ACTIVITY 6

Modeling Migration

GAME

The population of bluefin tuna has changed dramatically in the last 100 years due to multiple factors.

6: MODELING MIGRATION

GUIDING QUESTION

How can models include uncertainty?

INTRODUCTION

As ocean temperatures change, migratory species are changing their routes in favor of cooler waters. For example, the Atlantic bluefin tuna have returned to cooler waters around the United Kingdom after having disappeared from the area decades ago. There are also signs that tuna are moving away from the western Pacific Ocean to the east. As bluefin tuna appear in new areas, they move into parts of the ocean governed by different countries. This is a concern because governments make decisions about how much fish can be caught in their waters.

Models can help build a better understanding about bluefin tuna populations and the factors that impact this species during its migration, which extends thousands of kilometers across the ocean. In this activity, you will model the migration of bluefin tuna by playing a board game.

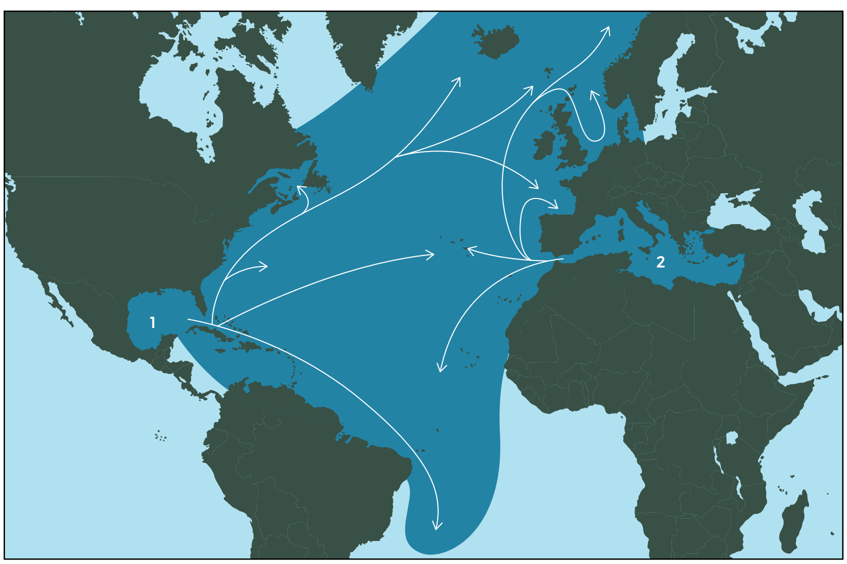
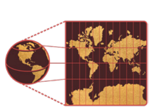


FIGURE 6.1
Map of Migratory Routes of Atlantic Bluefin Tuna

Two different populations of Atlantic bluefin tuna are expanding their ranges into cooler waters and sharing feeding grounds.

- Atlantic bluefin historic range
- 1 Main western spawning area
- 2 Main eastern spawning area

CONCEPTUAL TOOLS



MATERIALS LIST

FOR EACH GROUP OF FOUR STUDENTS

- BLUEFIN TUNA MIGRATION GAME BOARD
- NUMBER CUBE
- COIN
- 4 SMALL GAME PIECES (4 DIFFERENT COLORS)
- SET OF 20 EVENT CARDS

FOR EACH STUDENT

- STUDENT SHEET 6.1 "Bluefin Tuna Game Tracker"

PROCEDURE

1 Imagine scientists tracked a school of 500 bluefin tuna during their migration from their feeding grounds to their spawning grounds thousands of kilometers away. The population of the school of tuna is affected by environmental conditions and predators during the journey.

PART A: POPULATION GRAPH

2 Table 6.1 shows the rules that predict tuna population size as they migrate. In your science notebook, use the equations in the table to calculate the changing tuna population. (In this model, subtracting 0.05 of the previous week's population represents a 5% decrease in population, and adding 0.2 of the previous week's population represents a 20% increase in population.)

TABLE 6.1
Bluefin Tuna Population

TIME (WEEK)	CALCULATING POPULATION CHANGE	TUNA POPULATION
0 FEEDING GROUNDS	Week 0 population	500
1	(Week 0 population) – (0.05 x Week 0 population)	
2	(Week 1 population) – (0.05 x Week 1 population)	
3	(Week 2 population) – (0.05 x Week 2 population)	
4	(Week 3 population) – (0.05 x Week 3 population)	
5 SPAWNING GROUNDS	(Week 4 population) – (0.02 x Week 4 population)	

3 In your science notebook, create a line graph of the data and describe the trend in population size over time.

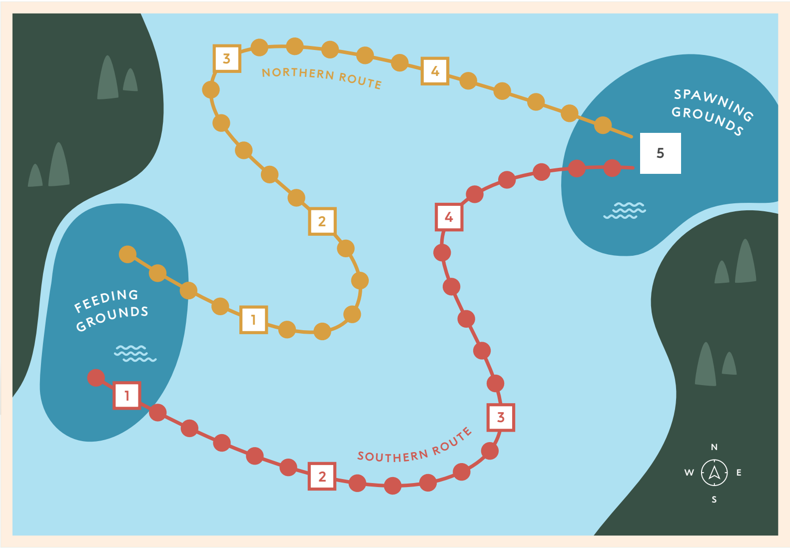
4 The graph is a model that can be used to predict future population size of the bluefin tuna. As a class, discuss what the model predicts and what could explain this pattern.

PART B: POPULATION GAME

5 You will model a population of a school of bluefin tuna on the same migration route and during the same time period as in Part A by playing a game. In this game, you will explore how different factors impact the tuna population. As a class, review the following game rules:

- Each game piece represents a school of bluefin tuna (starting with a population of 500 healthy adults).
- Each turn represents one week of migration.
- Each Event card represents something that happens during that week of migration.

FIGURE 6.2
Game Board



6 Set up the game by placing each player's game piece in the Feeding Grounds area. Divide the Event cards into five piles, according to the week.

7 Determine who starts the game by rolling the number cube. The player with the highest number starts first. Then take turns, moving in a clockwise direction.

8 Begin a turn by rolling the number cube and moving your game piece the number of places shown on the number cube. Start your migration by flipping a coin for either the northern route (heads) or the southern route (tails). Circle your migration route at the top of Student Sheet 6.1, "Bluefin Tuna Game Tracker."

9 When you land on or pass through an event space, draw an Event card from the pile for that week.

a Read the Event card aloud to your group and follow the instructions on the card.

b You will begin with an initial population of 500 fish in Week 0. Record and calculate the data for each following week on the student sheet. Be sure to record your data, even if there was no change in population.

c Replace the Event card at the bottom of the deck for that week.

10 Continue to play until you reach the Spawning Grounds. (A player needs only a minimum roll, not an exact roll, to enter the Spawning Grounds.) Then,

- draw a Spawning Grounds card and complete the instructions on the card. Record the final population of your school on the student sheet.
- observe the progress of the other players as they move toward the Spawning Grounds.

All three species of bluefin tuna—Atlantic, Pacific, and Southern—are commercially fished. A fully mature bluefin tuna averages about 225 kilograms (500 pounds) and 2–2.5 meters (6–8 feet).

11 In your group, compare the final populations for the four schools of tuna. Discuss what factors determined which school had the most successful and least successful migrations based on population size. Identify the one factor that had the greatest impact and two to three factors that had the least impacts.

12 You will help create a graph of all the class data. On the class chart, record your tuna population for each week (from Student Sheet 6.1).

13 Use your class data to construct a model.

a On the graph of class data, draw a line connecting the highest data points. Then do the same for the lowest data points. This shows the range of the tuna population during migration.

b Copy the class graph onto the graph from Part A that you created in your science notebook. (Use dotted or dashed lines so you can easily tell them apart from the line you drew in Part A.) This graph is a model that can be used to predict the future population size of the bluefin tuna. It shows a range of possible outcomes for the tuna, given the variety of possible events.

PART C: COMPARING MODELS

14 Discuss with your group what each model from Part A and Part B predicts about the future of the tuna population size over time. Under each model, describe this prediction in one sentence.

15 Read the following two definitions. With your group, decide what kind of population model—deterministic or probabilistic—was represented by each model (the one in Part A and the one in Part B).

A deterministic model is a tool that produces a single predictable outcome for a given set of initial conditions.

A probabilistic model is a tool that uses patterns in data to predict the likelihood of different outcomes. It produces a range of possible outcomes for a given set of conditions.

16 Using the two models, predict what you think will happen to the population and range of the bluefin tuna during future migrations if:

a nothing changes.
b fishing limits are introduced.
c environmental change continues to warm ocean waters.

BUILD UNDERSTANDING

1. Which type of model, deterministic or probabilistic, would be most useful for predicting the following phenomena? Explain your reasoning for each example.
   - a The future population of bluefin tuna.
   - b The height of a bouncing ball as it loses energy.
   - c The weather for next week.
   - d The change in range of a species.

2. In the game, what factors are a part of the highest and lowest orders of understanding of the tuna population? Rate the factors included in the game model according to orders of understanding. Explain your reasoning.

3. In this activity, the game was a model of bluefin tuna migration. Consider ways in which the model did or did not represent the real-world system. Describe one change you would make to improve the model, why you would make it, and how it would likely affect the population in this model.

4. Imagine that you live in a coastal town where the economy depends on the fishing industry. The local fish population has declined, and the remaining population has moved farther out to sea where fishing is more expensive and dangerous. A community group has proposed a law to protect the local fish population by severely limiting the number of fish that can be caught locally. Would you support the law? Support your answer with evidence from this activity and identify the trade-offs of your decision.

A coastal fishing town.

CONNECTIONS TO EVERYDAY LIFE

5. Imagine you visit an ice-cream shop regularly, and you would like to know how many people will be in line when you arrive. Over 20 visits, you observed the following information, shown in Table 6.2.
   - a What is the most likely line length in the shop? Explain your reasoning.
   - b If you made a model from this data, would it show a deterministic system or a probabilistic system? Explain your reasoning.
6. Ride-sharing apps and websites that sell tickets to concerts or shows often use an on-demand pricing model. In this model, the price is determined by the number of people who want the service or the tickets. More demand results in a higher price. Do you think on-demand pricing is a deterministic model or a probabilistic model? Explain your reasoning.

TABLE 6.2
Lines at Local Ice-Cream Shop

LINE LENGTH (NUMBER OF PEOPLE)	FREQUENCY OF THIS LINE LENGTH
0	1
1	4
2	8
3	5
4	2

KEY SCIENTIFIC TERMS

deterministic model
probabilistic model