated by the interlacing of multiple observations and potential explanations. For example, some people wondered if the increase in bleaching was artificial, theorizing that the increase was only an artifact of more observations because there were more SCUBA divers and snorkelers in the water. Both of these sports were used as scientific tools and both only became popular in or around 1960. The popularity boomed, but slowly, and it wasn't until 1980 or so that there was an abundance of people in the water. That progression coincides well with the increased reporting of Black Band Disease.

Returning to the observed decrease in pH, it was theorized that major portions of reefs were dying and the underlying limestone and coral skeletons were being dissolved, eliminating habitat for new colonization. The increased macroalgae also competed with coral larvae for space. Part of the increase in macroalgae was theorized to be a reduction in damselfish and others that grazed on these algae as well as the yet unexplained crash in the population of Diadema spinosa, which at one time was very abundant and which also controlled algal populations.

Within that were even more contradictions. Algae of all kinds use Carbon dioxide as an energy source indicating that the pH should be lowered by the increase in the algal populations. When limestone dissolves, the result is an increase of the pH and a corresponding increase in the buffering capacity of the ocean waters. That's just chemistry. Microalgal blooms were also blamed for lowering the ambient light that would reach the corals, which need sunlight to live.

The biggest part of the problem in resolving these apparent contradictions may be that no one, or no one that I ever heard of, was studying them as a cluster of events. Everyone was a specialist focused on only one part of the situation.

Both my training as an Intelligence Officer and my education in Successional Ecology led me in a different direction. Both taught me to look at webs of information, not lines of logic. Both taught me to ask what information was reliable and whether or not it was complete.

First, set some bars.

A *Working hypothesis* or *Partial* theory allows for *ALL* the observations and does not contradict *ANY* of the observations.

A *Unified* or *Comprehensive* theory accounts for, or explains, *ALL* the observations.

Here are some observations to consider.

Many of the reefs along the Florida Coast were examined for coral populations. I say examined because there were very few actual studies. Most of these reefs were classified as being degraded. Under closer examination and review of some of the older literature, these reefs had not been Scleractinian (hard coral) reefs for quite a long time. What changed, probably unintentionally, was the language. This was made most clear to me during an exchange during a conference.

"What is a reef?" was the question asked during a workshop on artificial reefs.

My answer, was, "Any sailor knows what a reef is. It's a shallow hard spot that will tear out the bottom of your boat." Yes, perhaps it was snotty, but I made the comment to demonstrate that the word 'artificial' was an adjective. So are the words coral, rock, Scleractinia, Alcyonarian, sponge, and algal when combined with the word 'reef.'

My point was rejected and the group went on to formally declare that artificial reefs were equivalent to coral reefs. That part, however, is not important. What is important is that it became commonplace to presume that all reefs in Florida were Scleractinian and, if observation showed them to be otherwise, they were considered degraded. The loss of the adjective precluded the acceptance of naturally occurring Alcyonarian, and sponge reefs, as well as algal reefs.

Coral Bleaching was linked to warmer water temperatures and lower pH levels. It was theorized that the coral became irritated with the temperature and ejected the zooxanthellae. The bleached coral then died. This violated the corals own evolutionary history as a group. Scleractinians evolved during a time when the waters were substantially warmer than they are today and when the waters were more acidic as well. My question was why the same water that led to their evolution would also lead to their demise. To even begin to answer that question, I had to come up with an alternative explanation. Anthozoans (soft corals with only one polyp) and Scyphozoans (jellyfish) both predate the Scleractinia. It is reasonable that in a world where there is an overabundance of Calcium Carbonate (dissolved limestone) and low pH an animal might develop the ability to exude excess calcium carbonate from its body fluids and to develop a relationship with an alga that countered the affects of the lower pH. The pathway might be that calcium carbonate in the seawater that was ingested precipitated within the coral and then was ejected by exudation through the body wall. In the solitary Anthozoan, this could lead to a calcification of the base beneath the polyp and eventually a coral skeleton. In the scyphozoan, the same process could lead to the animal being too dense to swim, allowing it to fall the bottom. These changes would occur over evolutionary time but could lead to the new Orders of Cnidarians.

Consider the coral organism itself, in light of having had years of a relationship with the Zooxanthellae. The coral had lost its ability to derive all the energy needed from its own predatory practices and had come to rely on the byproducts of the microalgal metabolism. Logically, a coral under stress would not be likely to eject a critical component of its survival, the Zooxanthellae.

Another troublesome fact I found was in the bleaching studies that were conducted in aquaria. While they claimed to prove that warm waters lead to bleaching, a close review disclosed that the warm waters of the aquaria were held at a constant temperature well above ambient for the entire period. There was no daily fluctuation built into the study. After two weeks or so, the corals bleached.

Another relevant fact was revealed when I was in the Tortugas attending a conference. During an off day, I went diving along the face of a deep ledge. The Scleractinians near the surface appeared healthy and abundant. At 90 feet or so, bleaching was evident.

Finally, during a review of the literature, I learned that there is a link between the presence of peroxides. Peroxide is a chemical that is released by Zooxanthellae when they die. That fact was the linchpin allowing me to develop an alternate theory. It would be logical that if the Zooxanthellae were dying inside the coral, then the coral would want to dispose of the remains. That would result in bleaching.

Putting this together, I theorized that the bleaching in the Tortugas was not caused by warmer water, but by cold water. Water temperatures less than 18 degrees Celsius (64.4 F) will kill our Scleractinians. The coral was not ejecting the zooxanthellae because the algae were dying. In the alternative theory the zooxanthellae in deep or cold water, were escaping by intentionally producing the peroxides that caused the coral to release them.

How should I test this?

Randomly, I encountered a statement in an environmental paper regarding the high Sea Surface Temperature (SST) in South Florida. The statement predicted massive bleaching and die-off's. Because I knew the people at USF who owned the satellite that collected SST and published it, I visited the lead scientist and asked a simple question: "How thick is the sea surface." I also conducted a poll among the leading scientists in the area, including professors, consultants, and government agents. The answers included "I don't know," "It varies with the season," "20 feet," and "100 meters." The owner of the satellite answered more directly: "It's two dimensional. What we collect is actually the black body heat radiation, not the actual temperature. Then we calculate the temperature using a model or algorythm." They did not take readings over a 24-hour period, but only during the mid-day hours. That alone created estimates of average SST that were higher than the actual 23-hour averages.

That gave me an idea. For the next year (2007), my team visited the reefs and placed temperature recording devices at various depths in the keys. Data were collected on an hourly basis. Recorders were attached to buoys to collect surface temperature, staked to the bottom at 30, 60, and 90 feet to record temperatures at those depths as well.

The results were surprising to almost everyone who was not on my team. These are presented elsewhere, but in summary, daily fluctuations were evident at all depths. Deeper waters were always a few degrees colder than the next layer up. On one occasion, at the deeps site, we recorded temperatures below the 18 Deg. C. survival threshold. The results are provided elsewhere.

I presented this data at a state conference, after which a professor at an east coast (Florida) university approached me and said he had observed the same thing. His paper was not accepted for publication. Neither was mine. I didn't press the point because of my experience in publishing my paper on the colonization of hard substrates by epilithic organisms. That story is also related elsewhere.

A secondary question was why many of Florida's non-Scleractinian reefs were growing on base material that had been determined to be Acropora (palmata and or cervicornis) and why those species were not abundant in those same waters today. The information presented here answers that question, at least in theory. When the old reefs formed, the sea levels were lower and warmer at depth than they are now. Acroporids can be found in shallow areas, but seldom in deep ones.

I never did come up with a theory for the population reductions in Diadema and Damsels.

End Note: The Global Warming Theory evolved from a reversal of the widespread fear of what had been promoted as The Coming Ice Age, in or near 1970. Global Warming formally arose from the United Nations conference in Rio. The shift to the Climate Change Theory was due to the fact that many scientists challenged the Global Warming theory when the actual data could not be reconciled with the predictions.