SCIENCE·3D

RIVER DRAGONS: NILE CROCODILES

In this packet, sample student answers are provided in red and notes to teachers are in blue.

In this **Science Mission**, students will explore changes in population sizes and how they influence genetic diversity. They will use mathematical models to estimate population sizes and determine how human activities and seasonal changes influence crocodiles. Throughout the lesson, they will develop hypotheses and predictions and test them using data that they graph and analyze. They will use their insights to determine where and when people, pets, and livestock will be most at risk from crocodiles.

Note: Different colored writing utensils may be useful for graphing. Otherwise, students will have to use different patterns.

ACTIVITY I: MODELS OF CELLS AND BODY SYSTEMS

Having genetic diversity is important for populations. Imagine the effects on resistance to a disease if all the individuals in a population have the same genetic makeup. If a new disease appears that individuals are not resistant to, then the population may go extinct. If individuals have different genes, some may survive the new disease. The population will survive. This is one reason that scientists want to make sure that genetic variation is high in populations.

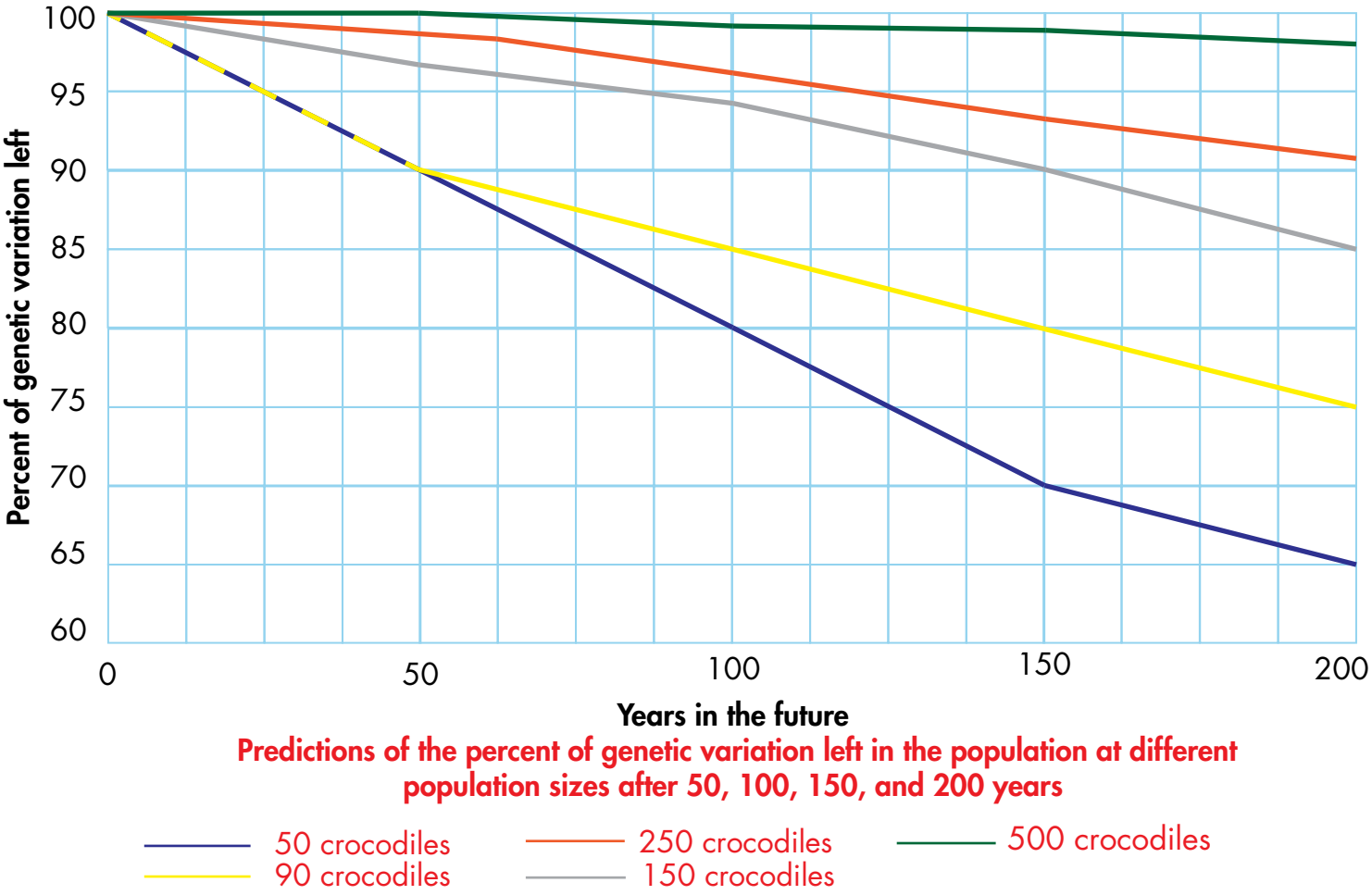
Computer programs can help by creating models to see what will happen in different situations. Scientists use mathematical formulas to tell the computer what calculations to make. Scientists created a computer model to see how much genetic variation might be lost from the Okavango Nile crocodile population if there are different numbers of breeding adults in the population. They entered different numbers of breeding adults into the computer program. They started by using genetic information gathered from crocodiles when they were captured. Then, they had the model make predictions about how much genetic variation would be left in the population after 50, 100, 150, and 200 years. The results are shown in Table 1.

Table 1. Computer simulation predictions of the percent of genetic variation left in the crocodile population at different population sizes after 50, 100, 150, and 200 years

Years in the future	Number of breeding adults in the population				
	500	**250**	**150**	**90**	**50**
0 years	100%	100%	100%	100%	100%
50 years	100%	99%	97%	90%	90%
100 years	99%	96%	94%	85%	80%
150 years	99%	94%	90%	80%	70%
200 years	98%	92%	85%	75%	65%

1. **Draw** a line graph showing the change in genetic variation over time based on different population sizes. Use a different color of line (or shape of symbol) for each population size. Include a legend to show what color (or symbol) goes with each number of breeding crocodiles. Write a caption for your figure.

If this graph is too challenging for some students, give them the graph in the teacher edition. Have them think about what the figure caption should be. Have them use the graph to answer the questions below. Another alternative is to have groups of students who might be able to help one another work together. Also, you could have the entire class work together to create the first two lines and then have students work independently or in groups to complete the problem.



Predictions of the percent of genetic variation left in the population at different population sizes after 50, 100, 150, and 200 years

2. **Describe** why scientists think that it is important that there should be at least 500 breeding individuals in the Okavango crocodile population they studied. Use data from your graph to support your answer. What happens to the rate at which genetic diversity is lost as the size of the population gets smaller?

If there are fewer than 500 breeding individuals, the population loses more genetic diversity. The smaller the population, the quicker the loss of diversity. That population would be at risk of dying out if there is a new disease or the environment changes.

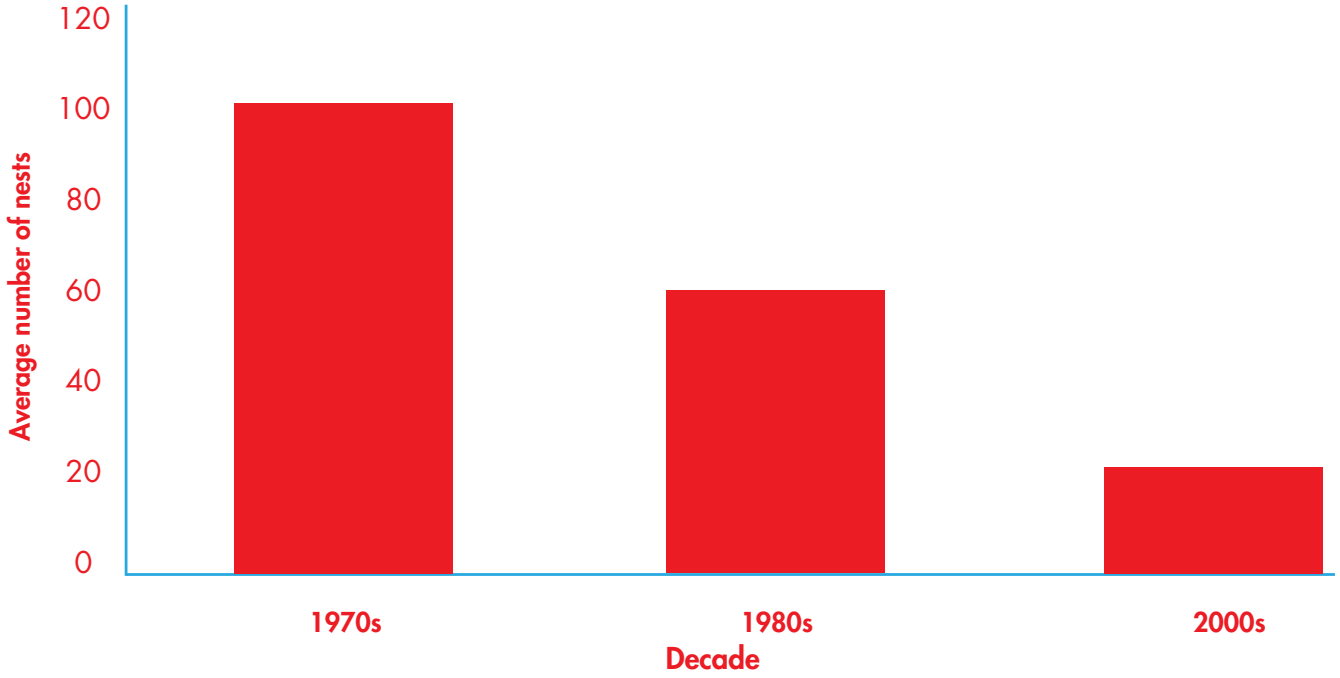
Scientists have been estimating the number of nests in an area of the Okavango for many decades. The nest counts are provided in Table 2.

3. **Complete** the table by calculating the averages for each decade.

Table 2. Crocodile nest counts during five breeding seasons in three decades in the northern Okavango

	Decade		
Year number	**1970s**	**1980s**	**2000s**
1	102	40	15
2	96	57	16
3	105	72	22
4	112	76	17
5	80	55	20
Average	99	60	18

4. **Draw** a bar graph of the average number of nests found in the three time periods. Label your axes and write a figure caption.



Change in average number of crocodile nest in the northern Okavango

5. **Predict** what has happened to crocodile populations in the northern Okavango based on the data you have analyzed.

I think the population has decreased. I suspect that because there are fewer nests, there are fewer crocodiles in the population.

6. **Describe** whether the data in your figure can tell you if there are fewer than 500 breeding individuals in the population.

This is not enough information. It looks like the population has gone down, but we don't know how many individuals are in the population.

ACTIVITY 2: COUNTING CROCS

A first step to understanding the well-being of crocodile populations, and the level of risk they might pose to people, is to know the number of crocodiles!

The eyes of crocodiles have a special structure behind the retina called the *tapetum lucidum*. It reflects light back through the retina. Capturing more light helps crocodiles see better in low light. It also helps scientists, because crocodile eyes glow at night when a light is shined at them! That is why herpetologists (scientists that study reptiles and amphibians) measure populations at night with spotlights. They can see crocodiles from very far away!

Extend the Lesson: Have students predict what other kinds of animals might have a tapetum lucidum (e.g. nocturnal mammals) and have them do online research to see if they are correct. This is a place where you can link to the **Life in the Trees Mission**.

The Okavango Crocodile Project has been counting crocodiles at night for many years. When they get close to a crocodile, they record the approximate size and age of the animal. When they are able, they catch the crocodile. Then they put a tag on it. This helps them estimate the population! How?

After tagging many crocodiles, they wait for a while. Then they go back out and catch another sample of crocodiles. They count the number that were tagged in the first survey and how many were not tagged in the second survey. Then, they can use an equation to calculate how many animals there are in the population.

Here is the equation:

$$N = \frac{C \bullet m}{k}$$

N = number of crocodiles in the population
m = number of crocodiles tagged during the first survey
C = number of crocodiles captured during the second survey
k = number of tagged crocodiles captured during the second survey

Let's practice! Let's say that we wanted to know how many turtles are in a lake. We caught 20 turtles and marked their shells. Then, we let them go. The next time we went out, we also caught 20 turtles. Ten of them had marked shells.

1. Use the data in the paragraph above to **complete** Table 3.

Table 3. Numbers of turtles marked, captured, and recaptured

Variable	Value
m (number of turtles marked in first survey)	20
C (number of turtles captured during second survey)	20
k (number of marked turtles recaptured during second survey)	10

2. **Calculate** the number of turtles in the pond. Show your work!

$$\frac{20 \bullet 20}{10} = 40 \text{ turtles in the pond}$$

Now you are ready for the crocodile data! The data for two years of tagging studies from the 2000s are provided in Table 4.

Table 4. Numbers of crocodiles marked, captured, and recaptured

Variable	Year 1	Year 2
m (number of adult crocodiles marked in first survey)	100	100
C (number of adult crocodiles captured during second survey)	325	160
k (number of marked adult crocodiles recaptured during second survey)	50	25

3. **Calculate** the number of adult crocodiles in the population during Year 1. Show your work.

$$\frac{325 \bullet 100}{50} = 650 \text{ adult crocodiles}$$

4. **Calculate** the number of adult crocodiles in the population during Year 2. Show your work.

$$\frac{160 \bullet 100}{25} = 640 \text{ adult crocodiles}$$

5. Around 80% of the population of adults are likely to be breeding in a particular year. Using this information, **calculate** the number of breeding adults in each year. Show your work.

650•0.8 = 520 breeding adults in year 1

640•0.8 = 512 breeding adults in year 2

6. Based on the calculations you have made and the nesting data, **describe** what you think has happened to the crocodile population from the 1970s to the 2000s when the population size was measured.

I think the population has decreased through time. Based on the number of nests, there may have been a much larger number of adults in the population at first. But now, there are fewer nests and the number of adult crocodiles has decreased as well.

7. Based on your work so far, should wildlife managers be concerned about the genetic diversity if the population size stays at its current level? **Explain** your answer based on the data in Activities 1 and 2.

Answers could go one of two ways: 1) They should not be concerned because there are more than 500 individuals, so genetic diversity should be maintained in the future. **OR** 2) They should be concerned because the population wouldn't have to decrease much more to have the genetic diversity start decreasing.

8. Based on your work so far, should wildlife managers be concerned about the genetic diversity of the population if it declines further? **Explain** your answer.

Yes, they should be worried. The population is at its minimum size of 500 breeding adults to maintain genetic diversity. If the population goes down further, genetic diversity will be lost.

Figure 1 shows the change in the number of breeding crocodiles in another part of the Okavango.

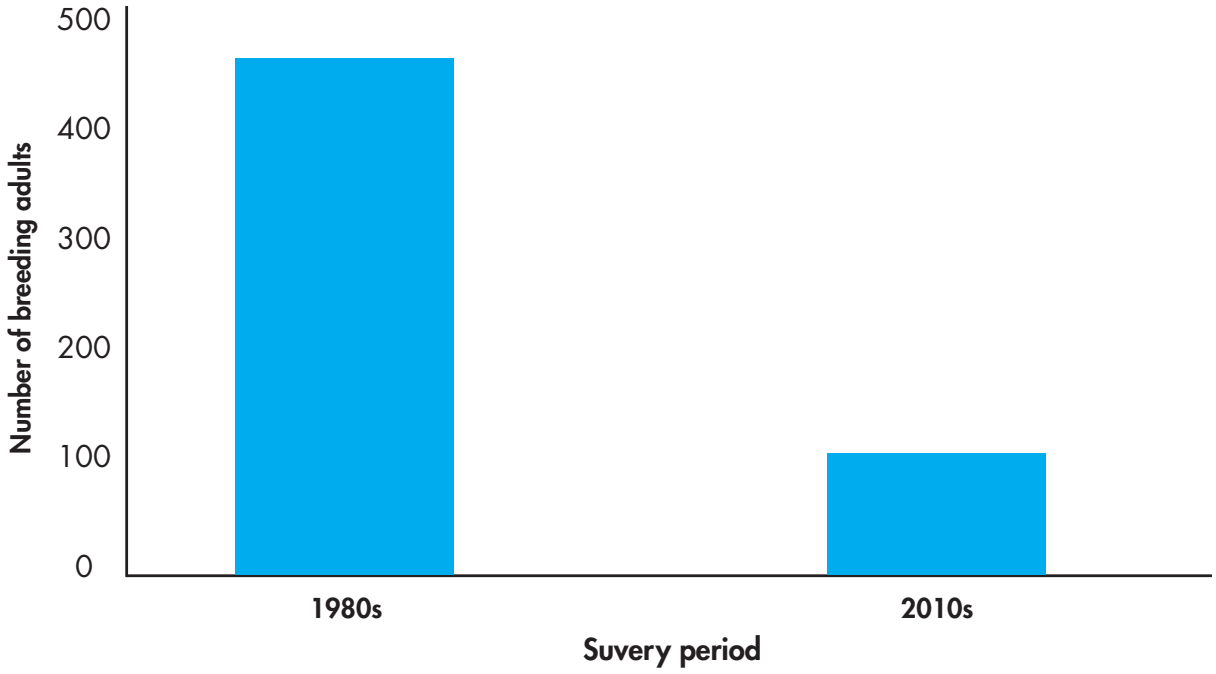


Figure 1. Estimated number of breeding individuals in a crocodile population in the Okavango

9. Should wildlife managers be worried about this population's genetic diversity? Cite evidence to support your answer.

Yes, managers should be worried. In the 1980s there were enough breeding adults to maintain genetic diversity based on the computer model. With only about 100 breeding adults now, the genetic diversity is likely to go down quickly based on the model.

ACTIVITY 3: CROCODILE SURVIVAL

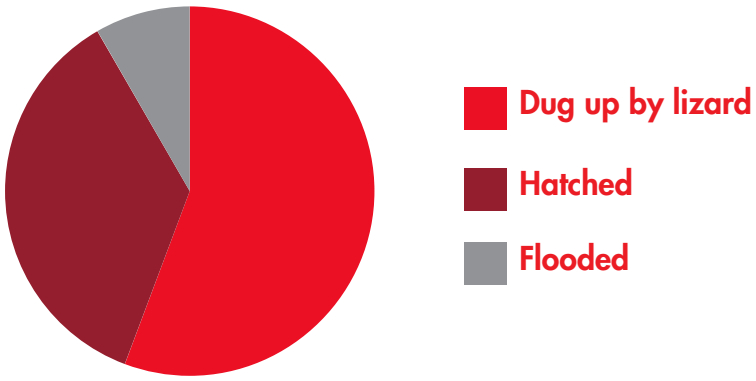
People are one threat to crocodiles. They used to harvest crocodile eggs and hunt adults. Now, there is a crocodile farm. That means that humans are no longer as much of a threat to wild crocodiles. What about natural threats?

Table 5 shows what happened to 20 crocodile nests that the team monitored.

Table 5. The fate of 20 crocodile nests

Nest number	Fate
1	Hatched
2	Dug up by lizard
3	Hatched
4	Dug up by lizard
5	Dug up by lizard
6	Hatched
7	Dug up by lizard
8	Dug up by lizard
9	Dug up by lizard
10	Dug up by lizard
11	Flooded
12	Dug up by lizard
13	Dug up by lizard
14	Dug up by lizard
15	Hatched
16	Hatched
17	Hatched
18	Hatched
19	Hatched
20	Dug up by lizard

1. **Draw** a pie chart of the fate of the nests from Table 5. Label each slice and write a caption for your figure. *Hint: the first step is to calculate the proportion of nests that had different fates.*



Fate of 20 crocodile nests

2. **Calculate** the percent of nests that survived to hatch. Show your work.

$\frac{8}{20} = 0.4$ 0.4 • 100 = 40% of nests survived to hatch

3. **Calculate** the percent of nests that failed to hatch. Show your work.

$\frac{12}{20} = 0.6$ 0.6 • 100 = 60% of nests failed to hatch

How dangerous is it for crocodiles once they hatch? Figure 2 shows the chances of survival under natural conditions for crocodiles of different sizes.

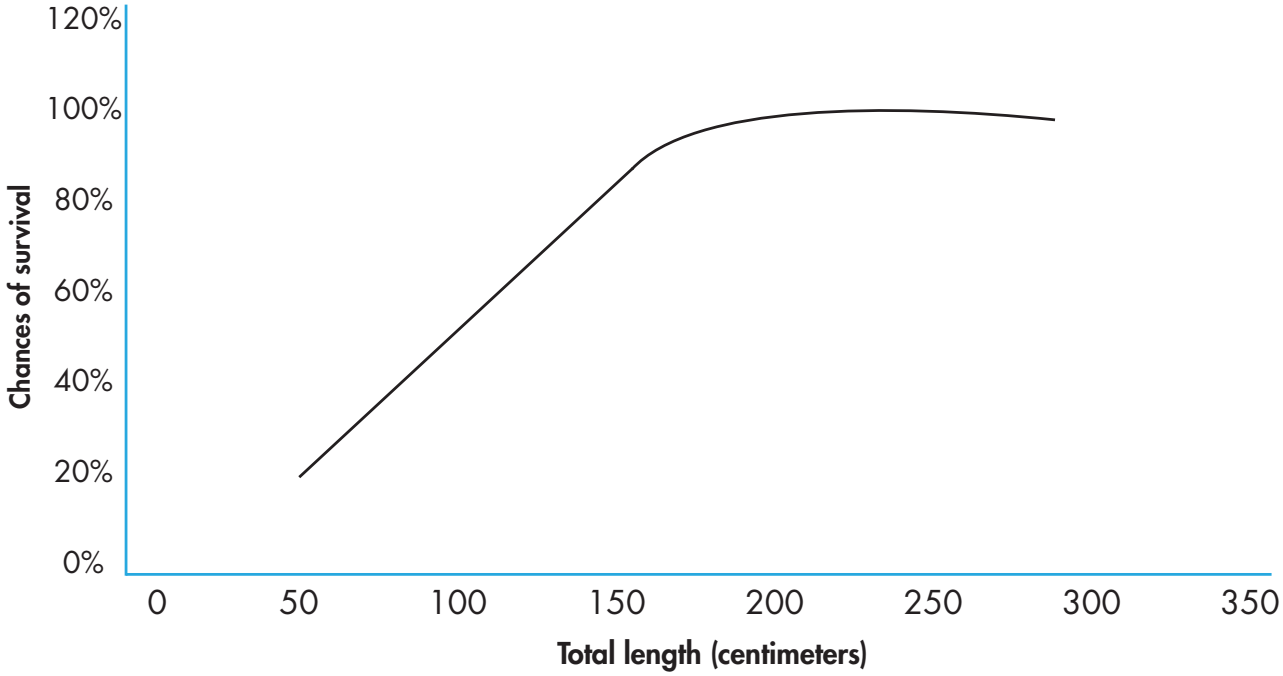


Figure 2. Chance of survival for crocodiles of different sizes

4. **Describe** how the chances of survival change as crocodiles grow.

The chances of survival are very low for small crocodiles. Less than 20% survive at 50 centimeters. But, as they grow, their chances of survival increase. Crocodiles over 200 centimeters are almost certain to survive to the next year.

5. **Explain** why wildlife managers are most worried about human hunting of adult crocodiles and are not worried about natural causes of death. Cite data in Figure 2 to support your answer.

The graph shows that adult crocodiles under natural conditions have a very good chance of survival every year once they reach a certain size.

ACTIVITY 4: ENCOUNTERING CROCODILES

Now that we know about crocodile populations, we need to investigate when humans, pets and livestock might be most likely to encounter crocodiles. The Okavango Crocodile Research team has been mapping where crocodiles spend their time in wet seasons and dry seasons. They made counts of crocodiles in three habitats. *Main channels* always have water. *Temporary channels* have water during the wet season and are mostly dry during the dry season. *Seasonal shallow marshes* only have water during the wet season. They completed the survey in one area far away from people. Then they completed the survey in another area near human populations and farms.

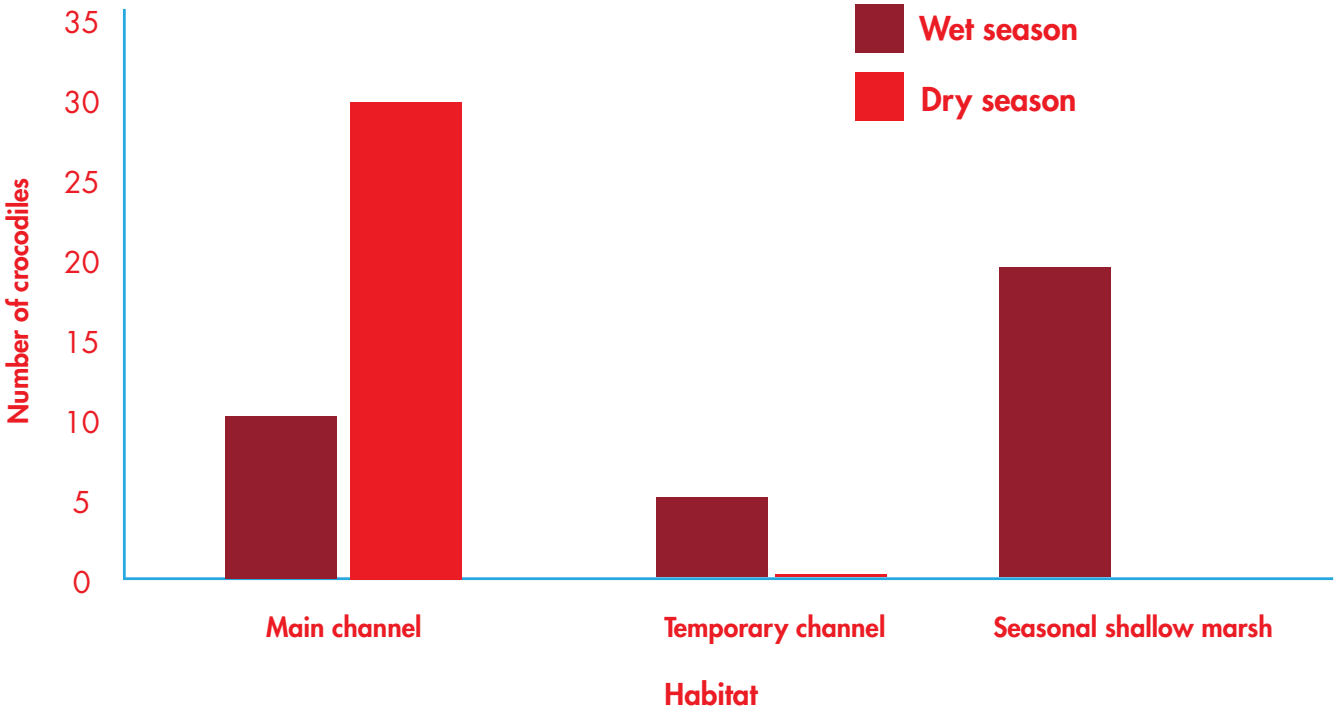
1. **Complete** Table 6 below by calculating the average crocodile counts for each column.

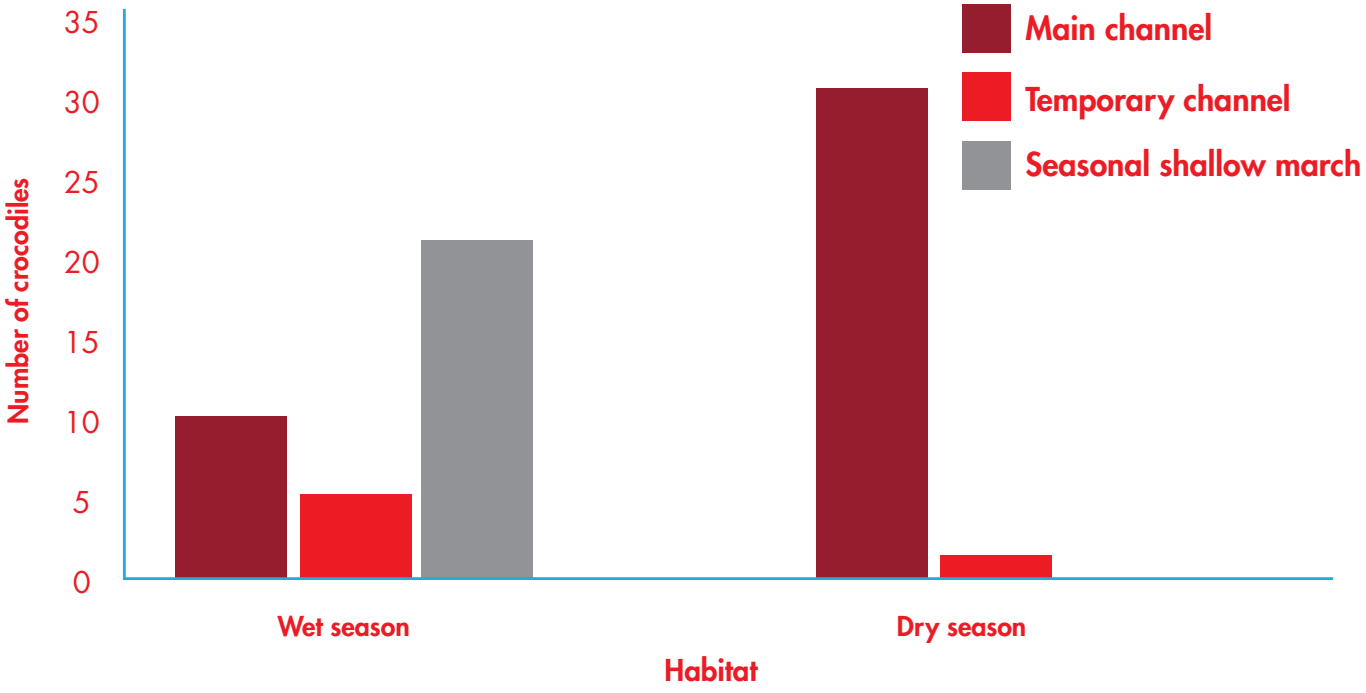
Table 6. Crocodile counts in different habitats during the wet season and dry season far away from human disturbance

	Wet Season			Dry Season		
Replicate	Main channel	Temporary channels	Seasonal shallow marsh	Main channel	Temporary channels	Seasonal shallow marsh
1	10	6	18	30	0	0
2	11	4	19	35	1	0
3	9	3	20	25	0	0
4	14	5	17	28	0	0
5	7	7	31	32	2	0
6	13	5	24	27	0	0
7	12	4	22	29	0	0
8	8	3	26	31	0	0
9	10	3	19	34	0	0
10	13	2	17	32	0	0
Average	10.7	4.2	21.3	30.3	0.3	0

2. **Draw** a bar graph that compares the number of crocodiles in different habitats far away from people during dry seasons and wet seasons. Use the data in Table 6. Label the axes and write a figure caption.

Note: Students may draw this graph in different ways. You can ask them to group seasons or habitats together. Two options are shown below. Instead of a legend some students may label each bar. You could also provide the completed graphs for students to interpret.





Number of crocodiles in different habitats far from people during the wet and dry seasons

3. **Describe** the changes in crocodile locations between wet and dry seasons.

Crocodiles spend almost all of their time in main channels during the dry season. Very few are found in temporary channels then. During the wet season, crocodiles spread out into the seasonal shallow marsh and temporary channels.

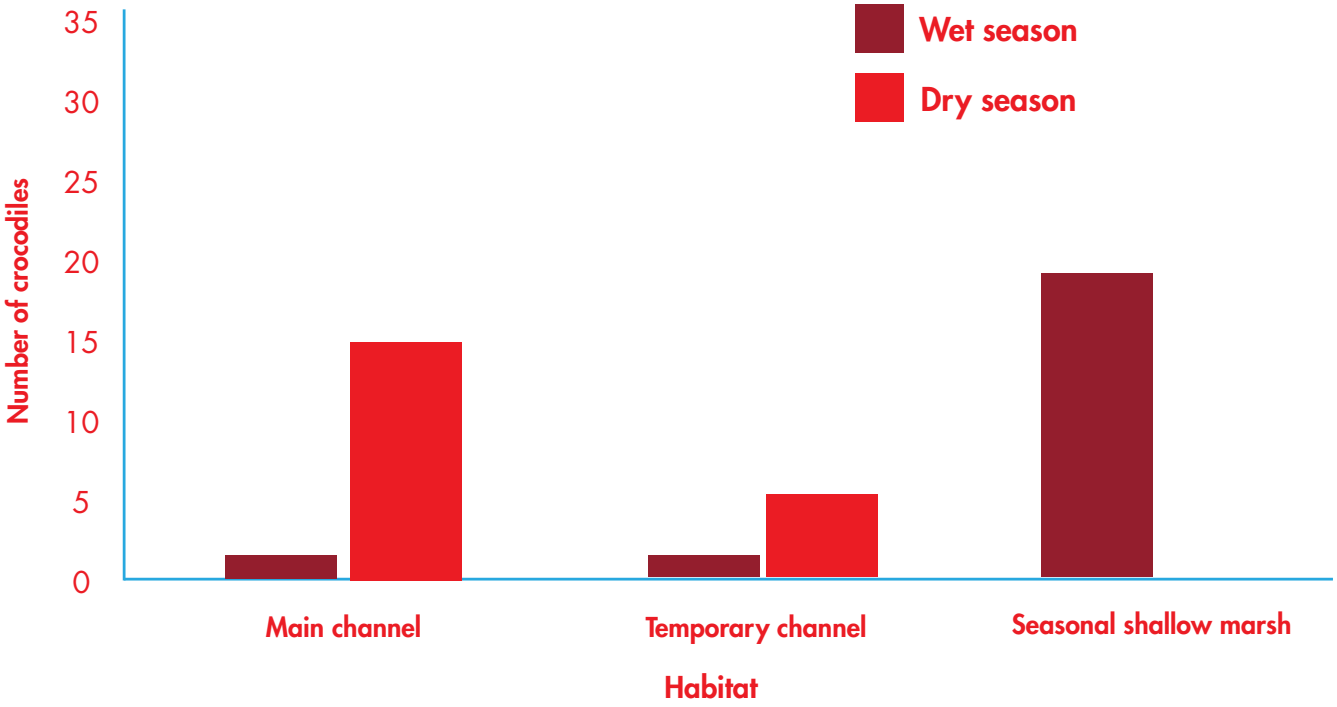
4. **Complete** Table 7 below by calculating the average crocodile counts for each column. *Note: Main channels have heavy human use including boating and settlements. Seasonal shallow marshes are farthest from people. Temporary channels often have people or livestock living near them.*

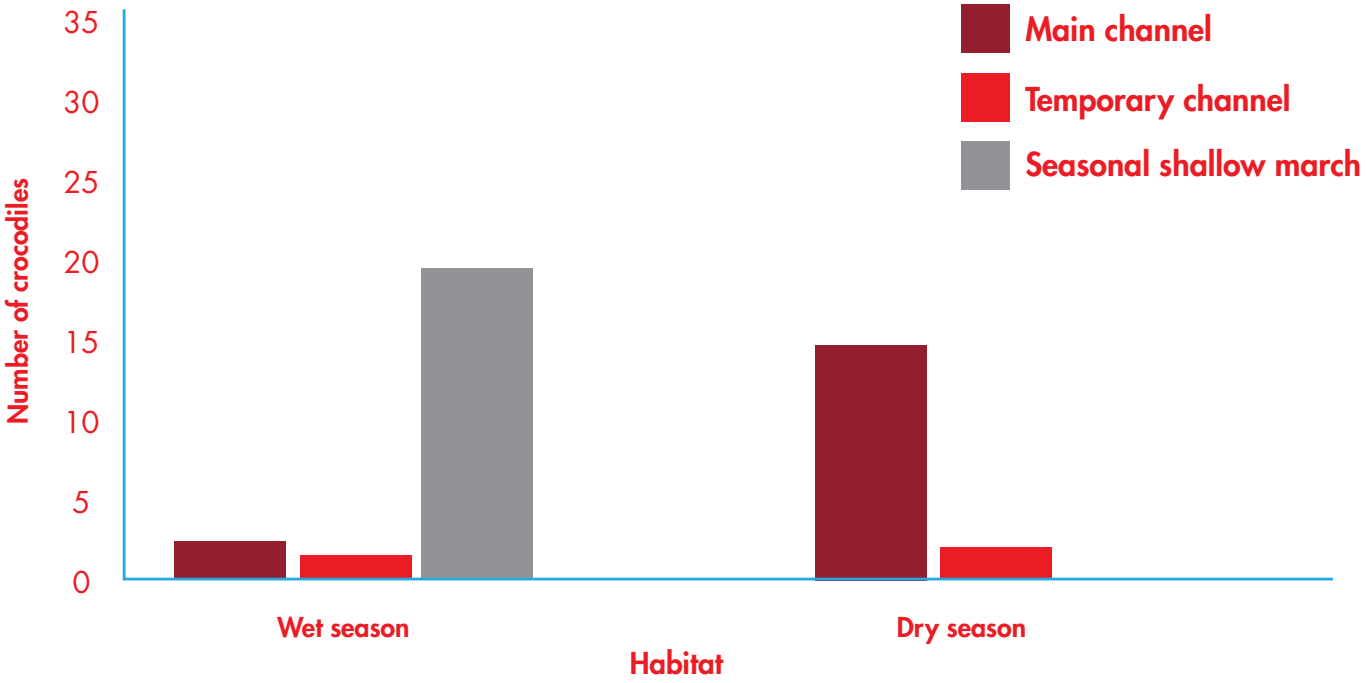
Table 7. Crocodile counts in different habitats during the wet season and dry season near humans settlements

	Wet Season			Dry Season		
Replicate	Main channel	Temporary channels	Seasonal shallow marsh	Main channel	Temporary channels	Seasonal shallow marsh
1	1	0	22	16	3	0
2	2	6	19	13	1	0
3	1	0	23	17	2	0
4	0	4	15	14	2	0
5	3	1	17	12	4	0
6	0	0	16	15	0	0
7	2	1	22	13	1	0
8	1	0	19	9	1	0
9	2	0	21	15	4	0
10	1	1	14	17	3	0
Average	1.3	1.1	18.8	14.1	2.1	0

5. **Draw** a bar graph that compares the number of crocodiles in different habitats near people during dry seasons and wet seasons. Use the same *y*-axis scale as you did for question number 2. Use the data in Table 7. Label the axes and write a figure caption.

Note: Students may draw this graph in different ways. You can ask them to group seasons or habitats together. Two options are shown below. Instead of a legend, some students may label each bar. You could also provide the completed graphs for students to interpret.





Number of crocodiles in different habitats near people during the wet and dry seasons

6. **Compare** and **contrast** the number of crocodiles and how they use habitats in the wet and dry seasons between areas with many people and few people.

Overall, there are fewer crocodiles near people. In the wet season, there are fewer crocodiles in main channels. They are almost all in the seasonal shallow marsh where there are fewer people. In the dry season, crocodiles have to be in main channels whether there are people or not. Near people, crocodiles use temporary channels a bit more than when there are no people. Getting the answer exactly right is not critical. Understanding the general contrasts between habitats is most important.

7. **Predict** when and where humans, pets, and livestock are most likely to be at risk from crocodiles. Use data to support your answer.

It looks like crocodiles will most likely be a problem for people in the dry season along main channels. They may also be a threat near temporary channels.