Student Version

Delaware Science Assessment Prototype: Biology Integrative Item Cluster

Prepared for the Delaware Department of Education
by WestEd

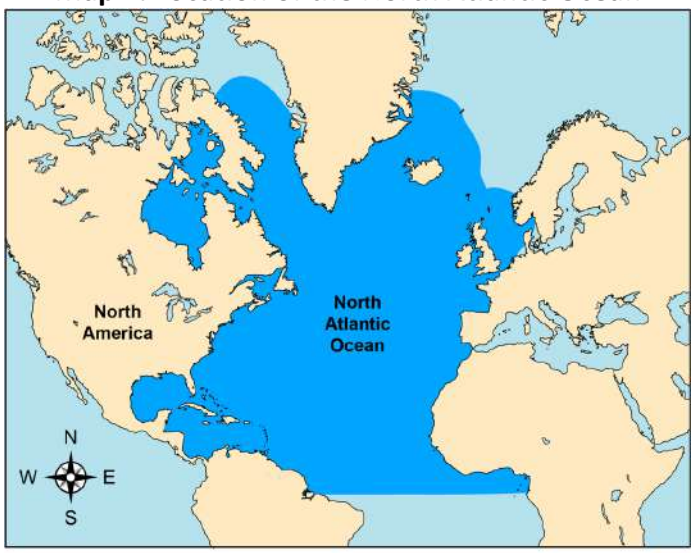
In this assessment, you will investigate how the flow of matter and energy in the North Atlantic Ocean ecosystem relates to right whale migration.

Introduction

Right whales are **baleen whales**[1] that feed by straining large amounts of **krill**, **copepods**[2], and microscopic organisms such as **phytoplankton**[3] and **zooplankton**[4] from the ocean.

Right whales live in the North Atlantic Ocean along the east coast of North America. Map 1 shows the location of the North Atlantic Ocean.

Map 1. Location of the North Atlantic Ocean



Each year, right whales migrate northward and southward along the entire east coast of North America. During each migration, the whales travel past the coast of Delaware.

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[1] **Baleen whales**: Baleen are long plates that hang in a row (like the teeth of a comb) from a baleen whale's upper jaw. Baleen plates are made of a protein similar to the protein found in human fingernails, making them strong and flexible. Baleen plates are broad at the gum line and taper into a fringe, which forms a curtain or mat inside the whale's mouth. (http://www.afsc.noaa.gov/nmml/education/cetaceans/baleen1.php)

[2] **Krill**, **copepods**: Tiny crustaceans that form large groups throughout the world's oceans. Nearly all species of krill and copepods eat phytoplankton and/or zooplankton.

[3] **Phytoplankton**: microscopic producers, such as single-celled algae, that use photosynthesis to make their own food.

[4] **Zooplankton**: microscopic consumers that feed on organisms such as phytoplankton.

Activity: Absorption of Solar Energy and Right Whales

Your handout materials contain two maps. Analyze the handout materials by following these steps:

1. Each map shows the average amount of solar energy absorbed by Earth's surface, in watts per square meter (W/m^2), at two different times of the year. Analyze the two maps to determine how the amount of solar energy absorbed in the North Atlantic Ocean changes seasonally.
2. The maps also show the migration routes and seasonal habitats of the right whales throughout the year. Analyze any relationships that appear among absorbed solar energy and right whale migration in different seasons.

Record notes from your analyses in the space below.

Light Intensity and Photosynthesis

A student investigates the relationship between light intensity and the rate of photosynthesis in algae. The pH of the water can be used to determine the rate of photosynthesis. Water with a lower pH has more carbon dioxide, while water with a higher pH has less carbon dioxide.

The student follows these steps:

- Place the same mass of algae into six different bottles.
- Measure the initial pH of each bottle.
- Place each bottle a different distance from a lamp and record the light intensity.
- Place a control bottle in a dark box.
- Record the pH in each bottle at 45 minutes and again at 90 minutes.

Table 1 shows the student's data.

Table 1. Student's Data

Bottle	Initial pH	Light Intensity (W/m^2)	pH After 45 Minutes	Final pH After 90 Minutes
A	7.6	238	8.8	9.0
B	7.6	182	8.4	8.6
C	7.6	126	8.2	8.4
D	7.6	71	8.0	8.2
E	7.6	16	7.7	7.8
Control	7.6	0	7.6	7.6

Question 1.

Part A

Which claim is **best** supported by the data in Table 1?

A. The change in pH over time indicates that the amount of carbon dioxide is lower at lower light intensities.

B. The change in pH over time indicates that the amount of carbon dioxide is lower at greater light intensities.

C. The change in pH over time is highest at the greatest light intensity, so the amount of carbon dioxide must be higher at greater light intensities.

D. The change in pH over time is lowest at the greatest light intensity, so the amount of carbon dioxide must be lower at greater light intensities.

Part B

Which claim about rates of photosynthesis is supported by **both** the data in Table 1 and the claim you identified in Part A?

A. Rates of photosynthesis increase as light intensity increases and as length of exposure to light increases.

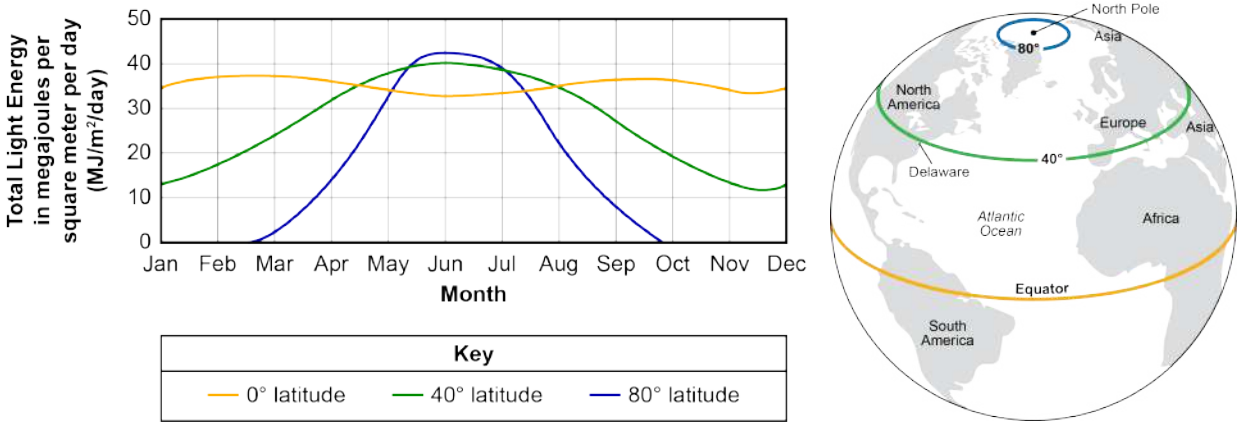
B. Rates of photosynthesis increase as light intensity increases and are unchanged by length of exposure to light.

C. Rates of photosynthesis increase as light intensity increases and decrease as length of exposure to light increases.

D. Rates of photosynthesis decrease as light intensity increases and as length of exposure to light increases.

Graph 1 below shows how the total amount of incoming solar (light) energy changes by month at three different latitudes in the Northern Hemisphere. Each latitude is shown on the globe beside the graph.

Graph 1. Total Light Energy by Month for Various Latitudes



Question 2. Based on the information from Table 1 and Graph 1, which statement explains how the rates of photosynthesis in the North Atlantic Ocean will **most likely** change from winter (January) to summer (July)?

A. The total amount of incoming solar energy decreases slightly in summer, so rates of photosynthesis will decrease slightly during the summer months.

B. The total amount of incoming solar energy is about equal in summer and in winter, but rates of photosynthesis will decrease in winter because the length of light exposure is less in winter than in summer.

C. The total amount of incoming solar energy increases as the seasons change from winter to summer, so the rates of photosynthesis will increase during the summer.

D. The total amount of incoming solar energy is more in summer, but the rates of photosynthesis increase only slightly in summer because the length of light exposure is less in summer than in winter.

Carbon and Energy Transfer

You have analyzed seasonal changes in the North Atlantic Ocean. Now, you will analyze how these changes affect changes in matter, energy transfer, and right whale migration, in the North Atlantic Ocean ecosystem.

Question 3. The processes of photosynthesis and cellular respiration are modeled below.

Photosynthesis: $CO_2 + H_2O + \text{light energy} \rightarrow O_2 + H_2O + C_6H_{12}O_6$

Cellular Respiration: $O_2 + C_6H_{12}O_6 \rightarrow CO_2 + H_2O + \text{energy}$

Explain why **both** processes are required for the movement of matter (in the form of carbon) and the transfer of energy within an ecosystem. In your explanation, describe how the two processes depend on each other and how carbon is moved by each process.

Question 4. Complete the model below to show the flow of energy and the cycling of carbon in the North Atlantic Ocean ecosystem by following these steps:

Step 1. Look at the orange arrows in the model. Each orange arrow represents the direction of energy flow within the ecosystem.

Step 2. Write the name of the organism (from the right of the model) that belongs in **each** white box based on the directions of the orange arrows.

Step 3. Draw arrows between the white boxes to show the movement of **carbon** among the organisms in the model.

Step 4. Draw arrows to show how carbon cycles among the living and nonliving parts of the ecosystem.

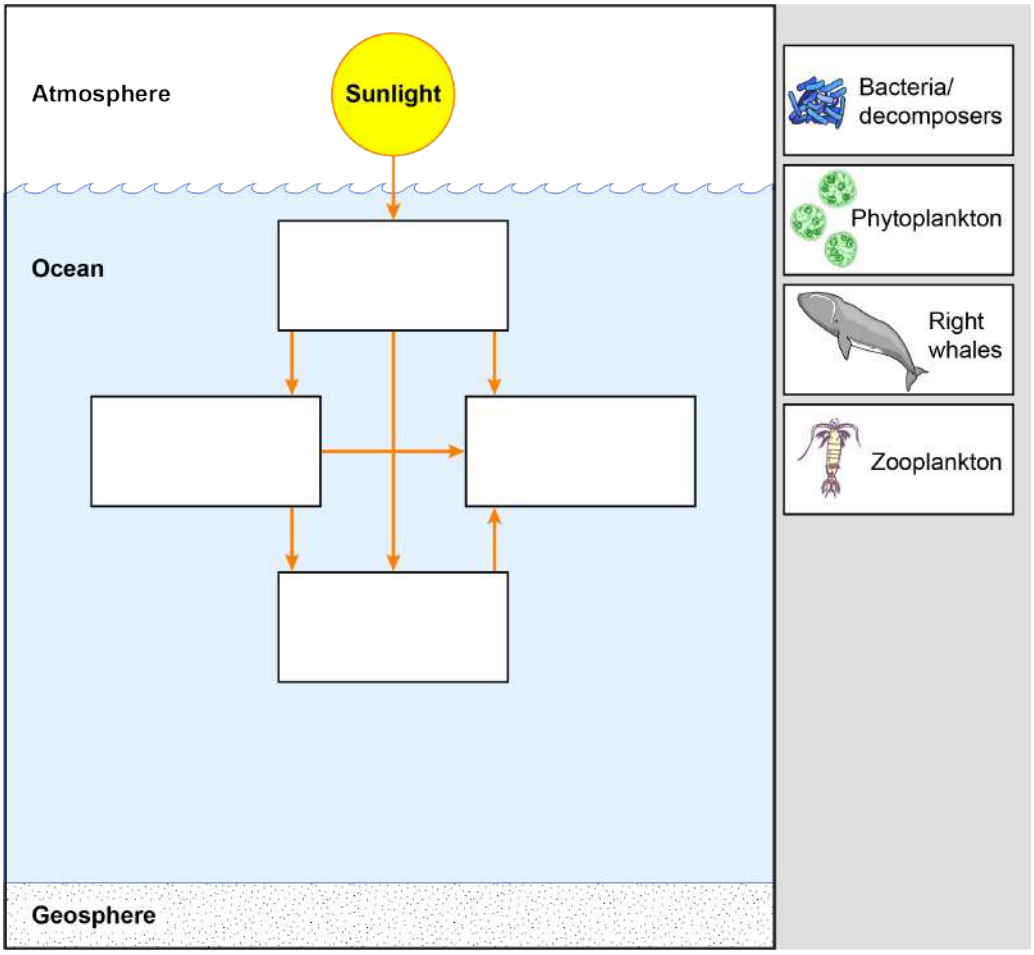


Diagram not to scale

Global Connection

Question 5. The model you completed shows some of the ways in which matter, in the form of carbon, moves through different trophic levels (producers and consumers) in the North Atlantic Ocean ecosystem. Which claim is **best** supported by evidence from the model?

A. Carbon is transferred into different trophic levels by way of cellular respiration, and is transferred among organisms as organisms consume one another.

B. Carbon is fixed in the oceanic food web during photosynthesis, and some of that carbon is released as heat energy during cellular respiration by organisms in every trophic level.

C. Some carbon moves from the oceans into living organisms at every trophic level during photosynthesis, and some carbon is transferred among organisms during cellular respiration.

D. Some carbon moves from living organisms at each trophic level into the oceans during cellular respiration, and some carbon moves among organisms as organisms consume one another.

Question 6. Explain how the difference between the amount of matter and energy in winter and summer in the North Atlantic Ocean ecosystem is part of a larger global system of Earth's oceans.

In your explanation,

- describe how the difference in energy and matter affect how right whales obtain the matter and energy they need to survive, grow, and reproduce;
- use evidence from any of the tables, graphs, and maps provided to support your answer.