

Lecture 13. Global Wind Patterns and the Oceans

Table 7.1 Major Ocean Currents

1. Gulf Stream	9. South Equatorial Current	17. Peru or Humbolt Current
2. North Atlantic Drift	10. South Equatorial Countercurrent	18. Brazil Current
3. Labrador Current	11. Equatorial Countercurrent	19. Falkland Current
4. West Greenland Drift	12. Kuroshio Current	20. Benguela Current
5. East Greenland Drift	13. North Pacific Drift	21. Agulhas Current
6. Canary Current	14. Alaska Current	22. West Wind Drift
7. North Equatorial Current	15. Oyashio Current	
8. North Equatorial Countercurrent	16. California Current	

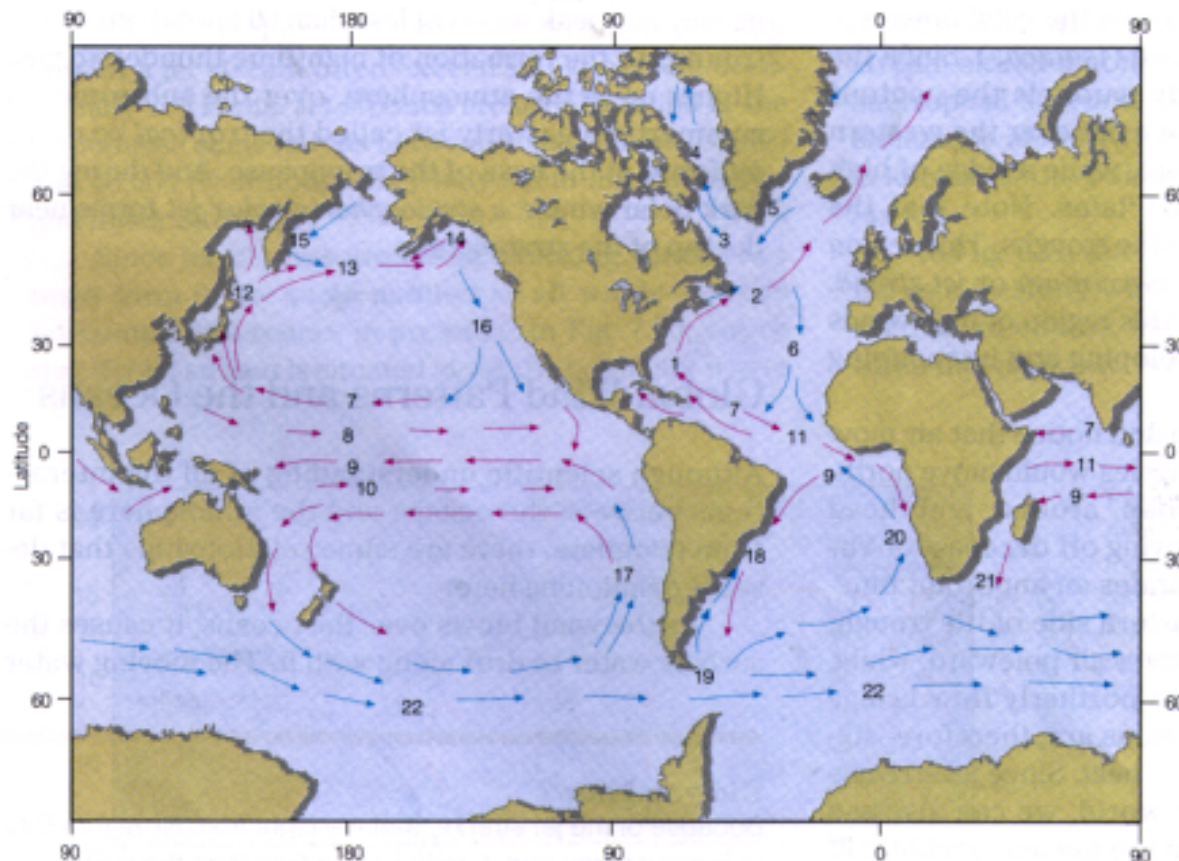


Figure 7.23

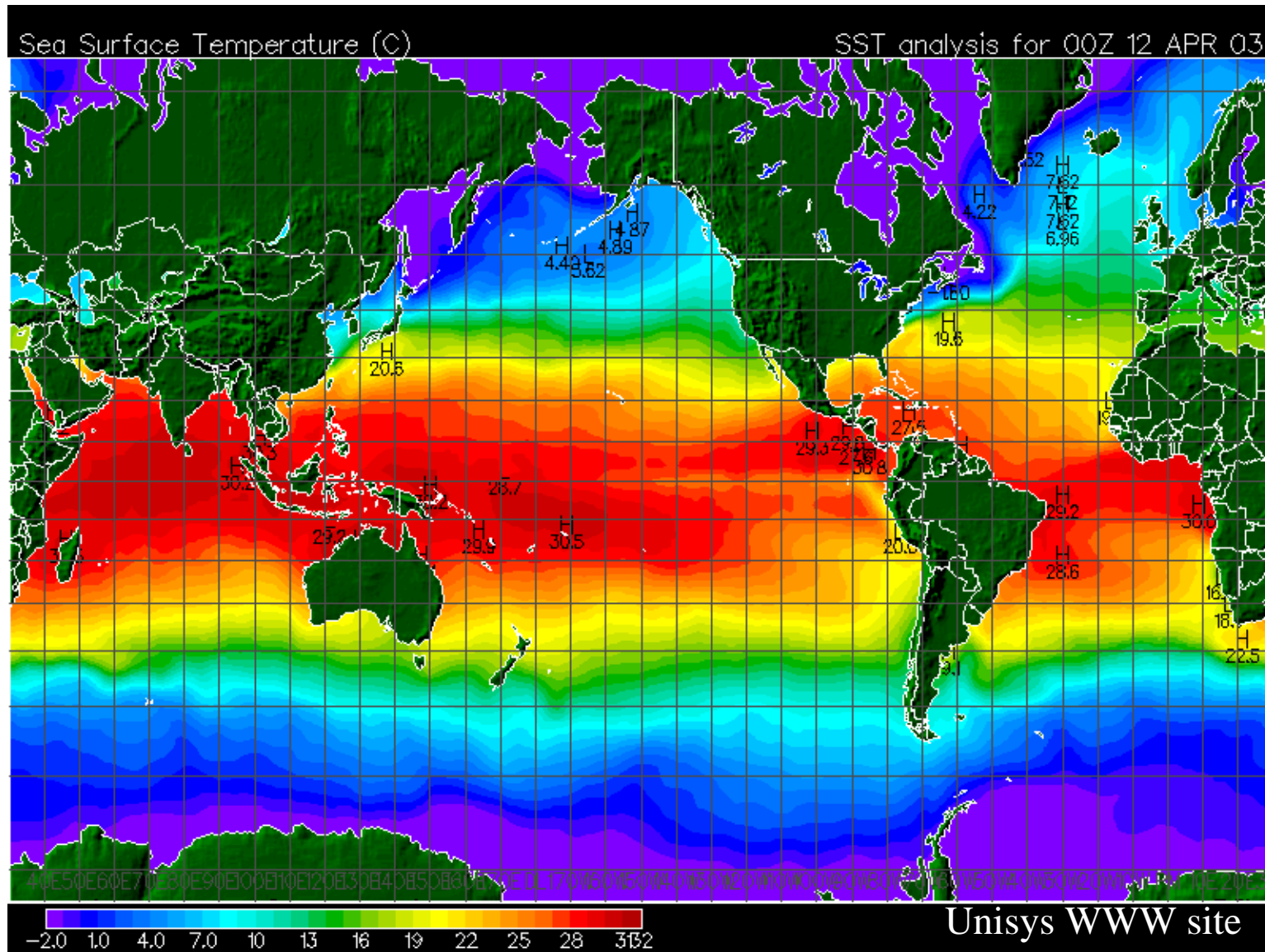
Average position and extent of the major surface ocean currents. Cold currents are shown in blue; warm currents are shown in red. Names of the ocean currents are given in Table 7.1.

EOM

Global Wind Patterns and the Oceans

- Drag from wind exerts a force called ‘wind stress’ on the ocean surface in the direction of the wind.
- The currents in the upper ocean are driven by the wind
- In general, they tend to flow in a similar direction to the prevailing wind
- Poleward currents are warm; equatorward currents cold, so ocean currents move heat from the tropics toward the poles, doing a comparable amount of heat transport as occurs in the atmosphere.
- This heat transport helps warm the climate of higher latitudes, while cooling the tropics.
- In the winter, strong temperature contrasts occur between the warm Gulf Stream and the cold interior of N America. This produces a strong jet stream and a ‘storm track’(region of particularly intense storms) along the Atlantic coast of N America.

Current Sea-Surface Temperatures



Upwelling

- Along the Pacific coast in the summer, ocean temperatures stay quite cold, particularly off N California.
- This is due to *upwelling* of cold (and nutrient-rich) water induced by the prevailing N winds.

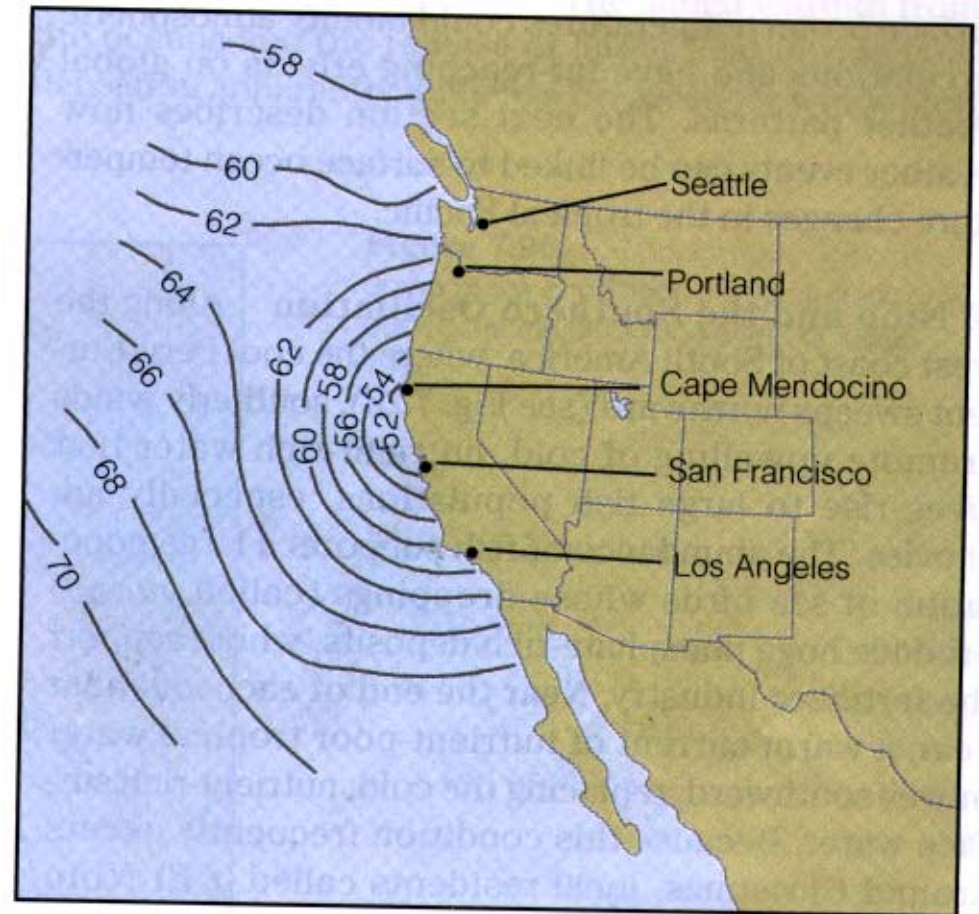


Figure 7.24

EOM

Average sea surface temperatures (°F) along the west coast of the United States during August.

How Alongshore Winds Make Upwelling

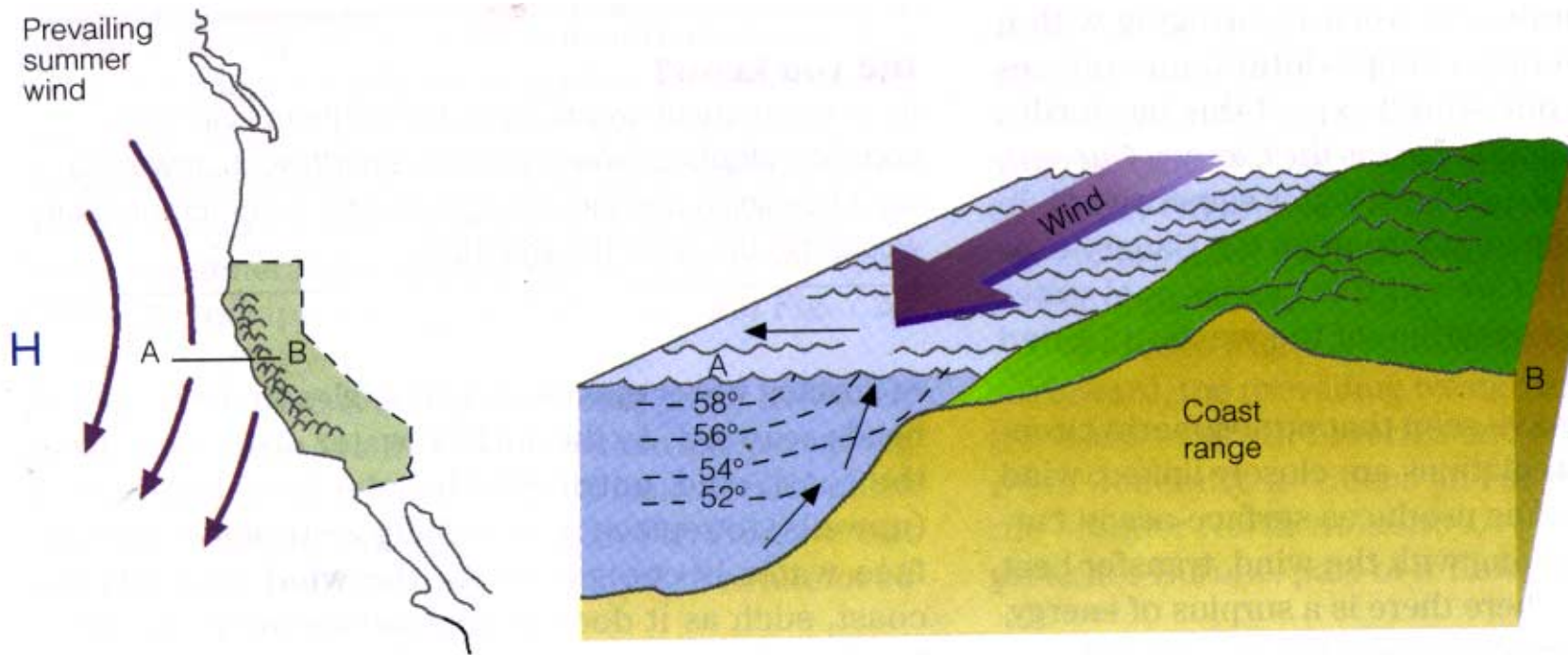


Figure 7.25 EOM
As winds blow parallel to the west coast of North America, surface water is transported to the right (out to sea). Cold water moves up from below (upwells) to replace the surface water.

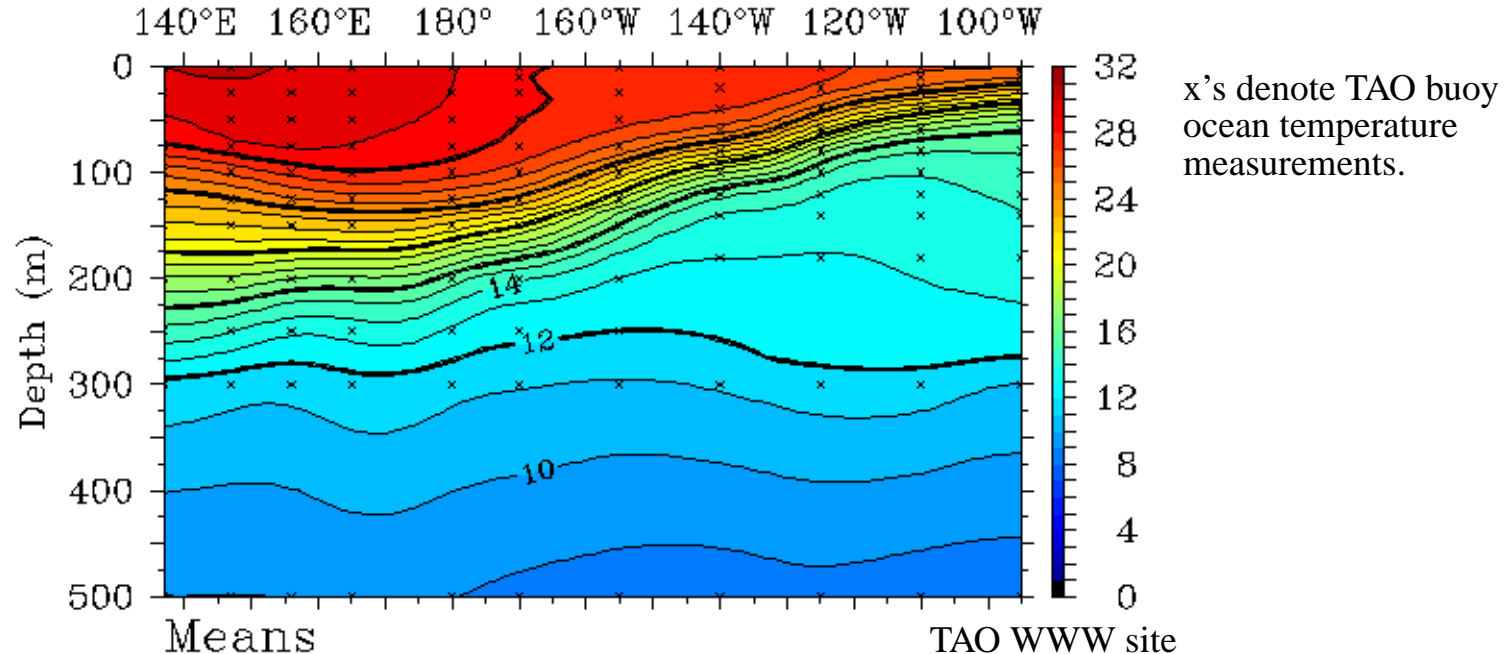
- Wind ‘stress’ pushes surface water southward.
- Coriolis force deflects surface water to the right (offshore).
- Cold subsurface water upwells to take its place.
- Fog or persistent low cloud often forms in the chilled overlying air.

Equatorial upwelling

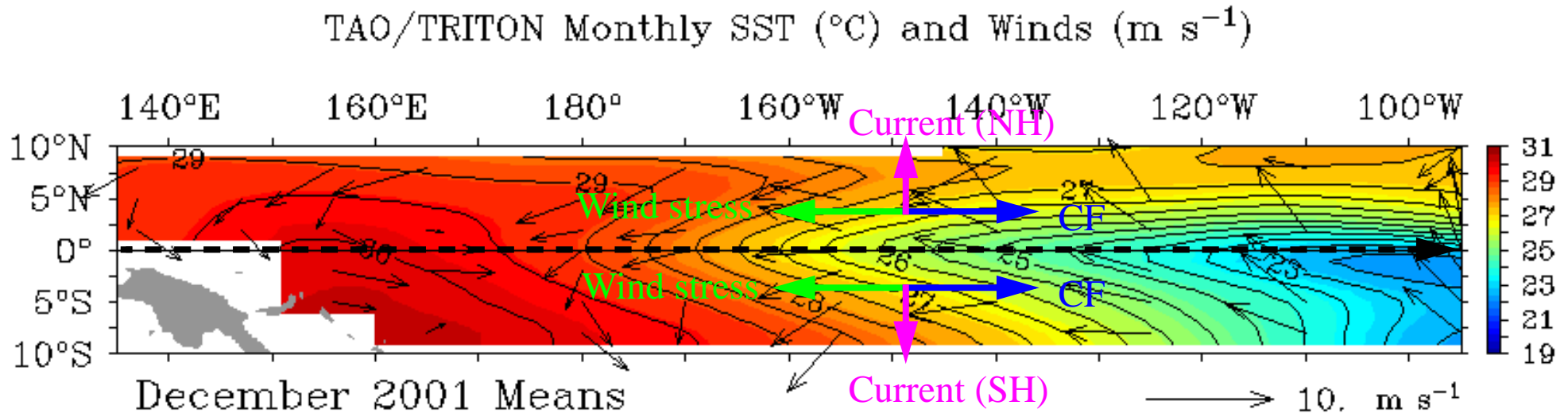
- Well below the ocean surface, it is icy-cold even in the tropics. A **thermocline** separates the warm surface waters from the cold deep waters
- Prevailing tropical easterly winds tend to pile up the warm surface waters on the west side of ocean basins, so the equatorial W Pacific thermocline is deep (200 m) while the E Pacific thermocline is shallow.

TAO/TRITON 5-Day Mean Temperatures ($^{\circ}\text{C}$)

Ending on April 16 2003 2°S to 2°N Average



- Easterly winds also induce ‘equatorial upwelling’ since



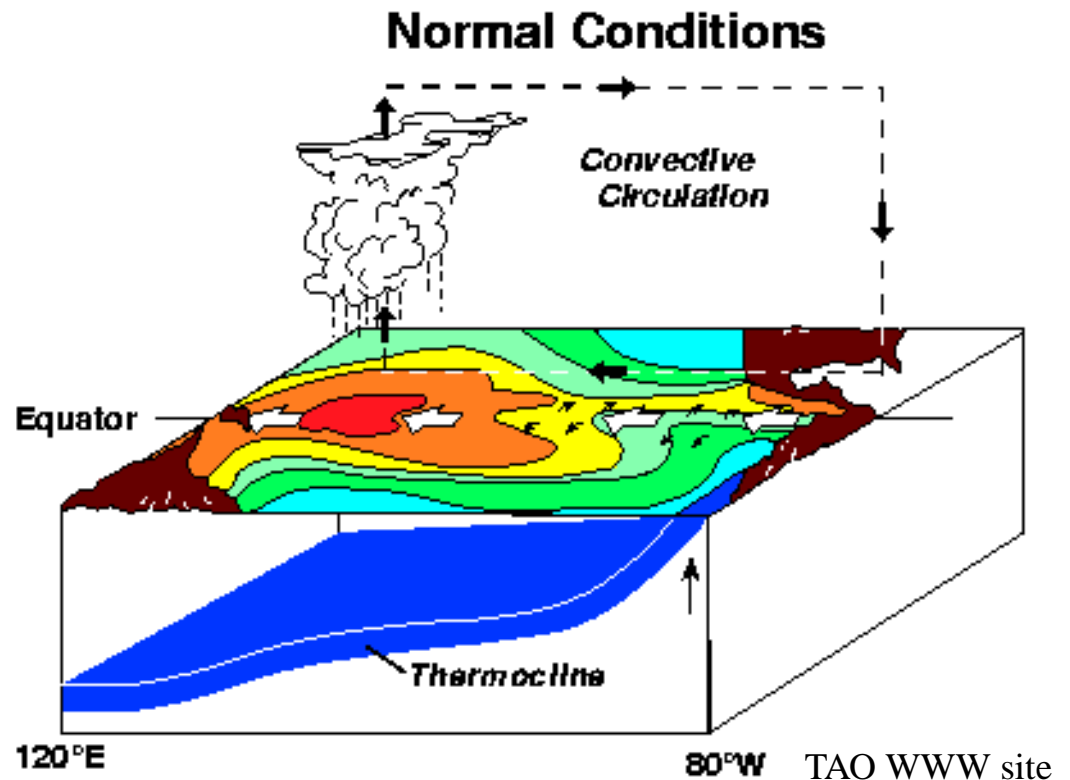
- the easterly winds push on the ocean surface.
- surface currents adjust so Coriolis force on the water balances wind stress.
- In the northern hemisphere, the resulting current is northward
- In the southern hemisphere, the resulting current is southward
- To replace the diverging surface water, cold water is upwelled at equator.
- This lowers SST along the equator.
- If winds change to westerly, there is equatorial downwelling and no source of cold water, so SST remains warm even near equator.
- If the thermocline is shallow (E Pacific), upwelling easily cools SST.

El Nino / Southern Oscillation (ENSO)

A coupled tropical atmosphere-ocean phenomenon

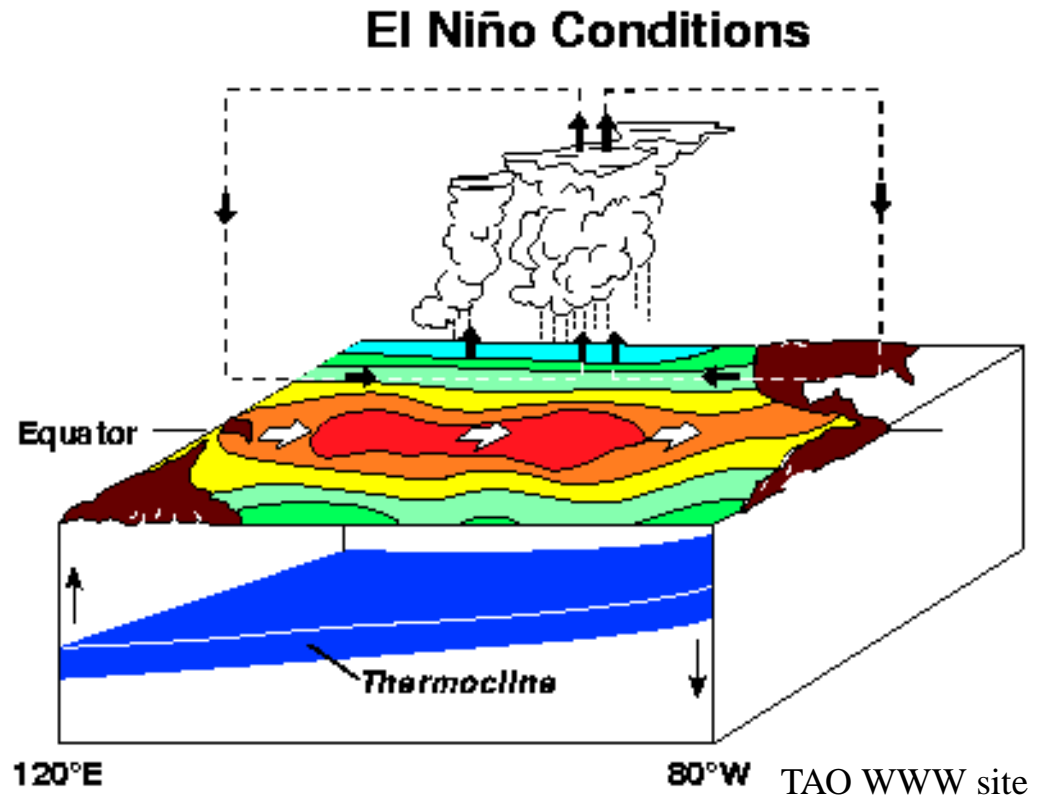
Normal conditions

- Warmest water, low surface pressure and persistent T-storms in W Pacific
- Strong subtropical highs in E Pacific
- Easterly winds and cool upwelled water along the equator in E Pacific
- Southerly prevailing winds off the Peruvian coast produce cold upwelling, good fishing.
- **La Nina** is an intensification of the east winds, upwelling and equatorial cooling.



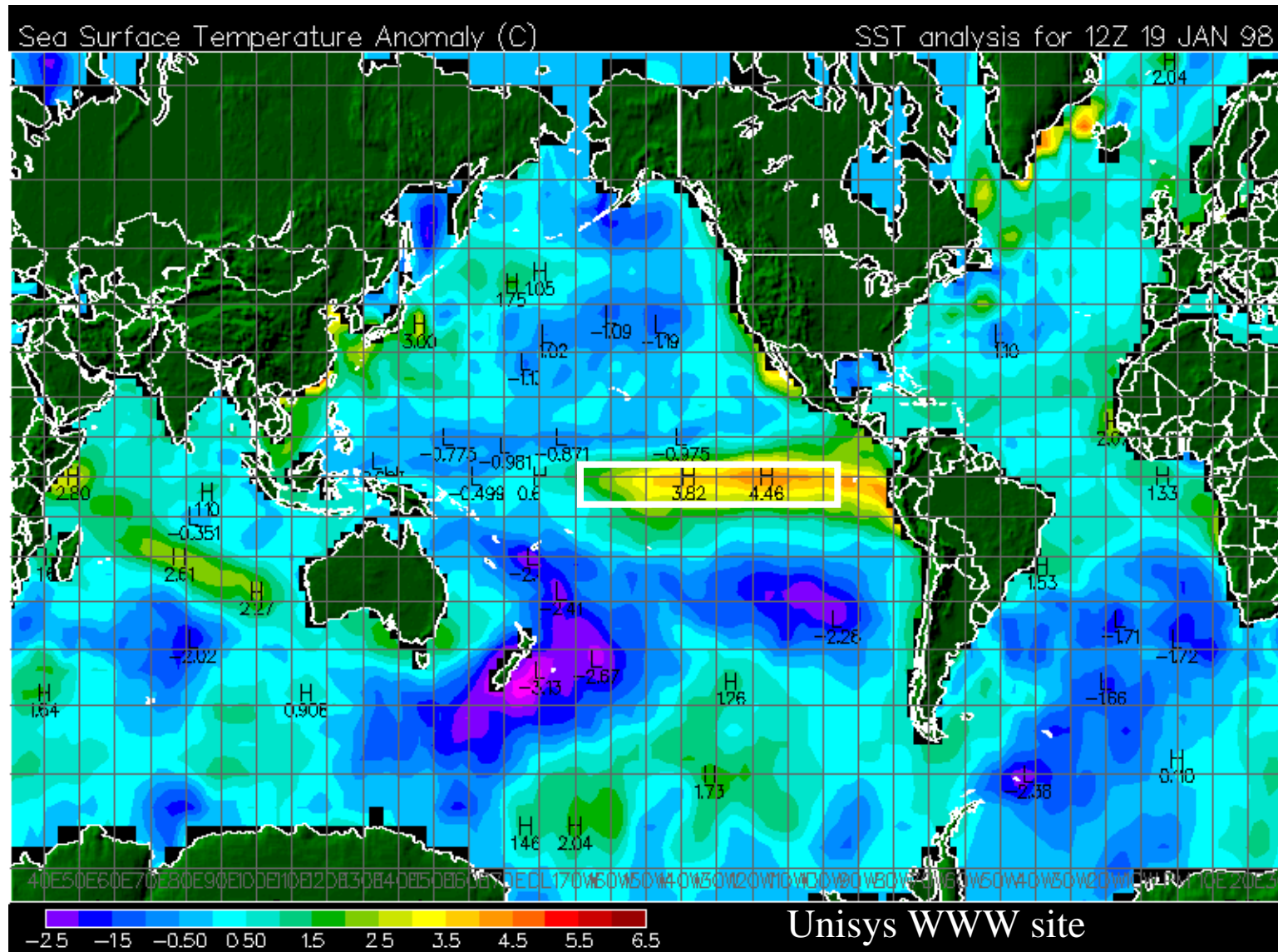
Every few years- an 'El Nino' or 'warm event':

- Central equatorial Pacific ocean warms
- Storms and low surface pressure move to central and east Pacific (the Southern Oscillation).
- Trade winds and coastal southerly winds weaken
- Off Peru, upwelling diminishes and ocean surface warms (an El Nino event), leading to fish dieoff and ocean warming.
- The changed tropical Pacific wind and pressure patterns influences the entire tropics and much of the midlatitudes.



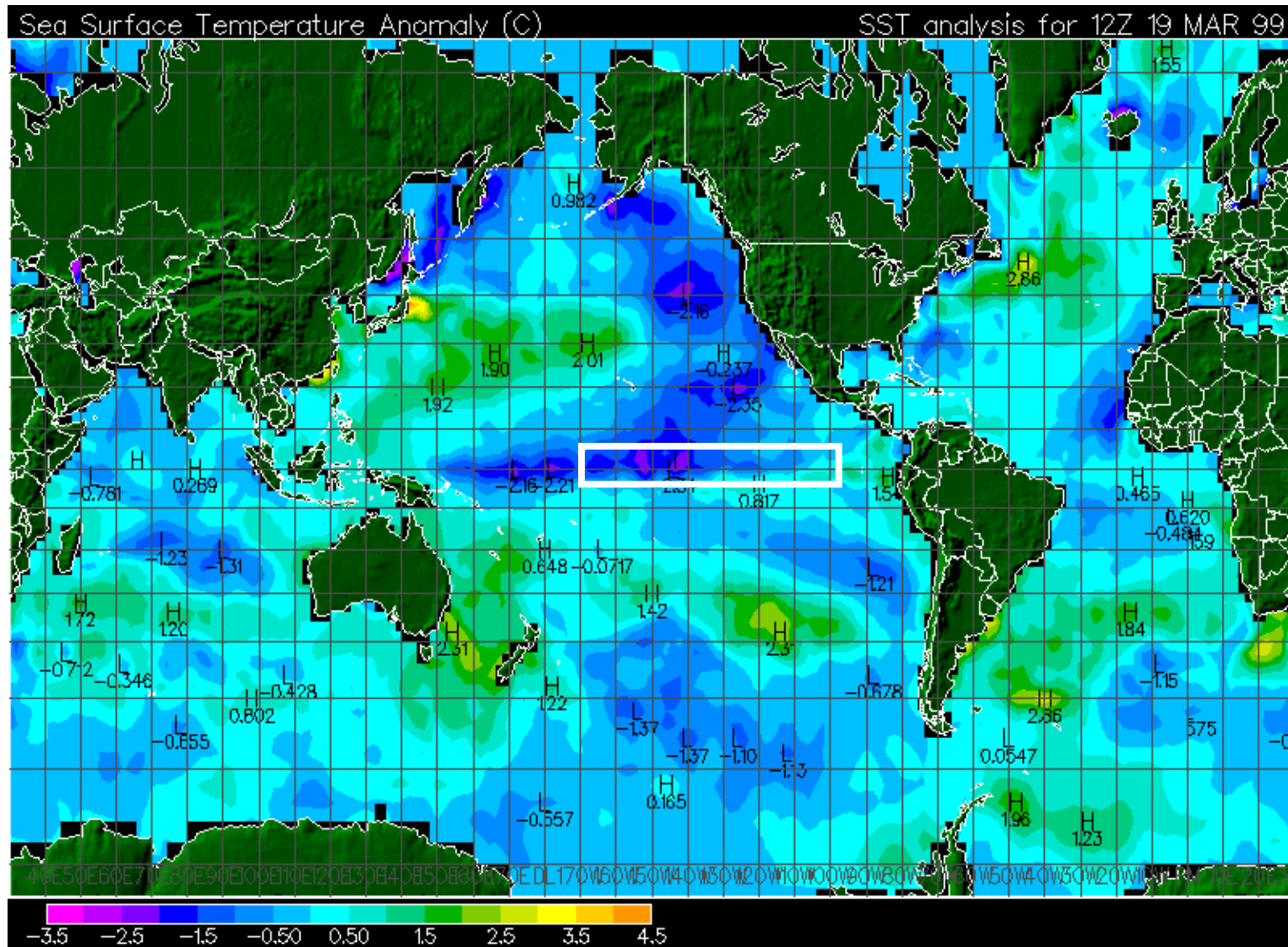
The mega-El Nino of 1997-1998

Ocean 3-5°C warmer than normal along equator in E Pacific, off Peru.



The La Nina of 1998-1999

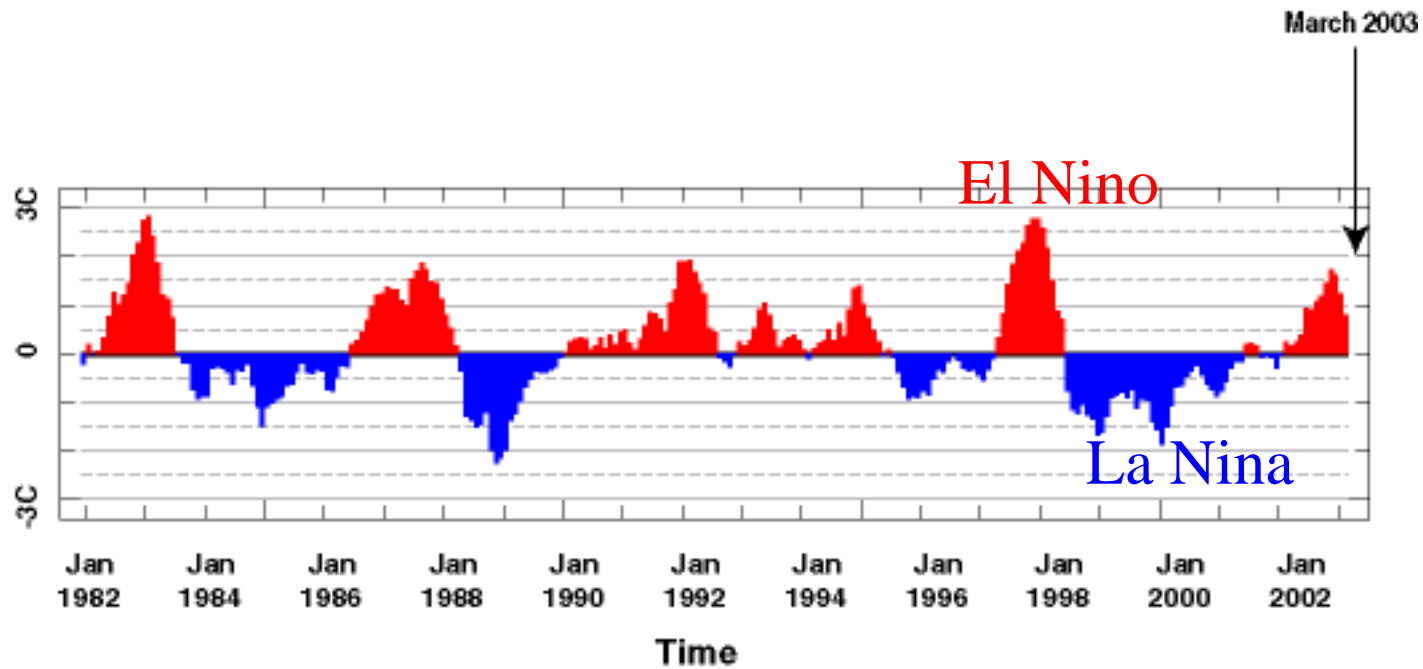
- Ocean 2°C colder than normal along equator in central Pacific.



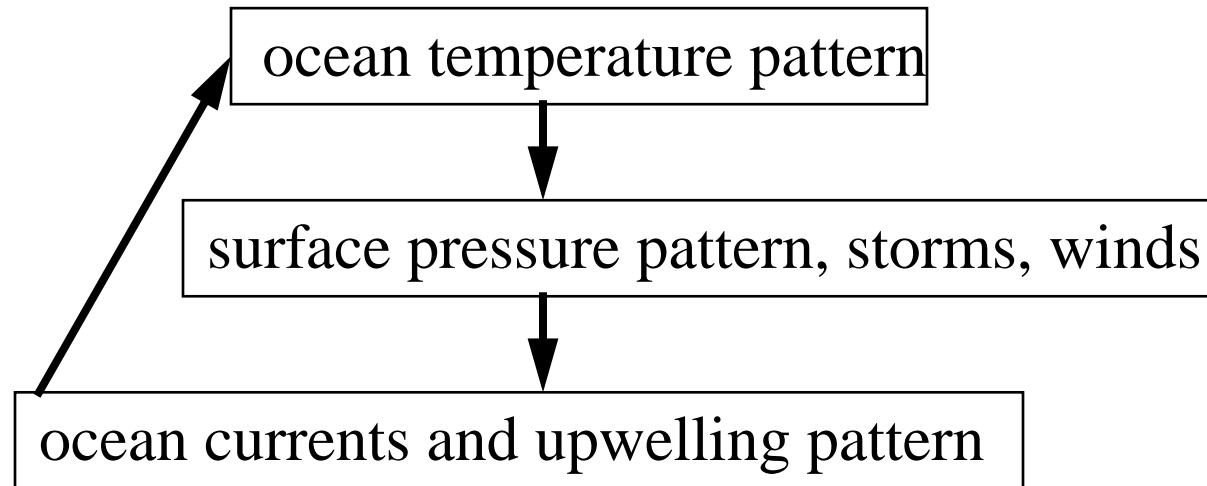
ENSO over the last 20 years

(SST anomaly in white box 2S-2N, 90-180W of previous figures)

Historical Sea Surface Temperature Index



The ENSO Ocean-Atmosphere Feedback



With monitoring of the temperature in the upper ocean in the equatorial Pacific and the atmosphere using NOAA's TAO (Tropical Atmosphere Ocean) buoy array, currently run out of PMEL here in Seattle, and satellite and other measurements, we can now forecast an El Nino with considerable skill up to a year in advance.