

Teachers' Guide for Atmosphere-Ocean Interaction

National Weather Service, Shreveport, LA

<u>Slide Number</u>	<u>Notes</u>
1	<i>Title Slide</i>
2	<i>Outline Slide</i> <p>Here are some exact numbers. Water covers 71% of the earth's surface and contains 97% of the earth's water. 60% of the world's population lives within 60 miles of the coast. This means that a significant amount of the earth's population uses the oceans and other large bodies of water for recreational (such as swimming and fishing) and commercial (such as transportation, fishing, etc.) purposes. El Nino/ENSO are long-term climate impacts which are affected by area oceans. The transport of low-level moisture across the United States, especially from the Gulf of Mexico and Atlantic, play major roles in the day-to-day weather and aid in thunderstorm development. Of course, we can't forget food. As we will see, El Nino/ENSO play roles in the cost of chicken at KFC.</p>
3	<i>The "Basics"</i> <p>A good beginning point for discussion here would be to ask the question, "WHO CAN NAME ALL FOUR OCEANS?"</p> <p>Honestly, there is some debate on this point. Just about everyone agrees there are definitely THREE oceans – the Atlantic, Pacific, and Indian. Most people agree there is a fourth ocean – the Southern Ocean (which was created in 2000). However, most oceanographers argue the Arctic Ocean isn't really an ocean since it's almost completely enclosed by land. Most textbooks, though, still mention (what will be called here) the Arctic Sea as an ocean. The next couple of slides will discuss each of the four world oceans in detail.</p>
4	<i>Around the World in 4 Slides... (Atlantic)</i> <p>You might want to begin by asking the audience to "POINT OUT SOME THINGS THEY NOTICE ABOUT THE ATLANTIC."</p> <p>As shown on the map, the Atlantic Ocean encompasses pretty much everything north of 60° South latitude (which is a little north of the Antarctic Circle). The Mediterranean, Caribbean, and Arctic Seas, as well as the Gulf of Mexico are all included in the Atlantic basin. It also provides some of the earth's most heavily trafficked routes.</p>
5	<i>Around the World in 4 Slides... (Pacific)</i> <p>You might want to begin by asking the audience to "POINT OUT SOME THINGS THEY NOTICE ABOUT THE PACIFIC."</p> <p>Similar to the Atlantic, the Pacific Ocean encompasses pretty much</p>

everything on the map north of 60° South latitude. The Bering and Japan Seas, as well as the Gulf of Alaska are all included in the Pacific Basin. Covering 28% of the global surface, the Pacific Ocean contributes more than half to the world's annual fish catch. The Pacific Ocean also has the most coastline of the four oceans.

The Pacific Ocean also contains the Mariana Trench. The Mariana Trench is the deepest part of the earth's oceans. The deepest point is called **Challenger Deep**, named after the British exploration vessel HMS Challenger II. It has a **depth of 10,911m or 35,798ft**. It is further below sea level than Mount Everest is above it. The U.S. Navy bathyscaphe *Trieste* reached the bottom at 1:06 PM on January 23, 1960. What's at the bottom? Reportedly, flounder about a foot long and shrimp. At the bottom of the trench, the water exerts a pressure of 1086 bar or almost 16,000 psi. That's more than 1,000 times the standard atmospheric pressure at sea level (1013.25mb).

-
- 6 *Around the World in 4 Slides... (Indian)*
You might want to ask the audience to "POINT OUT SOME THINGS THEY NOTICE ABOUT THE INDIAN OCEAN."

The Indian Ocean encompasses areas between the Indian subcontinent/Asia and 60° South latitude. The Arabian and Red Seas, as well as the Persian Gulf are all included in the Indian Ocean basin. An estimated 40% of the world's offshore oil production comes from the Indian Ocean.

-
- 7 *Around the World in 4 Slides... (Southern)*
Again, you might ask the audience to "POINT OUT SOME THINGS THEY NOTICE ABOUT THE SOUTHERN OCEAN."

The Southern Ocean encompasses anything poleward of South latitude and is made of "parts" of the Atlantic, Pacific, and Indian Oceans. It is also the newest ocean, as it was defined in 2000.

-
- 8 *Ocean or Sea, What's the Big Deal?*
There's no real hard or fast definition for this. Seas are delineated by land masses. This definition is the most widely accepted definition provided by oceanographers. Using this definition, bodies of water such as the Gulf of Mexico are actually seas. It can easily be seen why the Arctic Sea is not considered to be an ocean by Oceanographic experts. On the map of the Mediterranean Sea, be sure to point out the Black Sea, which borders Turkey. The Black Sea is an excellent example of a sea.

-
- 9 *Bragging Rights... (Which Ocean is the Biggest?)*
To engage the audience, you might ask, "WHICH OCEAN DO YOU THINK IS THE BIGGEST?"

The numbers for the Atlantic basin presented here encompass the

Arctic Sea. As stated before, some people consider this (the Arctic Sea) to be the fifth ocean. If these two are separated, the numbers are as follows:

Atlantic: 29,637,000/22.8%

Arctic: 5,427,000/4.2%

-
- 10** *Bragging Rights... (Which ocean has the most coastline?)*
From the numbers presented here, both the Atlantic and Pacific oceans are close, with the Indian and Southern Oceans behind. It might also be interesting to point out here that coastal areas around the Pacific are known as the "Ring of Fire." This is due to the plate tectonic action that takes place.
-
- 11** *Water is Water...or is it?!*
Most bodies of water are either freshwater or saltwater. **Freshwater** areas are mainly rivers, streams, or lakes. Meanwhile, oceans, gulfs, and seas typically possess **saltwater**. Some water bodies near coastal inland bodies of water may have a mixture of salt and fresh water. This type of water is called "brackish." An example of this would be Mobile Bay (in Alabama), where the Mobile River (freshwater) meets the Gulf of Mexico (saltwater).
-
- 12** *Water is Water...or is it?!*
Saltwater is not just saltwater. As will be shown in a couple of slides, there are regions of higher "saltiness" and lower "saltiness". The "saltiness" or salinity of the water is measured as a ratio of grams of salt per liter of water. As mentioned on the slide, the Atlantic Ocean is usually the "saltiest".
-
- 13** *Please Pass the Salt...*
The average salt concentration for seawater is $3.5 \text{ g } \ell^{-1}$. Some places have a higher salinity, while some have lower.
-
- 14** *Please Pass the Salt...*
This is a picture of the average salinity of the world's oceans.

The first H that flies in is over the Persian Gulf/Red Sea area. With 40% salinity, this is the saltiest water on earth. Why? Primarily because there's no real "outlet" for fresh and ocean water to be exchanged. This is also a location of very high evaporation rates. When the water is evaporated, the salt is left behind. The "freshest" water is near the Arctic Circle due to melting ice. Other relative maxes and mins are shown. Note that there are mins near the equator. Persistent thunderstorm activity in this region keeps the water a little better fresher here.
-
- 15** *Mmmmm...Salty!*
The Dead Sea is actually a large lake, 47 miles long and about 11 miles wide. The intense evaporation leaves behind the salt, which precipitates onto the sea floor. In fact, the *surface* of the lake is the least salty. Here are some other trivia facts about the Dead Sea. The surface of the Dead Sea is over 1300 ft. below sea level, with the very

bottom part of the sea is over 2300 ft. below sea level. It's kind of obvious why the Dead Sea was called the Dead Sea. Christian Monks found no life in the body of water because of the high salinity.

16 *So??*

As stated on the slide, the increased density of water means just about anything will float. The lady in this picture may look like she's floating on a pool raft, but she's not. She's actually floating on the water with very little effort. In fact, several websites say that swimming in the Dead Sea takes much more effort than floating.

At this point an experiment could be conducted using a couple of fresh eggs and some mason jars of salt water. The goal is to use the eggs to discern which jar of water has the greatest salinity.

17 *We're Goin' Down, Down, Down...*

Believe it or not, the atmosphere and ocean are quite similar. Like the troposphere, stratosphere, mesosphere, and thermosphere of the atmosphere, studies have shown the presence of several homogeneous layers in the ocean. Just like the atmosphere, each ocean layer has unique characteristics of pressure, types of life, temperature, etc. The next few slides will cover each layer of the ocean.

18 *The Epipelagic Zone*

The top layer of the ocean (down to about 200 m) is the **epipelagic zone**, which receives the most heating from the sun. This results in a wide variation of temperature in a relatively short distance. This is also where the wind has the most influence, and results in mixing and heat distribution within the layer.

19 *Bridge Over Troubled Waters...*

Similar in nature to the tropopause in the atmosphere, the **thermocline** is the transition layer between the mixed waters of the Epipelagic Zone and the deeper waters below. Where, relatively speaking, the Epipelagic and Mesopelagic Zones are homogeneous temperature-wise, the **thermocline bridges the gap**, so-to-speak.

20 *The Mesopelagic Zone*

With most of the temperature change near the top of this zone, the **Mesopelagic Zone** (between 200 m and 1000 m) is also called the "twilight zone". Why? Sunlight is very faint. One also starts seeing changes in animal characteristics in this region. How? You start seeing bioluminescence. Eyes are generally larger and directed upward, probably to see the outline of animals above.

21 *The Bathypelagic Zone*

Because of its depth, the **Bathypelagic Zone** is also known as the "midnight zone". No light reaches into the ocean at these depths. As such, the animals that live in this region of the ocean are bioluminescent. The increased "weight" of the water above this region results in a pressure in excess of 5800 p.s.i. Remember, the

average pressure at the earth's surface is 14.7 p.s.i.

-
- 22** *The Abyssopelagic Zone*
The ancient Greeks thought there was no bottom to the ocean. This is how the **Abyssopelagic Zone** got its name. With water temperatures near freezing (0 °C, 32 °F, 273.15K), this region encompasses areas between 4000 and 6000 meters.
-
- 23** *The Hadalpelagic Zone*
The **Hadalpelagic Zone** encompasses everything below about 6,000m. Reiterate the fact that the Mariana Trench is the deepest trench in the world. You might even want to ask the question, "WHAT IS THE NAME OF THE DEEPEST PART OF THE MARIANA TRENCH?" (Answer is Challenger Deep at a depth of 10,911 meters) Believe it or not, life still exists in this region. However, it's mostly in the form of plankton.
-
- 24** *Our Mr. Sun*
The sun is the "driving force" of all weather on earth. Incoming solar radiation (or insolation) is the ultimate cause of the weather on the earth. As solar insolation hits the earth's surface, it heats the atmosphere during the day and cools at night. When it heats the ocean, pretty much the same thing happens, only more slowly. As such, once the epipelagic zone is warmed, it stays warmer longer. These temperature differences cause wind. But more on this later, though.
-
- 25** *Ocean Currents – Just the Facts*
There are 2 types of ocean currents. The first, **wind-driven currents**, occurs in the epipelagic zone. Meanwhile, **deep water** currents bring very cold water closer to the ocean surface. For this presentation, though, we're going to focus on wind-driven currents (as noted by the star). These ocean currents are responsible for 40% of the global heat transport as they move relatively slowly across the ocean surface. As an example of the long-term climate impacts, the overall climate of Norway and the British Isles is about 10 °C warmer than other cities at the same latitude due to the effects of the Gulf Stream.
-
- 26** *Ocean Currents – Development*
This is a confusing diagram. To put it simply, as the oceans near the equator heat more rapidly, it sets up an imbalance in temperature. This allows cold air, sinking from the poles, to replace the rising warm air near the equator. This picture illustrates the concept on a non-rotating model of the earth. As the earth rotates, the model gets more confusing (not shown here because of this reason). In short, this sets up nearly permanent pressure areas and associated wind fields. It's this constant push of wind on the water that results in the development of wind-driven ocean currents.
-
- 27** *Ocean Currents – The Big Picture*
Here, we proudly present the big map of ocean currents. Red arrows denote **warm ocean currents**, while blue arrows indicate **cold ocean**

currents. Keep in mind that the water temperature associated with warm and cold ocean currents may not be warm or cold. The warm or cold descriptor refers to the sea surface temperature **relative** to the surrounding area. The important ones to point out on this map – Peruvian and California Currents, as well as the Gulf Stream.

28 *The Gulf Stream*

The **Gulf Stream** can be seen on this image as the ribbon of warmer waters from the Florida East Coast, stretching north-northeastward along the United States coast into the Atlantic.

29 *Dust in the Wind – During the Day*

This slide describes the development of the **seabreeze**. Since the beach heats up faster than the ocean during the day, the air will start to rise here. To replace the rising air, slightly cooler, more dense air has to move onshore from the ocean to replace the rising air. This results in a breeze blowing from the ocean, and, if conditions are right (such as an unstable atmosphere), possible thunderstorm development by the afternoon.

30 *Dust in the Wind – At Night*

This slide describes the development of the **landbreeze**. After dark, the ocean still has more heat than the land. As such, rising air will be found offshore at night. Since it cools down more quickly, cooler, more dense air from the beach will replace the rising air offshore. This results in a breeze blowing from the land. If atmospheric conditions are right, possible nocturnal thunderstorm development offshore may be seen.

31 *Wave Action*

As it's mentioned on the slide, waves are another byproduct of winds. Wave size depends on three things. First, the wind has to be blowing faster than the tops of the waves. That meets the speed criteria. The longer that strong wind has been blowing, the better chance it has to generate large waves. The distance criterion is also known as the "**fetch**". Basically, this is the uninterrupted distance over which the wind blows without a big change in direction. Estimating the wind speed using this method is known as the **Beaufort Scale**. The Beaufort Scale is not provided in this presentation. However, it may be downloaded from the internet at <http://www.spc.noaa.gov/faq/tornado/beaufort.html>.

32 *Battle of the Bulge*

Another type of wave action is the tide. As stated on the slide, **tides** are changes in the ocean water level, which results from the gravitational pull of the moon.

33 *POP QUIZ*

It is suggested that this question be presented to the class. Ask the audience not to answer the question now, but think about it. The answer to the question will be found on Slide 39.

34

Battle of the Bulge

The first question that arises when discussing the development of tides on the earth's surface is simply "why?" True, the sun's gravitational pull on the earth is greater. In fact, it's 178 times greater than that of the moon. But the determining factor is distance. Simply put, the earth is a lot closer to the moon than the sun. Because of that reason, the moon has twice the tidal pull on the earth when compared to that of the sun. Most of the time, we'll see a "bulge" of water mainly in line with the moon. One bulge will be found on the side of the earth facing the moon, with the other generally in the same spot on the other side of the earth. It is mentioned that mariners have known for a long time that tides were related to the moon. How long you say? About 4,000 years.

35

Battle of the Bulge

Some of the greatest scientific minds of our time have devoted countless hours to the study of tides. This slide just provides a brief list of some of those people.

36

POP QUIZ

This is just a reminder of the question asked a couple of slides ago. It also provides a hint.

37

Two tides? Four tides?

The number of tides a coastal location receives is dependent upon two factors. First, the shape of the coastline determines how water interacts with the land. In addition, the sea floor elevation also plays a role in determining whether two or four tides will be seen. This is simply how quickly the sea floor slopes toward the beach.

Remember the "bulge" in water I mentioned earlier? In general, when we see tides, we are seeing the result of the earth rotating under the "bulge". Using this principle, most places should see a high or low tide every 6 hours or so. However, like I said before, this is dependent upon the coastline's shape and the elevation of the sea floor. One thing to note: when the moon is closest to earth in its orbit, the tidal influence is obviously greater.

Some places have only one high/low tide cycle, though. This is called a **diurnal tide**. A few locations which experience a diurnal tide are provided on the slide. Note that many of these places are along the Central Gulf Coast.

38

Two tides? Four tides?

Other coastal locations experience two high/low tide cycles. This is called a **semi-diurnal tide**. A few locations which experience a semi-diurnal tide are provided on the slide.

39

Largest Tidal Range in the World

The largest tidal range in the world is found on the Bay of Fundy. Tidal ranges here can be as much as 15 meters in some spots.

- 40 *Where is the Bay of Fundy?*
This map shows the location of the Bay of Fundy. It can be seen from the map that the bay is located between New Brunswick and Nova Scotia.
-
- 41 *The Knights Who Say "Neap"*
The moon rotates around the earth once every 28 days (or so). About twice a month (every 14 days), the moon and the sun will be at right angles with respect to the earth. When this occurs, the tidal influence of the moon and sun will partially cancel each other out, resulting in little difference between high and low tides. When little difference is seen between high and low tides, it is called a **neap tide**. For example, in places that only see one high/low tide cycle a day, you'll see 2 or more cycles when tides are neap.
-
- 42 *Springing Onward...*
A **spring tide** is basically the opposite of a neap tide. It occurs when the moon and sun are in line with each other, which maximizes the gravitational effects.
-
- 43 *About the Cost of Your Food...*
In a normal year, the Peruvian Current brings colder waters from the Southern Ocean northward along the coast of Peru. These waters are filled with lots of nutrients, which feed the fish living in the southern Pacific Ocean. Note also that the Equatorial Countercurrent tries to bring warmer water eastward toward the coast of South America. Before leaving this slide, ask the audience, "WHAT WOULD HAPPEN IF THE EQUATORIAL COUNTERCURRENT WAS TO STRENGTHEN?"
-
- 44 *About the Cost of Your Food...*
Regardless of whether or not you hear about it, El Nino occurs each year. It is actually named for the Christ Child, since it takes place toward the end of December. Usually, we only hear about the bigger El Nino events. When these events occur, there can be a major shift of the warm waters with several effects, especially in regard to the track of major storm systems.
-
- 45 *About the Cost of Your Food...*
During a La Nina year, the Equatorial Countercurrent relaxes, allowing an "abundance" of cooler water to return to the region. When this takes place, the warmer waters will be pushed (so-to-speak) into the western Pacific. This is basically the opposite of El Nino conditions. Like El Nino, though, it can have major effects on the path major storm systems take.
-
- 46 *What Does This Mean Weatherwise?*
In large El Nino events, leads to a more active jet stream in our part of the country. This means a large trough of low pressure appears to generally be over the eastern half of the country during the winter, which spells cooler and wetter conditions for our region.
-
- 47 *What Does This Mean Weatherwise?*

In large La Nina events, increased ridging tends to be seen over our part of the country during the winter. This implies warmer and drier conditions over our region during the winter.

48 *So???*

This slide begins describing how El Nino affects the cost of food. Fishing is a major source of economy for many people in Peru, where Pacific waters are more than adequate to sustain large populations of anchovy fish. These fish are caught and used to make chicken feed.

49 *So???*

So when big El Nino events develop, the warmer waters off the Peruvian coast drive the anchovy population away from the coast. Basically, warmer water temperatures result in less food for the anchovies, so they move away from major fishing areas. This results in fewer anchovies being caught, an increase in the cost of chicken feed and finally, chicken.

50 *Thank You!!!*

51 *Credits*
