Name(s): _____

Case Study: Survivorship and Population Models

Part 1: Hatchling Exodus

Amy was very excited to be staying at a resort in Florida where loggerhead turtles lay their eggs. She had carefully read the literature that outlined the rules for her stay. Rules that were in place so that visitors would not interfere with the nesting females. Though her cabin was next to the beach, there were no exterior lights and she was warned to not use flashlights or flash photography. The beach was also to be kept clear of any toys or furniture that may block a female from a nesting site. Amy was surprised to learn that loggerhead turtles cannot back up.
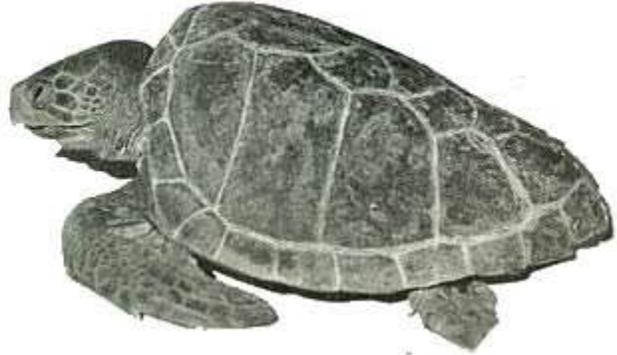
At night, Amy and her tour group were allowed to carefully walk the beach and observe a female turtle as she laid her eggs. The massive 275 pound loggerhead had a shell that was almost 3 feet long. The huge reptile used her hind flippers to dig a trench and lay over 100 eggs. The tour guide explained that the hatching success rate of an *in situ* nest has a success rate of 80-100%, but a relocated nest will only have about a 60% success rate.

"Why would anyone want to relocate the nest?" Amy asks.

The tour guide answered, "Sometimes the nests are in high traffic areas, or areas that have been compromised. During the gulf oil spill, thousands of turtles nests were relocated." She shares a link with them on her iPad showing how painstaking it is to relocate the nests. (You can use the QR code to view the video or wait for your instructor to show it to you.)

"What happens after the loggerhead turtles hatch?"

The tour guide sighed as she relayed that the odds of their survival is really low. "Many of the hatchlings die before they ever reach the ocean, they fall prey to birds and crabs. Some become disoriented and go the wrong direction."

"Where do they go if they do make it to the ocean?"

"That's the strange thing," answered the guide, "Biologists didn't really know what happened during the decade after they were hatched. They even called that period of time 'the lost years.'"

A member of the group raised his hand and speaking quietly so as not to disturb the female, shared additional information. "I'm from the University of Florida, and I know that they've managed to attach solar trackers to some of the juvenile turtles. It seems that the turtles enter the North Atlantic Gyre which is part of the Gulf Stream. They live in the seaweed there, using it as food and shelter."

In the back of the group, someone whispered: "Like in Finding Nemo!"

Amy watched as the female turtle finished laying her clutch of eggs and pushed sand over the nest to cover them. This female must have beaten all the odds to return to this beach to lay her eggs many years later.

Check for understanding Qs

1. What reproductive challenges do female sea turtles face?

2. What factors must be considered when relocating turtle nests?

- based on the context of the reading, what does "*in situ*" mean?

3. Some conservation efforts remove eggs and raise the hatchlings in captivity to ensure their survival. Do you think money should be spent for captive breeding programs? Why or why not?

Part 2: Survivorship Curves

When Amy returned from her vacation, she decided to look into sea turtles to find out how many of them actually survived those early years. She discovered very little data on sea turtles as teenagers, but she recalled how the guide had referred to that time period as the "lost years." One data set did include turtle hatchling numbers and then numbers of turtles who returned to the beach a decade later.

Sea Turtle Data →→→

	Individuals Present (or hatched)	Survived	Survivor-ship
Time 0 (eggs laid)	1100	1100	1.0
Day 1	1100	1000	1000/1100 = .91
Day 2	1000	600	
Day 3	600	230	
Day 4	230	80	
Day 5	80	18	
Year 15	18	16	

5. Calculate the survivorship by dividing the number that survived by the initial population (hatched). Complete the table to show survivorship at each time frame.

6. Create a graph that has % of organisms surviving (survivorship) on the Y axis, and time on the X axis. (Year 15 can be treated as a distant point on the graph)

As Amy looked at the graph she found it odd that a whole species would invest so much into a clutch of eggs, and have so few survivors. She took the data to her biology instructor to see if Dr. Franklin could shed some light on this. As he looked over the data, he nodded slowly. "I think I can explain what is going on here."

"In the animal kingdom there are different strategies for reproduction. Remember that evolution favors behaviors or traits that ensure the survival of the species. Sometimes this means that the adults have a large number of offspring where only a few are expected to survive. These type of animals are called "**R-Strategists**" like the loggerhead sea turtles. As long as a few of the offspring survive to reproductive age, then there is continuity within the species."

"What does the "R" stand for?" asked Amy.

"Well, that is a little more complicated. There is a formula for population growth, where r represents the maximum reproductive capacity. This basically means that the turtles would be at maximum if so many of them didn't die that first year of life. Imagine what would happen to the sea turtle population if there were no predators!"

"There would be a lot of sea turtles out there. Probably too many for the environment to support."

"Exactly." Replied the professor. "Fortunately, very few organisms reach their **biotic potential**."

"What is biotic potential?" Asked Amy.

"Thats the maximum rate the population can grow given optimal conditions. It basically means the growth rate if there were no **limiting factors**like food, space, or water."

Amy felt the topic was veering off track. She really wanted to understand why evolution would select for organisms that would lay hundreds of eggs but only have a few that survived the first year of life. It seemed like a waste of resources. "But what about the turtles, why lay so many eggs to just have them all die?"

The professor thought about how to explain it and then went to a blackboard. He quickly sketched a graph. "You see, there are three types of **survivorship curves**. One of these looks like the graph you made of the sea turtles."
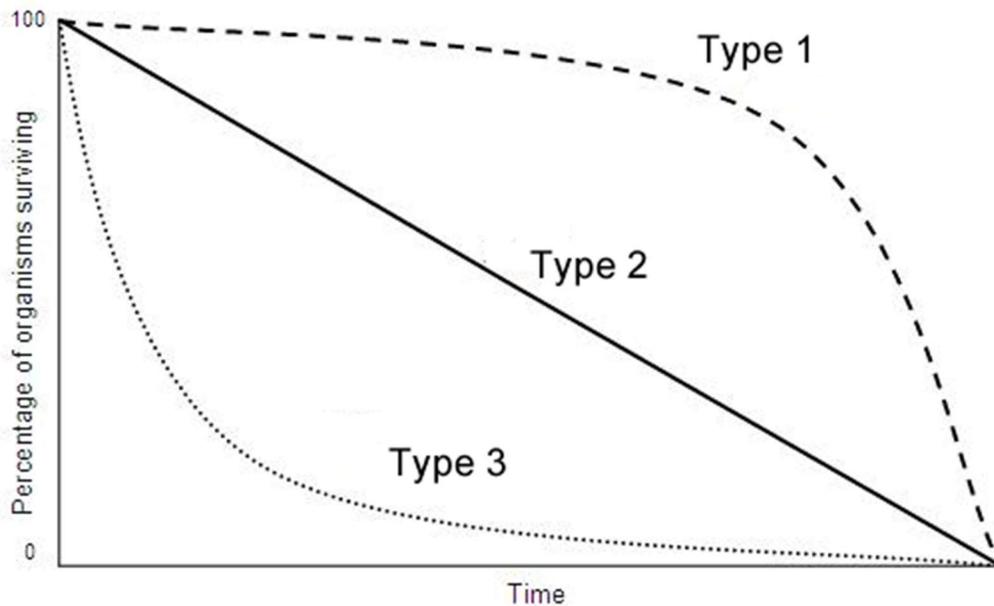
7. Which type of survivorship pattern is observed with the sea turtles?

8. What other animals can you think of would be R strategists?

9. What kind of survivorship curve would you expect to see in humans? Explain how you came to this conclusion.

10. In some cases, animals reach their biotic potential (if for a short period of time) and wreak havoc on the environment. What is biotic potential and why would reaching it create problems for the environment?

11. The three types of curves are also described as: **early loss**, **late loss**, and **constant loss**. Explain why these descriptions work to describe the trends in the graph.

12. Propose an organism that would have a Type 2 curve. Defend your choice by describing this animal's life pattern using the data and growth curve as a guide. (If you are really stuck, use google to look up survivorship curves)

Part 3: Population Models

Amy became really interested in how populations work and how different groups of organisms evolved different strategies for reproduction. Though Dr. Franklin mentioned that the "R" was part of an equation, she decided to look up the actual equation. A simple google search located the equation that Dr. Franklin had referred to:

$$\frac{dN}{dt} = rN \left(1 - \frac{N}{K}\right)$$

Where (dN/dt) is the rate of increase of the population and N is the population size, r is the intrinsic rate of increase. *K* is the carrying capacity of its local environmental setting. Thus, the equation relates the rate of change of the population *N* to the current population size and is the theoretical maximum rate of increase of a population per individual.

The equation was developed from the r/K selection theory which relates to organisms that trade off between quantity and quality of offspring. If "r" was the maximum growth rate and referred to animals like sea turtles, then there must be a different type of strategy that referred to animals like humans or whales that had very few offspring but invested in years of parental care.

Another internet search revealed that animals that invest more heavily into fewer offspring are called **K-strategists**. Traits associated with these animals are large body size, long life expectancy, production of fewer offspring and more parental care.

Amy sighed deeply, that equation looked like the differential equations she learned in math class. She barely remembered how to work those types of problems. Her roommate, who is a math major, looked at the equation and quickly sketched what the graph would look like. Amy took one look at the graph and realized she'd seen it before. "Oh, that's a **logistic growth curve**!"

$$-\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$
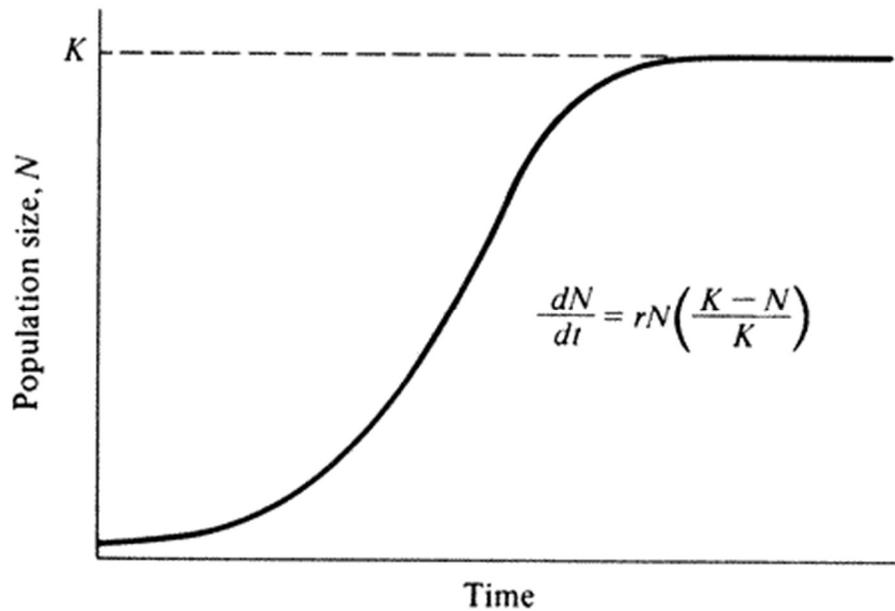
Her roommate looked puzzled and Amy explained further. "Logistic growth curves occur when there is a limiting factor in the environment. A population grows until it levels out, usually because the population runs out of resources. Some populations, like humans, are in exponential growth, they haven't leveled out."

Her roommate shrugged and went back to calculus. "I guess humans will reach that point someday...."

Check for understanding Qs

13. "K" refers to the carrying capacity. Based on the graph and the text, suggest a definition for "carrying capacity."

14. What factors would affect the carrying capacity of turtles?

15. The following growth curve shows a population of crab in areas where loggerheads are known to gather. Crabs are a food source for the turtles who can use their strong jaws to crack their shells.

Graph Analysis
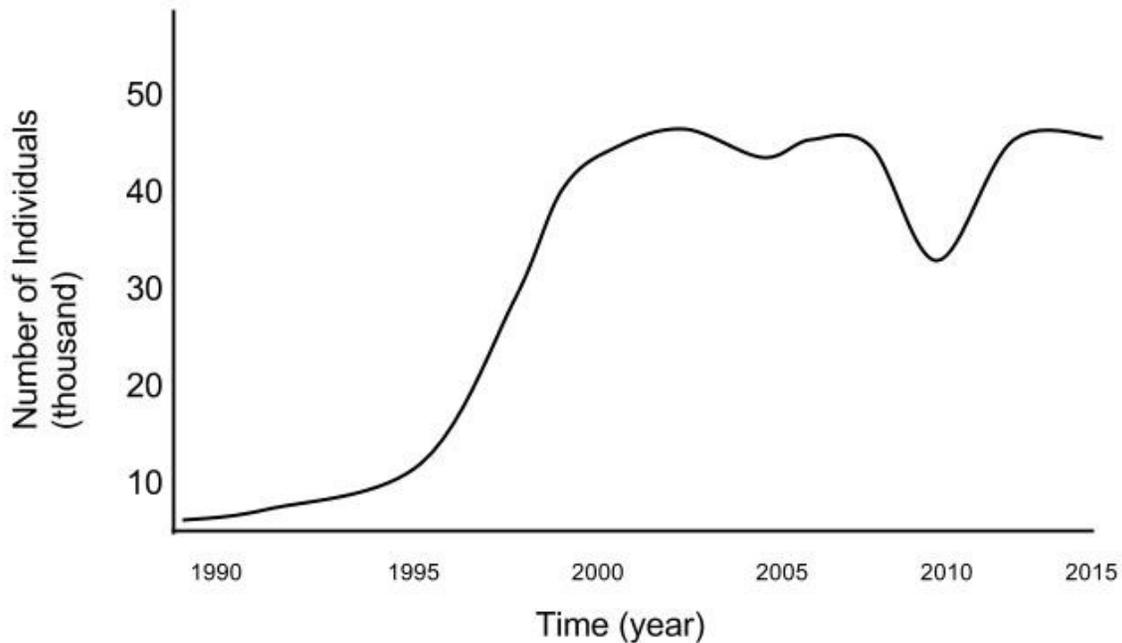
a. Based on the graph, what is the carrying capacity for crabs in the area being studied?

b. Propose a reason that the population dropped in 2010.

c. What does the population curve of crabs tell you about the loggerhead turtle populations in the same area?

16. **Summarize**: Using all of the information from the case study, summarize the relationship between the following terms:

carrying capacity | r-strategist | survivorship | biotic potential | logistic growth curve

Write your response on the back of the page please!