Evidence for increased coral bleaching and disease from accelerated marine corrosion due to electromagnetic pollution and induced stray electrical currents in seawater

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Abstract

Electromagnetic pollution from man-made sources has increased exponentially over the past century. This paper explores the hypothesis that much of the accelerated disease in coral reefs may in fact be due to accelerated marine corrosion and electrochemical attack triggered primarily from man-made sources of electromagnetic radiation inducted and conducted into seawater and the seafloor. This form of pollution and damage would be highest within a few miles of coastlines with lots of antennas and radars as well as areas of heavy boat traffic, due to vessels with multiple antennas and radars along with motors and metal surfaces in contact with conductive seawater.

Figure 1: Lots of radiating electrical gear on this boat. Radars and antennas

Discussion

Marine corrosion is a well-known phenomenon that originates from electrochemical attack of metals in contact with seawater. Seawater is a very strong electrolyte with many dissolved ions and is approx. 20,000 times better conductor than distilled water[1]

Marine corrosion rates are accelerated by two means: 1) Galvanic action between dissimilar metals immersed in seawater, which is also the basis for galvanic battery design and 2) Stray electrical currents in water at levels as low as 0.01 mA of DC electrical current and 1 mA of AC electrical current [2] and is typically much faster than typical galvanic corrosion rates. When stray electrical currents leak into the water near boats due to faulty wiring, steel propellers can be destroyed within just a few days or weeks.

Galvanic corrosion on immersed metal surfaces on boats such as propellers and metal hulls is a very common problem, especially around marinas where there are many boats with immersed metals nearby. The dissimilar metals themselves can set up low level electrical currents in the seawater between their surfaces due to their differing electrical potentials[3] . In order to minimize corrosion of expensive metal parts such as stainless steel, owners will place "sacrificial" anodes of zinc metal in contact with the more expensive metal. Since zinc has an electrical potential that is lower than that of stainless steel, it will corrode first before the stainless steel does, protecting the steel. The inexpensive sacrificial zinc anodes are then routinely replaced as they corrode. Cathodic protection systems are utilized widely to protect marine structures and underground piping from premature marine corrosion and also employ sacrificial anodes made of reactive metals such as zinc, magnesium and aluminum placed around the structure or pipeline

Stray electrical current corrosion can be much more damaging to vessels and structures than galvanic corrosion due to the accelerated attack from the electrical currents. While galvanic corrosion between dissimilar metals can take months or years to do significant damage to metal surfaces, stray electrical current can do damage within days or weeks.

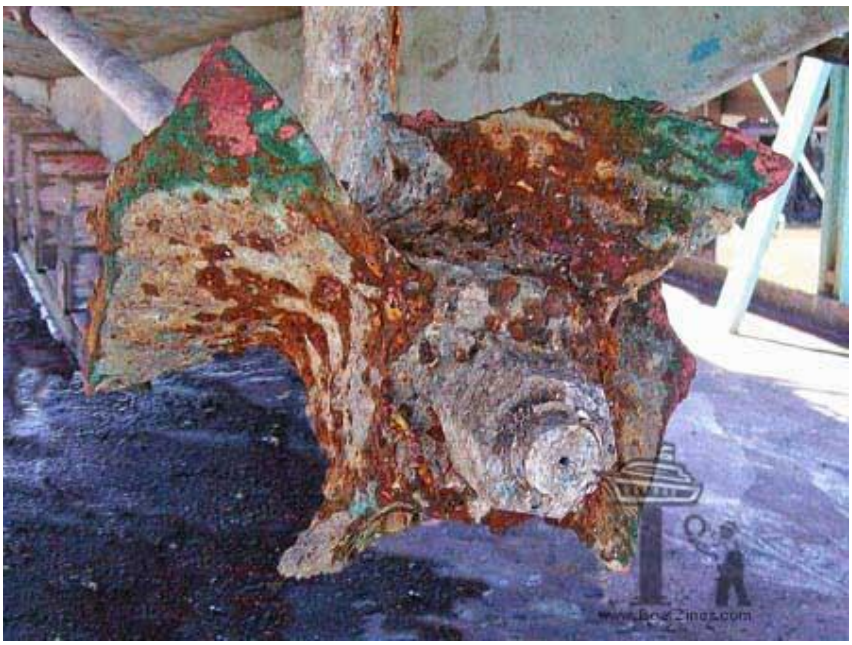

Figure 2: Accelerated marine corrosion due to stray electrical currents

Sources of electrical currents in seawater can originate from improperly wired boats especially around marinas where boats are plugged into a power source. Another often overlooked source of electrical currents in seawater is from electromagnetic fields on the surface of the water. The electromagnetic fields can induce electrical currents in the seawater due to electromagnetic induction, coupling and conduction [4] at the water's surface. Electromagnetic induction was one of the great discoveries of the 19th century and is responsible for our power distribution systems around the world.

Electrical currents within seawater trigger electrolysis and increased chloride ion content. This is the basis of operation of salt water swimming pools with a "chlorinator cell" to electrolyze the dissolved

salt. Chloride ions are a strong oxidizing and bleaching agent and are used widely in industry and at home for bleaching and whitening. It is due to the increased chloride ion content and resulting increased oxidizing potential of the saltwater that it becomes a very good bleaching and sterilizing agent.

In this simulation[5], 6 typical antennas on a naval warship can impart up to 6mA/sq meter of electrical current on the ocean surface up to 50 feet away from the vessel. The typical naval vessel today has 50-100 radars and antennas and commercial vessels may have multiple antennas and radars for navigation, communications and weather tracking.

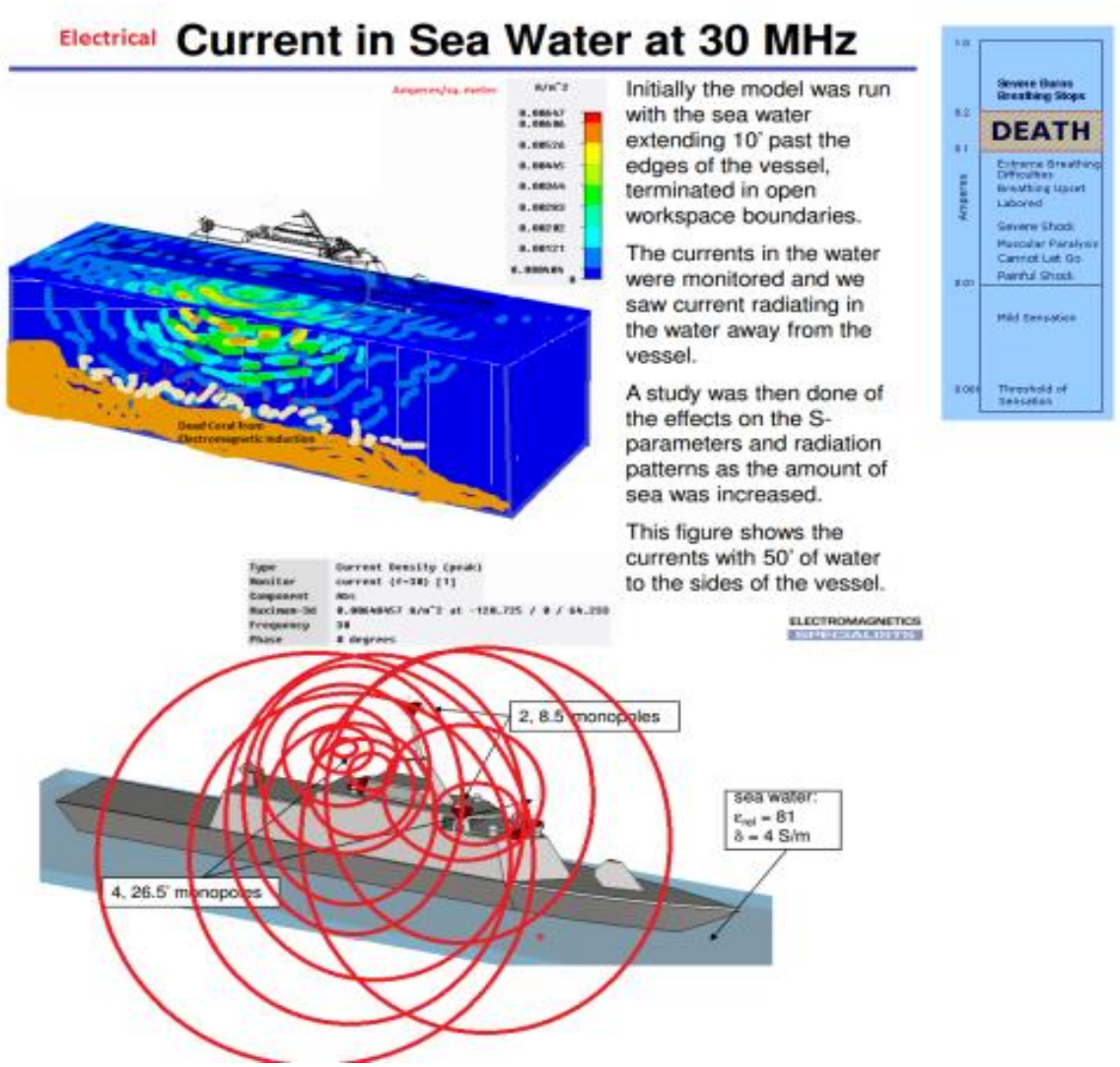

Figure 3: EM Simulation showing electrical currents induced in seawater due to EM Radiation from antennas

In another example[6], the USS Independence, a new naval vessel was recently grounded due to accelerated marine corrosion which was believed to be caused by the powerful radars and electronic systems on board inducing electrical currents between the wetted metal surfaces and the ocean. It is easy to see that the corrosion affected the wetted parts of the ship due to stray electrical current corrosion in contact with the seawater.

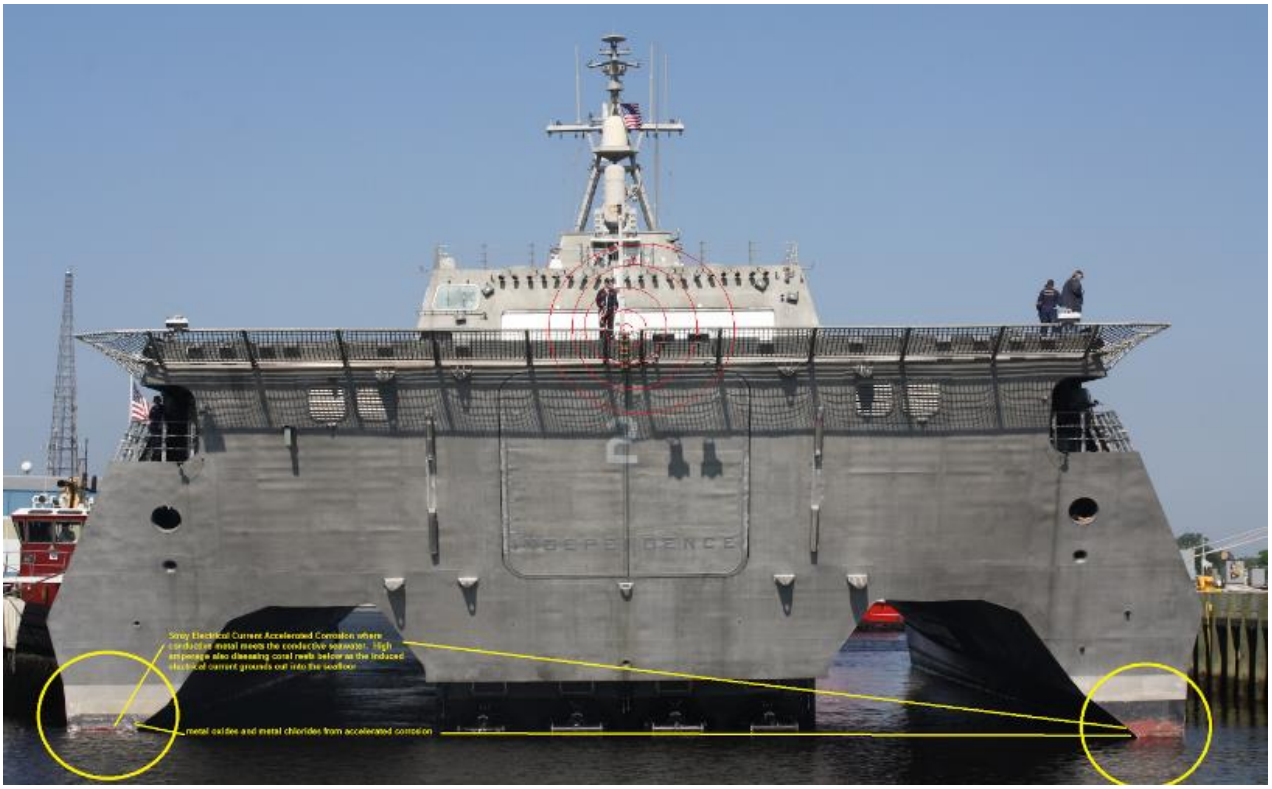

Figure 4: Accelerated stray electrical current corrosion attacked this vessel in a short period of time due to high power, high gain radars and antennas

Calcium is an even more reactive metal than zinc, with an electrical potential of -2.87 Volts vs. -0.76 volts for zinc[3]. Therefore calcium and calcium compounds will corrode even faster than zinc. Coral reef skeletons as well as exoskeletons of many marine species are made from calcium and calcium carbonate. Calcium based coral reef structures are also well grounded to the bottom of the sea to receive stray electrical current. It is easy to see how a shallow calcium based coral reef structure could undergo accelerated corrosion from stray electrical currents in the area.

The first stage of chloride attack can in fact be bleaching as the strong oxidizing agent attacks metals and creates metal oxides and metal chlorides. Calcium oxide is white in color. Calcium chloride precipitated from solution can be orange in color. The coral below exhibits the characteristics of corrosion and conversion of calcium carbonate to calcium chloride

Figure 5: It appears the Calcium carbonate reef structure is corroding to oxides and salts beneath radar stations in Kaua, HI. Photo Compliment by Terry Lilley, Kauai, HI

The oxidation and corrosion of calcium based coral reefs should follow a fairly well understood relationship for corrosion oxidation and reduction potential(ORP). The following graphic shows corrosion potential in volts vs. pH. The pH of the ocean is slightly basic at approx. 8.1 and has changed only about 0.1 pH over the past 100 years. You can see below that corrosion potential of a metal is fairly flat over a wide range of pH. Above a certain potential, the calcium will form Ca++ ions and react with chlorides and dissolved oxygen, effectively pulling the calcium from the reef structure, leading to accelerated corrosion and decay.

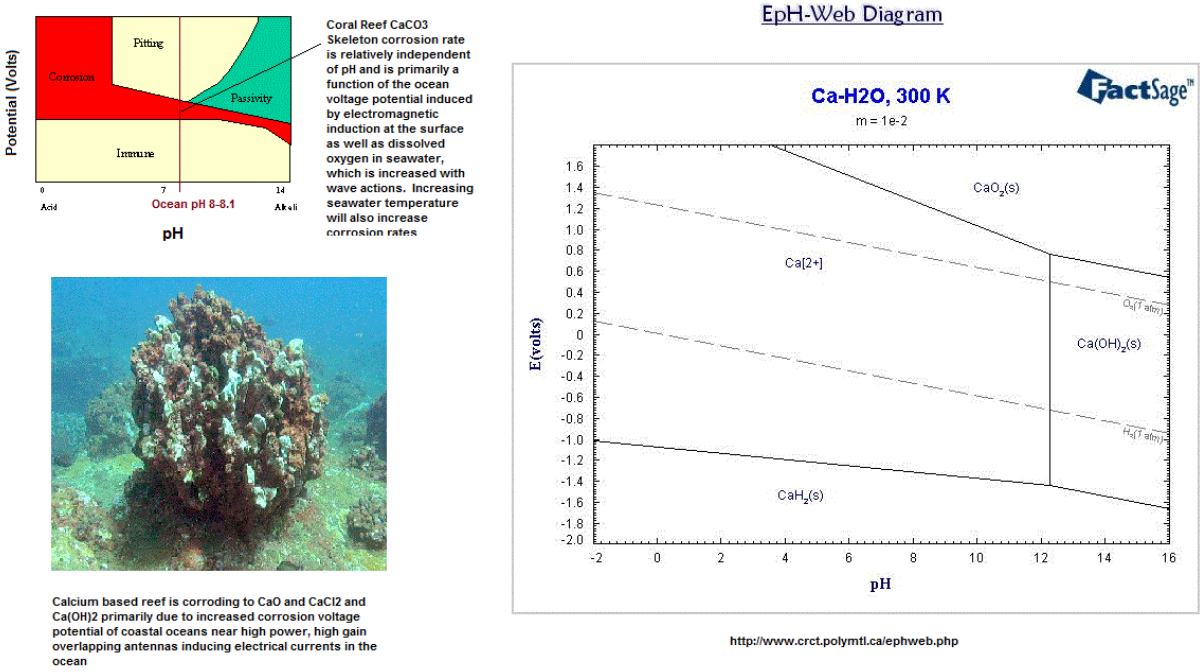

Figure 6: Marine corrosion of calcium based coral reefs and EpH diagram for Calcium Based Corrosion

Increasing corrosion rates are positively correlated with increasing ocean temperature as well as increasing dissolved oxygen levels [7]. During wet weather and rain events, bleaching rate should increase due to increased refraction of electromagnetic radiation from terrestrial sources refracting off the overhead atmosphere [8] and striking the surface of the seawater. As the salinity of seawater drops during wet weather, the conductivity of seawater will drop increasing the chance of electrical shock [9] and discharge into the reef, increasing bleaching and corrosion rates.

Summary

Reef surveys in Kauai, HI US [10] as well as statistical observations in Florida, US [11] are indicating that areas of higher atmospheric power density of RF & microwave radiation (both pulsed and continuous) may correlate well with higher disease rates in nearby marine life as well as coral reef destruction. The causation would be EM radiation, reflection, refraction, induction and conduction of electrical power into the surface of the ocean triggering stray electrical currents and accelerated marine corrosion and decay through oxidative stress and chloride attack of calcium and other metal/mineral based life and marine structures. If this impact is verified it could have wide ranging impact on many industries.

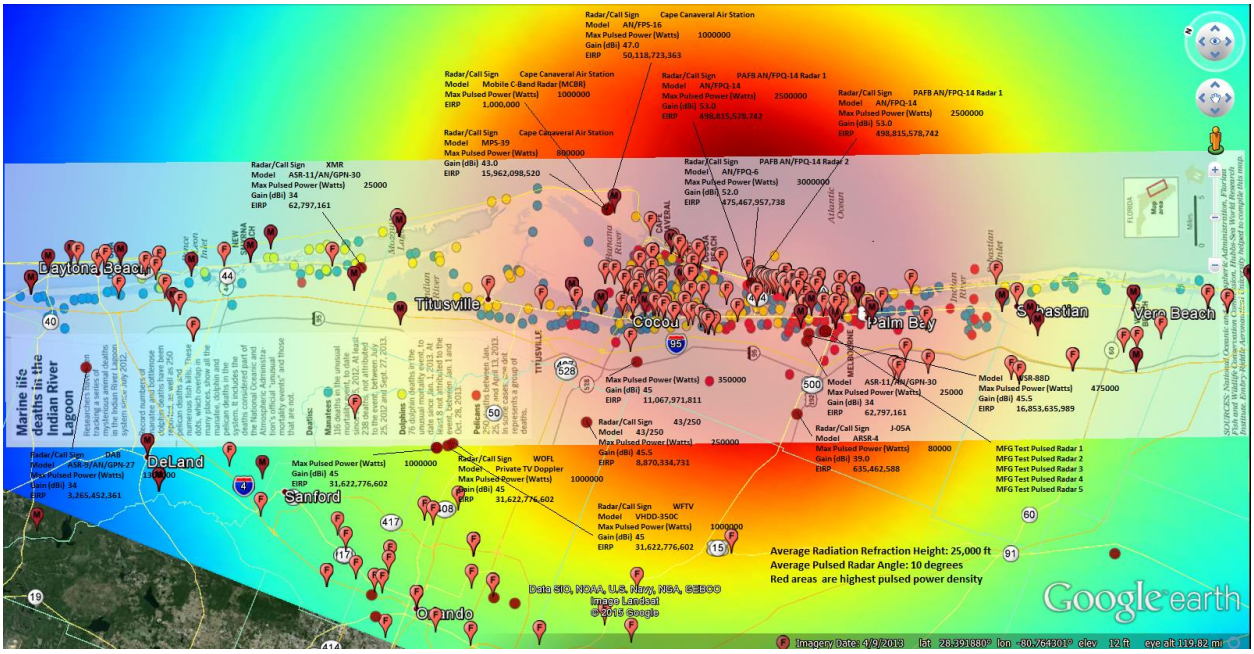

Figure 7: Microwave Radiation Power Density and diseased (F)ish, dolphin, pelicans and manatee in Florida near >20 high power microwave radars and earth stations

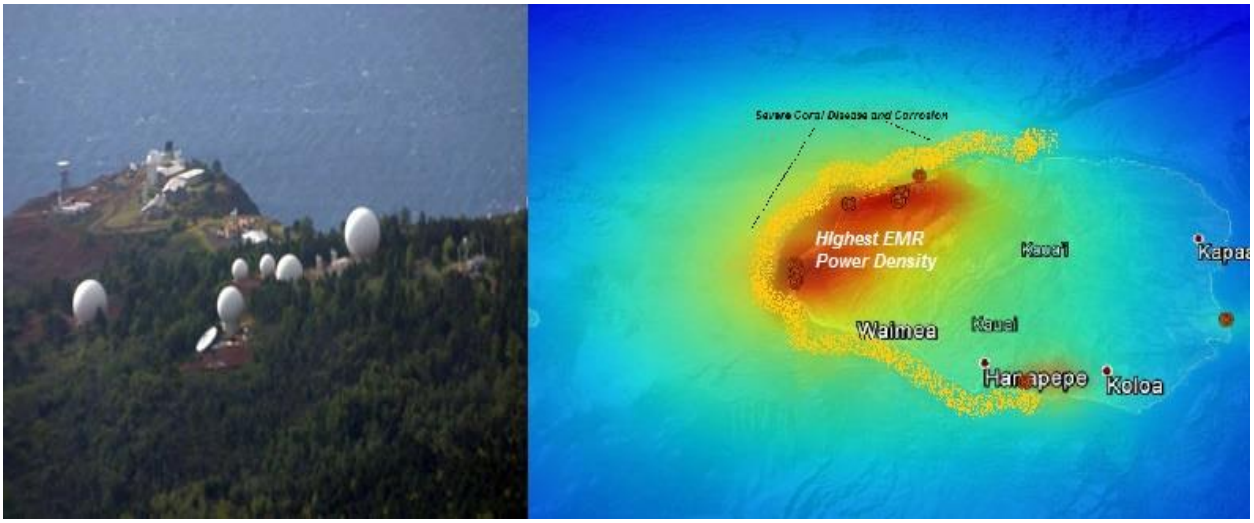

Figure 8: Highest coral bleaching and disease rates appear to correlate well with highest power density of microwave radars and antennas in Kauai, HI

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The author is a career chemical engineer (29 years) and is employed by a top 10 International Engineering, Environmental and Construction Company and is based in Atlanta, GA.

Credits: I have performed this research on my own time and cost over the past 3 years. My research is not affiliated or influenced by any company or government agency. I have received reef photography and reef survey support from Terry Lilley, a marine biologist in Kauai, HI

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