Small islands often leave downstream wakes consisting of swirling wind patterns, which distort the pattern of low clouds over the surrounding ocean. In this picture of Guadalupe Island off the Pacific coast of Mexico, the wind is blowing from the northwest (upper left toward lower right). The two largest vortices are approximately 15 miles apart. The rain areas over the tropical Pacific leave a similar wake more than a hundred times as large, which distort the winds aloft. When the rain areas are rearranged by El Niño, the shape of the wind pattern changes, as indicated in the maps on the following page.

as each partner sends back a stronger message. Small perturbations in the ocean and atmosphere can amplify one another until eventually a full-fledged El Niño is under way. And, just as it is often hard to say which partner was responsible for a change in the mood of a dialogue, or precisely what they said that set the conversation off in a new direction, it is often difficult to identify the subtle change in the ocean-atmosphere system that initiates a transition into or out of El Niño conditions.

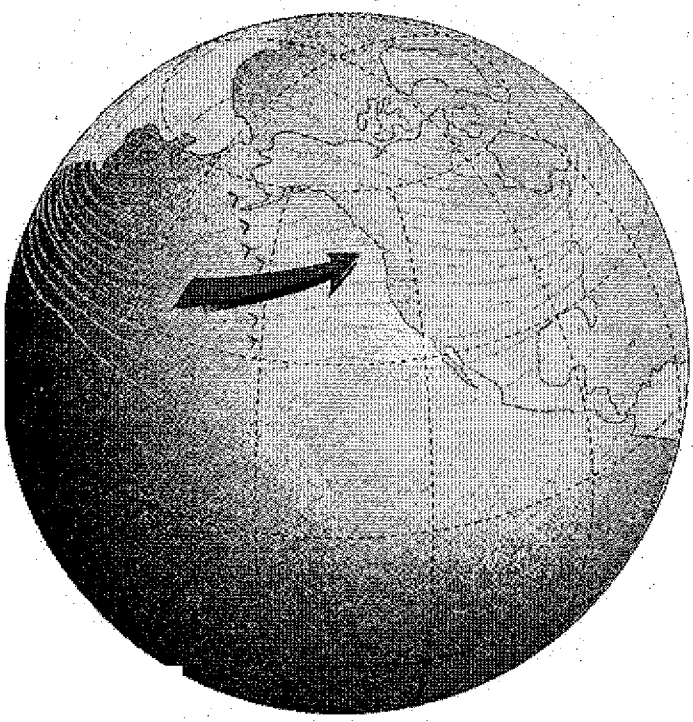
Global Consequences of El Niño

The twists and turns in the ongoing dialogue between ocean and atmosphere in the Pacific can have a ripple effect on climatic conditions in far flung regions of the globe. This worldwide message is conveyed by shifts in tropical rainfall, which affect wind patterns over much of the globe. Imagine a rushing stream flowing over and around a series of large boulders. The boulders create a train of waves that extend downstream, with crests and troughs that show up in fixed positions. If one of the boulders were to shift, the shape of the wave train would also change and the crests and troughs might occur in different places.

Dense tropical rainclouds distort the air flow aloft (5–10 miles above sea level) much as rocks distort the flow of a stream, or islands distort the winds that blow over them, but on a horizontal scale of thousands of miles. The waves in the air flow, in turn, determine the positions of the monsoons, and the storm tracks

and belts of strong winds aloft (commonly referred to as *jet streams*) which separate warm and cold regions at the Earth's surface. In El Niño years, when the rain area that is usually centered over Indonesia and the far western Pacific moves eastward into the central Pacific, as shown on p. 17, the waves in the flow aloft are affected, causing unseasonable weather over many regions of the globe.

The impacts of El Niño upon climate in temperate latitudes show up most clearly during wintertime. For example, most El Niño winters are mild over western Canada and parts of the northern United States, and wet over the southern United States from Texas to Florida. El Niño affects temperate climates in other seasons as well. But even during wintertime, El Niño is only one of a number of factors that influence temperate climates. El Niño years, therefore, are not always marked by "typical" El Niño conditions the way they are in parts of the tropics.



Winds at the jetstream level (small arrows), five to fifteen miles above sea level, change their course between normal (above) and El Niño (right) winters. A ridge of high pressure over North America's west coast during El Niño winters keeps temperatures above normal in the orange region and steers storms that would otherwise pass through Washington and Oregon northward toward the coast of Alaska as indicated by the heavy arrow. El Niño also creates a favorable environment for storms to develop in the Gulf of Mexico, bringing heavy rains to much of the southern United States. An analogous strengthening of the westerlies in the Southern Hemisphere during its winter season brings heavy precipitation to parts of southern Brazil and northern Chile and Argentina (not pictured).

El Niño Prediction

In the preceding pages, we have considered how El Niño develops, how it perturbs marine life in the Pacific, how it influences weather patterns throughout the world, and how the abnormal atmospheric and oceanic conditions during El Niño affect human beings. Scientists are now taking our understanding of El Niños a step further by incorporating the descriptions of these events into *numerical prediction models* (computer programs