Southern AER

Atmospheric Education Resource

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AER Supply:

Did You Know?

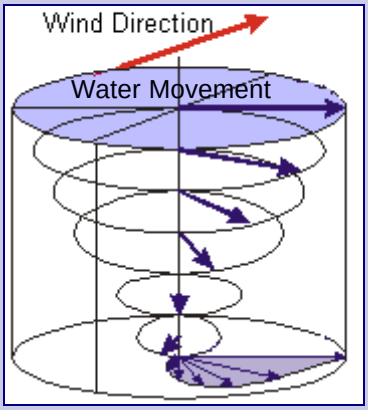
The amount of water circulating in ocean gyres is about 100 times the amount carried to the ocean by rivers!

OCEAN CURRENTS
~ EARTH'S THERMOSTAT ~

If you look at a globe, you'll find both Trenton, New Jersey and Madrid, Spain located about 40° North of the Equator. It may surprise you that Trenton's average yearly temperature is four degrees Farenheit cooler than Madrid's. Four degrees may not seem like much of a change from day to day, but over time it accounts for significant differences in the two cities' plant and animal life, amount of snowfall and number of storms per year. This average weather over time is called the **climate** of an area.

One of the major reasons for the climatic difference between Trenton, New Jersey and Madrid, Spain is **ocean circulation**. Because sea water temperature takes longer to change than that of air or land, ocean currents keep Western Europe warmer than Eastern North America at the same latitudes.

The ocean surface gains heat from the sun. Once warmed, the water is mixed as deep as 100 meters (330 feet) by winds blowing over the surface of the water. This mixing occurs by ocean *gyres* – huge amounts of water spinning in ocean basins. An exciting aspect of these gyres was discovered by a Norwegian explorer named Fidtjof Nansen and further calculated by a Swedish physicist named Walfrid Ekman. Ekman found that because of **friction** between the air and water surface, the water does not receive all of the wind's energy and moves in a slightly



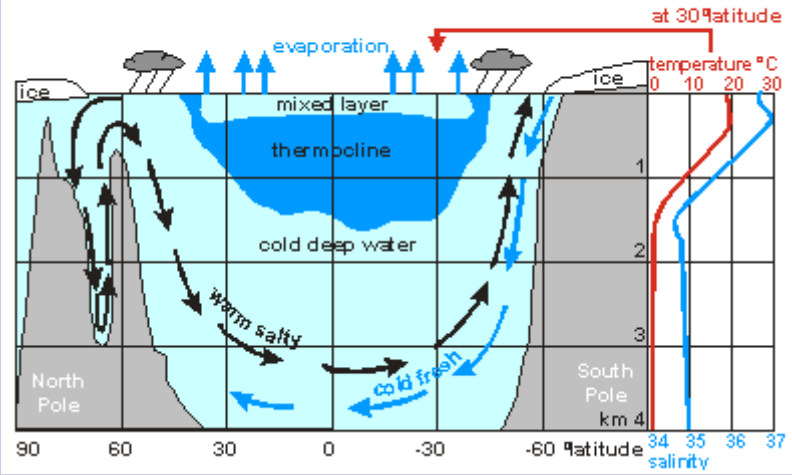
"…the overall or net movement of the water is 90 degrees to the right of the wind blowing over it."

different direction from the wind. Just as the top layer of water does not move with the wind, the second layer of water does not move with the top one, the third layer doesn't move with the second and so on. As this pattern continues deeper in the water, the overall or **net** movement of the water is 90° to the right of the wind blowing over it. This net movement is called *Ekman transport*. The drawing on page 1 shows how water moves in this way. It is important to know that because of the earth's rotation, Ekman transport is 90° to the right in the Northern the Northern Hemisphere and 90° to the left in the Southern Hemisphere. This is called the **Coriolis deflection**.

Because net water movement is away from the poles as described in the previous paragraph, sea water must find a way to move back toward the poles. In the North Atlantic, the prevailing pole-ward current is called the *Gulf Stream*. This concentrated flow is a stream of warm salty water flowing north next to the Southeastern United States. A second current called the *North Atlantic Drift* is a continuation of the Gulf Stream.

A great amount of heat is transferred in the ocean currents mostly from South to North through what has been nick-named the "**ocean conveyer belt**." The conveyer belt delivers as much heat to the cold air in the North pole as the sun does!

All the water movement discussed above occurs at very shallow depths of the ocean. One important part of ocean depths is the *thermocline*. A thermocline is a zone where temperature changes from top to bottom in an area. The red line in the drawing to the left represents a thermocline. There are two of these thermoclines in the ocean basins: one near the surface which changes seasonally with the sun, and the second much deeper where the water remains cold all year.

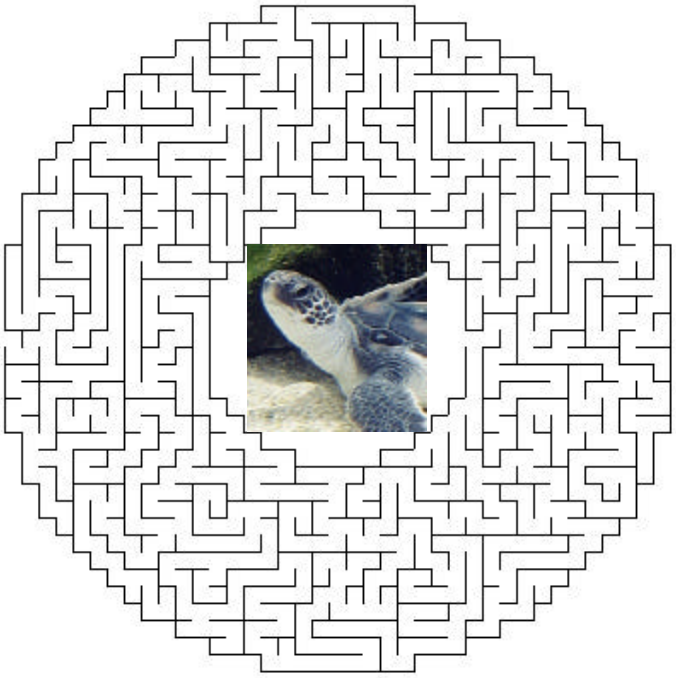


Cross-sectional view of deep ocean circulation in the Atlantic Ocean. Note the thermocline (left or red line) and halocline (right or blue line) to the right of the drawing representing change in temperature and salinity at 30° South of the equator.

Deeper water becomes that way because it is more **dense** than the water above it. Temperature is one reason - cold water is denser than warm water - but another factor is the salt content or *salinity* of the sea water. Salinity makes sea water more dense than fresh water. The average salinity of sea water is 35 parts per thousand and salinity can be increased two main ways. First, near the equator, where evaporation is high, water leaves the ocean as vapor and leaves behind the salt that was dissolved in it so the salinity of the remaining water is higher; secondly, near the poles where water freezes into sea ice, *salt rejection* causes salt to be left behind in the cold polar water.

...Continued on Page 4...

Crazy Currents Maze



This little sea turtle needs to get back into the North Atlantic Drift and join his brothers and sisters. Can you help him out of this little ocean gyre?

Fun Facts

~ Between **50%** and **60%** of the world's population lives near the ocean. That's about 3.5 BILLION people!

~ It takes about 1000 years for water in DEEP ocean basins to come back to the SURFACE again.

~ **The Gulf Stream flows nearly 300 times *FASTER* than the typical flow of the Amazon river.**

Two major masses of water flow deep in the ocean basins. *North Atlantic deep water* is formed when evaporation in the mid-Atlantic ocean causes the salinity to increase there. This saltier water is carried northward by the Gulf Stream and the North Atlantic Drift until it becomes very cold and sinks to the bottom of the North Atlantic. This water remains between two and four kilometers (1-2.5 miles) deep in the ocean and travels south until it rises again in the Southern Ocean.

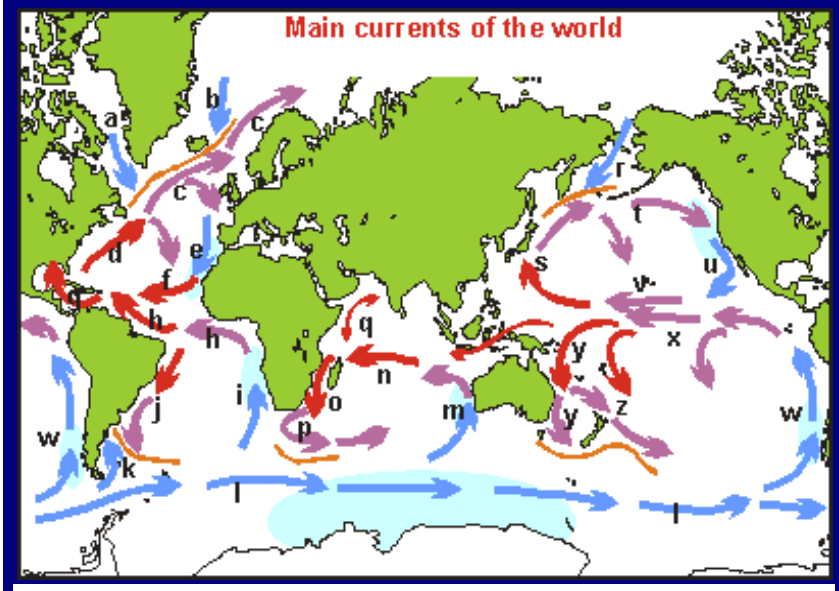
So what is below the North Atlantic deep water? A mass of water even colder and even deeper forms in the Antarctic Ocean near the South pole and flows northward along the ocean bottom. This water is called *Antarctic bottom water.*

With all this water sinking, sinking, sinking, how does it return to the surface? A process called *upwelling* brings water from intermediate depths to the surface. As wind blows over the sea surface, the top layer of water moves away that area as we have already seen. In the northern hemisphere, this means water is moving away from the land; it is pushed offshore and out of the way of the water below it which rises up to fill the space. The upwelling water is cooler and has more **nutrients** than the warmer water because it has not been used by sea surface plants and animals. In addition to moving away from the land surface, the Northern and Southern **trade winds** cause warm water to move away from the equator. The same thing happens here as warm water is pushed away and cooler water upwells to fill the space left behind.

Name that Current!

Ocean Challenge: A to Z

Take some time to find the names of these ocean currents doing research on your own. If you find **1-5** Keep Looking! **5-10** Great Effort. **10-15** Super Research. **15-26** Challenge Champ!



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u _____ x _____
v _____ y _____
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O	A	P	J	E	A	Q	N	E	Z	E	A	N	L	I	V	G	Y	C	N	G	H
R	G	E	W	T	F	I	R	D	C	I	T	N	A	L	T	A	H	T	R	O	N
T	B	D	J	E	C	S	Z	G	F	F	A	C	G	O	S	V	A	T	E	V	U
H	C	Z	T	K	L	P	O	C	U	N	V	Q	M	T	M	R	V	R	G	A	G
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I	G	Y	M	X	P	Z	J	P	T	R	I	A	T	B	M	K	E	K	W	F	F
C	M	M	T	J	X	Z	N	T	T	L	T	T	K	L	U	U	J	H	F	D	R
D	Z	G	X	A	I	H	O	W	C	G	R	N	Q	C	V	Z	E	P	X	Z	L
E	Z	Q	D	Z	G	M	H	O	H	L	I	X	A	A	O	G	R	O	D	O	S
E	F	I	T	X	W	G	M	I	R	V	Z	B	A	M	L	L	T	E	J	L	M
P	X	R	F	A	E	R	Y	J	W	H	V	M	P	D	K	J	L	C	M	Q	L
W	B	F	T	V	E	B	Z	I	G	D	O	K	N	L	E	E	A	F	K	B	T
A	K	E	H	H	D	T	B	J	Y	B	S	L	D	N	J	M	S	Y	K	W	P
T	R	Z	T	H	M	N	K	U	R	X	N	G	U	L	F	S	T	R	E	A	M
E	R	P	Z	W	E	O	E	Q	E	F	T	U	L	C	J	E	V	O	F	Q	I
R	Q	E	V	A	F	P	E	J	B	Q	T	P	P	Q	H	Z	B	S	S	T	S

CRISS CROSS Currents

Can you find these Ocean Currents Key Words among the sea of letters to the left? Remember, words can be backwards and diagonal so keep a sharp eye!

ANTARCTIC BOTTOM WATER
EKMAN TRANSPORT
GULFSTREAM
GYRE
NORTH ATLANTIC DEEP WATER
NORTH ATLANTIC DRIFT
SALT REJECTION
THERMOCLINE
UPWELLING

Ocean Currents Quick Quiz!

Use your Ocean Currents Key Words from the box above to complete each sentence. These words also appear in *italics* in the text of the main article.

1. A ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ is the layer of water where temperature changes rapidly from top to bottom.
2. A spinning mass of water in an ocean basin is commonly called a ___ ___ ___ ___.
3. ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ is the term which describes the movement of water at a 90 degree angle to the wind direction.
4. The ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ is a continuation of the Gulf Stream, flowing into the high latitudes of the North Atlantic.
5. The narrow current of warm water coming from the Gulf of Mexico and flowing northward along the southeastern US is named the ___ ___ ___ ___ ___ ___ ___ ___ ___ ___.
6. The rise of cool nutrient-rich water to the ocean surface to replace warm nutrient-poor surface water is called ___ ___ ___ ___ ___ ___ ___ ___ ___.
7. ___ is a mass of water more than 4 km deep which forms near Antarctica and flows along the seafloor.
8. The measure of the amount of salt in sea water is called ___ ___ ___ ___ ___ ___ ___ ___.
9. When sea ice forms the salinity of the surrounding water increases because of ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___.
10. When salty surface water cools, sinks and flows southward, a mass of water 2 to 4 km deep forms in the North Atlantic Ocean called ___.

Learn More About It!

These resources can help you discover more about Ocean Currents and their affect on Earth's climate.

- The International Year of the Ocean Homepage: http://www.yoto98.noaa.gov/
- Oceanography for Kids! http://www.mi.mun.ca/mi-net/ocean/index.htm
- NOAA's National Ocean Service: http://www.nos.noaa.gov/
- Windows to the Universe: http://www.windows.ucar.edu/tour/link=/earth/Water/ocean_currents.html

References:

- Ruddiman, William F. Earth's Climate: Past and Future. W.H. Freeman and Co. New York, NY. 2001. Pg. 39-44
- Kump, Lee R., James F. Kasting, and Robert G. Crane. The Earth System. Prentice Hall. Upper Saddle River, NJ. 2000. Pg. 82-3, 95

Thanks to all of the following:

- www.netstate.com, www.worldclimate.com, www.infoplease.com, www.endangeredcoast.org, and www.oceanfacts.com for tidbits of information used throughout this publication.
- Practical Ocean Energy Management Systems, Inc. for some of the images used herein: www.poemsinc.org/home.html
- Kathy Boast at www.kathyboast.com for her photograph of the young turtle.

Remember to check out our website too for more climate resources and fun learning tools!

w w w . s e r c c . n e t

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