Coral Reefs In Crisis

By Abigail Alling

Abigail has studied coral reefs around the planet and, as a member of Biosphere 2, lived for two years sealed inside an enclosed mini-world constructed in the Arizona desert, where she managed and monitored a million-gallon reef system. She currently lives aboard and works from a research ship engaged in marine conservation programs in Southeast Asia.

I visualize coral reefs as a sparkling jewel, the colors of the rainbow, circling the equatorial regions of the ocean like ring, a vibrant and busy ecosystem whose organisms are experts at captivating the beams of sunlight and using the available quanta to express fantastic forms of life, an underwater biome that has specialized in creating photosynthetic organisms such as algae, plankton and zooxanthellae as compared to trees, grasses and plants.

This image is the quintessence of a reef, but most reefs look nothing like this anymore. Instead they have been dynamited, fertilized by all forms of excess waste and pollution, over fished to species extinction or the decimation of populations, suffocated by erosion and sick due to the rising fever known as global warming. Today a dull ring circles the equatorial regions of our planet; our biosphere is sick and the decline in the health of corals is an expression of this illness.

My first sailing experience was onboard a twelve-foot dingy in the cold waters of Maine. It didn't take long to discover that I loved it, the lick of salt water on my lips, the wind in my hair and the feeling of flying across water with my sails tucked and my hands grasping the tug of the tiller. Immediately I dreamed of exotic lands and a longing to follow dolphins out to the sea and learn what was beyond the horizon. This initial calling eventually carried me to all the world's oceans and face to face with joy as I gazed at the beauty and radiance of life and grief as I witnessed its destruction by human activity, everywhere.

In 1981, when I joined a newly-formed "Indian Ocean Marine Mammal Sanctuary," I was ignorant about such indifference, especially the worldwide decimation of fish stocks. Our home for those years was a small thirty-three foot boat based out of

Trincomalee harbor, a large natural bay on the east coast of Sri Lanka where we lived alongside Pygmy blue whales, sperm whales, beaked whales, pilot, risso, pygmy and false killer whales, as well as spinner, spotted, bottlenose, striped and common dolphins. We had arrived at the Mecca for cetaceans and were dazzled by the diversity and wealth of sea, land and culture.

It was there that I first began to track the bycatch of marine mammals in Sri Lanka and by 1984 had estimated that 38,000 marine mammals were killed wastefully each year. For another decade a fisherman friend of mine kept records of the overall daily catch and he reported to me that with each passing year, fewer and fewer marine mammals were taken and the amount of fish caught a year was plummeting. By 2004 when we next met again, he said that no dolphins had been caught in these nets for over a decade and only a handful of boats were used for fishing. Trincomalee was a coral reef coast and as we stood on the beach talking, I could hear dynamite exploding. Frustrated fishermen had resorted to dynamiting the reefs to "catch" their fish.

One of the most tragic scenes I know is seeing a reef destroyed by dynamite or cyanide fishing. The extent of such fishing is not well known because it occurs usually offshore from small boats, but I have seen evidence of it during our voyages not only in the Indian Ocean and Southeast Asia, but also in some parts of Melanesia and Polynesia. My first encounter with dynamite fishing was off the coast of Sulawesi in 2001 when we found ourselves in the midst of repeated blasts that rocked our 120-ton ship! We popped our head up the hatch and saw a small sixteen-foot boat about a half-mile away that must have set off the bomb. By the time we reached the area with our diving gear, we observed a few dead fish along with fragments of living reef; the fishermen had scooped up most of the fish and hastily retreated. Although dynamite fishing is illegal, it is a cheap way to secure a quick catch of reef fish.

Cyanide fishing is a similar technique where potassium cyanide is released onto the reef killing the fish and leaving a chemically scarred area that remains inhospitable to reef organisms for years to come. I have recently seen such a scarred reef in the Anambas Islands (South China Sea) and what was most striking about the damaged area was the total lack of life. Nothing was growing on the place that was touched by the chemicals, not even algae.

Usually when a coral reef is sick or when it dies, the corals are replaced by red, brown and green algae and when this happens the reef changes from a coral garden into an algae garden. The presence of large macro algae suggests large concentrations of available nutrients. Although corals are not able to utilize large amounts of nutrients, algae will grow rapidly and colonize the reef like weeds in a garden. "The solution to pollution is dilution" was normal practice in the early Eighties when I was a graduate student. Ecology was only beginning to be recognized as a science and even the word "biosphere" was a foreign word needing explanation. The ocean and nature in general was viewed as an unlimited resource, not only teaming with life, but large enough to absorb our wastes.

It was in this general milieu that a project called *Biosphere 2* emerged in the early Eighties. A 3.15-acre miniature biosphere sealed off from Earth in the Arizona desert by steel below ground and a glass/steel space frame above ground, *Biosphere 2* was the first self-sustaining and evolving world ever created by humans and I was one of the lucky few to live inside for two years. Because it was a very small "world," it cycled rapidly and we learned quickly to be accountable for our actions since one mistake could result in the contamination of our drinking water or atmosphere. We experienced the necessity of becoming active participants within an increasingly complex and coherent living system. It was delightful to understand this inside world, to appreciate the synergy of life and to live day to day with the pleasure of being part of a something larger than ourselves. We learned first hand about the challenges of being a "planetary community" as we struggled to live together in one world and leave behind, where appropriate, our own individual cultures and viewpoints that stood in the way of this process. We had an accelerated chance to rapidly adapt and become stewards of our biosphere while using our minds, the most powerful tool available, to do work and solve problems that seemed impossible.

At the completion of the experiment, I desired to apply this experience to life at "home" on planet Earth. In the spirit of this wish, I soon found myself on an airplane looking out the window back at the receding Mexican landscape. It was 1998 and my eyes melted into the gorgeous sparkling blue of the Caribbean Sea and almost like a cartoon my gaze came to a sudden halt and closed in on the black water surrounding Cancun! "Wow! That is sewage spreading out from the city into the ocean," I exclaimed out loud. Cancun has no waste treatment law other than pumping raw sewage deep into the limestone coast where the black water oozes through the rock and eventually into the marine coastal environment. A fellow traveler looked at me and said with disgust that her son had been playing in the lagoon behind the hotel where they were staying and had seen feces floating in the water. She had packed up and left.

The lack of wastewater treatment is not unique to Mexico, it is a phenomena occurring worldwide. Even countries that treat wastewater chemically are contributing to the nutrient overload. Wastewater, in general, is a fabulous nutrient resource that is wasted when not used and it becomes toxic to environments in excess often resulting in the death of ecosystems such as coral reefs and lagoon seagrass beds. One result is that the coral reef coast of Mexico is suffering from exactly this kind of nutrient overload. Coral gardens are slowly becoming algal gardens because algae are very good at taking up the excess nutrients.

Even off the remote island of Kitava in Papua New Guinea we witnessed a reef suffering from an overgrowth of algae smothering the corals. In this particular location there is only one house on the beach adjacent to the reef and the amount of sewage from it is not enough to impact the reef. However, just a few miles offshore is a large shipping lane with tankers steaming back and forth day and night in a deep pass with strong ocean currents. A tide brings this offshore water to the Kitava reef, washing it daily with water from far away places. This is where the algae must be getting the nutrients to grow so well. The villagers are not contaminating their reef, but they are experiencing a loss of the reef's biodiversity due to contaminants from far away.

The United States has one reef system on its mainland that begins in the Dry Tortugas, runs along the Florida Keys and continues north into the greater Miami metropolitan area. It has been decimated by land-based sources of pollution including treated and untreated wastewater and urban, suburban, farming and agricultural run off, all of which flood the Florida coast. Repeated studies of these reefs by Phil Dustan have shown that just three to five percent of their living coral cover remains today. This is one of the most documented reef systems in the world, yet there is very little said about it publicly; imagine what is happening in areas far out of sight.

It's quite powerful to actually witness a reef being killed; it is a helpless experience, one I experienced last year during a dive along an undeveloped coastline on the west coast of Lombok, Indonesia. The dive began well, but when we came around the corner and got into the lee of the coast, the water became still and the reef quiet. Soft corals were bent towards the sand, dripping with sediment that covered the entire organism. A thick clay/silt layer of soil lay over the reef and its large boulder corals like a grey-brown blanket. Three lionfish floated motionless in the still water, their eyes staring out at the eerie sediment wasteland. A few other fish appeared here and there, but that was it. My fellow divers and I looked at each other as bewildered as the lionfish. One of us finally signaled "lets go up." There, just inland, was the answer: Tractors were plowing the land, trees had been felled and a swath of soil laid bare in preparation for a large construction project.

The runoff from construction and deforestation makes it to rivers or to the water's edge where it runs into the sea and settles out of the water column. When this happens in tropical seas, the sediment falls like a gentle snow onto the coral colonies suffocating the coral (which is a small animal) and starving it, as well as preventing sunlight from reaching the small algae, known as zooxanthellae that live in its tissue.

Some island cultures prefer to mine coral rock (either living or dead coral) to use in constructing houses, roads and jetties. On remote islands where cement for is very expensive, locals see reef rock as free building materials. In the Maldives and other low-lying tropical coastal communities this has had drastic ramifications though, because the removal of the reef rock removes underwater walls key to helping prevent surging seas from swallowing coastlines. I dove on the reef of Ghizo, in the Solomon Islands, soon after the April 2, 2007 tsunami and the familiar underwater coral landscape we had been surveying since 2000 looked like a computer simulation, as if an underwater hurricane had swept through mowing down coral formations and turning them over all in the same direction. After seeing a reef turned “upside down” like that it is easy to appreciate how a healthy reef will help “slow down” tsunami waves before they impact the coast.

In other places, entire reefs have been decimated by nuclear testing. The first thermonuclear device was detonated in 1952 by the United States in Micronesia at Elugelab Island in Enewetak Atoll. The island was vaporized along with its reef. To our dismay we learned that many islands had been used for such practice in the Pacific Ocean, including the Kiribati Islands where our friends in Ghizo were from. They described how their entire village had been relocated to the Solomon Islands just three days after a big black cloud appeared near their island; within days after the cloud’s appearance they became ill and their cows died after drinking in a nearby watering hole. Similar testing – and after-affects -- has been carried out across the water world by the U.S., U.K., Russia, France and China throughout the Fifties and Sixties on remote coral reef islands (the French didn’t stop its nuclear testing in the Tuamotus until 1996).

In December 2004 my phone rang and it was friends aboard our ship in the Kiribati Islands, detailing an alarming discovery, that the corals surrounding the atoll of Kanton Island were dead.” “Dead?” I answered thinking it was not like her to speak so emotionally. It wasn’t until I saw her video of the corals that I realized the impact of what had happened. We downloaded NOAA’s sea surface temperature data and deduced that the reefs had suffered from unusually high and persistent water temperatures for seven months, from August 2002 to March 2003. The mysteriously warm waters had left the remote and beautiful coral reef ecosystem and its lagoon dead.

We had been studying these atolls for nearly a decade and had experienced some degree of bleaching corals at nearly every reef, but had never witnessed a field of table corals killed all at once due to any similar temperature “event.” When corals “bleach” there is a rapid change in the color of the coral tissue to white because the minute algae living in the tissue migrates from the coral due to a change in temperature or the environment that it cannot tolerate. Because a coral animal needs these zooxanthellae algae in its tissue for food and oxygen, it will die unless the circumstances change and the algae return. For exactly those reasons, climate change has become the greatest threat to coral reefs today. The increasing amounts of greenhouse gases in our atmosphere –

particularly carbon dioxide -- has led to global warming which in turn has led to increased sea temperatures and a lowering of water pH known as ocean acidification. These twin processes have already had harmful effects on coral reefs and threaten to become even more pronounced in the near future.

These harmful changes make me think back to times in *Biosphere 2* when we would lower the ocean water temperature as well as the overall temperature in the facility in order to slow down its metabolism and minimize carbon dioxide production. A biosphere is one large breathing system in which plants and algae produce oxygen and all living organisms, including the teaming activity of microbial fauna in soils, respire carbon dioxide. Slowing down the metabolism of an organism by cooling it down works the same for a biosphere and thus the amount of daily carbon dioxide released is decreased. A related phenomenon is happening on earth right now: Greenhouse gases are trapping heat and thus the overall concentration of atmospheric carbon dioxide is rising as well as sea surface temperatures.

Another threat to reef ecology is a phenomena known as “red tides.” I have only seen such an event once, off the coast of Sumatra when the sea turned the color of Coca Cola due to millions of tiny red-brown phytoplankton per millimeter of water. The high surface water temperature and calm seas had provided an ideal soup for the bloom to occur, but where was the added nutrient coming from? Red tides can occur naturally, but both pollution and global climate change have increased their intensity, frequency and duration. While red tides will eventually pass and the waters clear, coral reefs may be left decimated by a prolonged incident because the phytoplankton obstructs the sunlight from reaching the coral colonies. During this time other reef organisms may be suffocated due to the lack of oxygen in the water and toxins emitted by the algae can affect the central nervous system of fish resulting in their death.

When I saw this red tide it took me back to a moment at *Biosphere 2*, about six months before the system was permanently sealed. The reef tank was intact, some of the coral reef organisms were already in the “ocean” and pumps were cycling currents, waves and tides. Construction workers were harnessed on steel struts overhead while caulking and screwing the glass to frame structures. In the middle of the cacophony of activity, it rained a quick Tucson summer desert rain. I didn't think much of it and went about my business, until about thirty minutes later when a colleague called by radio to say the ocean, which had a visibility of about thirty feet, had turned a dark pea green. This was my first experience with acid rain and the extreme rapid-response characteristic unique to coral reefs.

At the moment of rainfall, nitrogen and phosphorous-laden rain poured into the ocean and algae began to take up the nutrients, quickly replicating itself over and over again with all the newly available food. Pollution, whether organic such as sewage or inorganic such as industrial smog in acid rain, is a common word usually used to describe various concentrations of nitrogen, phosphorous and potassium. These are the basic elements used in fertilizers because usually these molecules are scarce and a limiting source to plants. A coral reef is an ecosystem that depends on the concentrations of these elements to be nearly non-existent. Thus I realized I was watching algae in the small ocean gorge itself with acid rain fertilization and threaten the rest of the coral reef's health.

Remarkably though, the *Biosphere 2* coral reef also illustrated a very hopeful message about the capacity of life to evolve. This particular reef was collected from Akumal Mexico, transported in six tractor-trailers and transplanted four days later into a covered steel tank in the mountains of Arizona. These corals had traveled to a temperate region where sunlight disappeared into seasonal snow storms; migrated out of the pressure of the ocean depth to 3,900 feet above sea level; survived nearly 1,000 miles from the nearest salt water biome; and relied on technology to remove nutrients, create currents and waves, and maintain water temperature. The reef successfully survived for three years in this alien world with 986 coral colonies of which eighty-seven were babies found growing on the reef or the walls of the tank. It was proof that if you give life a chance and simulate necessary environmental parameters, that living systems can adapt. For this biosphere, technology was designed and used to enhance life, not to harm it, which is a profoundly appropriate worldview deserving much further contemplation.

When I exited from *Biosphere 2*, I did so knowing that coral reefs were an indicator biome for the health of the oceans as well as the health of our earth's biosphere.

It was this realization that birthed the Biosphere Foundation's "Coral Reef Satellite Mission," a global stewardship program designed to create the most advanced underwater observation program from space and one that would be visible to everyone via Internet as the satellite traversed the seas. We envisioned this as the first of many space observation programs that would engage us in the visual exploration of our biosphere and thankfully it is now becoming possible because of collaborative programs such as Google Earth. The future of conservation will be more effective because it is increasingly possible to view the biosphere as a whole as well as zoom into its every detail. Through this process anyone accessing the Internet will hopefully become familiar with thinking globally.

Put another way, each of our individual actions makes a difference because we are all connected to a larger synergetic network of life. Corals are the ocean's early warning beacons, signaling a drastic change in the biosphere. If coral reefs are dying worldwide, then the health of the ocean must also be in decline. What can we do in the face of such devastating knowledge? A first step may be simply to "fall in love" with the ocean and the biosphere. While this may sound like a simplistic solution, it is at the heart of a growing global disconnect that we are experiencing with regards to the planet's loss of life. In that embrace, we will care to learn more, to find solutions to otherwise daunting challenges and become more intelligent navigators. As we used to say in *Biosphere 2,* with a sparkle of new-found realization, "if our biosphere is well, then we are well."