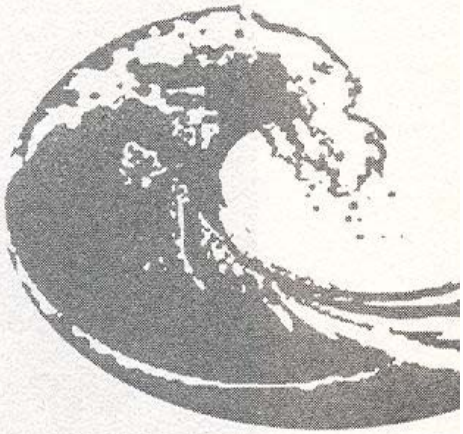
two**Rip Currents**



During a long, hot summer, nothing is more exhilarating than taking a plunge into the sea at your favorite beach. Never mind that the waves look a little larger than normal or that no lifeguards are on duty—the urge is almost irresistible. A big beach party celebrating Kwanzaa at American Beach, Florida, in 1994 ended in disaster when five people were pulled offshore to their death. The culprit was a rip current—a concentrated flow of water that can jet you offshore (figure 5). Unfortunately, these beachgoers did not know how to spot the killer currents, nor were they at a guarded beach. The group was completely unprepared to deal with these seaward rushes of water.

Most people are only vaguely familiar with beach hazards and the threats they pose to their safety. While coastal scientists have long studied waves and currents, the media are much less aware of the circumstances that can lead to drownings. Newspaper accounts of beach tragedies often lay the blame on nebulous causes, such as undertow, freak waves, or collapsing sand-

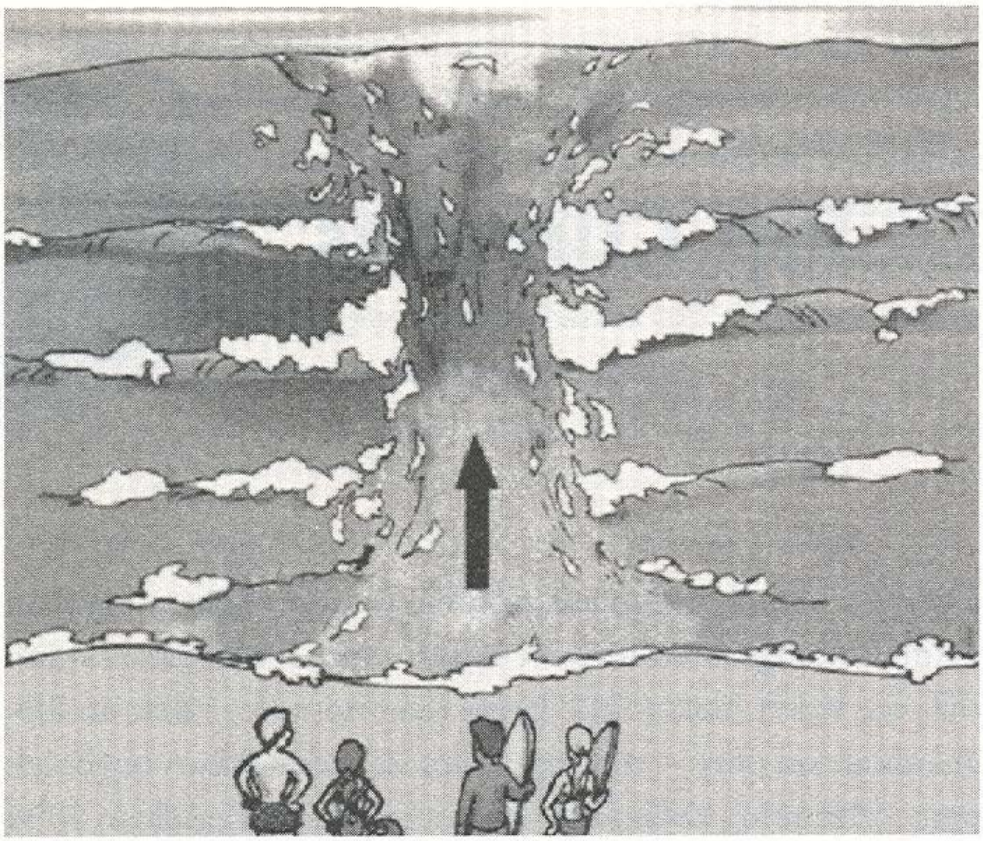


Figure 5. A rip current—a river through the surf. People sometimes look for areas where the waves are smaller and then go right into the rip current to their death. *Source:* Modified from U.S. Lifesaving Association manual.

bars. As Andy Short has pointed out, these catchy and alarming terms may have little relevance to the actual circumstances that contributed to the accident.

The Surf Beach

One of the things that makes ocean beaches so appealing and exciting is the surf—waves are the heartbeat of the ocean. We

are drawn to this rhythmic pounding of the waves. I can spend hours gazing at the ever-changing shore. The fresh, salty air invigorates the body as the sheer beauty of the scene and the interplay between the waves and beach capture the imagination and refresh the psyche. Also, nothing is more fun than jumping into the water and playing in the surf, feeling the power of the waves crashing ashore. Unfortunately, the unpredictable nature of the surf and its power results in many injuries and deaths each year, even affecting experienced swimmers and surfers.

The 6,000 or so waves that strike a beach every day are generated by the wind. Generally speaking, as the wind speed increases, so does the surf. Waves that break on beaches can be generated locally or be spawned thousands of miles away by storms at sea. Hurricanes cause the largest waves, termed swell, along the Atlantic coast, while migratory low-pressure cells (storms) at high latitudes generate the great Pacific Ocean swells. Because distant storms are responsible for them, huge swell waves can hit beaches when the weather is perfect, sunny and cloud-free. The north shore of Oahu, Hawaii, is directly exposed to these giant ocean swells, which can reach 30 to 40 feet in January, the season of international surfing contests.

Wave height is the primary determinant of rip current strength, but wavelength is also significant. Wavelength refers to the width of the wave, measured from trough to trough. The height and width determine the volume of water in a wave. Some waves that peak when breaking may appear powerful, but there is no real force behind them without a large mass of water. I have sometimes been fooled while boogie boarding on the Carolina coast by these waves. By contrast, the big swells

that dominate the Pacific coast tend to have long wavelengths, making them powerful waves that break with considerable force. While it is nearly impossible to measure wavelength when in the water, you can easily count in seconds the time between waves as they break. The longer the time between breakers (termed the wave period), the longer their wavelength and, consequently, the greater the force for a wave of a particular height. Long-period swell waves of 20 to 25 seconds are the best surfing waves along the Southern California coast, but these turbulent waters are best avoided for swimming; I suggest heading to the nearest heated swimming pool.

High waves can be very dangerous. What is not often understood by the public is that the energy they produce is proportional to the height of the wave squared. Therefore, a three-foot wave is nine—not three—times more powerful than a one-foot wave. When onshore breaking waves reach five feet, the surf is generally too dangerous for swimming. Experienced surfers look for the big waves, but good surfing beaches are often not safe for swimming.

Breaking waves can be classified into three primary types: plunging, spilling, and surging (figures 6 and 7). Plunging waves are by far the most exciting and dangerous, forceful and fast. These breaking waves are formed when swell suddenly encounters a shallow bottom, such as a reef, large sandbar, or steeply sloping beach. The wave is forced to peak and break suddenly, with all of its force concentrated in a limited area. Plunging waves often generate rip currents and shorebreaks on steep beaches and are responsible for many more injuries than spill-

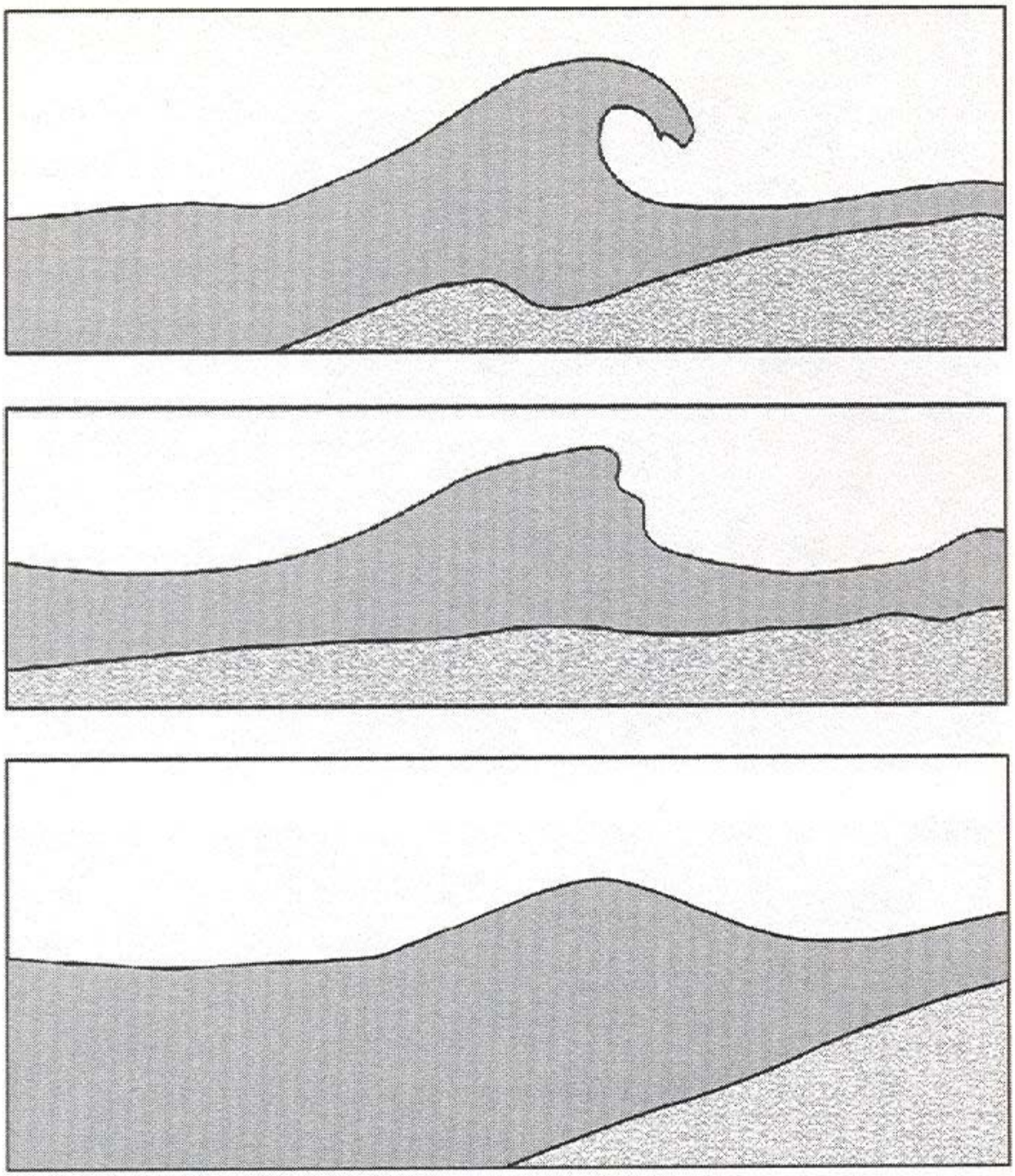


Figure 6. Types of breaking waves. Plunging breakers, top, are the most spectacular to watch. Spilling waves, center, break over long distances, gradually losing their energy. Surging waves appear as "humps" moving through the water and do not even appear to break.

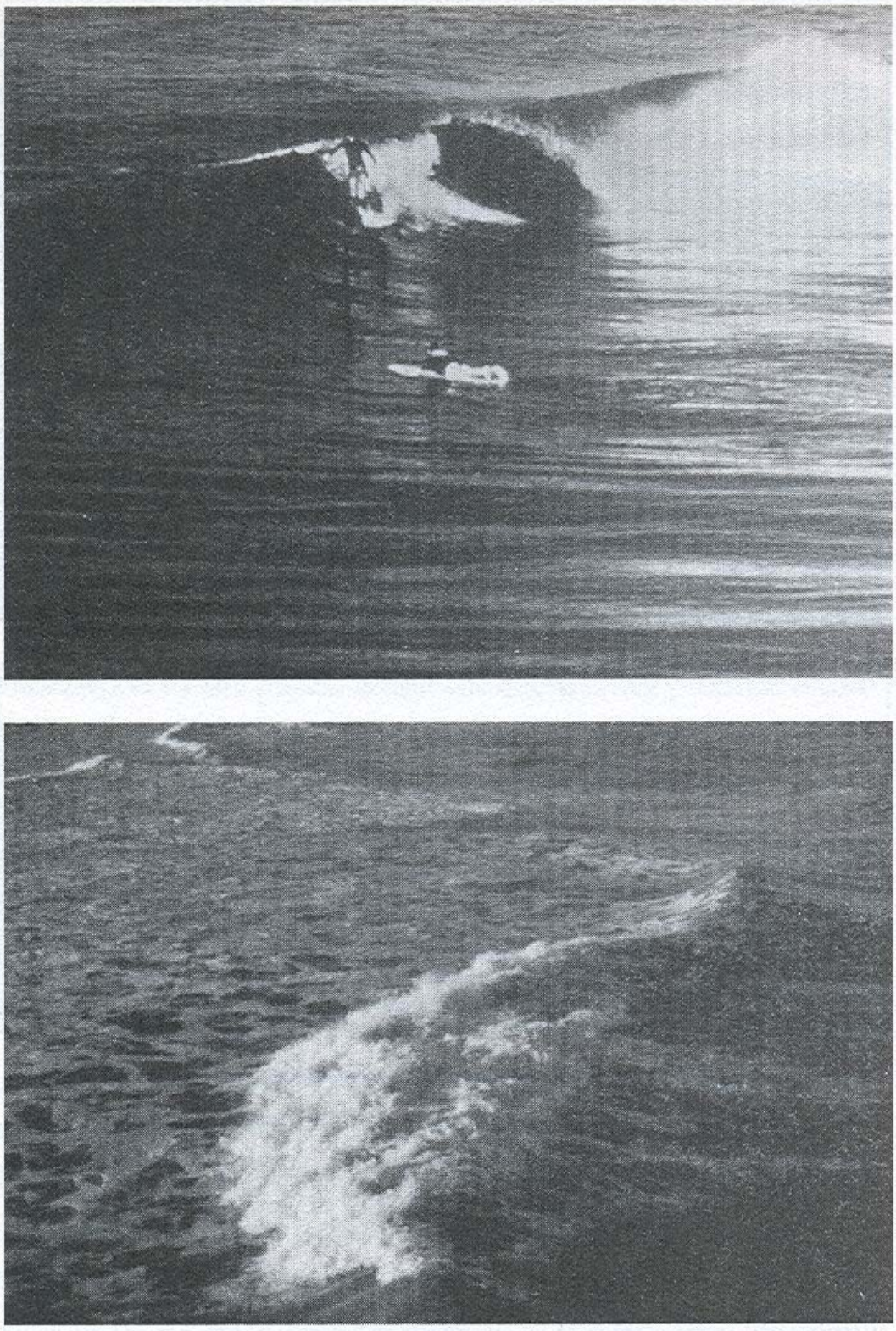


Figure 7. The two most common types of breaking waves, plunging breaker (top), and spilling breaker.

ing or surging waves. Shorebreaks occur when large waves break directly on the beach.

Spilling breakers are much less imposing and lose their energy over long distances. They are formed when waves move over beaches with gradually sloping bottoms. The breaking water rolls or tumbles forward as the wave advances into shallower water, producing a wide surf zone. Spilling waves generally provide safe conditions for waders, inexperienced swimmers, and novice boogie boarders; the East and Gulf coast beaches are most often subject to this type of breaking wave.

Surging waves are much more rare than spilling and plunging waves. These waves are created where the water is relatively deep near shore cliffs and coral reefs or at very steep beaches composed of gravel or small stones (called shingle in Great Britain). Surging waves can be deceptive because they do not truly curl or break; instead, the surge causes a sudden rise and fall of the water level. Serious injuries have been caused by surging waves on rocky coastlines.