CHAPTER 8 BOX 2: EQUATORIAL CURRENTS.

EKMAN TRANSPORT IN THE EQUATORIAL REGION

Because the atmospheric intertropical convergence zone is displaced north of the equator, part of the southeast trade wind zone extends into the Northern Hemisphere. Consequently, although the Coriolis effect is weak near the equator, trade winds are deflected to the right after they pass north of the equator. Once the Southern Hemisphere trade winds have crossed the equator into the Northern Hemisphere, they generate Ekman transport that is deflected to the right, away from the equator, in a generally northeast direction toward the Doldrums (**Fig. 8B2-1**). This pattern contrasts with the Ekman transport to the southwest, or away from the Doldrums, that was assumed in the simple model (**Fig. 8-7**). Ekman transport is directed to the southwest in the major portion of the southeast trade wind belt that lies south of the equator (**Fig. 8B2-1a**).

When the intertropical convergence zone is displaced north of the equator, the sea surface slopes up in a northward direction toward the center of the Northern Hemisphere subtropical gyres throughout the northeast trade wind zone (**Fig. 8B2-1b**). In addition, the sea surface slopes up in a southward direction toward the center of the Southern Hemisphere subtropical gyre throughout the portion of the southeast trade wind zone in the Southern Hemisphere. These slopes are the same as the slopes developed in the simple model of the subtropical gyres shown in **Figures 8-7 and 8-8**. However, the sea surface slopes upward toward the north in the portion of the southeast trade wind zone that lies between the equator and the Doldrums (**Fig. 8B2-1b**). In this region, Ekman transport is northeast, to the right of the wind, toward the Doldrums, where the sea surface level is undisturbed by local winds.

Geostrophic Currents in the Equatorial Region

As a result of Ekman transport processes, a small "hill" of water is present in the Northern Hemisphere, and its **crest** is at the intersection of the Doldrums with the southeast trade wind

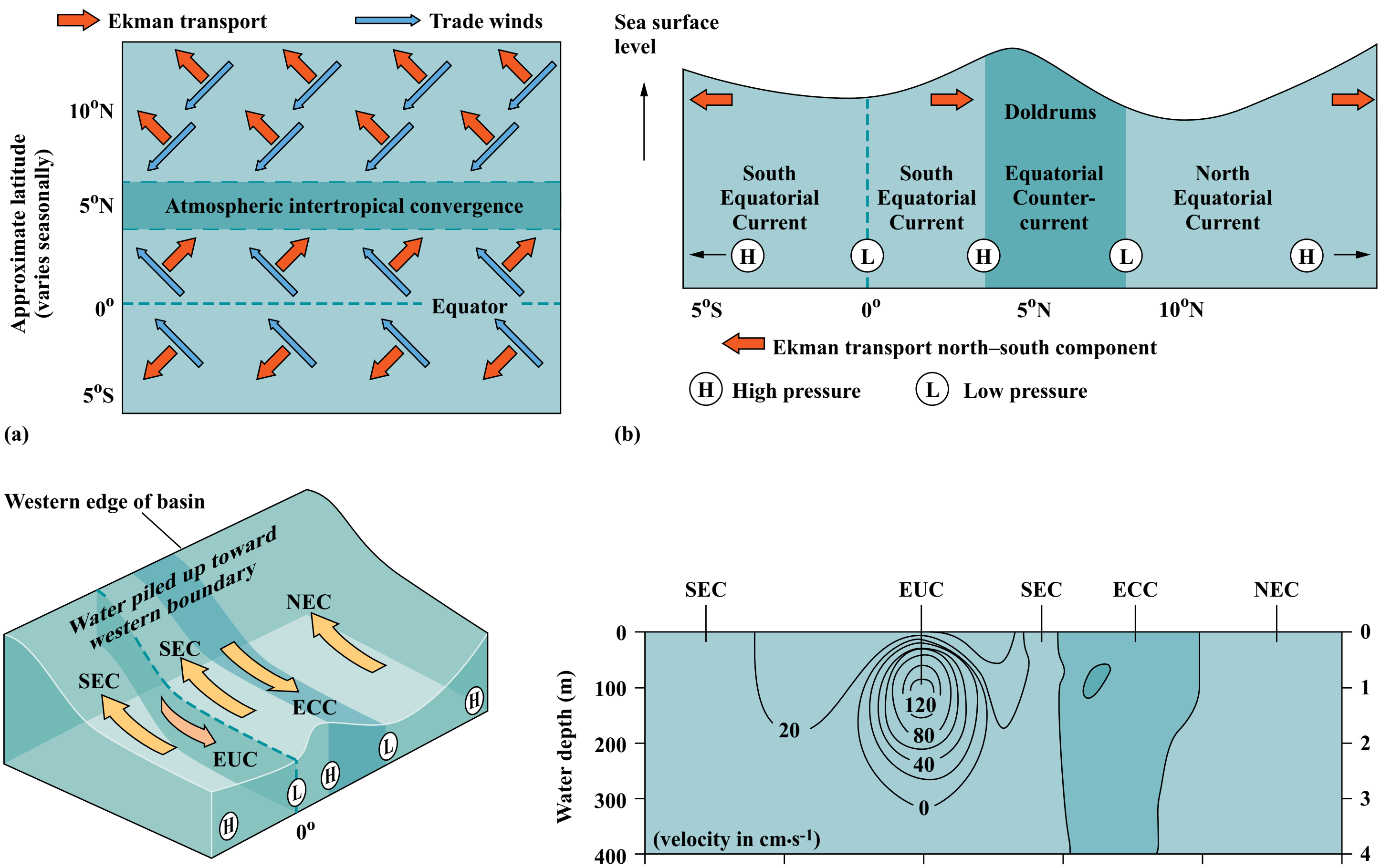

FIGURE 8B2-1 Currents of the Pacific Ocean equatorial region. (a) The intertropical convergence is displaced north of the equator, especially in the winter, such that the Southern Hemisphere southeast trade winds extend north of the equator. Because Ekman transport is to the right of the wind direction in the Northern Hemisphere, the pattern of Ekman transport just north of the equator is complex. (b) This pattern of Ekman transport produces complex latitudinal variation of sea surface elevation in the equatorial region. (c) The complex sea surface elevation pattern sets up a eastward-flowing Equatorial Undercurrent (EUC) between the South Equatorial Current (SEC) and the Equatorial Countercurrent (ECC). (d) The Equatorial Undercurrent is a fast current—much faster than the North and South Equatorial currents (NEC and SEC) or the EquatorialCountercurrent. The EUC flows between the surface and a depth of about 300 m, and its maximum velocity occurs at about 100 m.

zone (**Fig. 8B2-1b**). In the pressure gradient south of the crest, geostrophic flow is to the west, in the same direction as the geostrophic flow immediately south of the equator. North of the crest, in the pressure gradient within the Doldrums, geostrophic flow is to the east. This is the Equatorial Countercurrent. The arrangement of sea surface slope, pressure gradients, and geostrophic currents in the equatorial region is shown in **Figure 8B2-1c**. The characteristics of each of the currents are described in **Table 8B2-1**.

The equatorial currents of the subtropical gyres and the westward component of Ekman transport in the trade wind zones move very large volumes of surface layer water toward the west. Consequently, the sea surface slopes upward toward the western boundary. Much of the water that flows westward is either diverted north or south in the subtropical gyres or transported back toward the east in the Equatorial Countercurrents. However, water also flows back to the east in a current called the "Equatorial Undercurrent."

Equatorial Undercurrents flow at the equator, are about 400 km wide, and have a vertical thickness of about 200 m (**Fig. 8B2-1d**). In the Pacific, the core of the current rises from a depth of about 200 m in the west to about 40 m in the east. In the Atlantic, the core is at about 100 m depth. Equatorial Undercurrents are very swift, with speeds comparable to that of the Gulf Stream. The Equatorial Undercurrent flows on the west-to-east pressure gradient created by the "piling up" of surface water toward the western boundary. However, the fact that it flows directly down the pressure gradient distinguishes it from other geostrophic currents, which all flow parallel to the contours of constant pressure (across the pressure gradient) to balance the pressure gradient and the Coriolis effect (**CC12, CC13**).

The Equatorial Undercurrent can flow down the pressure gradient because it flows precisely west to east at the equator, where the Coriolis deflection is zero. If the current deviates slightly to the north, the Coriolis deflection (to the right in the Northern Hemisphere), although weak, turns the current back to the south. If it deviates slightly to the south, the Coriolis deflection (to the left in the Southern Hemisphere) turns it back to the north. Thus, the Equatorial Undercurrent flows directly across the oceans for thousands of kilometers without deviating from its west-to-east direction. The Pacific Ocean Equatorial Undercurrent is particularly important for the critical role it plays in **El Niño** (Chap. 7).

TABLE 8B-1 Boundary Currents

	Western Boundary Currents	*Eastern Boundary Currents*
Northern Hemisphere examples	Gulf Stream Kuroshio Current	California Current Canary Current
Southern Hemisphere examples	Agulhas Current	Peru Current
	Brazil Current	Benguela Current
Width	Narrow (≤100 km)	Broad (≈1000 km)
Depth	Deep (to 2 km)	Shallow (≤500 m)
Speed	Fast (>100 $km \cdot day^{-1}$)	Slow (<50 $km \cdot day^{-1}$)
Volume transport	Large (50 $\times 10^6$ $m^3 \cdot s^{-1}$)	Small (10–15 $\times 10^6$ $m^3 \cdot s^{-1}$)
Boundaries with coastal currents	Sharply defined	Diffuse
Upwelling	Almost none	Frequent
Nutrients	Depleted	Enhanced by upwelling
Fishery	Usually poor	Usually good
Water temperature	Warm	Cool

CREDITS

8B1-2 Adapted from J.A. Knauss, 1961, Scientific American, 214:105–19;