Teacher Version

Delaware Science Assessment Prototype: Biology Integrative Item Cluster

Prepared for the Delaware Department of Education
by WestEd

Delaware NGSS Assessment Prototype
Biology Integrative Item Cluster

Background:

The Delaware Department of Education engaged with WestEd to design and develop sample tasks to measure the Next Generation Science Standards (NGSS). These tasks were administered to Delaware students as part of a process to evaluate the tasks' effectiveness at measuring all three dimensions of the NGSS—Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs), and Crosscutting Concepts (CCC). These tasks were revised based on the data collected during the research period, and are now available to Delaware educators as sample NGSS-aligned assessments for use in their classrooms.

Recommendations on how to use the Integrative Item Cluster Prototype:

The following Integrative Item Cluster (IIC) is designed to elicit evidence of a student's understanding and ability to apply specific science skills in a real-world context. Each IIC is designed around a central phenomenon and requires students to use and apply all three dimensions to respond to questions associated with a common stimulus. ***It is recommended that this IIC be administered following the instruction of Performance Expectations (PEs) HS-LS1-5, HS-LS1-7, and HS-LS2-5.***

This IIC also assesses a student's ability to apply science practices that are not specific to PEs HS-LS1-5, HS-LS1-7, or HS-LS2-5. For example, in addition to the SEP of *Developing and Using Models* (MOD) that was originally part of all three PEs, the IIC also requires students to apply the practices of *Mathematics and Computational Thinking*, *Planning and Carrying Out Investigations*, *Analyzing and Interpreting Data* (DATA) and *Constructing Explanations and Designing Solutions* (E/S) as part of the assessment. In this way, the IICs prepare students to ***integrate, transfer, and apply*** knowledge and skills to novel situations, an important expectation of Delaware's Comprehensive Science Assessment System.

This IIC prototype is provided as a formative assessment tool and is not meant to demonstrate the exact mode or content that will appear in Delaware's future assessments (e.g., some IICs may be delivered online). Rather, we invite teachers to explore the use of IICs in their classroom to better understand the nature of NGSS assessment.

Materials:

Student Version PDF: This version is available to download and print in order to administer the IIC prototype directly to students. All student responses can be captured on this hard copy, **OR** a set of class copies can be printed and student responses can be captured on a separate piece of paper. The IIC is designed to be self-explanatory and should require little instruction on the part of the teacher or proctor. The suggested time to complete the IIC is 20–25 minutes.

Teacher Version PDF: In addition to the content contained in the student version, the teacher version provides alignment information in gray metadata boxes. Scoring information (the key) is included in the metadata or is provided as a detailed rubric/scoring information section below items where relevant. Keys and recommended point values for each question are provided in the metadata tables (13 points total for the IIC), but point values can be adjusted based on overall class performance.

These resources are available for public use and we encourage you to share them freely. Questions can be sent to april.mccrae@doe.k12.de.us.

Student Note:

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

Grade: Biology	
PE/PE Bundle: **HS-LS1-5:** Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. **HS-LS1-7:** Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. **HS-LS2-5:** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon in the biosphere, atmosphere, hydrosphere, and geosphere.	
Dimensions: SEP: MOD, MCT, INV, DATA, E/S; **DCI:** LS1.C, LS2.B; **CCC:** E/M, SYS	
Focus: Energy and matter interactions occur at each level of nested system cells > multicellular organisms > ecosystems > planet.	
Phenomenon (if applicable): North Atlantic right whales migrate past the coast of Delaware in a northward direction in the spring and in a southward direction in the fall.	

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.

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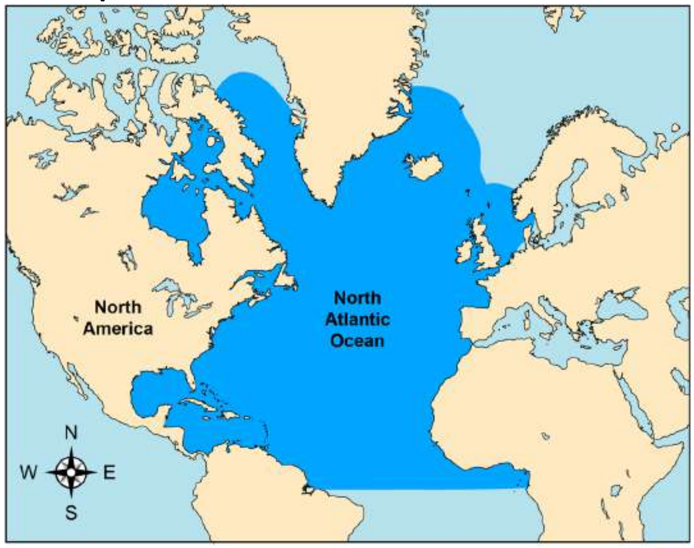
[1] **Baleen whales**: Baleen are long plates that hang in a row (like the teeth of a comb) from a baleen whale's upper jaw. Baleen plates are made of a protein similar to the protein found in human fingernails, making them strong and flexible. Baleen plates are broad at the gum line and taper into a 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.

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.

Activity: Absorption of Solar Energy and Right Whales

TEACHER Note: Handouts are found at the end of this document – Please Print the two maps (pages 15 and 16) in COLOR. Maps may be laminated for future use.

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.

{response space is provided in student version}

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

Item: 1	**Item Format:** MC, MC
Grade: Biology	
PE/PE Bundle: HS-LS1-5	**Total Points:** 2
Dimensions: DCI: LS1.C **SEP:** MCT, DATA **CCC:** E/M	**Key(s): Part A:** B; **Part B:** A
Focus: Photosynthesis rates vary with light energy.	

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.*

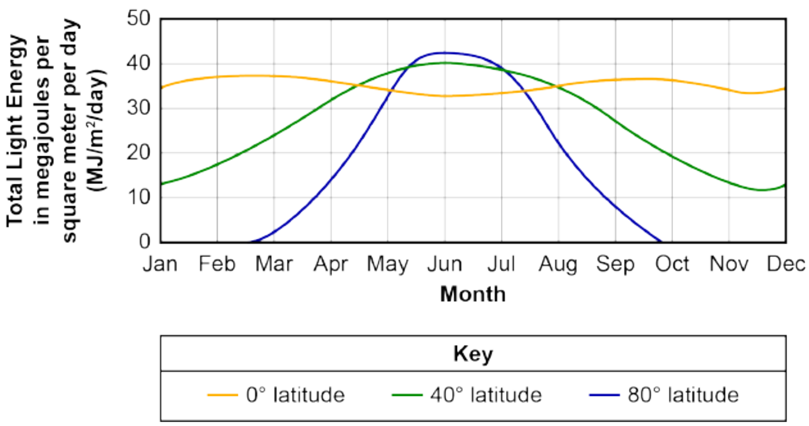
B. Rates of photosynthesis increase as light intensity increases and are unchanged by length of exposure to light.

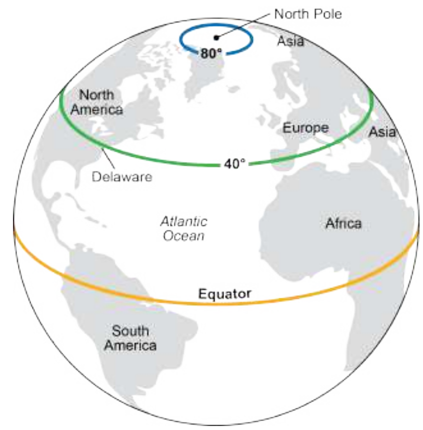
C. Rates of photosynthesis increase as light intensity increases and decrease as length of exposure to light increases.

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





Item: 2	**Item Format:** MC
Grade: Biology	
PE/PE Bundle: HS-LS1-5, HS-LS1-7	**Total Points:** 1
Dimensions: DCI: LS1.C, LS2.B **SEP:** INV, DATA **CCC:** E/M	**Key(s):** C
Focus: Photosynthesis productivity at a given latitude on Earth varies by season, due to the angle of light incidence.	

Question 2. Based on the evidence 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.

Item: 3	**Item Format:** CR
Grade: Biology	
PE/PE Bundle: HS-LS1-5, HS-LS1-7, HS-LS2-5	**Total Points:** 3
Dimensions: DCI: LS1.C, LS2.B **SEP:** E/S **CCC:** E/M	**Key(s): See Scoring below**
Focus: Carbon and energy transfer in the North Atlantic ecosystem.	

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

Photosynthesis: $CO_2 + H_2O$ + light energy → $O_2 + H_2O + C_6H_{12}O_6$

Cellular Respiration: $O_2 + C_6H_{12}O_6$ → $CO_2 + H_2O$ + 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.

{response space is provided in student version}

Scoring for Question 3

Three points total:

- One point for explaining how the two processes depend on one another
- One point for explaining how energy and matter (carbon) is moved by photosynthesis
- One point for explaining how energy and matter (carbon) is moved by cellular respiration

Sample Student Response: During photosynthesis, light energy is captured and converted to chemical energy that is stored in the bonds of glucose. Carbon from the environment (as carbon dioxide) is rearranged into glucose ($C_6H_{12}O_6$) during photosynthesis. During cellular respiration, the glucose molecules that were produced during photosynthesis are broken down, releasing energy that can be used by an organism for cellular function, and the carbon atoms (matter) are rearranged back into carbon dioxide that are released to the environment. Carbon cycles among the two processes, and the products of one process are the reactants of the other.

Item: 4	**Item Format:** Modeling
Grade: Biology	
PE/PE Bundle: HS-LS1-5, HS-LS1-7, HS-LS2-5	**Total Points:** 3
Dimensions: DCI: LS1.C, LS2.B **SEP:** MOD **CCC:** E/M	**Key(s):** See Scoring below
Focus: Carbon and energy transfer in the North Atlantic ecosystem.	

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 among the four organisms that are shown to the right of the model.

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.

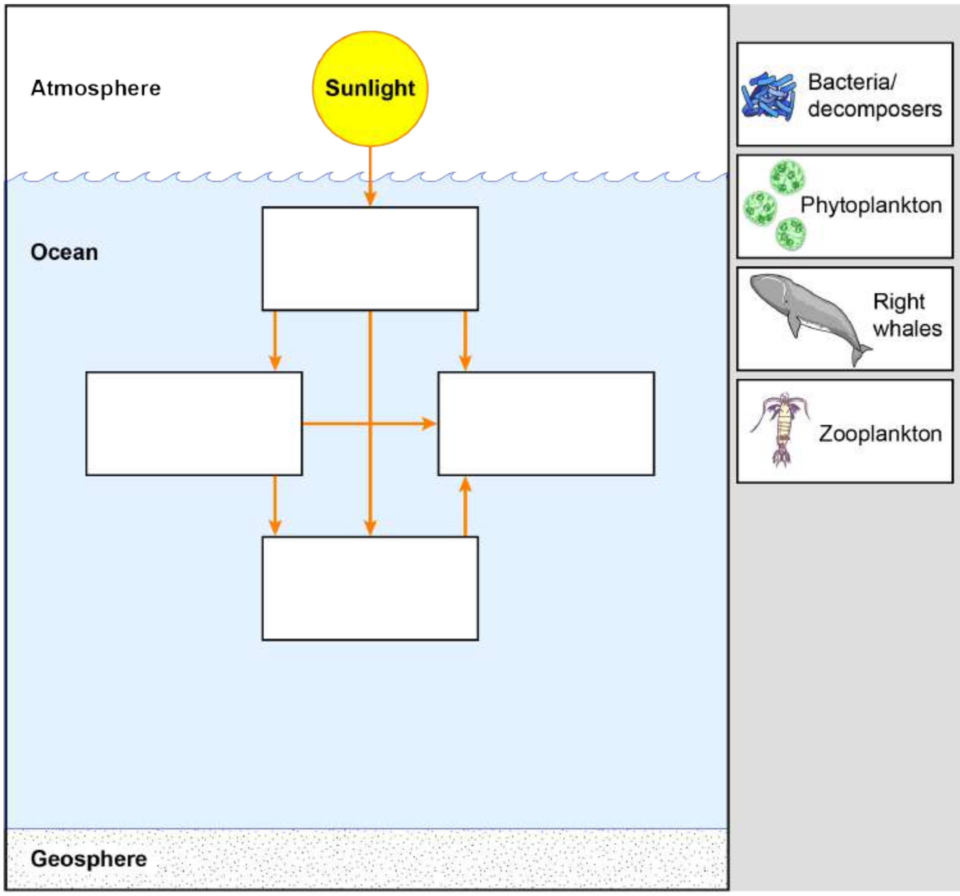


Diagram not to scale

Scoring for Question 4

Three points total:

- One point for correct placement of each organism
- One point for correct arrows to show carbon flow among organisms (shown in green)
- One point for correct arrows to show movement of matter between living and nonliving parts of the ecosystem (shown in green)

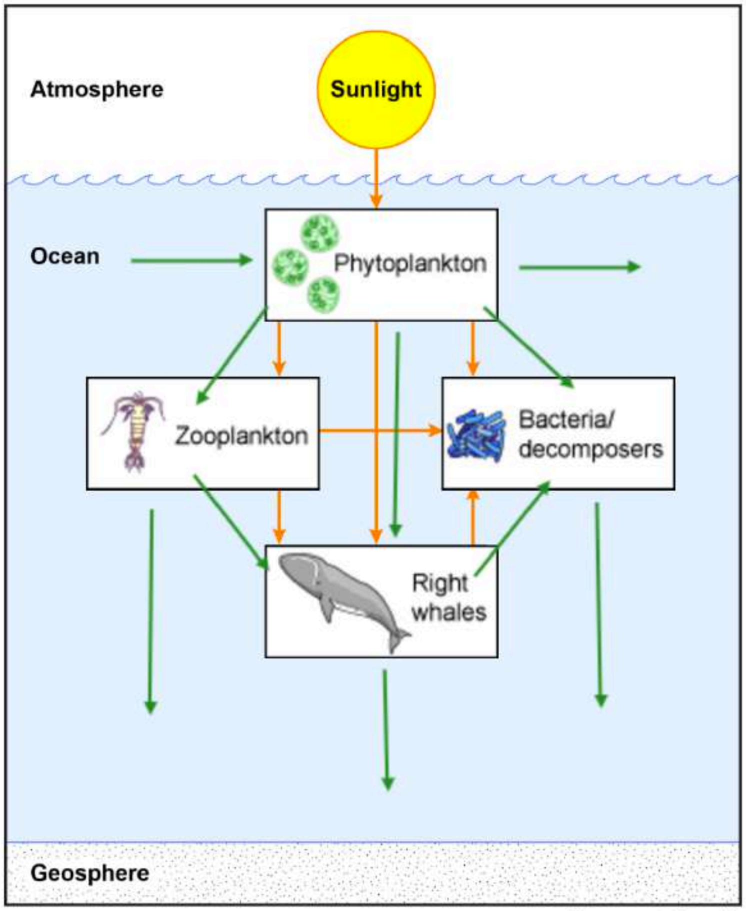


Diagram not to scale

Global Connection

Item: 5	**Item Format:** MC
Grade: Biology	
PE/PE Bundle: HS-LS1-5, HS-LS1-7, HS-LS2-5	**Total Points:** 1
Dimensions: DCI: LS1.C, LS2.B **SEP:** E/S **CCC:** E/M	**Key(s):** D
Focus: Carbon and energy transfer in the North Atlantic ecosystem.	

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.*

Item: 6	**Item Format:** CR
Grade: HS	
PE/PE Bundle: HS-LS1-5, HS-LS1-7, HS-LS2-5	**Total Points:** 3
Dimensions: DCI: LS1.C, LS2.B **SEP:** E/S **CCC:** E/M	**Key(s):** see Scoring below
Focus: Carbon and energy transfer in the North Atlantic ecosystem.	

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.

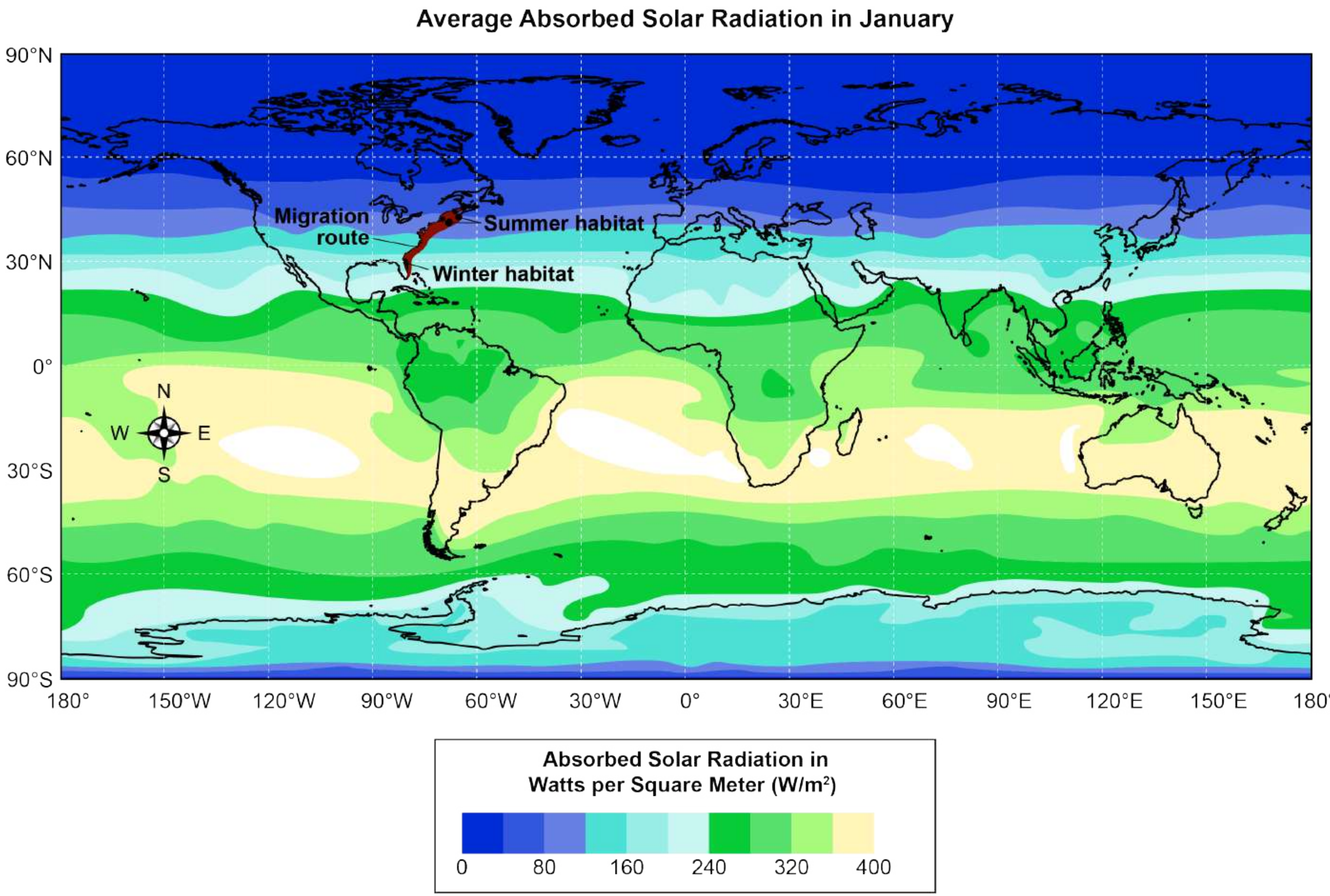
{response space is provided in student version}

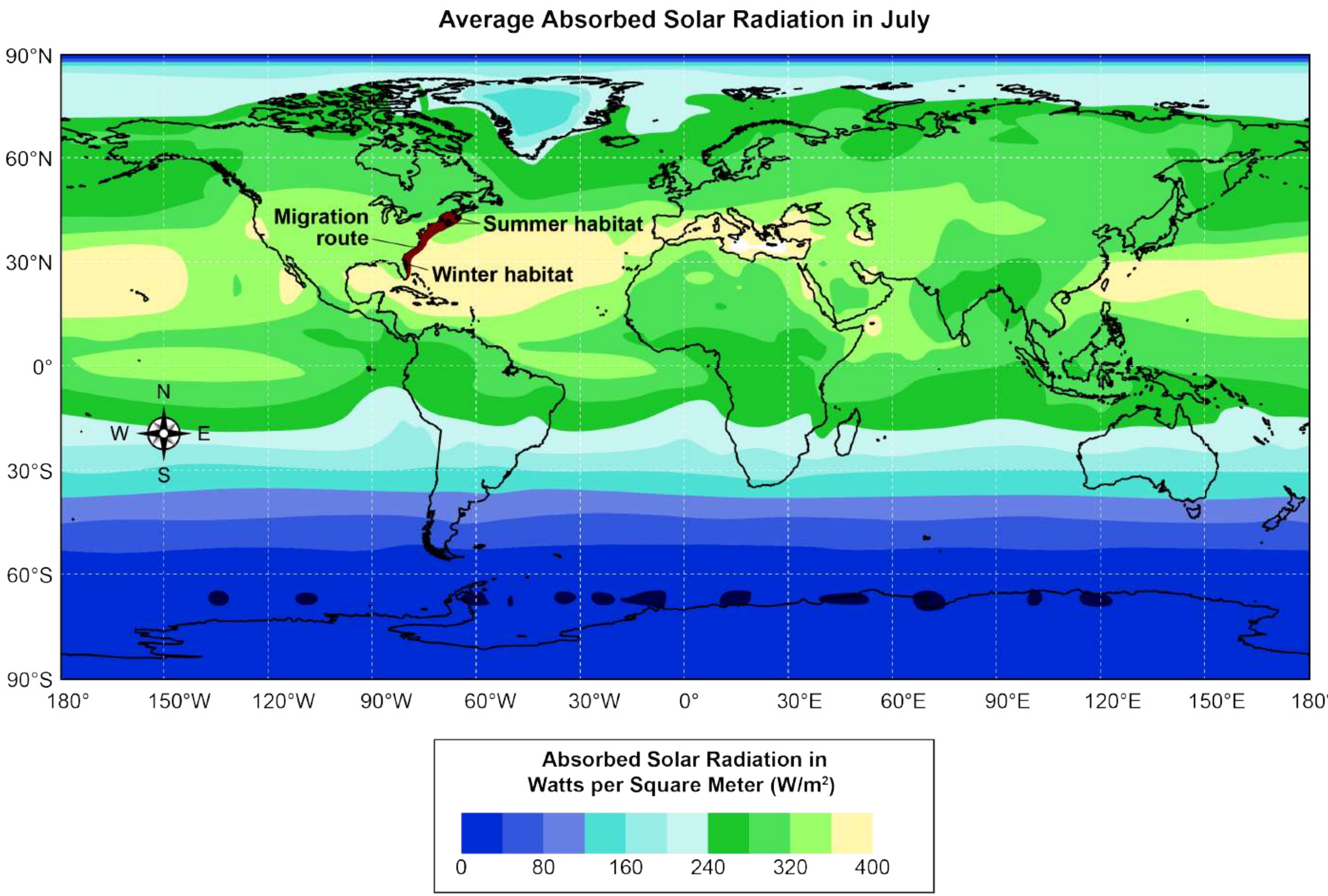
Scoring for Question 6

Three points total:

- One point for explaining how the differences between the energy and matter in winter and summer is part of a larger global system.
- One point for describing how seasonal differences affect how right whales get the energy they need to survive.
- One point for using evidence from tables, graphs, and maps to support the answer.

Sample Student Response: Sunlight that reaches the ocean water provides energy that drives the cycling of carbon and water through the organisms in the North Atlantic Ocean ecosystem. When sunlight hits the ocean water, some of the energy is absorbed by phytoplankton. The phytoplankton get the matter for photosynthesis—water and carbon dioxide— from the ocean. Graph 1 shows more light energy reaches phytoplankton in summer, allowing phytoplankton to take up more water and carbon dioxide molecules from the ocean and combine them to form glucose. Glucose moves through the food chain as zooplankton eat phytoplankton and whales eat zooplankton. The right whales migrate to places where greater input of energy from sunlight maintains higher population levels of phytoplankton and zooplankton. As the whales migrate, they carry carbon and energy that is stored in their bodies. The whales and zooplankton release some of the carbon and water back into the ocean during cellular respiration and when they die. The cycling of carbon and water through living and nonliving parts of the North Atlantic ecosystem is part of the global carbon and water cycles.


Average Absorbed Solar Radiation in January
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
180°
Migration route
Summer habitat
Winter habitat
N
W
E
S
Absorbed Solar Radiation in Watts per Square Meter (W/m²)
0
80
160
240
320
400


Average Absorbed Solar Radiation in July
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
180°
Migration route
Summer habitat
Winter habitat
N
W
E
S
Absorbed Solar Radiation in Watts per Square Meter (W/m²)
0
80
160
240
320
400