Unit I Antarctic Ecology

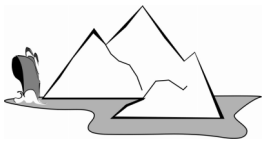
On the cutting edge….
Antarctica is the most extreme continent in terms of climate and topography. The land and water habitats present challenges for the plants and animals that live there. Scientists from the University of South Florida hope to gain a better understanding of some of the Antarctic ice and water food webs by studying the pelagic fish and their adaptations. They want to use this information to study the human impact on this unique ecosystem.

Antarctic Ecology I

Lesson Objectives: Students will be able to do the following:
- Describe an Antarctic ecosystem
- List three ways ice is used as a habitat
- Explain the importance of ice algae in the Antarctic food chain

Key concepts: Southern Ocean, Antarctic Convergence, Antarctic Circumpolar Current, food web, ecosystem, biomass

Antarctic Region



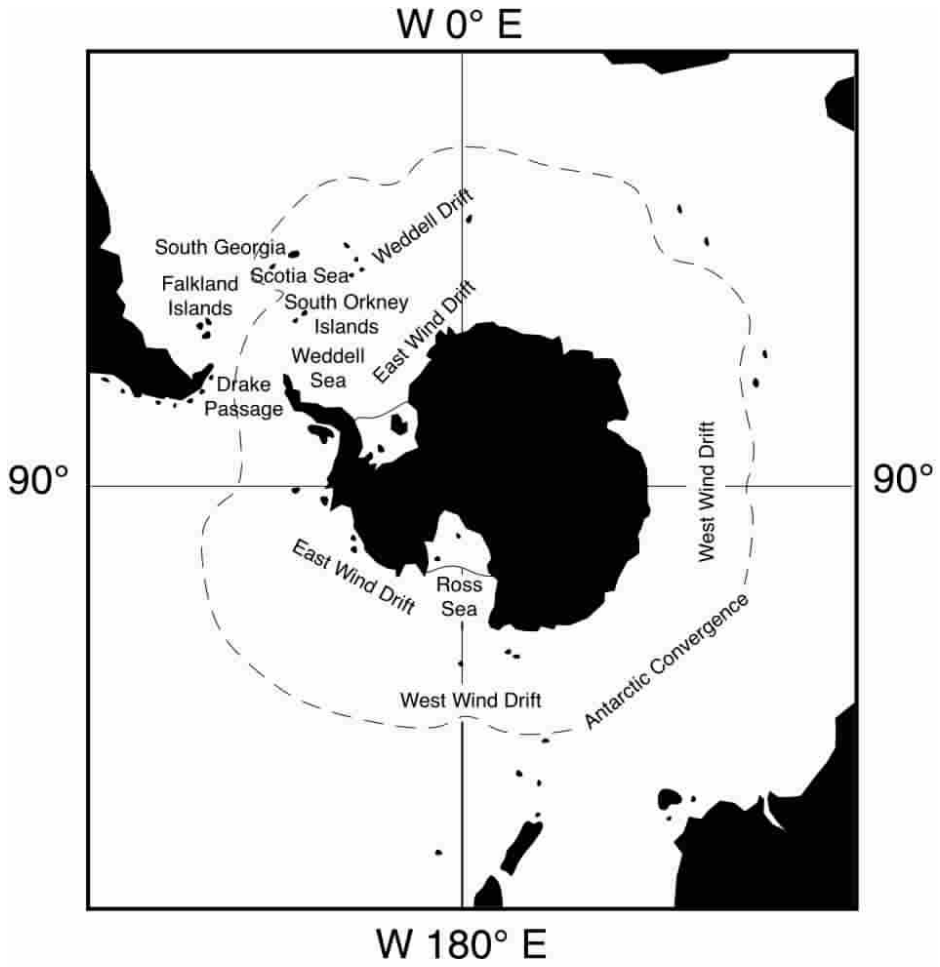
The Antarctic region includes a continent that covers the southern pole and the water that surrounds it. The landmass itself has been separated from the other continents for millions of years and has been gradually cooling to its present temperature. It is a land of extremes, containing high mountain ranges and interior deserts that are subjected to profound changes in day length and seasonal temperatures. This environment is influenced by intense changes in climatic conditions that affect the physical components of the ecosystem and the organisms that live there. The extremes of this continent have allowed only a few types of organisms to live successfully upon this landmass.

The Antarctic land mass is surrounded by the **Southern Ocean**. It is considered one of the most hostile oceans because of its high winds and churning seas. The southern boundary of this ocean is the continental landmass with its narrow **continental shelf** dropping off abruptly in some areas to depths up to 1500 feet. The northern boundary is 60° south latitude. The true Antarctic ecosystem includes all of this area extending to the **Antarctic Convergence**.

The Antarctic Convergence, located in the vicinity of 50° south latitude, is actually a front or a place where

water masses of different temperatures meet. In this case, the colder surface water flowing north meets warmer water flowing south. Since the density of water increases as the temperature decreases, the denser cold water sinks beneath the warm water creating a thin icy bottom layer covered by a warmer surface layer. This provides a nutritionally rich feeding zone.

The **Antarctic Circumpolar Current**, or West Wind Drift, carries surface water from west to east around the continent. This current, affected by land mass shape and ocean **topography**, creates an irregularly shaped zone of water with unique properties. The mixing of water both vertically and horizontally sets up a thermal barrier that isolates the Antarctic ecosystem. This thermal barrier results in many **species** that are unique to the Antarctic.

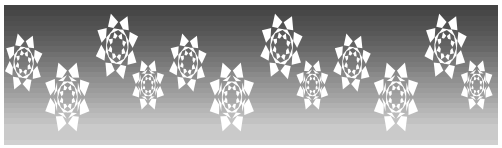


Antarctica and the Surrounding Waters
Adapted from R. M. Laws (1985)

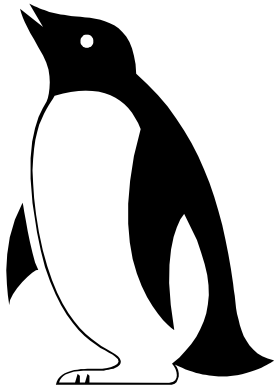
Ice and Water as a Habitat

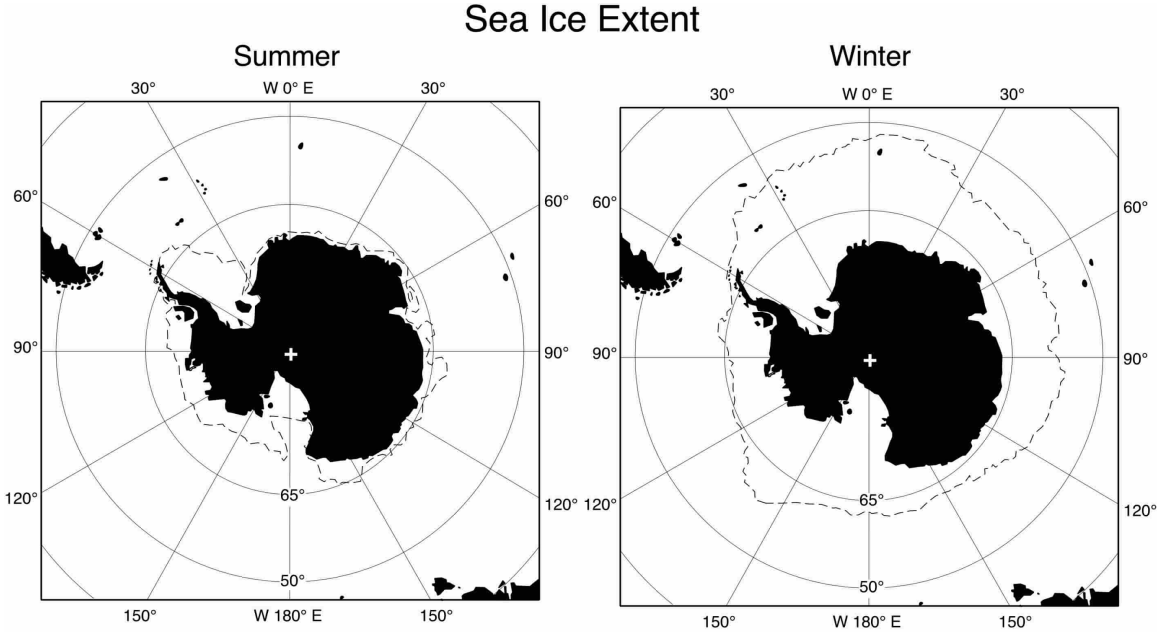
Most organisms in the Antarctic make their homes in the marine component of the environment that is greatly influenced by the amount and extent of sea ice. Seasonal changes influence the sea ice **habitat** in a couple of ways. During the Antarctic winter temperatures plunge as the sun stays below the horizon causing twenty-four hour darkness in some areas. This severely limits the growth of the microscopic plants found at the base of the Antarctic food chain. Also during the winter, a portion of the ocean surrounding the continent freezes into a large ice pack that doubles the size of the continent. At its maximum extent, this ice pack covers an area one and a half times the size of the United States. The swelling and shrinking of the Antarctic pack ice is the largest seasonal process in the world ocean and is key in the life cycles of the organisms that live there.

During the Antarctic winter, the surface of the water cools to –1.86 degrees centigrade. At this temperature the seawater begins to freeze, leaving behind the salt as **brine**. During the freezing process, some plankton may become trapped in the ice as it grows into larger and more solid forms. At this point the ice is called **pancake ice** because it resembles stacks of pancakes. As the pancake ice melds together, some of it forms solid chunks called **pack ice**. The floating pack ice, responsible for the change in size of the Antarctic continent, provides three different types of habitat for animals adapted to exploiting this environment. Tiny **plankton** can live within the pack ice. Seals, penguins, and flighted sea birds can use it as a floor. Additionally, it forms a roof over animals swimming in the water.



What are the implications of all of this ice? First remember that the ice is covering the surface of the ocean and floating from place to place helping to cool the atmosphere above and insulate the ocean below. Thick ice prevents sunlight from penetrating the water while moving ice crushes against the landmass causing topographical changes. All of this ice provides extensive habitat as it freezes and thaws throughout the seasons.





The shaded area represents the Antarctic Continent. The area between the broken line and the continent is the region covered by sea ice. This figure is adapted from satellite passive microwave images of Antarctic sea ice as reported by Zwalley et al. (1983).

The Importance of Ice in Antarctica's Ecology

Energy is transferred through every **ecosystem** in the form of food. Whether organisms are **producers** or **consumers**, the acquisition of food is necessary for life. This energy flow can be represented by **food chains**, **food webs** or **food pyramids**.

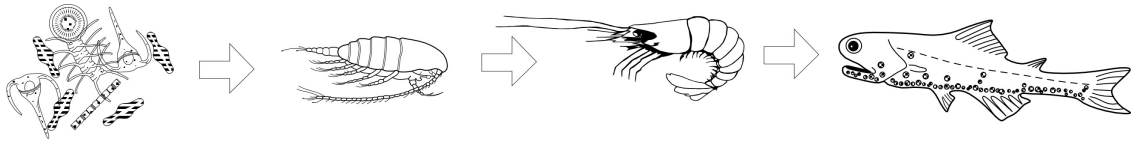
In addition to the **biotic** factors affecting the energy flow through a system, the **abiotic** factors also contribute to the distribution of the **biomass**. In the Antarctic the life cycles of many animals are tied to the Antarctic pack ice.

The **ice algae** form the base of the food chain. They can be found free living in the water or at the bottom of the ice. Other organisms in turn respond to the cycle of algal growth associated with the change in seasons. During the summer, the algae are abundant; but in the transition seasons of fall and spring, the algae seem to be found only in conjunction with the **sea ice**. This phenomenon affects the abundance and distribution of organisms further up the food chain that utilize these algae.

The Antarctic **krill**, a distant relative of the shrimp you eat, is an important link in the energy transfer in the Antarctic ecosystem. They eat the ice algae and are in turn eaten by

animals further up the food chain including fish, seals, and penguins. They are associated with the ice edge throughout their life cycle. The young krill use the underside of the ice as a nursery area. It affords them protection from **predators** within its many cracks and crevices, as well as abundant food in the form of ice algae. In late winter, with limited food available, the older krill also feed upon the ice algae. Their population distribution and size are tied to the amount and extent of the sea ice.

The fish species that feed upon the krill also have to be able to tolerate the temperatures associated with the sea ice. Some of these Antarctic species, such as the ice fish, have developed biological antifreezes that circulate in their blood and prevent ice crystals from forming in the blood stream. Many of these species also use the pack ice as a hiding place to avoid the penguins and seals that use the sea ice as a hunting platform.



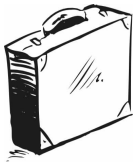
PHYTOPLANKTON COPEPODS KRILL LANTERNFISH

Activity: Antarctic Adventure

Antarctica is a land of extremes. It is the coldest and driest place on earth. It is also isolated from the other continents by a great expanse of water. Researchers visiting the Antarctic need to be prepared to stay for long periods of time isolated from the other parts of the world. They have to pack everything they will need for their personal use and scientific research for several months.

Objectives: Students will be able to do the following:
1. Interpret information pertaining to the Antarctic.
2. Use this information to develop an appropriate packing list for a four month stay in the Antarctic.
3. Design traveling gear to hold necessary items.

Materials:



- Paper
- Pencil
- Colored pencils
- Current newspaper articles or other reference materials
- Internet access (optional)

Procedure:
1. Make resource materials such as newspaper articles and books available to students. The following Internet sites also contain great information:
   http://www.marine.usf.edu/icestory2000
   http://www.yourexpedition.com
   http://www.blue ice. com
2. Have students read and discuss this material with regard to the necessities for a four-month trip to the Antarctic.
3. In small groups have students categorize the items they would take on this trip.
4. Have students create lists of items in each category.
5. Now tell students that the number of items they are allowed to take is limited.
6. Have individual students prioritize their items and keep them to the limited number.
7. Have students design Antarctic explorer gear to hold their items. Be sure students draw and color a detailed picture, labeling all pockets etc.
8. Have students explain their design and the factors that were involved in their final packing list decisions.
9. Have students compare and contrast what they did in this exercise to decisions made by real Antarctic explorers.

Possible Extensions:

1. Students design outerwear for the trip.
2. Students list the items they would take in just one category, tell how many of each item they would take, and why.
3. Groups collaborate to come up with their design, prioritize, and then finalize their drawing to include the seven (or other number of your choosing) most important items to be included.
4. Groups design gear for a particular person. For instance one group designs gear for a scientist studying pelagic fish, another group focuses on designing gear for the ship's cook. They then compare and contrast items most important for each person.

Student Information: The Antarctic Ecosystem

Imagine a world of ice and water separated from the rest of the continents for millions of years. As the wind blows across the **Southern Ocean**, it chills the air to subzero temperatures. The landmass covering the bottom tenth of the globe is owned by no one. It contains extreme environments subject to rapidly changing weather conditions. Most of the animals adapted to these conditions are found nowhere else on earth.

The Antarctic **food chain** is unique. At the base of the chain, microscopic floating plants called **phytoplankton** are driven with the wind and currents. They need light to **photosynthesize** yet find themselves caught in the ice crystals turning it to a brownish color. Even though encased in ice, phytoplankton are not protected from the microscopic animals called **zooplankton** that are waiting to eat them. The majority of these grazers are **copepods** that look like tiny aliens from outer space flailing their legs and whipping their antennae. These creatures are not safe either because they will be fed upon by the **omnivorous krill**. These tiny shrimp-like creatures swim in giant schools that turn the water red as they pass. They are easily seen by the birds overhead or by crabeater seals that need a meal. The krill are not safe in the water, either, for the treacherous ice fish or lantern fish with their **luminescent** organs and big eyes are ready to feed.

But why do we care about the plight of the phytoplankton, the krill, or even the ice fish? By studying **ecosystems**, we can understand how we are connected to and influence our environment. As more people travel to the Antarctic for scientific research and recreation, the global community needs information so it can decide what to do with this vast resource and how to protect it.