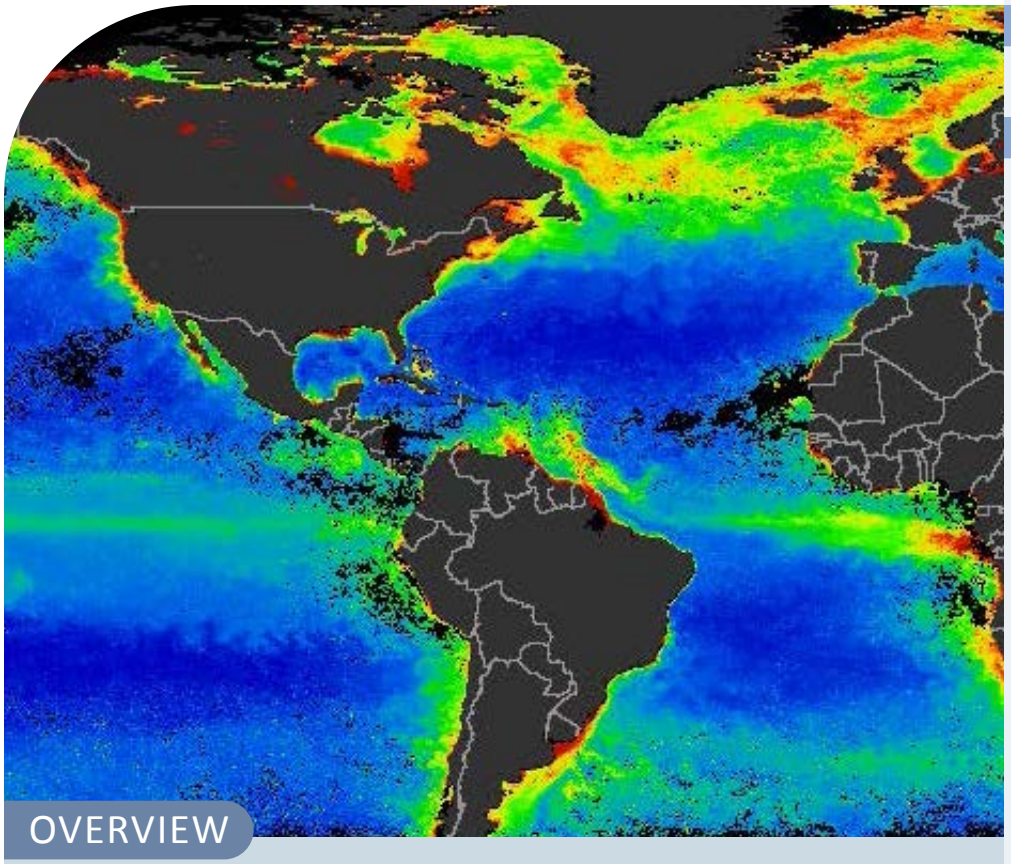
Ocean Productivity



ACTIVITY TIME

90 minutes

LEARNING OUTCOMES

- Explain how ice algae and spring blooms affect overall productivity.
- Compare and contrast the seasonal productivity of an open ocean in the arctic, a polynya and a warm-water ocean.
- Explain the technology that is used to study these habitats.
- Graph and analyze data from logarithmic scales.

OVERVIEW

WHY?

Phytoplankton are vital to the marine food web and the overall health of the planet. They are the biggest source of oxygen for earth's inhabitants as well as a primary indicator for climate change.

WHAT?

1. The role of phytoplankton in supporting the food web
2. Logarithmic scales determining the activity of phytoplankton
3. The ways phytoplankton indicate climate change and events affecting the oceans

HOW?

- Watch a video
- Review Background section
- Complete a graphing activity
- Share results among the class
- Discussion Questions
- Phytoplankton video in the Amazon (Optional)

CONTENTS

RESOURCES

NASA phytoplankton video
5 minute video with good visuals which describes the importance of phytoplankton
https://arcticeider.com/links/ocp07

Monthly Ocean Chlorophyll a Concentration Maps
Maps showing the chlorophyll concentration of the earth's oceans on a monthly basis over the course of a year. Student use this in the main activity. It is included in the teacher guide and more copies can be printed from this link.
https://arcticeider.com/links/ocp09

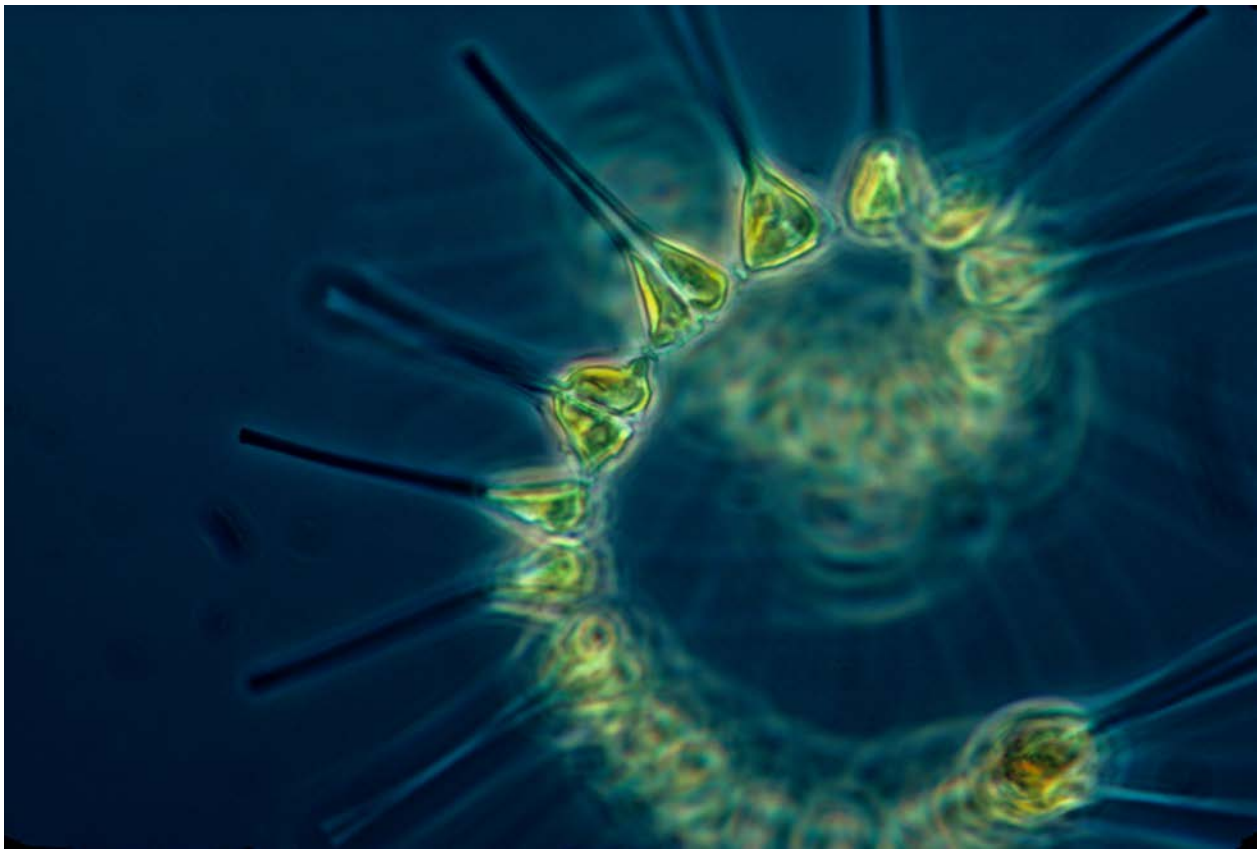


IMAGE 1 Phytoplankton - the foundation of the oceanic food chain. (NOAA MESA Project)

BACKGROUND

In the oceans, the main primary **producers** are **algae** rather than the vascular plants we see on land. Since sunlight is required for photosynthesis, algae and seaweeds can grow only in shallow waters where sunlight can reach the ocean floor. Free-floating algae, however, can grow anywhere in the ocean, as long as they have access to sunlight, carbon dioxide, water, and required nutrients like nitrogen and phosphorus. In many marine systems these nutrients are the limiting factor, because they settle to the bottom, below the **photic zone**, or depths at which photosynthesis can occur. Consequently, oceans with strong upwelling (vertical movement in the water column) are some of the most productive areas because these nutrients are returned to sunlit surface waters. The polar oceans tend to have lots of upwelling and nutrients are brought up from the sediment at the ocean bottom, enriching the surface layer. However, for long periods of the year, sunlight is lacking. When the ocean is frozen, very little light can penetrate the snow and ice to the water below. Even in **polynyas**, which may remain ice-free all winter, photosynthesis cannot occur because there may be little or no light for months at a time.

Primary production in polar oceans tends to be very seasonal. There is almost no primary-producer growth for many months through the winter, and then rapid growth in the spring and early summer. In the

IMAGE 2 These unicellular algae can live in the lower part of sea ice during the winter. They grow within little channels in the sea ice called brine channels and are released into the water column with the melting of the sea ice in the spring. (NOAA)

VOCABULARY

Algae: Simple photosynthetic, autotrophic organisms; may be unicellular, colonial or multicellular.

Biomass: The mass of living organisms in an area, often an estimate.

Chlorophyll a: A green pigment found in the chloroplasts of plants and algae; functions in the conversion of solar energy to biochemical energy.

Consumer: An organism that obtains food by eating other organisms or their by-products.

Photic zone: The upper layer of the ocean, where sufficient light penetrates for photosynthesis to occur.

Phytoplankton: Plankton that are capable of photosynthesis.

Plankton bloom: A rapid increase in the numbers and density of plankton, usually algae.

Polynya: An area of open water surrounded by sea ice; often remains open throughout the winter.

Primary production: The production of organic compounds from carbon dioxide, mainly by photosynthesis.

Producer: An autotroph, usually photosynthetic; collectively, producers form the trophic level that supports all other levels.

Proxy: In ecology a measurement used as an indicator for something else.

Spring bloom: A sudden and strong bloom of phytoplankton that usually occurs in temperate and subpolar waters.

Arctic Ocean, there are generally two main pulses of primary production each year. The first occurs when the snow and ice begin to melt. Especially adapted ice algae, which are able to photosynthesize at very low light levels and temperatures, begin growing quite early in the spring when most of the ocean is still covered by sea ice. Over the course of the winter, these algal cells and nutrients, which were trapped in the ice when it froze, slowly migrate down through the ice to the lower surface. This is where the ice algae grow in the spring, providing an important early food source for primary **consumer**s in arctic sea ice ecosystems.

The second pulse of growth occurs in early summer, as the ice melts further and starts to break up. In the open water, the spring **plankton bloom** of **phytoplankton** (floating algae and other autotrophs) begins. Polynyas, which remained ice-free all winter, provide areas where the **spring bloom** can get a 'head start' as soon as sunlight is sufficient to support photosynthesis. With abundant nutrients and long hours of daylight, phytoplankton growth is extremely rapid in the short polar summer.

Marine primary producers are amazingly efficient. They are responsible for almost half of total global primary productivity yet make up only 0.2% of the **biomass**. As all other organisms in an ecosystem depend on the ability of primary producers to convert light into food, measuring primary productivity in the oceans can tell us a lot, not only about the photosynthesizing algae, but also about the distribution of marine life in general. In this activity, students will use maps of global marine primary production to create graphs that illustrate the annual fluctuations in primary productivity in different parts of the oceans.

Marine primary production is estimated from satellite images that measure the concentration of **chlorophyll a** in surface waters. The level of chlorophyll a is used as a **proxy** to indicate how much photosynthetic activity is occurring. Tropical ecosystems tend to have a fairly constant and comparatively low rate of photosynthesis. This is because there is a little upwelling and nutrients from deep waters rarely mix with the very warm surface waters. This differs from the nutrient-rich waters of arctic ecosystems where upwelling is common.

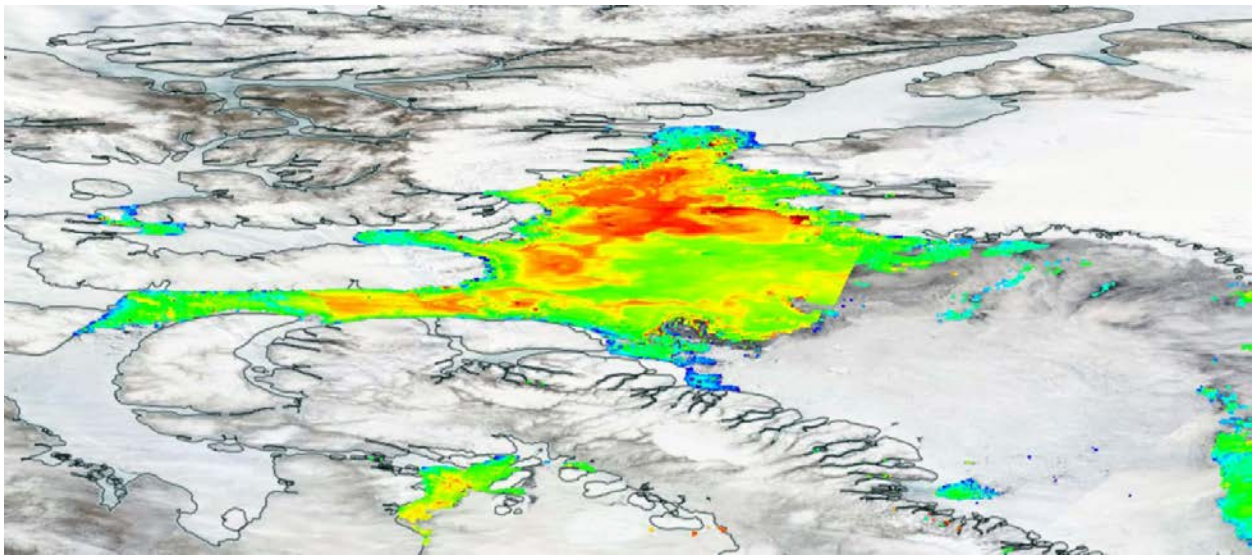


IMAGE 3 A close up visualization of the primary productivity, as measured using a logarithmic scale, of the Northwater Polynya and Lancaster Sound on June 14, 2016. (D.Fuglestad)

WORKSHEET

1. Choose 1 of the 3 locations on the Monthly Ocean Chlorophyll Concentration Maps (pg. 2).

   A. Northwater Polynya
   B. Davis Strait
   C. Indian Ocean

2. For each of the 12 months, use the logarithmic scale to estimate the Chlorophyll concentration value for your chosen location.
3. Record your value in *Table 1*.

Month			
Jan			
Feb			
Mar			
Apr			
May			
Jun			
Jul			
Aug			
Sep			
Oct			
Nov			
Dec			

TABLE 1 Using the Chlorophyll a concentration maps, record the logarithmic chlorophyll concentration values for each month of your chosen area.

4. Plot your data from *Table 1* on *Figure 1*.

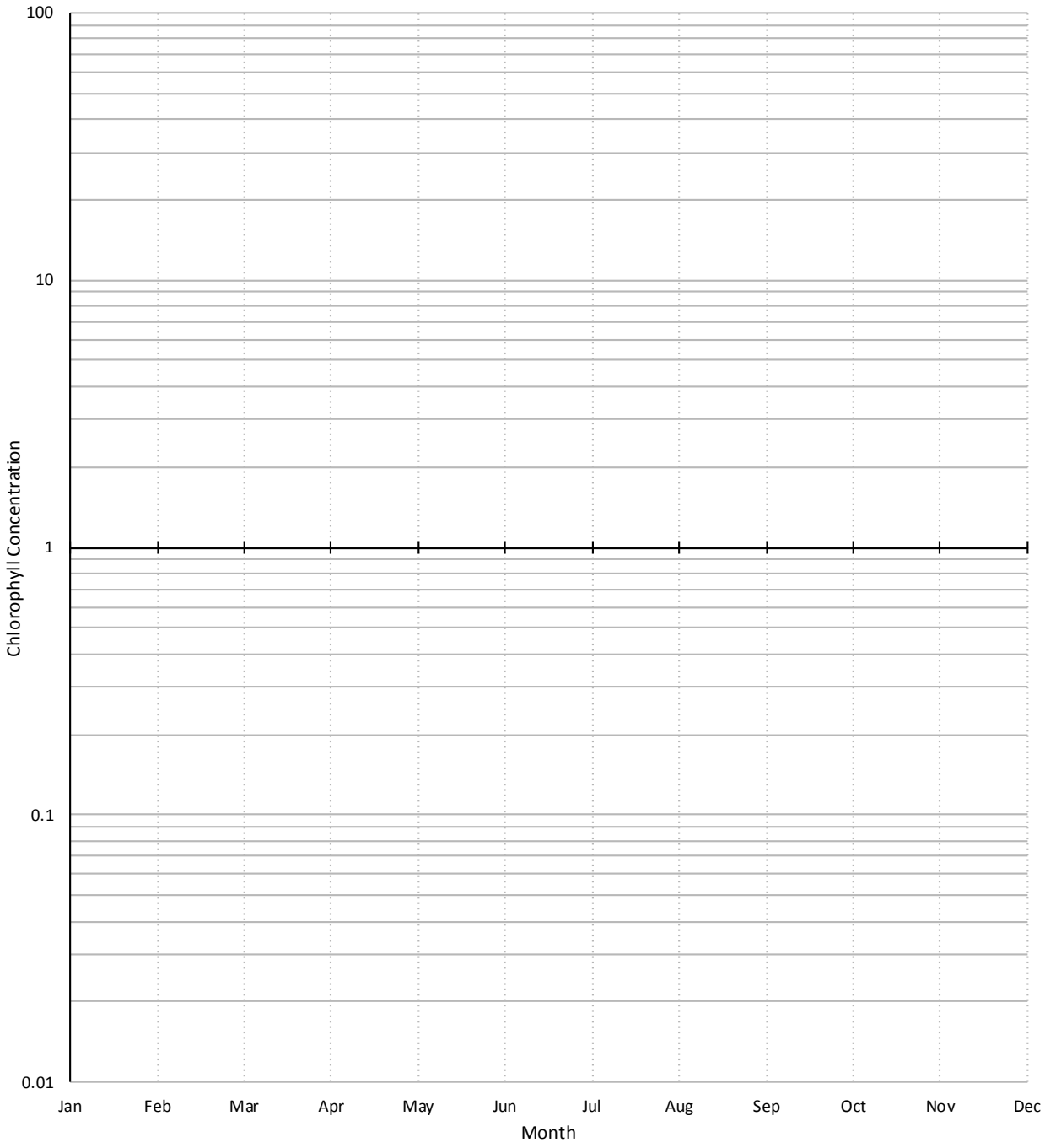


FIGURE 1 Plot your chlorophyll a concentration values onto this logarithmic graph.

DISCUSSION QUESTIONS

1. How does phytoplankton indicate climate change?

2. How does sea ice influence primary productivity in arctic marine environments?

3. How are the graphs for the locations different? Similar? Why?

4. Discuss the different annual patterns of primary productivity (slow/continuous, rapid/pulse) and the implications these have for consumers. Why do so many bird and whale species migrate to the Arctic during the summer and return to tropical areas in the winter?