

Mystic Seaport for Educators  
Science on the 38<sup>th</sup> Voyage of the *Charles W. Morgan*  
Lesson 5 of 6: The Whale Pump  
Teacher Worksheet

Name: \_\_\_\_\_

Questions:

1. Figure 1 shows a model of the whale pump created by scientists Joe Roman and James J. McCarthy. Use this figure to answer the questions below. *This question addresses MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem, and MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*

- a. If whale populations decline, will nitrogen in the surface waters increase or decrease? Circle one.

Students should circle “decrease.” Fewer whales will decrease the amount of nitrogen recycled to the surface.

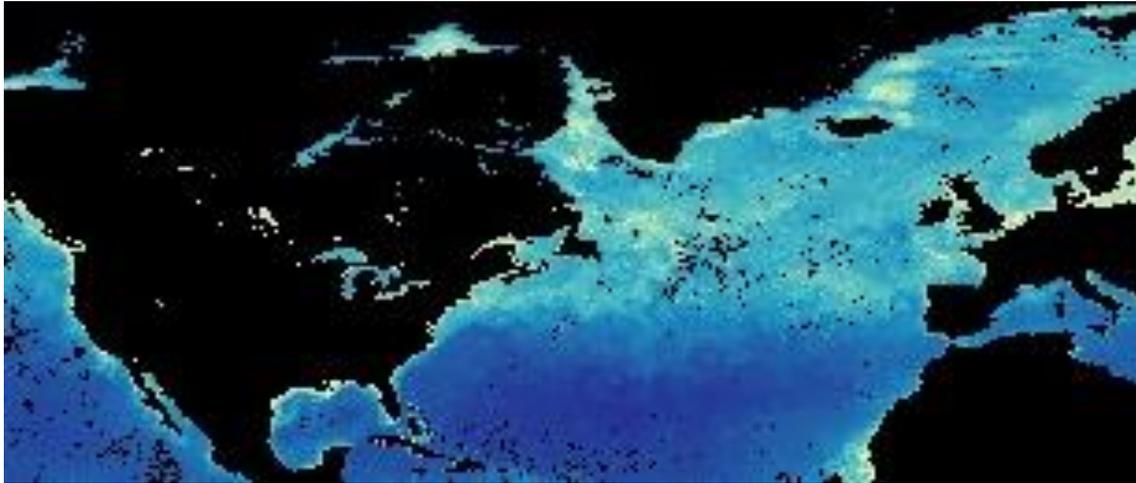
- b. What indirect effect will a decline in whale populations have on plankton? Explain your reasoning.

Students should recognize that with a smaller supply of nitrogen at the surface, plankton will not be able to photosynthesize and grow at the same rate. Therefore, populations of plankton will also eventually decline. Some students may note that fewer whales will result in fewer predators for the plankton; however, the emphasis in this question is on the indirect effect of a decline in whale populations.

- c. Plankton produce 4% of the oxygen that we breathe and remove carbon dioxide from the air when they photosynthesize. If plankton populations decline, there will be **more/less** (circle one) food for whales and **more/less** (circle one) carbon dioxide in the atmosphere.

There will be **less** food for whales because of the decline in plankton populations and **more** carbon dioxide in the atmosphere.

2. Areas of the ocean that are highly productive, or have “high primary productivity,” possess large numbers of photosynthesizing phytoplankton, which in turn feed zooplankton and fuel the rest of the food web. The image below shows primary productivity (shown in lighter shades) in the North Atlantic in May, 2016. *This question addresses MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem, and MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*



May, 2016 (Source: NASA)

- a. Where would you expect to find whale species on this map – in areas of high or low primary productivity? Why?

Students should expect to find whale species in areas of high primary productivity. Higher levels of primary productivity indicate a greater density of phytoplankton and therefore zooplankton, a primary food source for many whales.

- b. The Gulf of Maine is located in the northern Atlantic Ocean. Circle this area on the map.
- c. **Challenge Question:** Scientists Joe Roman and James J. McCarthy found that the “whale pump” in this region is more active in the summer and spring. Does this result make sense? Explain your reasoning.

A complete answer to this question requires two components. First, the students should recognize that there is a large amount of sunlight in these seasons in the northern Atlantic, according to the image. This results in higher primary productivity and therefore more waste that is transported downward by the “biological pump”. Second, the higher density of phytoplankton and zooplankton attract a greater number of whales to the area to feed and excrete waste at the surface, thus recycling the nitrogen transported by the “biological pump.”