Disappearing Marine Iguanas: A Case of Population Collapse

Directions: Read the following scenarios and answer the corresponding questions

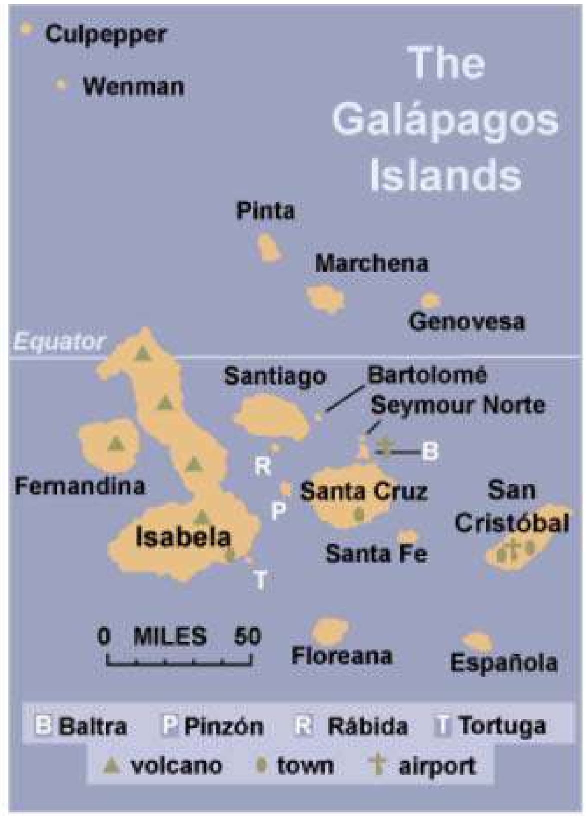
Part 1: Disappearing Marine Iguanas

Liz sat at a table in the student union enjoying a cup of coffee and flipping nonchalantly through her vertebrate biology textbook. She had a paper due in two weeks and still had not decided on a topic. Her instructor focused mainly on taxonomy and anatomy in class, but Liz was more interested in ecology. Her friend Abby, carrying a tray with an enormous cinnamon roll, sat down across the table.

"Still trying to figure out a topic for your paper, Liz? Why not follow up on those antifreeze mechanisms in Antarctic fishes?"

"I thought of that but I don't want to get into all that cell biology and chemistry. I'm more interested in whole organisms that I can see; like, maybe those marine iguanas in the Galapagos. Dr. Parisi had some pictures of them from a trip she took in 1999. She said that there were a whole lot less of them than she expected, and the guides told her that most of the islands had 40-90% mortality in the previous year."

"What could have killed the iguanas that fast?" exclaimed Abby as she pulled her laptop out of her backpack. "Just a minute while I Google the Galapagos." Abby quickly found a map of the Galapagos archipelago.



Questions

1. Using the map and the minimal knowledge that Liz has at this point, propose 3 different hypotheses regarding the sudden high mortality (cause of death) of marine iguanas.

   a.

   b.

   c.

2. Compare your hypotheses with another group. Were your hypotheses similar/different?

3. Choose and write the hypothesis that seems most likely to you and your group. Then determine what evidence you would need to support or refute the hypothesis.

Part 2: An Excited Phone Call

Liz checked the number on her cell phone before answering. “Hey. What’s up?”

“I think I might have a lead on the iguanas. In ecology today, we covered the Galapagos finches…”

“So?” said Liz sarcastically. She was still a little steamed that Abby got to take ecology this year. “Although finches are derived reptiles, I don’t see what they have to do with marine iguanas.”

“Let me finish! We were covering global weather patterns and talked about the effects of El Nino on finch populations. The normal weather in the Galapagos is really dry so the finches are limited by low food availability. But during an El Nino year, the vegetation grows like crazy and the finch populations may double or triple in size in just a few months.”

“I still don’t get it. The iguana populations didn’t grow rapidly, it crashed.”

“I know, I know, but didn’t you say that your instructor went there in 1999? There was a severe El Nino in 1997-1998.”

“Really!” Liz moved to the edge of her seat. “But why would the iguanas die off when the finch populations exploded?”

“No clue. You’re the one writing the paper.”

By this point, Liz had done some background research on the marine iguanas and knew a little more about their basic biology. The iguanas spend most of their time basking on boulders on rugged shorelines but enter the water for feeding. They have flattened tails for swimming, strong claws to hang on to rocks while feeding, and tricuspid teeth to scrape algae off the surface of underwater rocks. The smaller iguanas, juveniles and females, feed in shallower water while the larger males may dive down 5-8 meters. All iguanas show a strong preference for red and green algae and avoid brown algae if the other varieties are present. Since the water in the Galapagos is usually much colder than most tropical water (about 18-23 C), the ectothermic (“cold blooded”) iguanas can only feed for a limited time before they have to crawl out onto the black rocks to warm up in the sun. The iguanas’ natural predator, the Galapagos hawk, can only capture small hatchling iguanas, but predation risk can be high on islands with feral introduced dogs and cats.

Liz began to explore the El Nino (more appropriately referred to as the El Nino/Southern Oscillation or ENSO) idea and quickly found that the main effects in the Galapagos were elevated air and water temperatures and elevated rainfall. The total rainfall at the Charles Darwin Research Station in 1998 was an astonishing 3.4 m (over 11 feet!), second only to the 1982-1983 ENSO, and much more rain than typically falls in dray years (0.4-1.0m).

Questions

1. What is ENSO?

2. Define anomaly:

3. Examine the data that Liz ran into while researching ENSO in Figures 1-3 and answer the questions that follow on page 4.

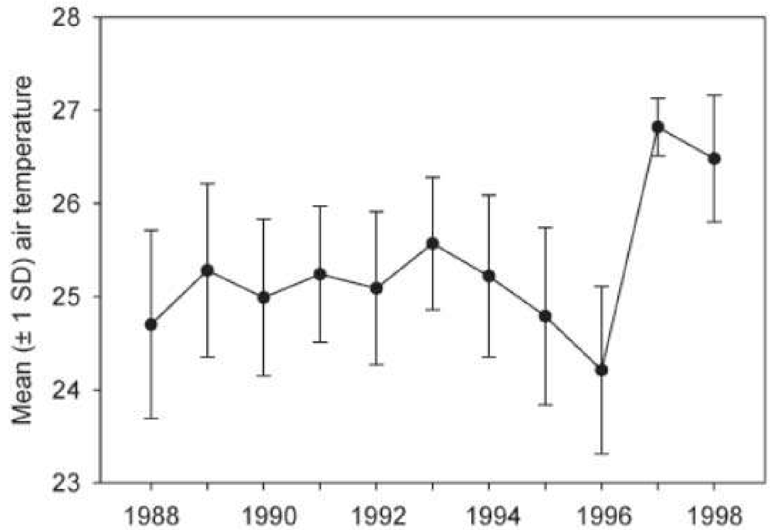


Figure 1. Monthly air temperatures (mean ± 1 SD) measured at Charles Darwin Research Station, Santa Cruz.

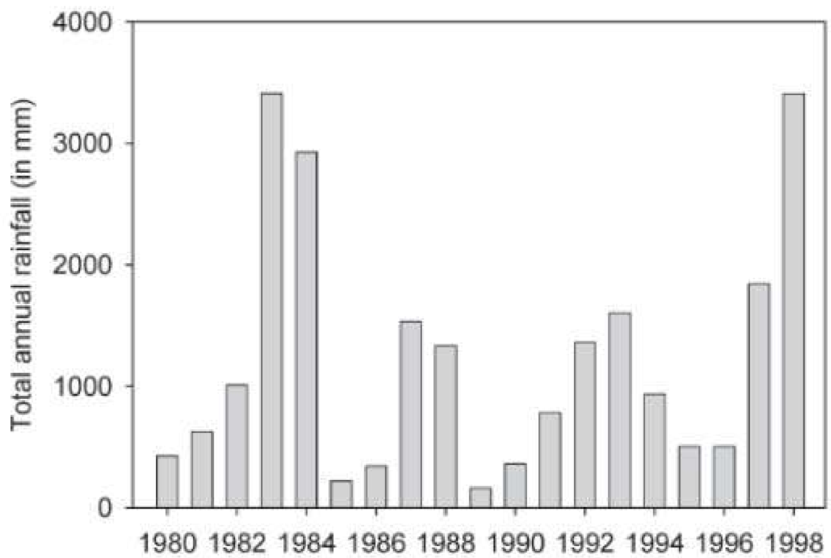


Figure 2. Total annual rainfall (in mm) measured at Charles Darwin Research Station, Santa Cruz.

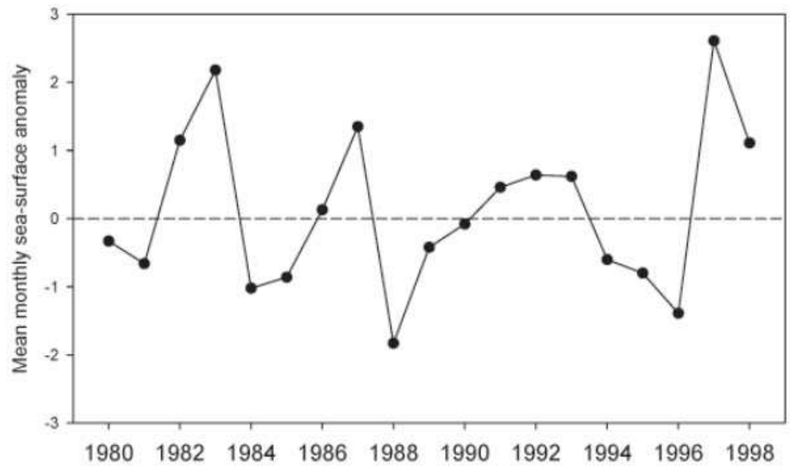


Figure 3. Mean monthly sea-surface temperature anomaly (in ºC).
The anomaly is calculated as the deviation from the 19-year mean of 23.72 ºC
(data from Snell and Rea 1999).

4. Given what information you know at this point about marine iguanas and the abiotic (nonliving) effects of ENSO, develop two possible directions of research that Liz should pursue to understand exactly why the iguanas suffered such a high mortality.

HINT: Keep in mind that you need to consider indirect effects. While environmental temperature does change metabolic rates of ectotherms, the iguanas are exposed to a wide range of temperatures as they feed and back on the lava. Direct mortality (cause of death) in response to a temperature change of couple of degrees is unlikely.

a.

b.

5. Choose one of your directions from Question #4. In the space below, write down what data you would need to either collect or find to support your ideas.

6. Design an experiment that would help you collect the data you identified in question #5.

Part 3 – Coming to a Conclusion.

It is not easy to explain why marine iguanas die during ENSO years. The connection were only recognized after the 1982-1983 event. Since the die-off was unexpected, relevant data from that time period are incomplete. There were three additional smaller ENSO events between the 1982-1983 and 1977-1998 events. Although scientists became better at recognizing the signals of an impending event, they were still surprised by the severity of the 1997-1997 ENSO. This means that what little data there are still come from the earlier events.

Liz did a lot of digging and decided that she could build a relatively strong argument for the cause of marine iguana mortalities. Her argument depended on the following sources of information.

NOTE: Relationship of algal growth to temperature (Figure 4; will also need to consult Figure 3 for interpretation)

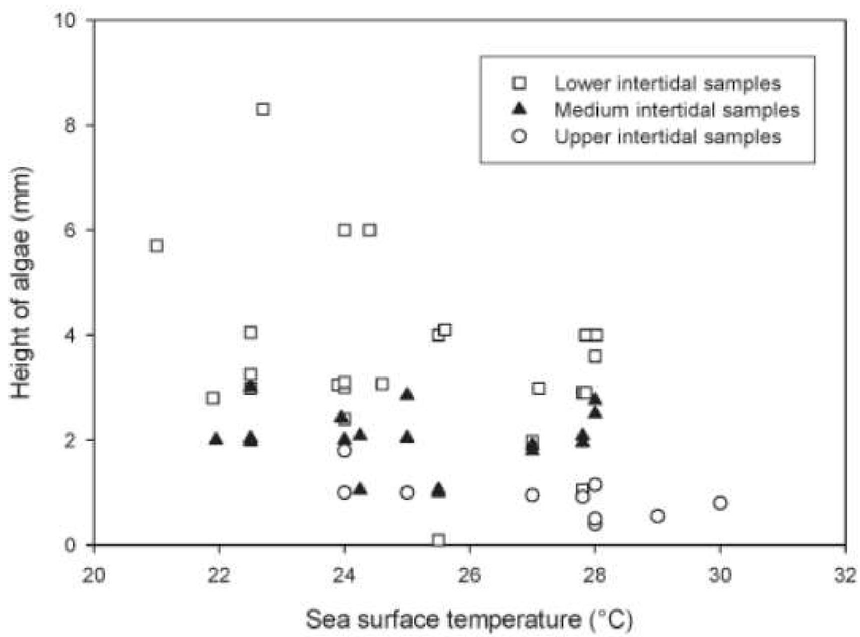
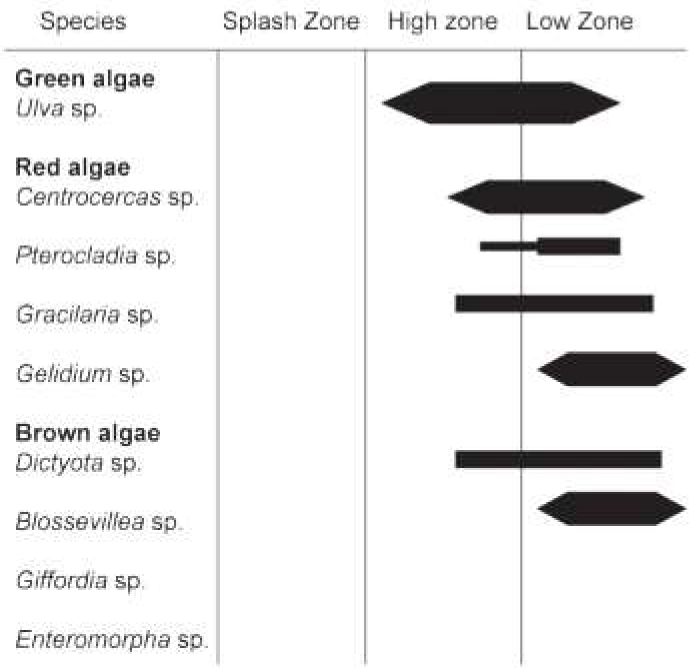


Figure 4. Algal growth on Genovesa and Santa Fe Islands during a period from 1991-1993. Each point represents the mean of 16 samples (after Wikelski et al. 1997).

NOTE on interpreting Figures 4-7: The splash zone is located above the high tide line and while it may be moist at high tide it is not submerged (under water). The upper or high intertidal zone is submerged at high tide but may be partially or completely exposed at low tide; the low intertidal zone is always submerged. In Figures 5-7 below, the location of the bars indicates where each species grows within the intertidal zone while the thickness of the bars gives an idea of relative abundance.

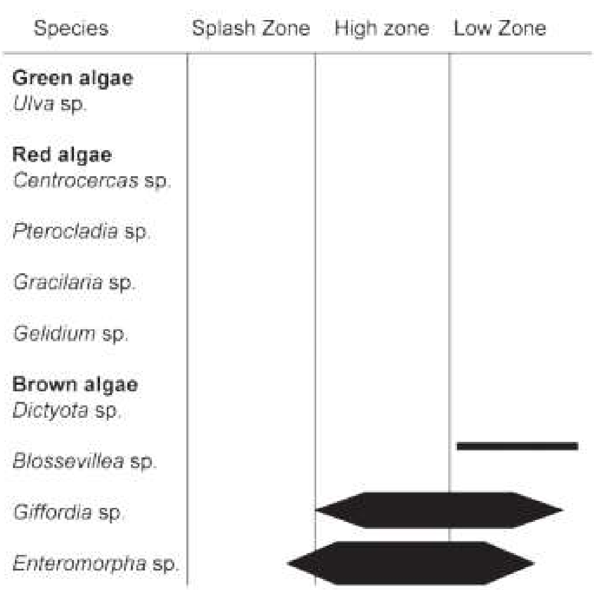
Distribution of algae from 1981-1984 (Figures 5-7)

Fig. 5. Distribution and abundance of algae, Santa Cruz, July 1981



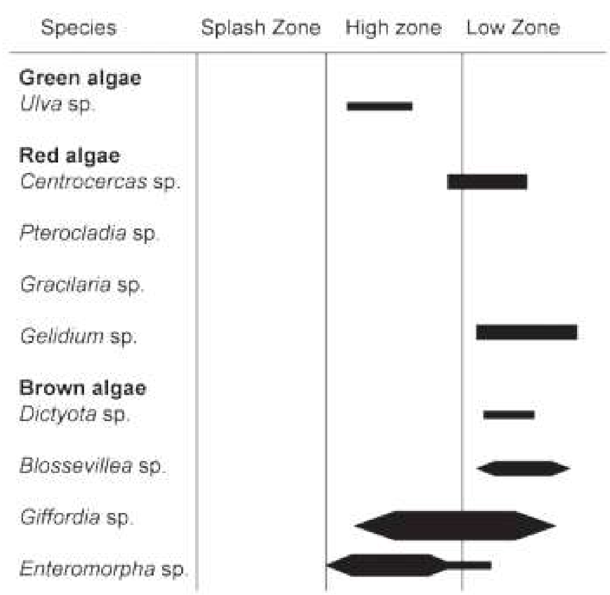
Width of band shows approximate abundance (blades/m^2)

Fig. 6. Distribution and abundance of algae, Santa Cruz, April 1983



Width of band shows approximate abundance (blades/m^2)

Fig. 7. Distribution and abundance of algae, Santa Cruz, October 1984



Width of band shows approximate abundance (blades/m^2)

Mass of stomach contents of marine iguanas from 1982-1984.	*Marine iguana conditions on Isla Santa Fe, 1981-1982 (Figure 9)*

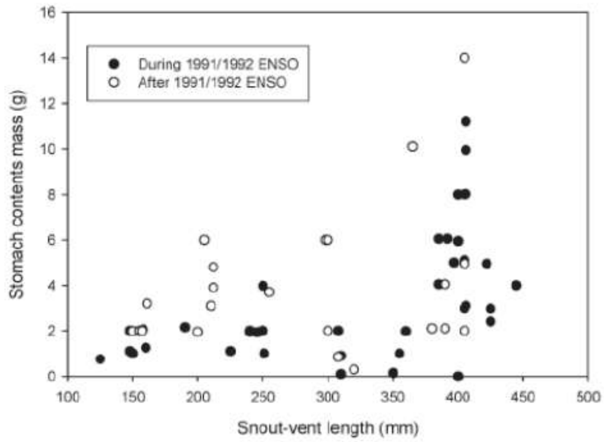


Figure 8. Dry weight stomach contents in marine iguanas on Santa Fe Island. (after Wilkelski et al. 1997). Gut contents during the 1991-1992 ENSO contained feces, iguana skin, and soil in addition to brown algae.

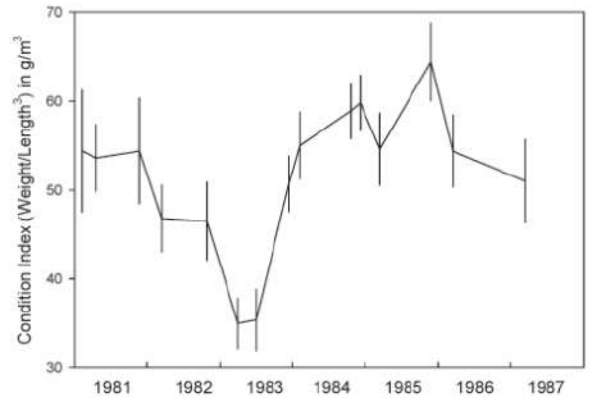


Figure 9. Adult female iguana condition index on Santa Fe Island. (after Laurie 1990)

Digestibility and cellulose content of algae (Table 1)

Table 1. Organic matter digestibility of selected algae. An *in vitro* experiment was conducted with sheep rumen fluid.

Species	% Digestible	% Cellulose
Green Algae		
Ulva sp.	71	2.6
Chaetomorpha sp.	62	3.4
Red Algae		
Centrocercas sp.	82	2.1
Pterocladia sp.	75	2.2
Gracilaria sp.	81	2.1
Gelidium sp.	74	2.2
Brown Algae		
Dictyota sp.	22	6.9
Blossevillea sp.	24	6.6
Giffordia sp.	15	9.8

(CONTINUE ON BACK)

Liz took a deep breath; that paper wasn't going to write itself. With only a few days left until the deadline it was time for you to get going. "So now, what do these studies tell me about ENSO and marine iguanas?"

Questions

1. What conclusions do you think Liz made about the cause of the population declines of marine iguanas?

2. Is it reasonable to assume that the data from 1982-1983 and 1991-1992 ENSO events are representative of what happened in the later 1997-1998 event? Why or why not?

3. What additional information do you think we need? Is there a potential problem with one or more of the studies?

4. How might climate change affect marine iguana populations?