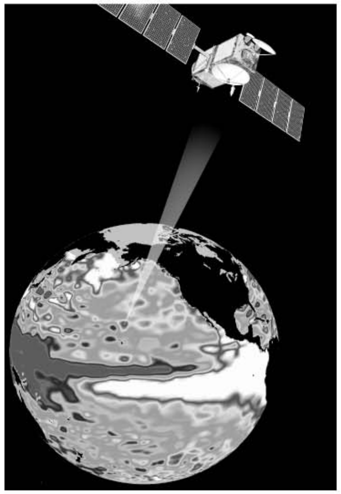
Mapping the Oceans



Unless you spend a lot of time at sea—or flying over it—it's hard to keep in mind that far more of our planet is under water than above water. It's also hard to imagine that the deepest parts of the ocean are far deeper than the highest mountains are high. But it's true! That's a lot of salt water.

A Big Energy Transport System

In addition to all the seaweed, fish, and whales that call all this water their home, the oceans also hold a huge amount of heat. The top 3 meters (about 10 feet) of the ocean contains as much heat energy as the whole atmosphere of Earth (which extends up hundreds of miles).

The water in the world's oceans isn't all the same temperature. In some places, like near Earth's equator, the water soaks up a lot of heat energy from the Sun. In other places, like near the North and South Poles, the water cools off, since not much direct sunlight reaches those places.

Since water flows easily, it moves all around Earth, picking up heat in one place and carrying it someplace else. Moving heat energy in the oceans and atmosphere are the primary causes of weather. Thunderstorms, rain, snow, wind, hurricanes, droughts, hot weather, freezing weather—in a very complicated way the oceans are in charge of them all. For example, "El Niño" is what we call the condition when a lot of warm water gathers in one place in the Pacific Ocean and causes unusual weather in many places all over the world. (See Panel 9 on this poster.)

Because the oceans are so important and so enormous, we use spacecraft in orbit around Earth, as well as ships and buoys, to collect information.

Global Weather Spies in the Skies

To understand weather, we have to understand the oceans and how they move heat around the Earth. Jason-1 is a new Earth-orbiting spacecraft to study the oceans. It was launched December 2001. It continues and expands the data that has been collected by the TOPEX/Poseidon spacecraft, which since 1992 has been orbiting Earth at an altitude of over 1300 kilometers (800 miles).

Jason-1 and TOPEX/Poseidon use *altimeters* (al-TIM-uh-ters) to measure the height of the ocean surface. As the spacecraft flies over an ocean, the altimeter sends microwave signals down to the surface of the water. The signals bounce off the water and back up to the spacecraft. By measuring how long it takes for the signals to bounce back and by precisely measuring the locations of the spacecraft, the altimeter can determine the height of the ocean's surface at that point. Using this information, scientists can create very detailed maps of the ocean surfaces all around the world. Warmer water expands a bit, making the ocean surface higher. Where Jason-1 detects a rise in the ocean surface of 1 centimeter (4/10 inch), the top 50 meters (164 feet) of ocean is 1 degree Celsius (1.8 degrees Fahrenheit) warmer than the surrounding water.

These ocean "hills and valleys" tell us how the heat is moved around the oceans. Large amounts of heat moving from one place to another can affect the weather. More evaporation comes from hot water than from cold water, so with hot water comes increased rainfall. In the Gulf of Mexico, people watch the movement of warm eddies very carefully, because if a hurricane goes over one of these warm eddies, the wind speeds in the hurricane can get even faster!

Jason-1, along with other ocean-observing spacecraft, will help us understand how the oceans change over time and how those changes affect the weather and climate everywhere on Earth.

To learn more:

El Niño: Stormy Weather for People and Wildlife, by Caroline Arnold. Houghton-Mifflin, 1998.

The Jason-1 spacecraft: *http://sealevel.jpl.nasa.gov/mission/jason-1.html*

Oceanography: *http://sealevel.jpl.nasa.gov/education/education.html*

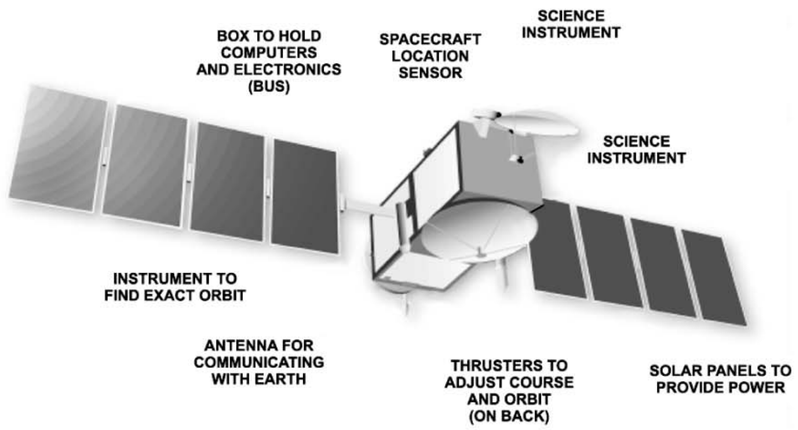
A fun activity about the El Niño condition and how it affects weather: *http://spaceplace.nasa.gov/topex_make1.htm*

An interesting classroom activity about how the Global Positioning System satellites work to enable Jason-1 always to know exactly where it is: *http://spaceplace.nasa.gov/teachers/jason_gps.pdf*

NASA Space Link, a comprehensive electronic library of information related to NASA's aeronautics and space research: *http://spacelink.nasa.gov*

NASA's Earth Science Enterprise: *http://www.earth.nasa.gov*

Activity: Build Your Own Jason-1 Spacecraft



Jason-1 has a lot of work to do! Here are some of its tasks:

- Measure changes in ocean circulation that affect our climate and weather.
- Forecast El Niño and La Niña events.
- Provide information on ocean currents to container ships, cable-laying ships, and racing yachts.
- Provide information to help predict wind strengths of hurricanes.
- Measure changes in sea levels (part of the effort to understand global changes).
- Help marine scientists understand ocean habitats and locations preferred by whales and other marine organisms.

Most spacecraft that orbit Earth (also known as satellites) have some things in common. Like Jason-1, most have a "bus" that contains the computer and electronics, a source of power, instruments to gather science information, communications antennas, small rockets called thrusters (for moving the spacecraft), and equipment for accurately locating the spacecraft. There are many other parts, but these are some of the basic ones.

Materials to Build Your Model Jason-1:

1 juice box (spacecraft bus)
1 Popsicle stick or a chopstick (solar panels)
Aluminum foil or other shiny paper (covering for solar arrays and the bus)
Egg carton (for antennas)
Fishing line or string (to hang satellite in space)
2 cotton swabs (for the Global Positioning system and other antennas)
4 push pins (thrusters on the bus)
Duct tape, transparent tape, or adhesive poster tac for attaching parts
Stiff paper (solar panels)
Scissors

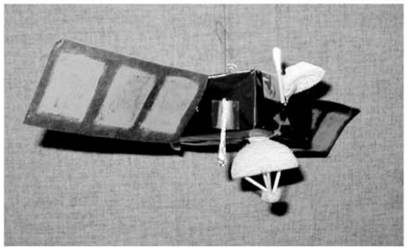
Note: Other materials may be used to make a more realistic-looking model.

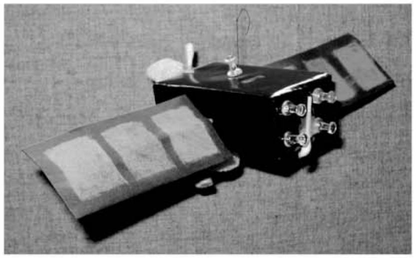
Instructions:

Note: As you construct your model, use the picture of Jason-1 as a guide.

1. Wrap an empty juice box (your spacecraft's bus) with aluminum foil or some other reflective material. This wrapping represents the space blanket that keeps the spacecraft warm.
2. Make small slits in the middle of the narrow sides of the empty juice container. Slide a Popsicle stick through the box so it sticks out equally on each side.
3. Tape a small piece of stiff paper about 5 centimeters (2 inches) wide by 7.5 centimeters (3 inches) long to each end of the Popsicle stick. Color the paper with crayons or cover the paper with foil to represent the spacecraft's solar arrays.

Activity: Build Your Own Jason-1 Spacecraft (cont'd)





On this model of the Jason-1 spacecraft, foil gift wrap was used to wrap the "bus," solar panels are constructed of paper colored with black and blue crayon, and the altimeter and radiometer are made of carved-out Styrofoam balls. The thrusters are push pins.

4. Cut out two cups from an egg carton. One cup will represent the altimeter and the other will represent the radiometer of the spacecraft. Using a small piece of silver duct tape or poster tac, attach the bottom of one of the cups to the bus on a surface between the solar panels, so that the inside of the cup faces outwards (Earthwards). This cup represents the altimeter.

5. Cut around the edge of the other cup so that it is smaller in diameter than the altimeter. This cup represents the radiometer. Tape or poster tac the side of the *radiometer* to one end of the bus so that it faces the same direction as the *altimeter*.

6. Cut one cotton swab in half and tape one piece on the end of the bus with the radiometer. This half of the cotton swab should point in the opposite direction from that of the altimeter and radiometer. This represents the *turbo rogue space receiver*.

7. Wrap the other half of the cotton swab in foil and attach it on a side of the bus near a solar panel, so that the end sticks out by the altimeter antenna. This half of the cotton swab represents the laser retroreflector array, which helps pinpoint the location of the spacecraft. (Knowing the exact location of the spacecraft is very important in order to measure the height of the ocean to within 5 centimeters—about the length of your little finger.)

8. Insert four push pins (at each corner of a square) into the end of the bus opposite the radiometer. These pins represent the thrusters—tiny rockets that are used to make small changes in the orbit of the spacecraft.

9. Cut another cotton swab in half and tape one piece on the end of the bus where the thrusters are located. The end of the cotton swab should stick out about one-half centimeter (1/4 inch) on the side with the altimeter, and the cotton swab should be pointed in the same direction as the altimeter. This piece of the cotton swab represents the radio receiver, which not only receives commands, but also transmits data back to Earth.

10. Attach fishing line to the model spacecraft, so you can hang it on display, or you can swing your spacecraft into orbit around a globe of Earth!

Topics for discussion:

- The role of satellites as "eyes in the sky," gathering data that are difficult for us to gather on Earth.
- The orbit of a satellite around Earth to collect a complete picture, made up of "strips" of data over a number of days.
- Types of measurements that can be made, for instance sea-surface height, ocean color, sea-surface temperature, winds over the ocean. The use of these measurements to improve human welfare and safety.

See How Winds Drive Ocean Currents

Although other causes are also at work, ocean surface currents are caused mostly by wind, especially winds that blow in one direction for long periods. In this activity, you will create a model ocean, blow "wind" over it, and see how wind affects ocean surface currents.

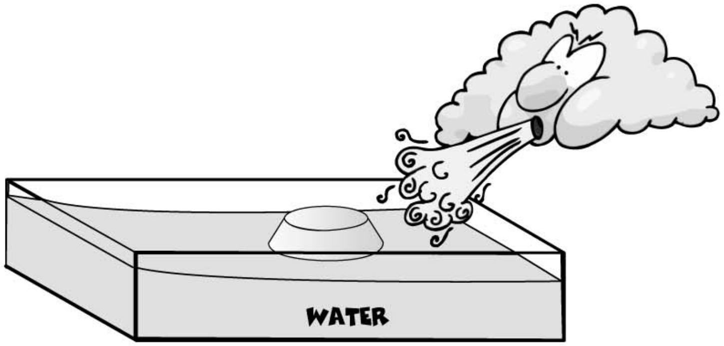
Materials:

- Clear, shallow, glass baking dish or clear tray
- Food coloring
- Cereal bowl (or finger bowl)
- Petri dish or small shallow bowl
- Assortment of waterproof objects with irregular shapes
- Map of ocean currents (can use Jason-1 Adventures game board)
- Map of global wind patterns (see Panel 6 on this poster)
- Towels

Preparation:

This activity is best completed in small groups. Make sure that the model ocean containers (glass baking dish or clear tray) are shallow, otherwise it is difficult to see the bottom counter currents.

In Step 3, you can use any bowl or object that sticks above the water. In Step 4, you can use any small bowl or other object that is short enough to be below the water line.



Teachers may wish to demonstrate this for the entire class by placing the clear "ocean" container on an overhead projector and adjusting the focus of the projector as needed.

Procedure:

1. Carefully fill the clear tray with water. Do not fill it completely to the top. Let the water settle.
2. Place a drop of food coloring at one end of the tray and gently blow across the tray. Observe and make a sketch of what you see happening at the surface of the water. Make another sketch of what you see happening along the bottom of the dish. Are your sketches different from each other? If so, how are they different? Where do the currents move most rapidly? What happens to the water as it moves away from the wind source?
3. Gently place the cereal bowl upside-down in the center of the glass tray. Make sure that the bowl sticks out of the water. If it does not, pour some of the water out of the tray and try again. The bowl represents an island. Add a drop of food coloring in front of the island and gently blow across the tray. Observe and sketch what happens to the food coloring in front and back of the island. What effect does the island have on the current? Is the current stronger in front of or behind the island? How can you tell?
4. Remove the cereal bowl. Change the water if the food coloring added during Step 3 makes in difficult to see additional drops. Add a petri dish that is completely below the water line. The petri dish represents a submerged island Add a drop of food coloring between you and the submerged island and blow

See How Winds Drive Ocean Currents (cont'd)

across the tray. Observe and sketch what happens to the food coloring. How are these results different from those obtained for the island in Step 3?

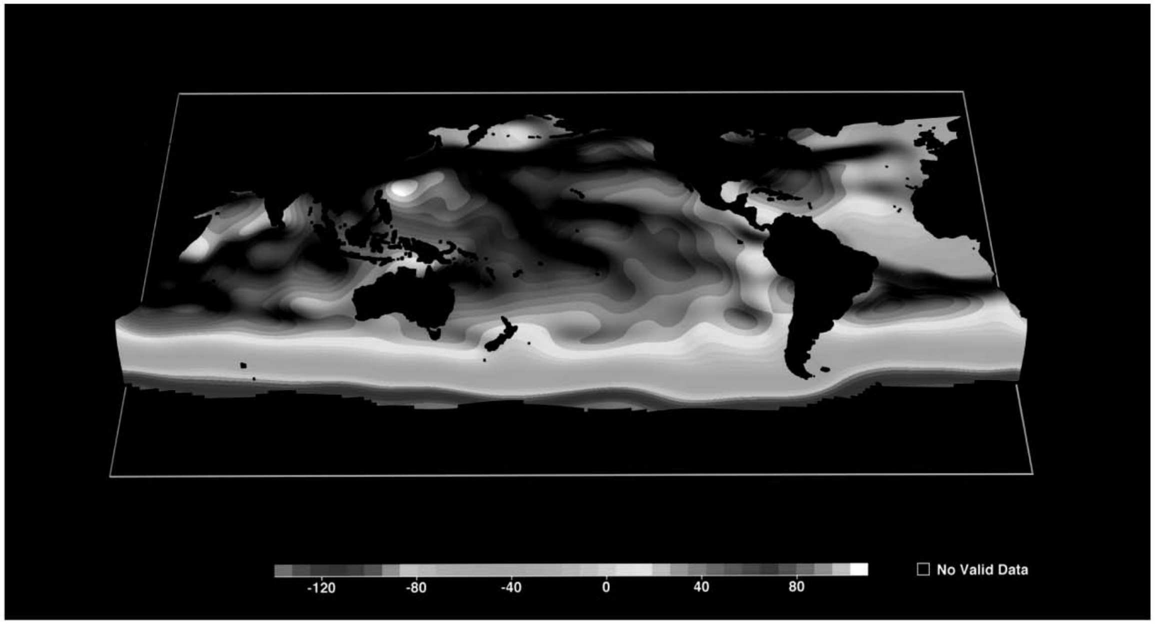
5. Repeat the procedure, but use objects of irregular shapes. Are the currents more or less complex with the odd-shaped objects? Explain.

Do the currents always move in the direction of the wind? If not, what factors might influence the direction of movement? How do bottom currents differ from top currents? Why?

Explanation:

Winds create ocean currents, just as your breath created currents in your model ocean. Wind-driven ocean currents are complicated by many other factors, including Earth's rotation, land masses, seafloor topography, and tides. The complex patterns of ocean currents are also influenced by the salinity (saltiness) and temperature of the ocean itself.

Ocean circulation patterns influence climate and living conditions for plants and animals, even on land. Ocean currents affect everything from the routes taken by ships to the distribution of plants and animals in the sea.



Ocean topography, as measured by the Topex/Poseidon satellite (Jason-1's older brother) in October 1992. Warmer water on the surface is pushed around by strong winds, creating ocean currents and such conditions as the occasional El Niño. Colors (which show here only as shades of gray) show the different heights of the ocean's surface, which also represents ocean temperature.

To Investigate Further:

As you might expect, flow in the ocean can be very different from flow in the laboratory. It is very difficult to model the motion, viscosity*, and geometry of Earth's oceans in a simple experiment. To see the real world effect of winds on ocean circulation, compare a map of wind patterns (see Panel 6 on this poster) and a map of surface currents (as shown on the Jason-1 Adventures on the High Seas game board on the front of this poster). Do these patterns look similar?

Source:

Adapted from James A. Kolb, *Marine Biology and Oceanography, Grades Seven and Eight*. Marine Science Center, Marine Science Project: For Sea. Poulsbo, Washington.

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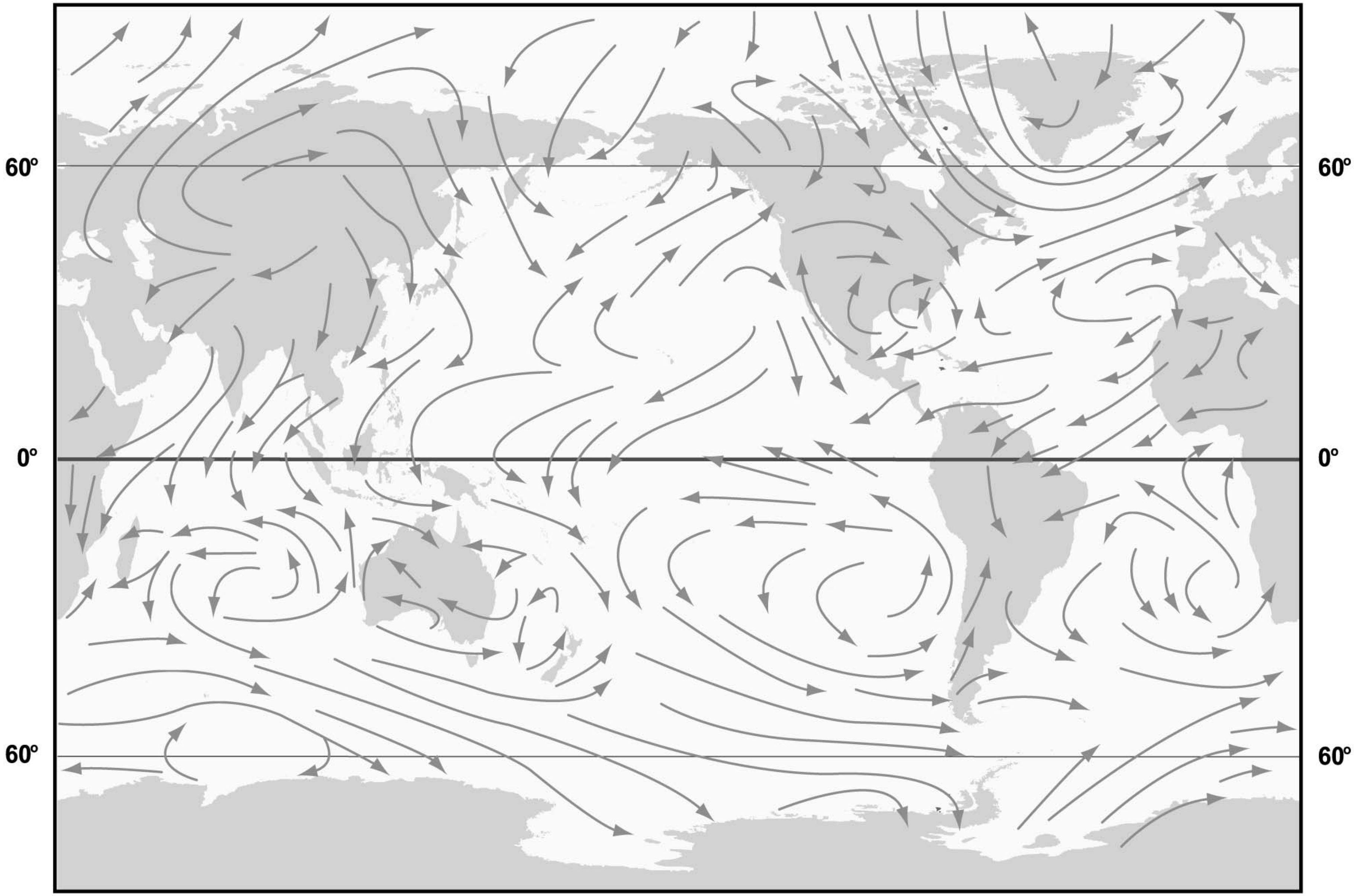
* *How easily a liquid flows: For example, honey has a higher viscosity than water.*



Global wind patterns

Jason-1: Voyage on the High Seas

A Board Game for 2-4 Players

Object:

Be the first to pilot your ocean research vessel from the Mediterranean Sea to Seattle, Washington, USA, while earning at least 150 Discovery Points.

Preparing to play:

Game Board: Your playing field is a world map, with possible ocean routes you can take (one little step at a time).

Cards: The Discovery Cards and Quiz Cards you need to play the game are printed on separate sheets. Carefully cut the cards apart. Put Discovery Cards in one pile and Quiz Cards in another pile. Shuffle the cards before playing. Put them face down on the spaces indicated on the game board.

Playing Pieces: Carefully cut out the Research Vessel playing pieces. They are made to be folded in half and glued to a push pin so they will stand up.

Spinner: Before cutting around the outside of the spinner, glue the spinner piece onto heavy paper or card stock (like a piece of file folder). Then cut out the spinner, being sure to make a straight cut on each of its 12 sides. Precisely in the center of the spinner, insert a round wooden toothpick and slide the spinner about half-way down. (*Note:* Instead of the spinner, you can use two six-sided dice.)

Equipment: You will also need paper and pencil.

How to play:

Each player picks a "Research Vessel" playing piece and places it near the *START* point in the Mediterranean Sea.

Each player, in turn, spins the spinner to determine who goes first. Highest number goes first, then play proceeds to that player's right.

When it's your turn, spin the spinner and move ahead the number of steps indicated. The following instructions apply to the step on which you land.

- *Red with white circle:* Follow the directions for the associated event or encounter that appears at the bottom of the game board. (Look for the matching cartoon.)
- *Red:* Draw a Discovery Card from the top of the Discovery Card pile and follow the directions. Place the used Discovery Card *face up* on the bottom of the pile. If you go through all the cards in one game, shuffle them and reuse.
- *Yellow:* Have your opponent (the one to your right, if 3 or 4 players) draw a Quiz Card and ask you the question on the card. The card will give the Discovery Point values for right and wrong (or no) answers. For example, if the card says "+10, -5" it means you earn 10 points for a right answer and lose 5 points for a wrong answer or no answer .
- *Blue:* Add or subtract the number (+ or -) on the step to/from the player's points. Double-headed blue steps also indicate a route decision point.
- *"x2"* on a red or yellow step doubles the points you earn or lose for the card.

Other instructions:

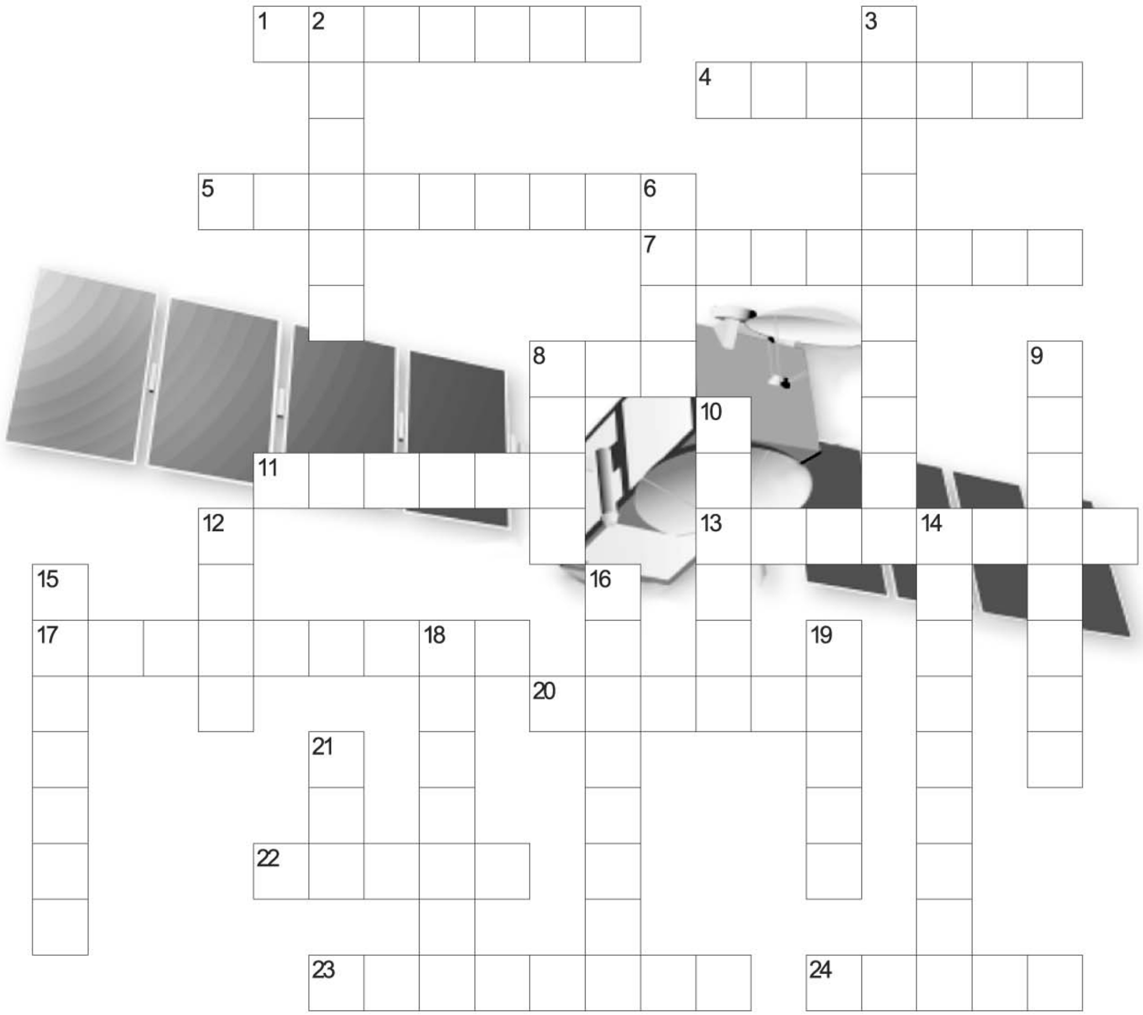
- If you must go back some steps, ignore the directions on the step where you end up. Your turn is over. However, if you are told to skip ahead some steps, *do* follow the instructions for that new landing spot.
- If you are within a few steps of reaching the *FINISH* point, you do not need to spin the exact number to land on the *FINISH* point.
- If you are the first to reach the *FINISH* and have at least 150 Discovery Points, congratulations! The game is over and you win!
- If you reach the *FINISH* but do not have at least 150 Discovery Points, you must go to the *McMurdo Research Station* in Antarctica, miss one turn, and then on the next turn start trying again to reach the *FINISH* while earning more points. If you are starting from McMurdo and are instructed to go back more steps than it would take to return to McMurdo, stop at McMurdo.
- The board has a few places where you can go one way or the other. The longer routes offer more opportunities to earn Discovery Points.

Keeping Score:

One player has the job of writing down Discovery Points earned and lost for all players. If a player has not accumulated enough Discovery Points to "pay" for the more unfortunate events, the player may go into "debt," with a negative Discovery Point balance.

Adventures on the High Seas

(Use the game board for hints)



Across

1 Nearly half of Earth is awash in the north and south of this ocean.
4 Head for high ground when you hear this is coming!
5 A craft with altitude.
7 Your sails are limp when you are in this.
8 Hudson ___ lets the ocean into North America.
11 Warm waters of __ ____ make fish scarce.
13 Divides Europe and Africa from the Americas.
17 Jason-1 instrument to measure sea surface height.
20 Northernmost North American gulf.
22 Yuk! This soup's as _____ as the ocean!
23 "Sea" of calm and kelp in the N. Atlantic.
24 Columbus sailed the _____ blue.

Down

2 Top ocean.
3 The "under" world.
6 Caught up in this, you will make the rounds.
8 Tiny floating island of technology.
9 The deepest trench in the oceans.
10 Largest mammals.
12 The biggest continent.
14 Stand here and turn once a day without moving your feet (two words).
15 Australia's Great Reef is no _______ to great diving.
16 Human-friendly water mammals.
18 Earth's fat waistline.
19 Will see the next El Niño before we do.
21 "One if by land, two if by ___."

(Across) 1. Pacific, 4. Tsunami, 5. Satellite, 7. Doldrums, 8. Bay, 11. El Niño, 13. Atlantic, 17. Altimeter, 20. Alaska, 22. Salty, 23. Sargasso, 24. Ocean

(Down) 2. Arctic, 3. Antarctica, 6. Eddy, 8. Buoy, 9. Marianas, 10. Whale, 12. Asia, 14. NorthPole, 15. Barrier, 16. Dolphins, 18. Equator, 19. Jason, 21. Sea

Blame El Niño!

What is El Niño anyway, besides a handy excuse when things go wrong?

The El Niño Southern Oscillation, El Niño for short, is a condition that occasionally occurs in the Pacific Ocean, but it is so big that it affects weather all over the world.

Weather depends a lot on ocean temperatures. Where the ocean is warm, more clouds form, and more rain falls in that part of the world. In the Pacific Ocean, near the equator, the Sun makes the water especially warm on the surface.

Normally, strong winds along the equator push the warm surface water near South America westward toward Indonesia. When this happens, the cooler water underneath rises up toward the surface of the ocean near South America.

However, in the fall and winter of 1997-1998, for example, these winds were much weaker than usual. They actually blew the other way (toward South America instead of Indonesia) in October. So the warm surface water along the equator piled up along the coast of South America (around Peru) and then moved north towards California and south toward Chile.

Many fish that lived in the normally cooler waters off the coast of Peru moved away or died. The fishermen call this condition of warm coastal waters and poor fishing "El Niño" meaning "boy child," because in the occasional years it comes, it comes at Christmas time, the celebrated birthday of the Christ child.

In 1997 and 1998, lots of rain clouds formed over this warm part of the ocean. These clouds moved inland and dumped much more rain than usual in South and Central America and in the United States. Meanwhile, other parts of the world suffered drought. Weather patterns all over the world were unusual, making lakes out of deserts and charcoal heaps out of rain forests.

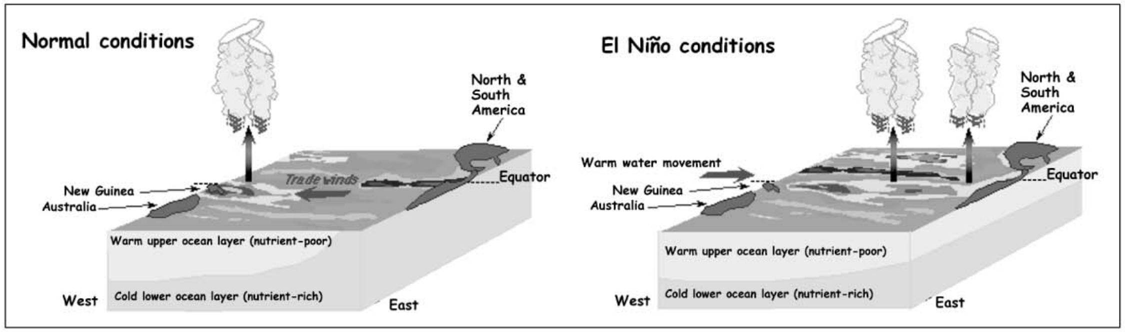
How do we know what is happening to the ocean temperatures around Earth? The best way is to go up into space!

Where the ocean is warmer, sea level is slightly higher. Using information from Jason-1 and TOPEX/Poseidon (see Panel 1 on this poster), scientists make topographical maps of the hills and valleys on the ocean's surface. The different heights of the ocean are shown on flat maps using different colors (See Panel 5 on this poster).

But is it only at the surface that the water is warmer or colder? No way! Where the ocean shows red or white on the map the water is warmer to depths of hundreds of feet!

Questions:

1. Severe floods and droughts can occur through the world during El Niño years. If scientists could make better and earlier forecasts of El Niño conditions, what might people do to prepare? How might they help each other?
2. Find out which years had the most severe El Niño conditions over the past 30 years. What parts of the world experienced the most severe flooding? The most severe droughts?



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