The high phytoplankton concentrations [illegible] upwelling along the South American coast [illegible] one of the world's richest fisheries.

Wherever the thermocline is shallow enough, stirring by the wind mixes the nutrient-rich water with the surface water. In the presence of sunlight, tiny plant species called *phytoplankton* use the nutrients to produce a greenish plant substance called *chlorophyll*. These explosively growing "blooms" of phytoplankton use up all the available nutrients within a week, at which time they die and sink. During their brief lifetime in the sun they are visible in satellite images as greenish patches of water, which serve as markers for places where upwelling is bringing nutrients to the surface. The surface waters above the thermocline would soon become devoid of nutrients were they not continually being replenished by upwelling.

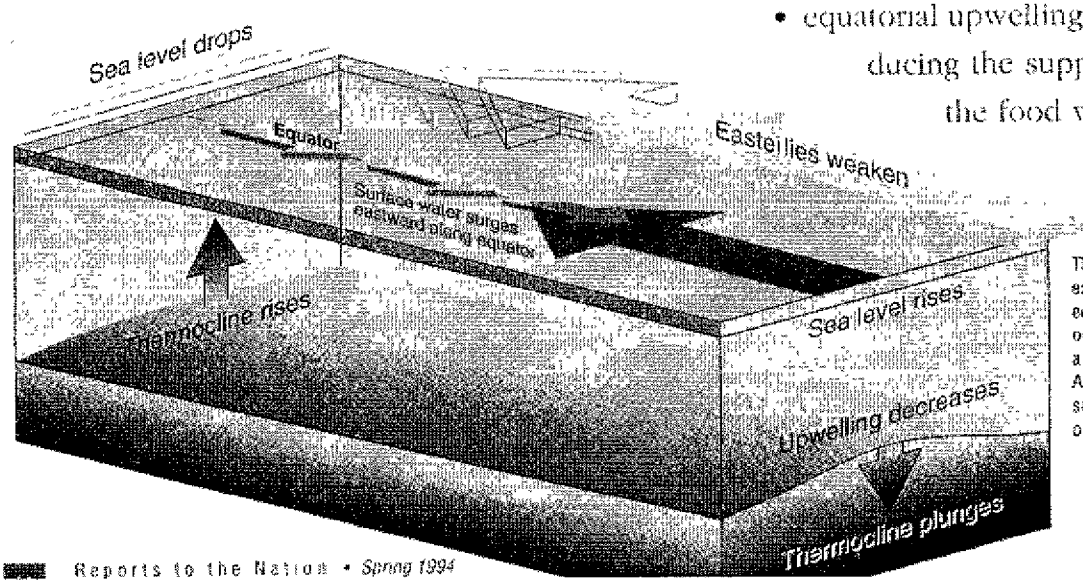
The newly upwelled water is colder than its surroundings. It can be tracked for several weeks using *infrared satellite imagery* that reveals the water temperature. Its signature in the infrared images takes the form of a distinctive "cold tongue" extending westward along the equator from the South American coast.

So it is that the winds control the upwelling and the upwelling controls the phytoplankton production. The phytoplankton production, in turn, affects the lives of the tiny sea animals called zooplankton, which "graze" on them and, ultimately, this affects all the creatures at higher levels of the marine food web. The winds are also responsible for the cold tongue in the sea-surface temperature pattern.

When the Winds Weaken

During El Niño years, when the easterlies retreat into the eastern Pacific, the ocean responds in the following ways:

- the thermocline along the equator flattens out, rising in the west and plunging several hundred feet below the surface in the east—deep enough so that coastal upwelling is no longer able to tap the cold, nutrient-rich waters from beneath it.
- equatorial upwelling decreases, further reducing the supply of nutrients to the food web.



The easterly winds (red arrow) that usually extend nearly all the way across the equatorial Pacific retreat eastward with the onset of El Niño conditions. This triggers a change in the upper layer of the ocean. Along the equator the slope of the sea surface and the thermocline both flatten out, as shown.