Sea Connections

Some people go whale watching. Some people long to swim with dolphins. Others earn their livelihood fishing for giant tuna in a vast ocean. These marine animals capture our attention and our imagination. We have a connection to all the living things of the ocean, from the microscopic floating plants that supply us with the oxygen we breathe to the huge blue whale that fills its belly with a ton of krill. Microscopic or oversized, plant or animal, from muddy shoreline to deep ocean floor, the ocean's living things attest to its endless variety, its biodiversity. Scientists say that there may be millions more species than we know swimming, floating, and crawling in the deep oceans and as yet unseen by human eyes. With the aid of submersible technology, entire new ecosystems are being discovered. Each ecosystem consists of a community of living things that interact with one another in complex relationships in unique conditions of water temperature, salinity, chemical composition, and currents. Far below the surface of the ocean, where no sunlight reaches, hot water laced with chemicals spews out of cracks in the ocean floor. These cracks (hydrothermal vents) occur most often along the mid-ocean ridge, where Earth's crustal plates are spreading apart. Water reaching temperatures of four hundred degrees Celsius and chemical compounds such as hydrogen sulfide billow out from the vents. At certain vents, as the hot, sulfide-rich water comes in contact with cold seawater, metal sulfides precipitate out. The chemicals pile up into structures that resemble chimneys, which scientists call "black smokers." Scientists have found one black smoker that is as tall as a fifteen-story building. Can living things survive in such a place? The answer is yes. In 1977, scientists aboard the submersible *Alvin*, exploring five thousand feet below the surface of the Pacific, saw large, four-foot-tall tube worms, some with bright red plumes, living around a hydrothermal vent. Later laboratory investigation revealed that the unusual worms had no digestive system but instead contained about 285 billion bacteria per ounce of tissue! In this sunless world, a type of sulfur-loving bacteria was the worms' food source. Clouds of bacteria, appearing white in the lights of the sub, were able to use hydrogen sulfide as an energy source. In most other food chains, plants convert carbon dioxide into food using sunlight during *photosynthesis*. These peculiar bacteria were able to convert hydrogen sulfide into food during *chemosynthesis*. Also found around the vents, feeding on the water rich in chemosynthetic bacteria, were certain kinds of clams and mussels. At this great depth and pressure, some species of octopus prey upon these shelled invertebrates. But when the hot water and chemicals coming from the vent slow down to a trickle, the animals disappear. In the past twenty years, more than three hundred species have been identified in this unique environment. Similar vent organisms have been discovered at the base of the continental shelf, where the ocean water is sulfide-rich but not hot, as in the hydrothermal vents. These "cold seeps," as they are called, illustrate how little we know about the productivity of the ocean bottom. As far as scientists can tell, hydrothermal vents and cold seeps have not yet been affected by human activities. Far away in a tropical ocean is another distinctive marine ecosystem. One in four marine species on our planet lives in a coral reef, an underwater world like no other with its colorful variety of swimming and floating animals making their way among the branching corals. The food chain of the coral reef begins with photosynthetic algae, microscopic organisms that use sunlight to make food. Most of the algae live in harmony within the tiny coral animals themselves. Reef-building corals secrete a hard, stony shell of calcium carbonate that builds up over time and provides the habitat for reef animals. Colorful invertebrates such as the coral shrimp feed on algae and detritus around the coral, where they in turn may become dinner for small fish. Large, sleek, and silvery barracuda patrol the outer reef, preying on smaller fish such as the butterfly fish. However, there is trouble in this paradise: pollution from pesticides, sewage, and soil run-off has damaged many reefs in the Caribbean and Pacific. The practice of dynamite fishing to stun fish and capture them for the aquarium trade has devastated reefs in parts of Asia, the South Pacific, and Africa. Perhaps not as familiar to us is the frigid water of the polar ocean. The food chains of the polar ocean also begin with algae, including symmetrically shaped diatoms with hard silicate shells. Algae are eaten by tiny invertebrate animals, including shrimplike krill. In the ocean around Antarctica, krill are an important food source, eaten by a diverse group of animals including fish, baleen whales, and Adélie penguins. The penguins are in turn preyed upon by leopard seals. The top predator of the Antarctic is the killer whale, which eats penguins and seals. Thus overfishing of krill in polar waters may jeopardize not only krill, but whales, seals, and penguins too. Along more temperate seacoasts, kelp forests form another unique ecosystem. Kelp are brown algae that can grow as much as sixty centimeters in one day, ultimately reaching as long as eighty meters. Tiny crustaceans called copepods are among the animal plankton that feed on the floating algae and detritus in the Pacific along the California coast. Larger invertebrates, such as sea urchins and abalone, graze on the kelp and are in turn eaten by sea otters. The overharvesting of kelp and a decrease in water quality have impaired the productivity of these ecosystems. Discharge from nuclear power plants on the California coast raises the water temperature just enough so that more sea urchins and abalone survive and grow, eating kelp and diminishing the size of kelp beds. Understanding the various marine ecosystems helps us to better understand the important connections among marine organisms and suggests how much we still have to learn about the oceans. This understanding also raises warning flags about the necessity of monitoring human activity to keep these connections from being severed and to protect marine biodiversity.

Sea Connections

Lesson Plan

Objectives

Identify producers and consumers from four marine ecosystems.

Describe the delicate balance among organisms in each environment.

Construct a food chain or web from a marine ecosystem.

List some of the human activities that can upset the balance in marine environments.

Materials

Student Page

Globe or world map

Playing cards to be copied and cut out

Heavy stock paper for photocopying or pasting cards

Scissors

Subjects

biology, geography, oceanography, political science, art

Procedure

1. Motivate students by rapidly spinning a globe and asking them to approximate how much of Earth is covered by ocean. Ask them to think about the variety of marine organisms and habitats that must exist on our watery planet, which is over three-quarters ocean. Then have students locate each of the following on a globe or world map: the Great Barrier Reef in Australia (coral reef); the Weddell Sea, Antarctica (polar ocean); Monterey Bay, California (kelp forest); and the Mid-Atlantic Ridge (hydrothermal vent). (If the Mid-Atlantic Ridge is not shown on your globe or world map, approximate its location by connecting Iceland and the Azores with a large letter C, or look at the map on page 11, the Sea Secrets Student Page.)

2. Using the introduction as a guide, describe to your students some of the amazing biodiversity of ocean life, including marine organisms in hydrothermal vents, coral reefs, kelp forests, and polar oceans. Challenge students to match each of the four ecosystems you have described with the correct location on the globe. Ask them to name the producers and consumers from each ecosystem. Producers always begin the food chain and, in the ocean, are generally algae, although chemosynthetic bacteria are the producers near hydrothermal vents. All the other organisms are consumers.

3. In advance, photocopy the three pages of playing cards and paste copies onto heavy stock paper. Cut each sheet into nine cards along the guide lines. Each complete deck will have twenty-seven playing cards and is suitable for a group of up to four players. After cards are cut out they may be laminated or stored in plastic sleeves designed to hold trading cards.

4. Divide students into groups of four or fewer. Pass out a deck of cards to each group and the Rules of the Game Page to each player. Read through the directions together. Make sure that students understand that they will be trying to collect all five cards from one ecosystem in order to see how they connect to each other. Tell students that only five organisms have been chosen from each ecosystem for the game, but that these representative organisms are part of much bigger food webs from each ecosystem. Read through the Disconnect and Reconnect cards to make sure students understand how they are used in the game.

5. As students start playing, circulate among the groups. As a player is carrying out the directions on a Disconnect card, have that student explain to you the relationship of the organisms within that ecosystem and tell in his or her own words the impact of the card.

6. As a student from one group wins, you might interrupt play to let that student describe the winning hand to the class. Use this as a jumping-off point to talk about how food chains and food webs connect the producers and consumers in an ecosystem. As the students resume playing, tell them that the winner from each group should lay out the winning cards to form a food web for other players to see. Then they can divide and trade the remaining cards so that each player has all five cards of one ecosystem—a winning hand.

7. Ask students to fill in their charts using their cards. Spot check the diagrams of each marine ecosystem. Student food chains and food webs should show a pattern of producers first, then primary consumers (those that eat producers directly), followed by predators. If students use arrows to connect the organisms, the arrow's point should mean "eaten by."

8. When students have finished their pages, discuss which of the Disconnect cards prevented them from winning. This can lead to a discussion of the international problem of overfishing. Explain to students that when too many people haul their fishing nets and cast their lines in the same waters, too few fish are left to reproduce. In addition, some fishing grounds have become polluted, so the overall result is a dramatic drop in the fish population. The overfishing problem is so great in some areas that the government has to limit or halt fishing until certain populations recover. Among those on the "hardest hit list" are the Pacific king crab and the Atlantic

cod and haddock. In 1991 the American Fisheries Society announced that about half the nation's stock of salmon was at risk. Even the mighty bluefin tuna, which can weigh fifteen hundred pounds and swim as fast as a speeding car, is down to only 10 percent of its 1980s population.

Commercial fishing practices of the past have also harmed nontarget species. In some places enormous driftnets up to sixty kilometers long were set over huge areas of ocean. The fine filaments would catch thousands of fish by the gills, but many other animals would get caught, too. Turtles, birds, sharks—even whales and dolphins—drowned in these nets. Loud cries from conservationists and governments brought about a ban on these driftnets, although shorter nets are still used close to shore. Other fishing gear still in use catches and kills young fish and other unwanted animals by mistake.

9. Ask students to imagine that they make their living catching fish, as some of their parents and grandparents did. Ask them to think about how they would feel if the government set a limit on their catch. Their first reaction might be to the loss of income; however, over the long term they should be concerned with finding ways to prevent the disappearance of the species.

10. Ask students if they've ever played the card game Go Fish. Then ask them why the game they have just played could be called Don't Go Fish. They might answer that overfishing causes the reduction or loss of desirable and profitable species of fish and shellfish. It also disturbs the delicate balance of producers and consumers in each marine ecosystem. The purpose of the card game is to show how both natural events and human activities, such as overfishing, can disturb this balance and break the links that connect species in an ecosystem.

Sea Connections—Sample answers to food webs

Kelp forest

kelp → copepod
kelp → sea urchin → sea otter
kelp → abalone → sea otter

Hydrothermal vent

chemosynthetic bacteria → tube worms
chemosynthetic bacteria → vent clams → octopus
chemosynthetic bacteria → vent mussels → octopus

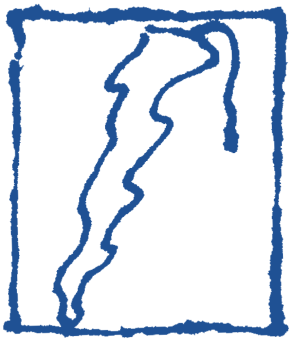
Coral reef

algae → staghorn coral
algae → coral shrimp → butterfly fish → barracuda

Polar ocean

algae → krill → Adélie penguin → leopard seal → killer whale kf

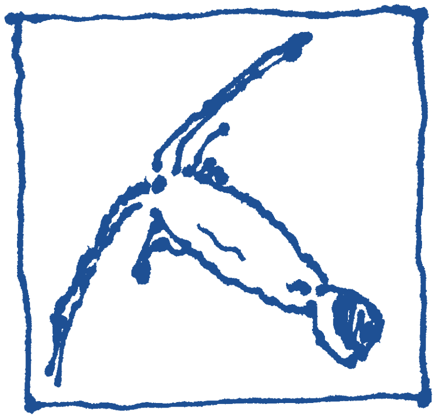
Kelp



produces food

kf

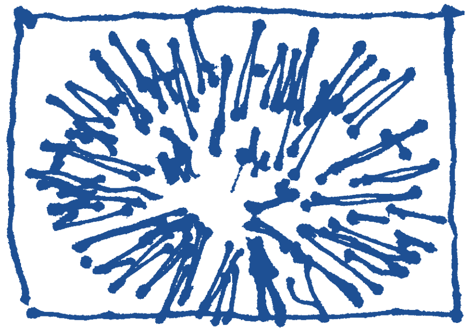
Copepod



eats kelp and other algae

kf

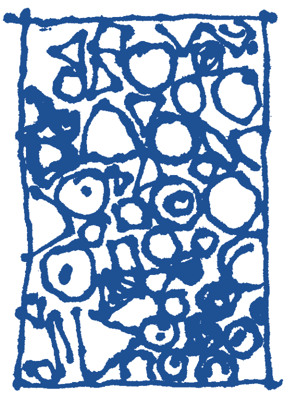
Sea urchin



eats kelp

cr

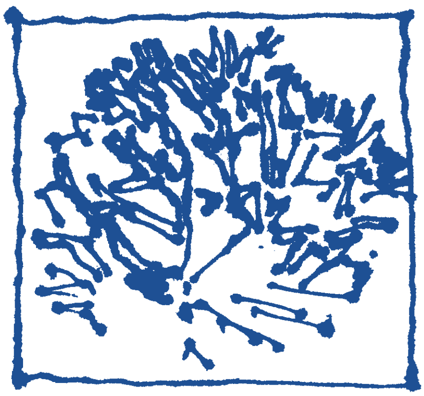
Algae



produce food

cr

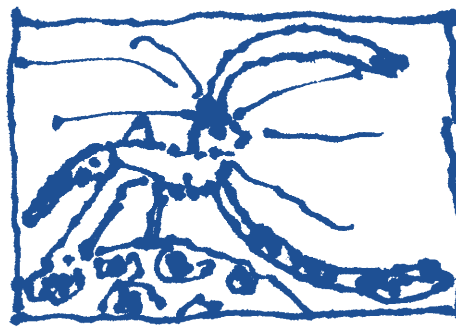
Staghorn coral



feeds on algae, other organisms

cr

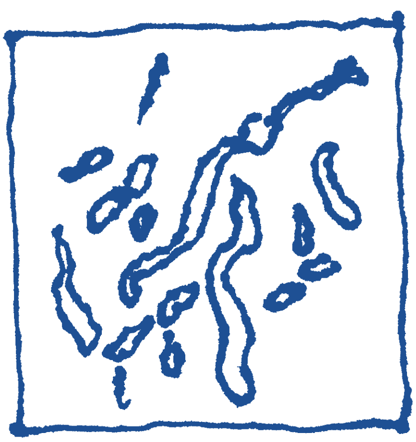
Coral shrimp



feeds around coral

hv

Bacteria



produce food from chemicals

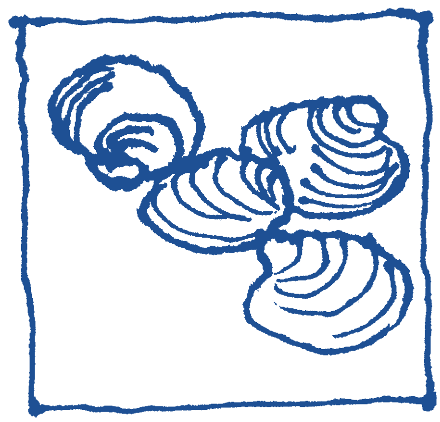
hv

Tube worms

feed on bacteria

hv

Clams



feed on bacteria

kf

Abalone

eats kelp

kf

Sea otter

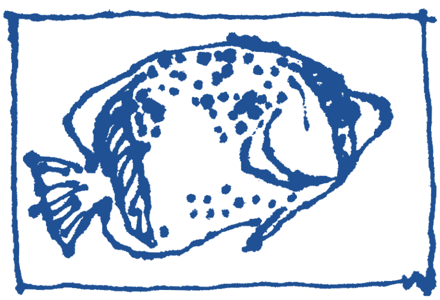
eats sea urchins and abalone

Disconnect

Kelp over-harvested!
Too much kelp has been harvested for use in industry. If you have any kelp forest cards, lose your next turn until the kelp forest recovers.

cr

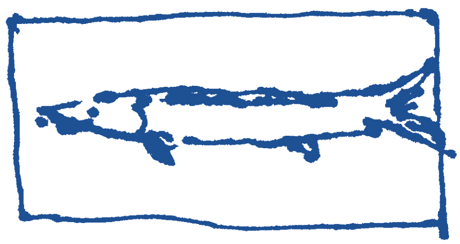
Butterfly fish



feeds around coral

cr

Barracuda



eats other fish

Disconnect

Blast fishing!
Dynamite blows up a coral reef. Coral is destroyed and the fleeing fish are captured. If you have any coral reef cards, discard them and take new ones.

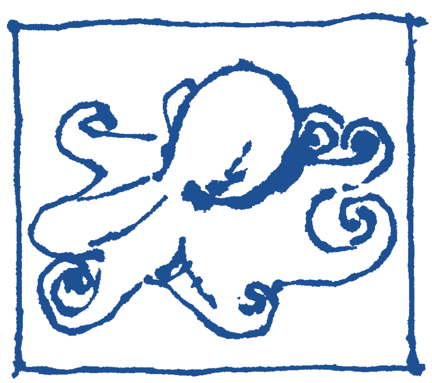
hv

Mussels

feed on bacteria

hv

Octopus

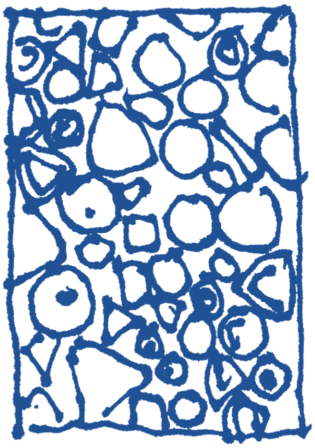


eats clams and mussels

Disconnect

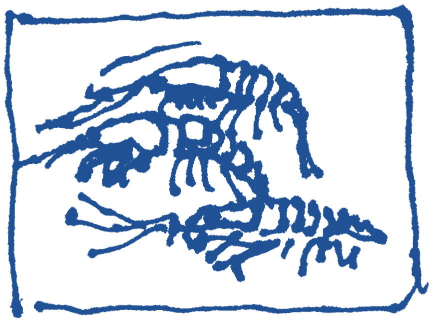
Smoker stops smoking!
A smoker stops spewing hydrogen sulfide. Few bacteria survive. The entire food chain is affected. If you have any smoker cards, keep them, but you lose your next turn.

Diatoms



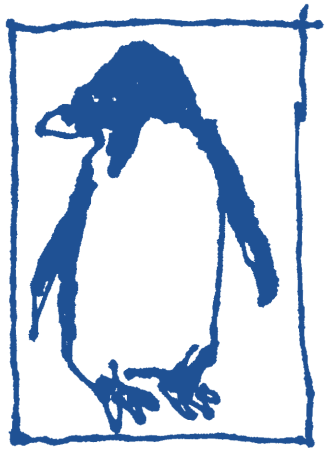
make food

Krill



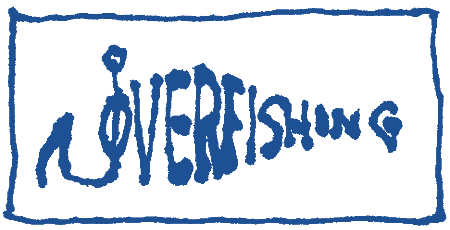
eat algae

Adélie penguin



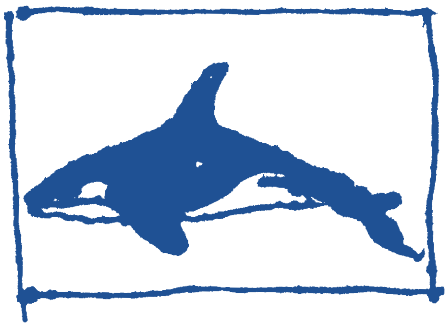
eats krill

Disconnect



Overfishing of krill!
As a result, whales, penguins and seals are also in danger. If you have any polar ocean cards, discard them and take new cards.

Killer whale



eats penguins and seals

Leopard seal

eats Adélie penguins

Disconnect

Ocean pollution!
Pollution from pesticides, and sewage harms all ecosystems. Whatever cards you are collecting, you lose two turns until the ocean recovers.

Reconnect

Good news!
Because of international agreements on overfishing, give the player that went before you a needed card from your hand. Ask for and receive one card that you need from any other player.

Reconnect

Good news!
Because of international agreements on overfishing, give the player that went before you a needed card from your hand. Ask for and receive one card that you need from any other player.

Sea Connections Student Page

In Sea Connections,
you and your team will play a card game. The playing cards represent some of the plants and animals that are connected together in the food webs of four very different marine ecosystems. The cards show how these ocean producers and consumers depend on one another. The objective of the game is to collect all five cards from one ecosystem. What will get in your way are Disconnect cards. These cards describe events that harm ocean ecosystems and interrupt the connections among the living things that are found there.

Rules of the Game

1. Decide who will be the dealer in your group. The dealer shuffles the pile and deals each player five cards face down, then places the remaining cards in a pile face down. The dealer turns the first card up next to the rest of the deck to start a discard pile.

2. Group your cards by the icon in the top left corner. The icons represent:

- kf — kelp forest
- cr — coral reef
- hv — hydrothermal vent
- po — polar ocean

The object is to collect five cards in one suit, which will include all the animals and plants from one ecosystem. For example, if you were dealt two cards from the coral reef, you may wish to collect all the cards from that ecosystem. (There are four suits, so each player should be trying to collect a different suit.)

3. When it is your turn, pick up the top card from the pile. If you don't need it, place it face up on the discard pile. If you wish to keep it, discard a different card from your hand. If you pick up a Disconnect card, use it during that turn. If you are dealt a Disconnect card, use it during your first turn. If you are dealt more than one Disconnect card, use one at each turn. You may use a Reconnect card at any time. Make sure that you finish each turn with five cards.

4. If the player before you discards a card that you want, you may pick it up instead of drawing from the face-down pile.

5. The first person to collect five cards in one suit wins. If no one wins the first time through the deck, the dealer shuffles the cards in the discard pile and you continue playing.

Sea Connections Data Chart

What suit did you collect?

What are the some of the living things found in this marine ecosystem?

Draw a food chain or food web that shows how the producers and consumers in this ecosystem are related. Use arrows to mean "eaten by . . ."

Resources

Online resources

Visit Ocean Planet online at **http://seawifs.gsfc.nasa.gov/ocean_planet.html**

Using the Exhibition Topic Outline, choose Ocean Planet Marine Life Facts, Creatures of the Thermal Vents, The Living Reef, and Aliens Among Us (under Educational Materials in the Ocean Planet Floor Plan); and Threatened Habitats and Fishing Issues (under Oceans in Peril). Click on “Resource Room” to link to such resources as the Electronic Zoo.Visit the Marine Biodiversity Sculpture (under Ocean Science) or use the Image Catalog (under Resource Room) for photographs of organisms from each of the marine ecosystems mentioned in the preceding activity.

Resources for students

Brower, Kenneth. *Realms of the Sea*. Washington, D.C.: National Geographic Society, 1991.

Cerullo, Mary M. *Coral Reef: A City That Never Sleeps*. New York: Cobblehill Books, 1996.

Charton, Barbara. *The Facts on File Dictionary of Marine Science*. New York: Facts on File, 1986.

Fodor, R. V. *The Strange World of Deep-Sea Vents*. Springfield, New Jersey: Enslow Publishers, 1991.

Resources for teachers

Duxbury, Alyn C., and Alison B. Duxbury. *An Introduction to the World’s Oceans*. 4th ed. Dubuque, Iowa: William C. Brown, 1994.

Earle, Sylvia A. *Sea Change, A Message of the Oceans*. New York: G.P. Putnam’s Sons, 1995.