# The Effects of El Nino Events on Marine Iguanas

Hunter Kerley

Stockton University

## Abstract

The Galapagos is a section of Ecuador that is more biodiverse than almost any other region of the world, with large numbers of endemic species spotting all over the various islands. One of their unique creatures is the Marine Iguana, who over time, has evolved to be the only lizard species that holds its breath and dives down into the ocean for its food. This distinctive feature gives it the ability to avoid most natural predators post adolescence. Their need for sub surface ocean food does post threats to them though, with events like El Nino and Cyclones disrupting their normal feeding patterns.

These disruptions cause massive drops in subsurface vegetation and can disrupt natural feeding patterns of the iguana population. Leading to large scale exterminations of the native populations and causing other unnatural anomalies such as species shrinkage. These events causing rifts in such a delicate unique population pose risks to the natural balance of the Galapagos ecosystem that will be closer looked at throughout this paper.

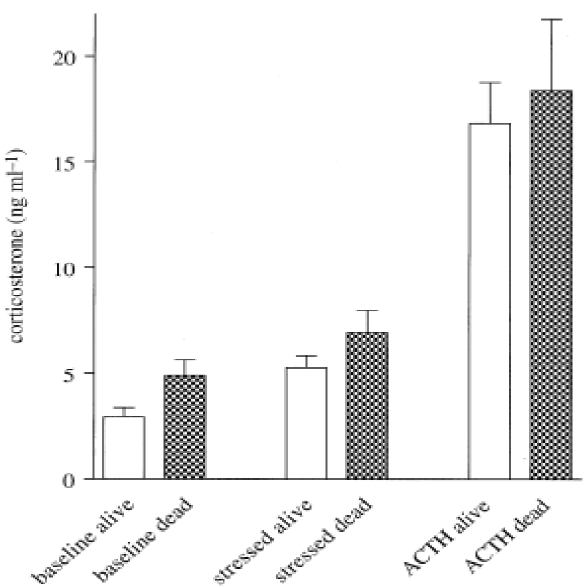
El Nino is an event that is known commonly throughout the hemispheres, but mainly impacts the pacific and equatorial areas. The event is a change in tidal patterns that bring forth warm waters and uneven tide changes with increasing tidal heights. Along with higher tidal patterns, the water that is brought forward in the equatorial areas are very nutrient poor. This causes marine animals to suffer greatly during El Nino, mostly due to inability to properly sustain themselves because of the chain reaction effect of low nutrient cycles causing the food chain of the area to weaken.

This event is noticed in one set of species in the equatorial region of Ecuador on the Galapagos. The unique marine iguanas of the region are the only water going lizard species in the world, with their diet consisting almost entirely of green algae. This alga is readily abundant during most times of the year, and the iguanas dive down into the rough tides to feed upon it. They hold their breath and swim down to pluck it from between the rocks when the tide is favorable enough to swim down. Adverse conditions can cause unfavorable times for the iguanas to swim down, and even more so during El Nino events with higher tides. Higher tides end up causing deeper diving for the iguanas which can cause them to end up going hungry from not being able to attain food or expending more energy to dive for the food. These extra hinderances on their diet and lifestyle can cause the lizards to change or die off in response to El Nino.

The Green algae is the lizards main source of calories and nutrients, with it being its only staple food for the most part. This is due to the brown algae that also grows in the same rocky areas in the subtidal zones being almost completely devoid of nutrients and being impossible to digest by the lizards. Causing them to only eat it in times of famine but posing large threats on their health due to the energy used to obtain and consume it and nutrient loss from throwing it up. During El Nino events, brown algae becomes more prevalent than green algae due to the nutrient poor water bringing in less favorable conditions for growth. The brown algae require less nutrients to flourish and end up overtaking the green algae. This causes a massive shift within the lizard population, where there are higher mortality rates for the young and elderly lizards of the area, due to the difficulty in obtaining food. Up to 90% of marine iguanas die when high-quality species of algae disappear during El Nino events, and the large size-classes die at disproportionate rates (Laurie 1989; Wikelski and Trillmich 19) This alone can cause a shift in the population towards a downward trend and can cause a bunched-up group of middle aged lizards due to them having no real natural predators after adolescence stage besides feral cats and dogs.

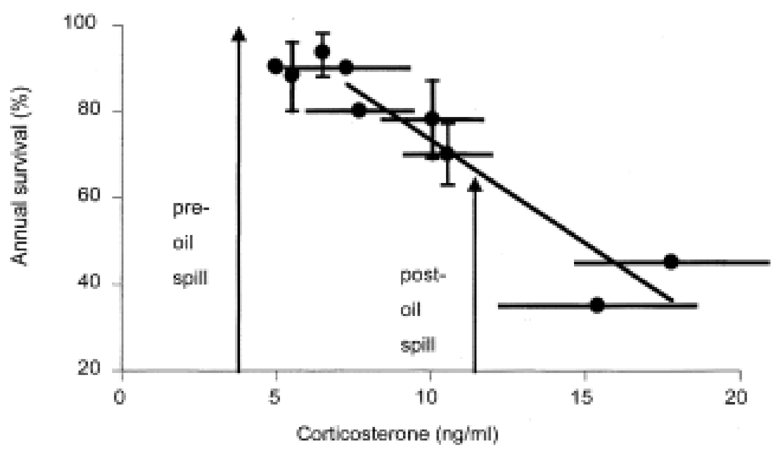
With the upper and lower ends of the population facing more mortality, another anomaly takes place within the lizard population as food becomes scarcer, where the lizards shift in size to adjust for the food available. This was noticed on many different islands where the lizards reside, with their general body size decreasing within a lifetime, instead of over generations, due solely to the fact that the el Nino events last years instead of decades. This is a change that is not often observed in the animal kingdom, as events often change the environment in ways that effect animals on a generational standpoint versus a lifetime one. The smaller size for the lizards helps aid them in lower energy expenditure in foraging efforts and allows them to require less calories and nutrients to survive as their body requires less to maintain. This is largely counterintuitive to how the animal kingdom works though, with most females in the population going for larger males during mating season, due to larger males often being stronger and hardier for survival. This creates a catch for the lizards where larger size means finding more suitable mates, but smaller size means longer lifespan and more resistance to environmental changes. These size events can be broken up into various categories, where larger size on certain islands is more favorable due to different plant life or algae availability, or where smaller size is just a commonality in general.

The way scientists study the body shrinkage of the marine iguanas is through sampling and observation of a stress reactant chemical known as corticosterone, this chemical is a steroid component in the bodies of small rodent's, birds, and reptiles. This steroid component helps understand metabolic rates and stress levels. The heightened stress levels lead to spikes in the corticosterone within the marine iguanas, causing them to have varying metabolic rates which can cause them to experience starvation over time. The heightened corticosterone levels rise with ACTH levels as well, which is a response hormone to stress that allows the animal to compensate with the increased steroid. These two chemical variances allow for scientists to study how the Iguanas are responding to El Nino. The noted results showed that heightened levels of corticosterone and correlated not only with the ACTH levels but also a heightened ability to survive. (Romero, Wikelski 3157-3162)




As seen here, the standard corticosterone levels were low in comparison to the more stressed iguanas but were especially low in comparison to the ACTH linked iguanas. Though it is notable that the dead iguanas seemed to have even more corticosterone than the living ones, showing that they reach a tipping point of stress before dying off, in a response to having less food to process and having their metabolic rates being disrupted. (Romero, Wikelski 3157-3162)

This study displayed that El Nino was a significant stressor in the iguana's life, and often resulted in about a 23 percent die off during the event. (Romero, Wikelski 3157-3162) Of these surviving members of the species, as aforementioned, they were significantly smaller in size, allowing their bodies not only to use less energy, but they also can lose the corticosterone faster due to less of it being in their body. This study opened the eyes of many in the field of corticosterone, where the normal idea was that heightened levels would lead to a higher chance of survival, but this study showed the contrary.




The spike in corticosterone levels is an indicator of early to middle stage of starvation, and often is in a response to the stress from food loss, resulting in a change in metabolism to attempt to correct a lack of nutrition. Tying a direct correlation between El Nino and the eventual starvation within Marine Iguana populations.

Another study on the impacts of the differing body sizes amongst the Marine Iguana populations is a study that shows how the body sizes vary from island to island, and how that can correlate to the shrinkage that occurs during El Nino. We learn that Iguana size is different from one island to the next, usually dependent on how readily available food resources are, and how large the iguana population is. These variations in size help scientists study the differences in foraging ability, body temperature changes, and how fast their metabolic rate. Allowing for an easy correlation of what happens to set populations during El Nino Shrinkage events. As the

Iguanas got larger, often their ability to eat quickly slowed down, due to the increased size of their jaw and how their body moved slower. This tied directly with the lizard's ability to raise its own body temperature as well, as a larger lizard needs more time to bask in the sun, which correlates to less time foraging for food due to lack of energy. This also coupled itself with the lizard's ability to pass the digested algae through its gut, which meant it required more time to digest. Overall, the larger the Iguana, the more energy and effort it requires to survive, which is often not an issue when dealing with a stable population and a stable environment, but El Nino throws a disruption into the mix that steers these larger lizards towards death.

A direct example of how these larger island iguanas were directly affected by El Nino events is the population of Edward Norton Islands, that are often very large in comparison to the general population of marine iguanas. This was due namely to the fact that the iguanas found a plant species they could forage for on dry land, in a substitution for the green algae during times of low yield or famine. This plant known as B. maritima is eaten when tidal patterns are unfavorable, often during storms or during El Nino events. The reliance of these plants allowed for the population to forage at a much faster rate with a lower energy expenditure, with them growing large, even though the plants are significantly lower in protein and nitrogen. Though the plants benefit to the iguanas is its fatal flaw, with it being so close to the coastline, it is easy to forage without moving very far, but also can be damaged by tides and wind. Therefore, during the very aggressive El Nino event in 1997-1999, the area was flooded by usually high tides, drowning the entire B. maritima population. Without the dry land plant population to support the massive body size increase of the iguanas, coupled with the tumultuous seas from the El Nino pattern, there was a massive die off that followed. This was mentioned in the beginning of the paper, showing that 90% of the iguanas perished after the event, allowing for a very small group of weaker iguanas to thrive after the event. This cyclical pattern of forced shrinkage and die offs due to weather patterns is indicative of how delicate the ecosystem is of the coastline of these islands.

Repopulation is a factor that is largely looked at when considering mass extinctions of populations, with their ability to be fecund and bounce back to stable numbers being a primary goal. This was especially looked at for the marine iguana population post El Nino due to their mating grounds and nesting areas being flooded and destroyed by the storm event. As they lay their eggs very close to the shoreline, their ability to properly produce offspring was hurt not only by their significant loss in numbers, but also their inability to protect their young in proper nesting. As tides washed in on the shores, large deposits of sand were washed out into the ocean, leaving poor nesting area for the iguanas to hide their eggs, and leaving them closer to the hot, sharp, black volcanic rock. This lack of sand bedding also left them more susceptible to snakes, rats, and birds that are potentially looking to eat the freshly hatched young or eat the unprotected eggs before they are born. These adverse conditions can spell disaster for an endangered recovering population. In the next graph we get to see the studies conducted post 1982 El Nino, which had a very powerful Southern Oscillation, resulting in a widespread die off and destruction of natural nesting habitats for the Iguanas. The results of this study were that there were weakened patterns of breeding and growth during the 82-83, resulting in a downward trend for populations, and during 1984 there were no breeding pairs, due to the adversities faced from the lasting El Nino conditions. This caused a large loss within the population for the year, but their resilience allowed them to bounce back after the failed mating year. The following year resulted in a nearly doubled increase in breeding activity, allowing them to maintain their restabilizing population again. (Laurie, 515-528)

520 *Marine iguana fecundity*

TABLE 2. Estimation of the proportion of females that bred in each season

| | Season | | | | |
|---|---|---|---|---|---|
| | 1981–82 | 1982–83 | 1983–84 | 1984–85 | 1985–86 |
| Total number of females painted on coast ($C$) | 99 | 157 | 202 | 206 | 228 |
| Total number of painted females seen nesting ($c$) | 35 | 36 | 2 | 157 | 181 |
| ($c$ as a percentage of $C$) | (33·3%) | (22·9%) | (1·0%) | (76·2%) | (79·4%) |
| Number of painted females under constant observation on coast ($N$) | 38 | 43 | 45 | 32 | 92 |
| Number of $N$ females seen mated ($n$) | 12 | 13 | 0 | 27 | 22 |
| Number of $N$ females seen nesting ($X$) | 13 | 12 | 0 | 25 | 72 |
| Number of $N$ females seen mated and nesting ($x$) | 10 | 9 | 0 | 24 | 20 |
| Number of $N$ females not seen mated ($N-n$) | 26 | 30 | 45 | 5 | 70 |
| Number of $N$ females not seen mated but seen nesting ($X-x$) | 3 | 3 | 0 | 1 | 52 |
| Estimated percentage of females actually mated ($Xn/Nx$) | 41·1% | 40·3% | 0% | 87·9% | 86·1% |
| 90% confidence limits for % of females actually mated | 34·2%–52·2% | 30·9%–58·0% | – – | 78·2%–100% | 75·0%–97·2% |

Following the population productivity of the iguanas is something that is monitored yearly and closely watched during El Nino events to help further the research on the effects of the storm events. The large contributor to all these extinctions of the iguana populations during this time were solely attributed to the massive influx of warm waters that were very nutrient poor. Unusually warm water often brings in unwanted algal blooms in the water that smother out sunlight and steal nutrients from the water, causing the native green and red algae populations to suffer exponentially. This tumbling effect is the chain reaction that sets off the extinction of the iguanas in the areas that occurred so detrimentally from 1997-1999. These events still occur today, as El Nino is a semi-regular weather pattern that sweeps the Pacific Ocean every 2-7 years roughly. Though the severity of the event varies significantly, the impacts of what happen to the populations of marine iguanas are still significant, posing threats to their populations as these weather patterns only intensify as global sea temperatures rise every year.

## Bibliography

http://www.vivo.colostate.edu/hbooks/pathphys/endocrine/hypopit/acth.html

Laurie, W. (1990). Population Biology of Marine Iguanas (Amblyrhynchus cristatus). I. Changes in Fecundity Related to a Population Crash. *Journal of Animal Ecology, 59*(2), 515-528. doi:10.2307/4878

Vinueza, L., Menge, B., Ruiz, D., & Palacios, D. (2014). Oceanographie and climatic variation drive top-down/bottom-up coupling in the Galápagos intertidal meta-ecosystem. *Ecological Monographs, 84*(3), 411-434. Retrieved from http://www.jstor.org.ezproxy.stockton.edu/stable/43188344

Romero, L., & Wikelski, M. (2010). Stress physiology as a predictor of survival in Galapagos marine iguanas. *Proceedings: Biological Sciences, 277*(1697), 3157-3162. Retrieved from http://www.jstor.org.ezproxy.stockton.edu/stable/20780103

Wikelski, M., & Romero, L. (2003). Body Size, Performance and Fitness in Galapagos Marine Iguanas. *Integrative and Comparative Biology, 43*(3), 376-386. Retrieved from http://www.jstor.org.ezproxy.stockton.edu/stable/3884984

Wikelski, M., & Wrege, P. (2000). Niche Expansion, Body Size, and Survival in Galápagos Marine Iguanas. *Oecologia, 124*(1), 107-115. Retrieved from http://www.jstor.org.ezproxy.stockton.edu/stable/4222672
https://www.sciencedirect.com/science/article/pii/B9780128010280002282