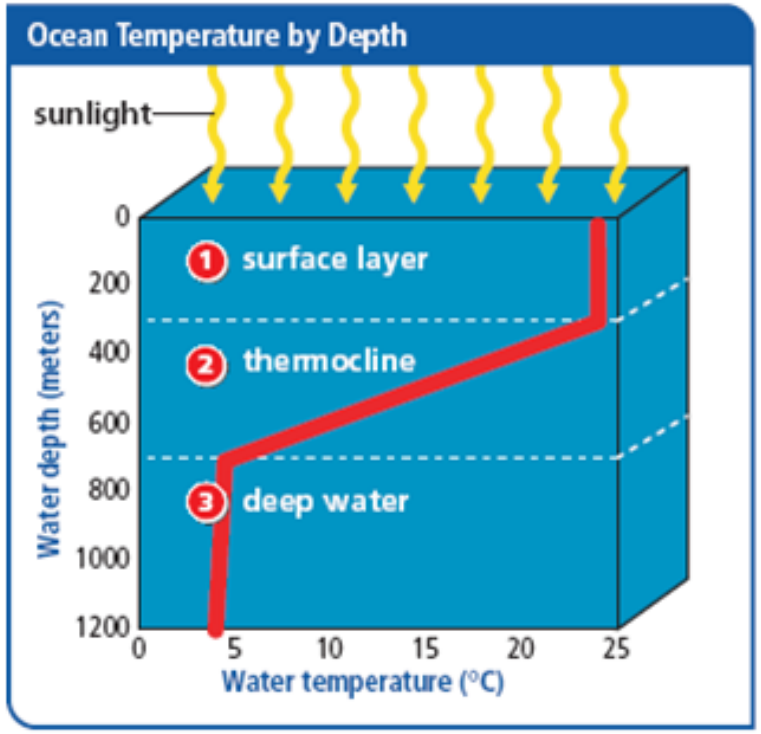
TOPIC 4.9

# OCEAN CURRENTS, EL NIÑO AND LA NIÑA

**Enduring Understanding:** Most of Earth's atmospheric processes are driven by input of energy from the sun.

**Learning Objective:** Describe the environmental changes and effects that result from El Niño and La Niña events (ENSO).

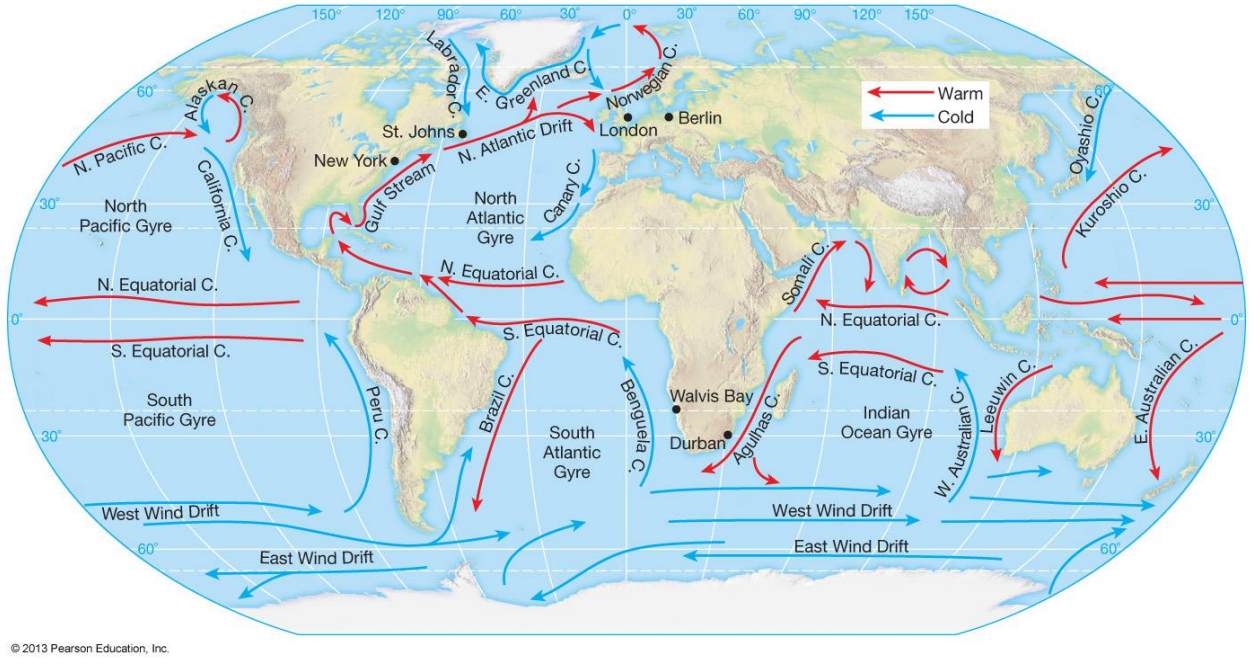
# Solar energy structures ocean water




- **Surface zone (2% of volume)**
  - Consistent water density down to about 150m
  - Warmed by sunlight and well mixed by wind
- ***Thermocline (18% of Volume)***
  - Reduced sunlight and poorly mixed resulting in increasingly cold, salty water as depth increases through this zone
  - Temperature decreases and water density increases rapidly with depth
- **Deep zone (remaining 80% of Volume)**
  - zone below the thermocline containing uniformly dense, sluggish water
  - Unaffected by winds, storms, sunlight, temperature

# Surface water flows horizontally in currents

- ***Currents*** **are vast river-like flows in the oceans**
  - Move horizontally in the upper 400m of water
  - Driven by density differences, differential heating and cooling, wind, and the Coriolis effect.
- **Transport heat, nutrients, pollution, and the larvae of many marine species**
  - The fast flowing warm water of the Gulf Stream current moderates Europe's climate
    - The Pacific Gyre has concentrated trash and debris in creating the "great pacific garbage patch"



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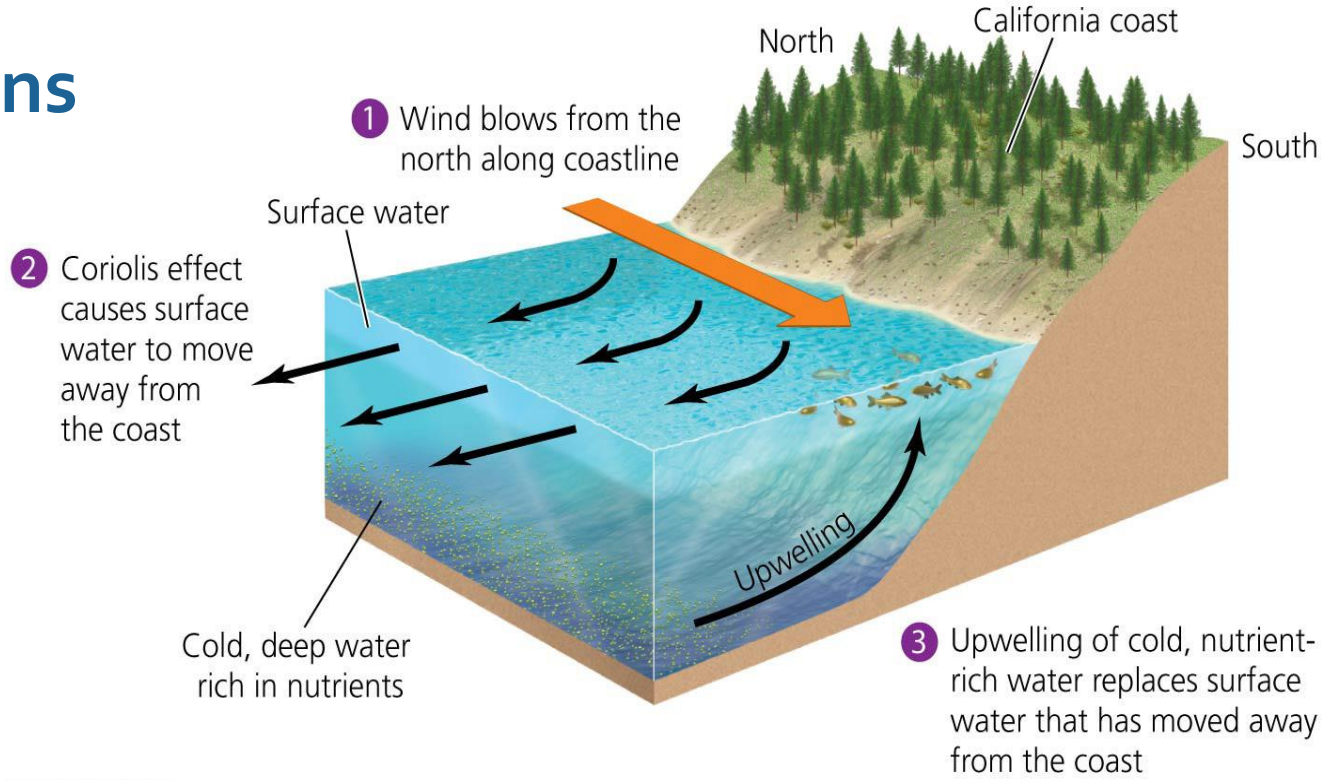
# Water Moves Vertically in Oceans

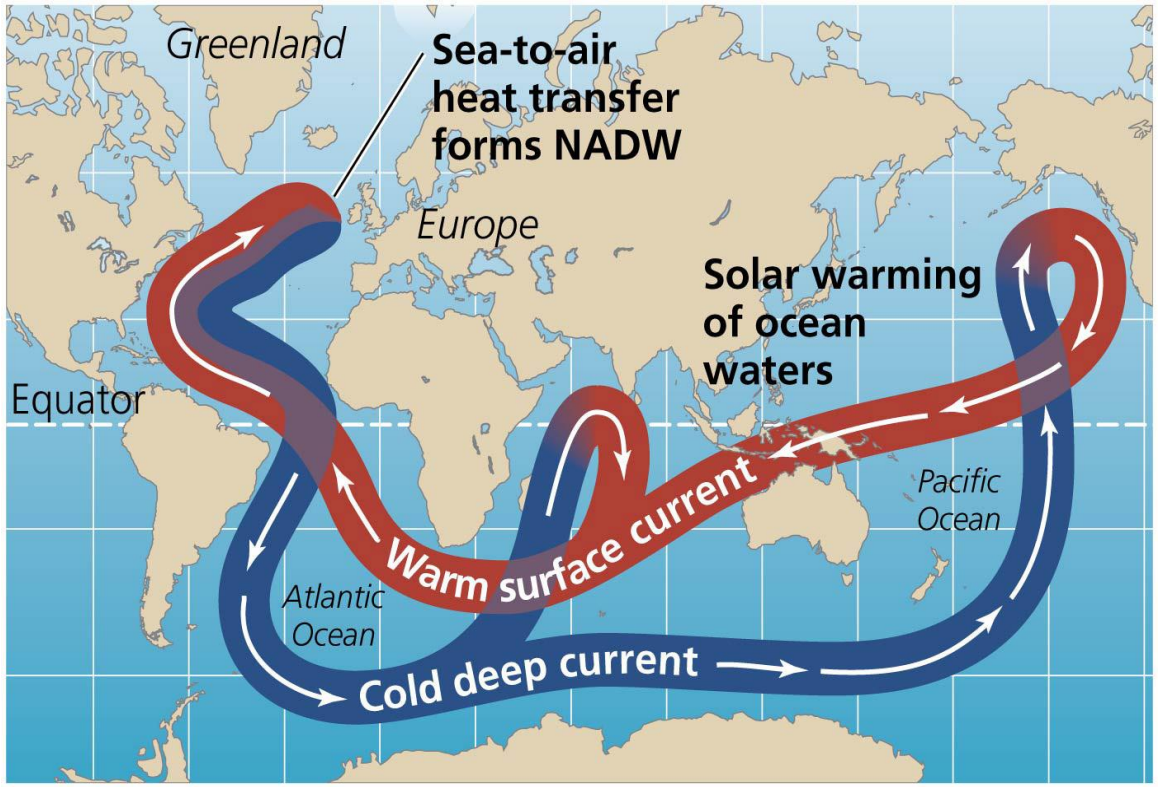
- ***Upwelling* is the localized upward flow of cold, deep water toward the surface**
  - Occurs where strong winds and the Coriolis effect move water away from the coastline.
  - As warmer surface waters move away from the coast, nutrient rich cold deep waters rise to the surface.
  - Deep waters are rich in nutrients since most detritus in the ocean sinks to the bottom where it is decomposed by benthic organisms
  - Regions of upwelling, such as the west coast of the Americas, typically have high primary productivity and therefore lucrative fisheries




- ***Downwelling* is the localized process in which oxygen-rich water sinks**
  - Occur where surface currents converge with each other or continents
  - Transports surface waters, rich in dissolved gases, to deeper waters
  - "Buries" $CO_2$ in the deep waters, and delivers $O_2$ to deep water life forms.

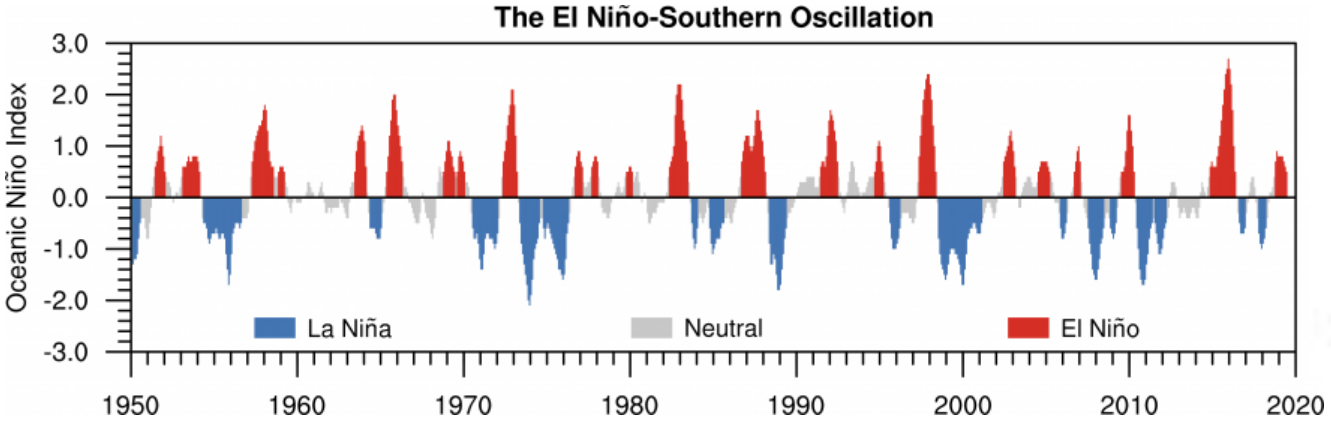
# Ocean Circulation

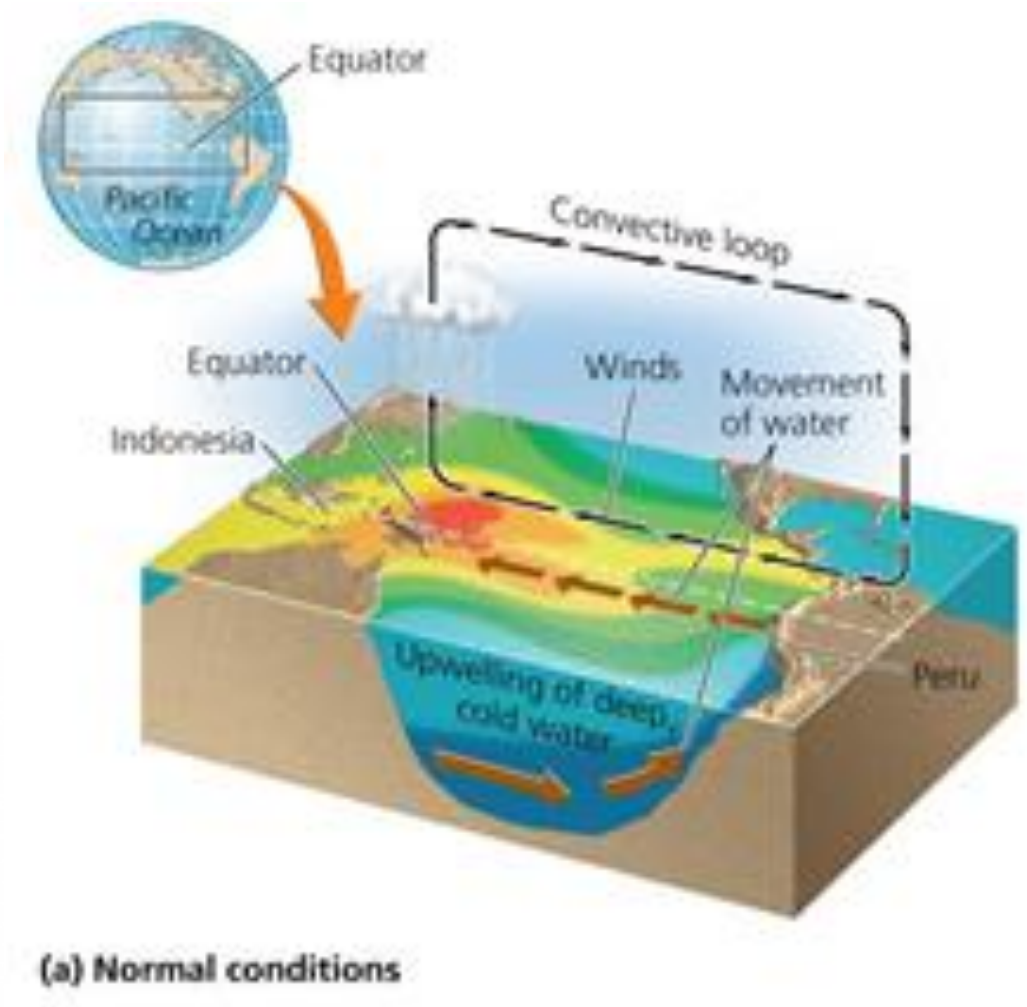
- **Horizontal and vertical movement causes the world wide current system known as *Thermohaline circulation***
  - Warmer, fresher (less dense) water moves along the surface. Cooler, saltier, (denser) water moves deep beneath the surface
- **The *Gulf Stream* is a warm Atlantic current running north, up the east coast of the United States**
  - results from winds pushing warm, low salt, equatorial waters to the west where they are deflected north up the coast
- ***North Atlantic Deep Water (NADW)* in the NE Atlantic**
  - As the Gulf Stream waters move north, it releases heat and cools, evaporation along its journey makes these waters saltier
  - Sinking cooler water creates a region of downwelling



# El Nino Southern Oscillation (ENSO)

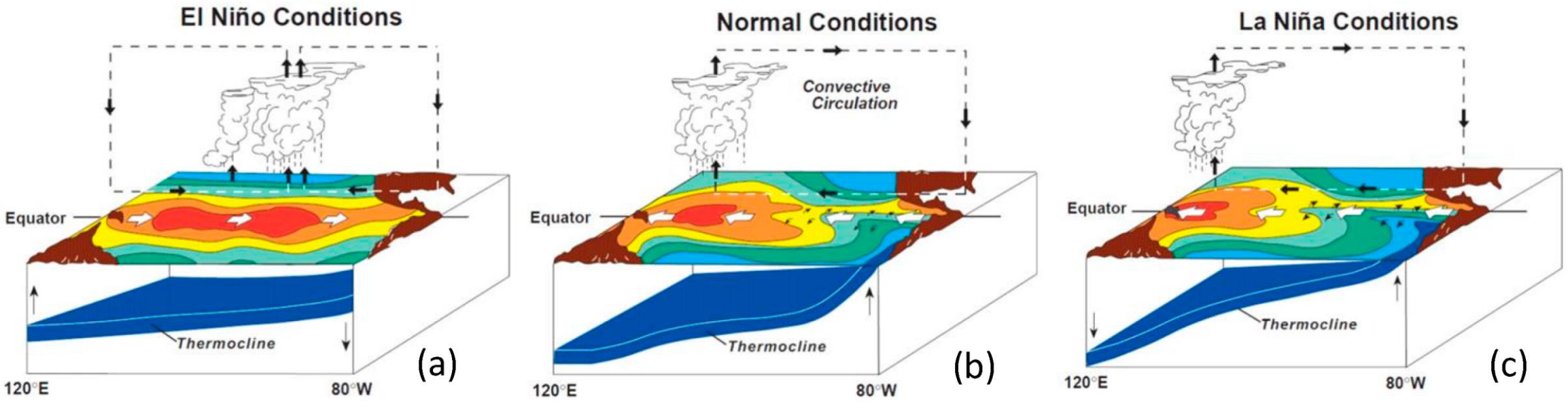
- **A pattern of shifting winds & ocean currents in the pacific ocean between South America and Australia/Southeast Asia**
  - Oscillates, or shifts regularly, from El Nino (warmer, rainier) to La Nina (cooler, drier) conditions along coast of Central and South America
- **Normal Conditions (Neutral)**
  - Equatorial Trade winds blow east to west across the Pacific resulting in moderate upwelling along the coast of the Americas



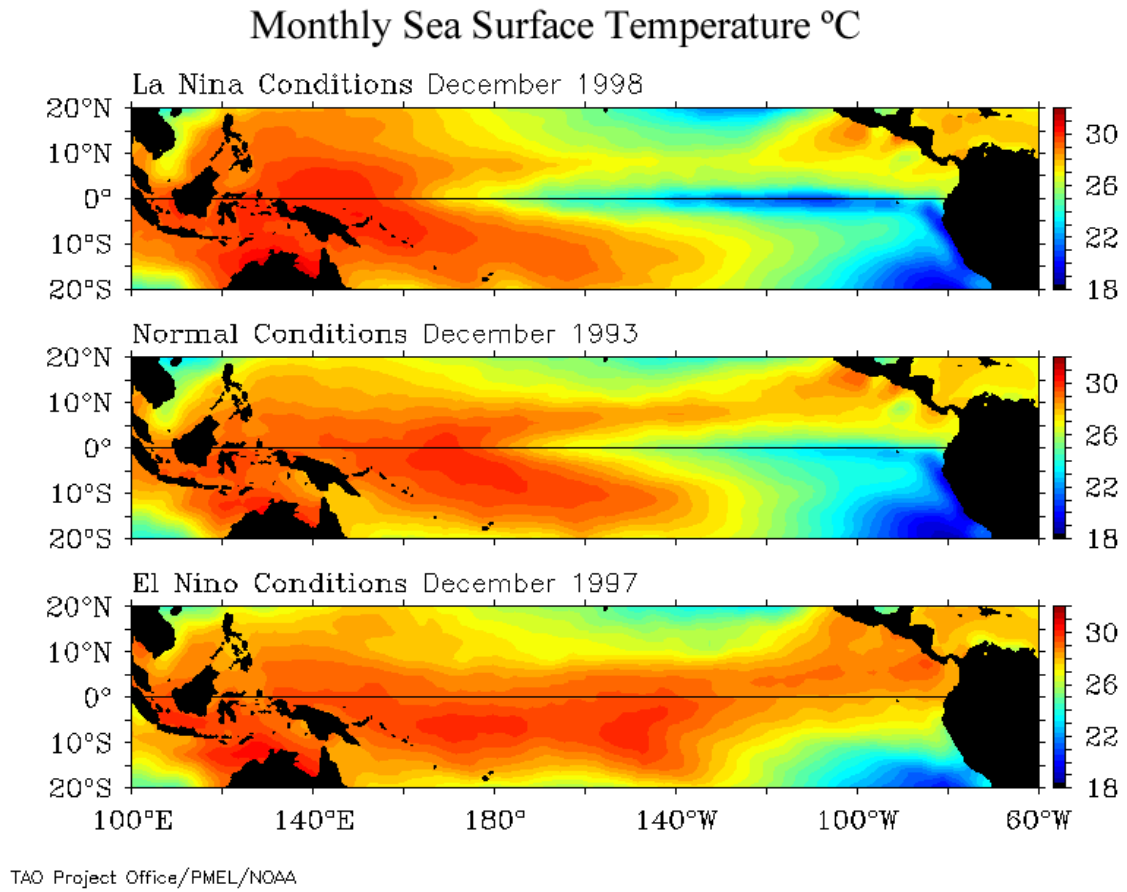
# El Nino Southern Oscillation (ENSO)

- **El Niño**
  - Trade winds weaken and may even reverse direction
    - west → east
  - Warm water spreads eastward, suppressing upwelling in the eastern pacific (west coast of the Americas)
- **La Niña**
  - Stronger than normal trade winds blow
    - west ←←← east,
  - Winds push water west, causing it to "pile up" along the east coast of Australia / Southeast Asia
  - Cold, nutrient rich waters rise to the surface along the equatorial, west coast of Central / South America



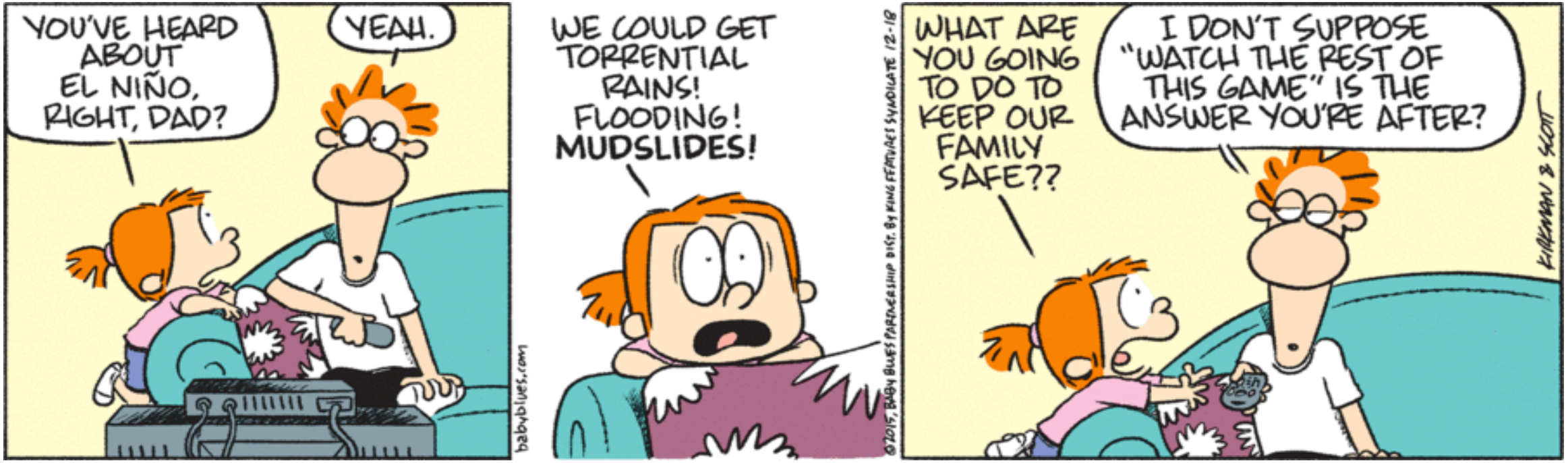
## Effects of El Nino

- Suppressed upwelling & less productive fisheries in the Americas
- Warmer winter in much of North America
- Increased precipitation & flooding in Americas (W coast especially)
- Drought in southeast Asia & Australia (fires)
- Weakened monsoon activity in India & SE Asia
- Temporary changes in species distribution, including vectors of disease (mosquitos)




## Effects of La Nina

- Stronger upwelling & better fisheries in the Americas than normal
- Cooler, drier weather in Americas
- Rainier, warmer, increased monsoons and flooding in SE Asia
- Temporary changes in species distribution


YOU'VE HEARD ABOUT EL NIÑO, RIGHT, DAD?
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