

Ocean Circulation, Food Webs and Climate

What does the wind have to do with feeding fish (and feeding us)?

El Niño: Tropical Oceans and Global Climate

Reading: 9.10-9.13, 9.15

Graphic: Upwelling off Cape Town South Africa, February 21, 2000 (red=high productivity). In this southern hemisphere case, the wind blows along the coast from south to north and the water flows offshore. Image Provided by the SeaWiFS Project, NASA/GSFC and ORBIMAGE.

What Influences Ocean Circulation?

- Wind
- Earth Rotation
- Heating, Cooling
- Geography
- Precipitation (i.e., rain) and Evaporation
- Gravity

Graphic: Sea surface temperature measured by satellite for October 1999. Courtesy of NOAA.

Regions Where Dense Water Forms

Deep & Bottom Water

- form due to atmospheric cooling

Med Sea Water

- forms due to

evaporation

Intermediate water

- forms due to

convergence of

ocean currents

Graphic: See Garrison, Fig. 9.26.

Water Mass Layering (Atlantic)

Antarctic Intermediate Water - flows northward

North Atlantic Deep Water - flows southward at mid-depths

Antarctic Bottom Water -flows northward along the bottom

Others: Mediterranean Sea water, Central water, Surface water

Graphic: Garrison, Fig. 9.29.

Thermohaline Circulation - Linking the Global Ocean

- 1. Sinking at poles in Atlantic**
- 2. Deep flow of cold, salty water into Indian and Pacific**
- 3. Upwelling in Pacific**
- 4. Return flow at surface via Indonesian Passages**

Graphic: Pinet, Fig. 6.16b, see Garrison, Fig. 9.26.

What happens when the wind blows over the ocean?

What Happens at the Coast?

If a coastline blocks the horizontal motion of a current, the water must move vertically

Upwelling – water moves upward

Downwelling – water moves downward

Graphic: Garrison, Fig. 9.5b,c.

Upwelling

Wind blowing along the coast moves water away from the coast

This water is "replaced" by water that moves vertically

West coasts in the northern hemisphere:

- Winds from the north drive offshore currents
- "upwelling" brings water up from below

Graphic: Garrison, Fig. 9.16.

Downwelling

When wind blowing along the coast moves water onshore...

The water next to the coast sinks downward

West coasts in the northern hemisphere:

- Winds from the south drive onshore currents
- "downwelling" causes water to sink toward the bottom along the coast

Graphic: Garrison, Fig. 9.17.

Vertical Motion Caused by Wind Along the Coast - Upwelling and Downwelling (N. Hemisphere) Upwelling and Biology

Water from below is cool and rich in nutrients, which supports plant growth and sustains animal communities

Upwelling zones are regions of abundant plant and animal life and some of the world's best fishing grounds

Red=high productivity

Blue=low productivity

Graphic: Upwelling off Cape Town South Africa, February 21, 2000 (red=high productivity). In this southern hemisphere case, the wind blows along the coast from south to north and the water flows offshore. Image Provided by the SeaWiFS Project, NASA/GSFC and ORBIMAGE.

**Thermal vs Geographic Equator
At the equator, you don't need a coast
to cause upwelling...**

Equatorial Upwelling

Biological Productivity in the Tropical Ocean

Air-Sea Interaction with Global Reach - El Niño and La Niña

El Niño and La Niña are reorganizations of atmospheric and oceanic circulation due to natural interactions between the atmosphere and ocean

El Niño = warm temperatures in the tropical Pacific ocean

La Niña = cold temperatures in the tropical Pacific ocean

El Niño and La Niña impact climate globally

Graphic: Sea surface temperature deviations from "normal". Images courtesy of NASA.

Normal Conditions (Non El Niño)

El Niño Conditions

Comparing Normal and El Niño Conditions

Which panel in the image on the screen indicates El Niño conditions?

What happens to the thermocline in the Eastern Tropical Pacific during El Niño events?

Impact of El Niño on Ocean Surface Temperatures

Watching El Niño Develop

Current Status: La Niña

El Niño and Society

Climate impacts last 9 months to 2 years, and affects

- **Water use**
- **Agriculture and fisheries**
- **Energy use**
- **Human health**
- **Natural hazards (fires, flooding)**

and many other segments of society

Graphic: El Niño impacts, courtesy of NOAA.

El Niño in North America

**US Temperature and Precipitation Trends
During El Niño
El Niño in the News
Predicting El Niño
Hunting El Niño from Space**

A developing El Niño can be detected from changes in tropical Pacific:

- **sea level**
- **sea surface temperature**
- **surface winds**

These have traditionally been measured at isolated locations using in-water instruments, but now, all of these can be measured by satellites that orbit the Earth

Graphic: (top) The TOPEX/Poseidon satellite altimeter measures sea level from space, (bottom) sea level signatures of a strong El Niño and strong La Niña. Courtesy of NASA/Jet Propulsion Lab.

Impacts of Improved El Niño Predictions

Preview of Next Lecture

Climate Change and Life in the Greenhouse

Reading: 18.22-18.24

Graphic: Sunrise over the Beaufort Sea in the Arctic. The potential impacts of climate change may be felt early and very severely here. Rear Adm. H.D. Nygren, photographer. Courtesy of NOAA.

Predicting El Niño