Jerome Smith

Caught Up in Rip Currents

BY JANET HOWARD

Little data have been gathered on rip currents to date because their unpredictable behavior makes them difficult to track. But a new instrument developed at Scripps is allowing scientists to look at the dangerous currents in a whole new way.

From the window of his hillside office, Jerome Smith has an ideal vantage point from which to spot rip currents that frequently appear along the popular La Jolla shoreline at Scripps.

"The trick is to look past where the waves are breaking and watch for clouds of muddy water," Smith said, pointing out the window to the blue waters below. "Sometimes the water is a little bit rougher there and quite often you'll see a whole group of surfers in the area because they take the free ride out."

A researcher in the Scripps Marine Physical Laboratory (MPL), Smith and his colleagues are trying to understand how rip currents work.

"The big question is what makes

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them happen–what pushes the water in such an erratic way," Smith noted. "It seems that rip currents occur when there is a strong longshore flow that eventually gets going so fast that it becomes unstable."

Commonly referred to as riptides, rip currents pose a serious threat to swimmers because the strong outward flow of water can quickly sweep even the most powerful swimmer out to sea.

To date, few measurements have been made of the threatening currents because their erratic behavior makes them an elusive target.

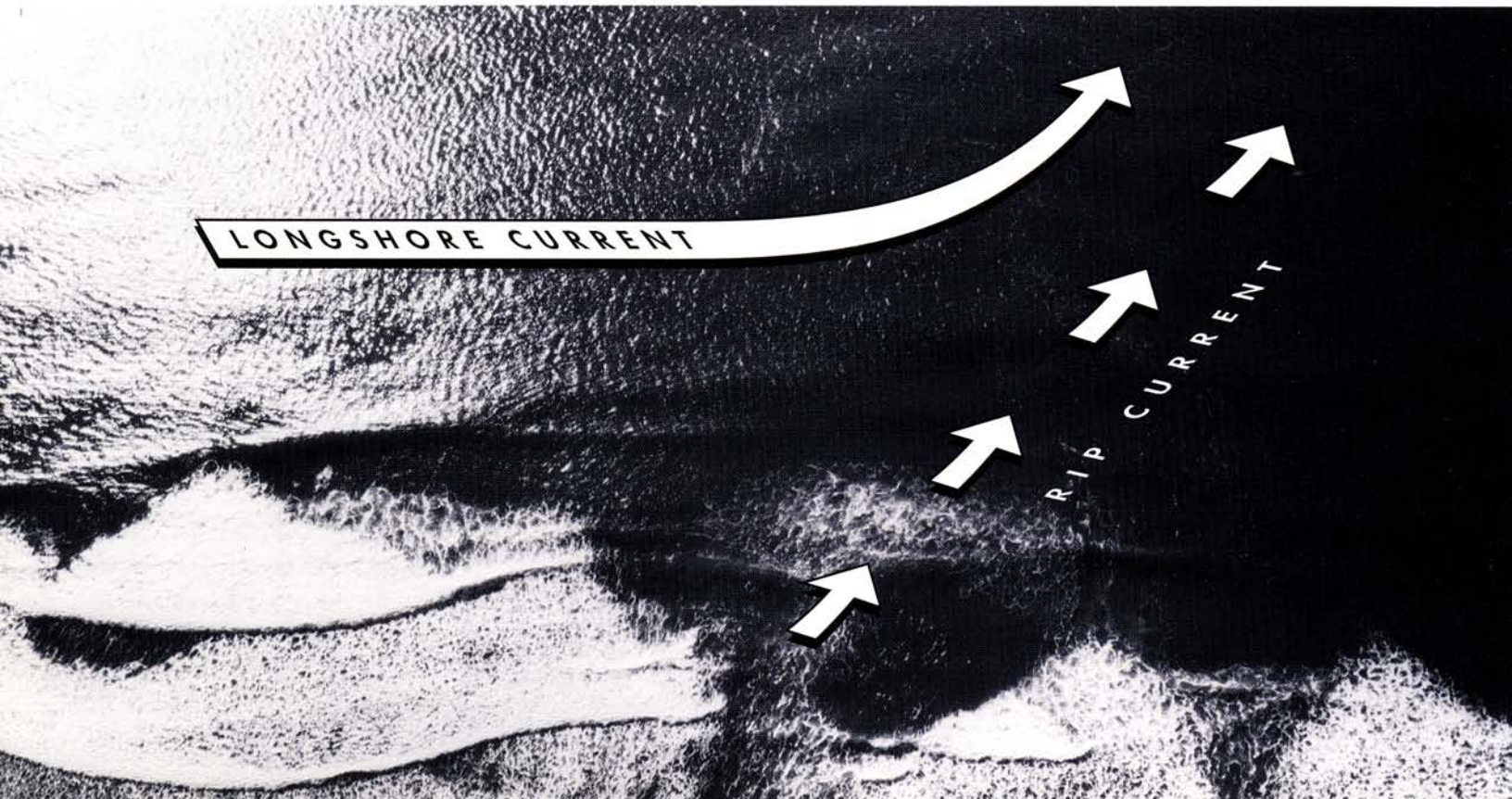
"One of the main reasons it has been very difficult to study rip currents is that if you wanted to make a current measurement, you had to use a current meter, which gives you velocity readings in only one spot," Smith said. "Rip currents occur anywhere, and they only occur briefly, so it's easy to miss them if you just put a few current meters out–and you never know what you are missing."

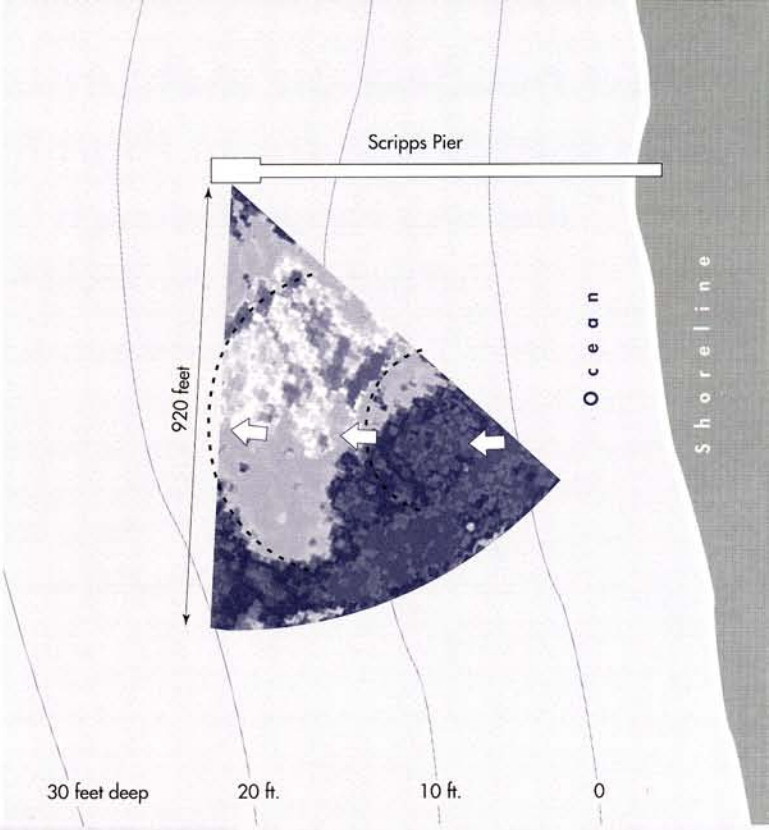
To overcome the problem, Smith recently deployed a new high-resolution Doppler sonar system off the end of Scripps Pier, capable of detecting rip currents in an area of water the size of several football fields.

The new system, developed by a team of MPL researchers headed by Robert Pinkel, works by emitting high-frequency sounds or 'pings' every half second and then recording the returning echo created when the sound bounces off of tiny bubbles in the water. The high-frequency sounds (195 kilohertz) are transmitted at 30 watts of power for about 1/100th of a second.

The instrument uses the principle of Doppler shift to determine the direction in which the bubbles are moving. Just as the pitch of a train whistle lowers as the train moves away from you, the frequency of the returning echo is lower if the bubbles are moving away from the instru-

A typical rip current is shown below. The offshore current can be as swift as 1 m/s (2 knots), carrying hapless swimmers or happy surfers outside the breakers. Often there is a strong longshore flow inside the breakers, driven by the waves. The offshore transport of water in a rip current can be comparable to the longshore flow in the surf zone. One possible explanation is that this longshore flow accelerates until it becomes unstable, at which point it turns offshore, producing a rip current.





View from above of a rip current, as seen in an image from a sector-scanning sonar. The image, of acoustic intensity, gives a qualitative estimate of the number of bubbles in the water. The brightest lines or arcs are seen along a surface 'front' associated with the advancing head of a rip current. Radial velocity is also estimated from the measured frequency shift of the acoustic signal. This permits quantitative analysis of the rip currents under varying conditions.

ment and higher if they are moving toward it.

By precisely measuring the frequency, the system also allows scientists to calculate the speed at which the water is moving.

"The bubbles don't move very fast compared to the water–they are kind of stuck in the water–so by sending a very short burst of sound and knowing the sound speed, then as a function of time we know it is bouncing off of water farther and farther away," Smith explained. "So we get a map of the current versus the distance, which gives us the velocity."

Because the system has an array of 16 detectors all 'looking'

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The Other Side of Rips

The words 'rip current' conjure up images of an unsuspecting swimmer suddenly being swept out to sea. But despite the very real danger riptides pose, they also may help preserve the quality of coastal waters.

To help determine the importance of rip currents in coastal ecology, a team of Scripps researchers headed by John Largier, an oceanographer in the Center for Coastal Studies, is conducting a three-year study of rip currents that occur along the north jetty at the entrance to Mission Bay in San Diego.

Largier chose the site because the strongest rip currents are usually observed near structures, such as groins or jetties, that block the longshore flow of water along the beach.

One of the questions Largier hopes to answer is how much water rip currents carry offshore from the surf zone.

"The fundamental motivation for our work stems from concern about water quality and associated ecological health in the nearshore, particularly in the presence of increasing non-point pollution of nearshore waters," Largier said. "It is cross-shore flow that can remove polluted waters and replace them with offshore oceanic water, thus allowing the coastal pollutants to be assimilated by the ocean."

He said that the influx of offshore water also could help carry needed nutrients and larvae into the coastal waters.

In order to determine if water transported by rip currents remains offshore or is merely recirculated back into coastal waters, Largier is conducting a series of experiments in which he is deploying a fleet of drifters in the rip current and tracking their paths.

The team of researchers already has tested various designs of drifters in the surf zone off of Scripps in order to develop a model that works well in the coastal environment. The drifters are tracked using Global Positioning System (GPS) satellites, which send out a signal that is received by microprocessing electronics aboard the drifters. Because the position of the satellites is known, their signal can be used to calculate the drifters' location.

The experiments are being conducted in conjunction with another study Largier is directing on the impact of tides on the flushing of Mission Bay.

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that was compact enough to fly in a helicopter, and that could float if dropped in the water. Those were stiff requirements for a prototype.

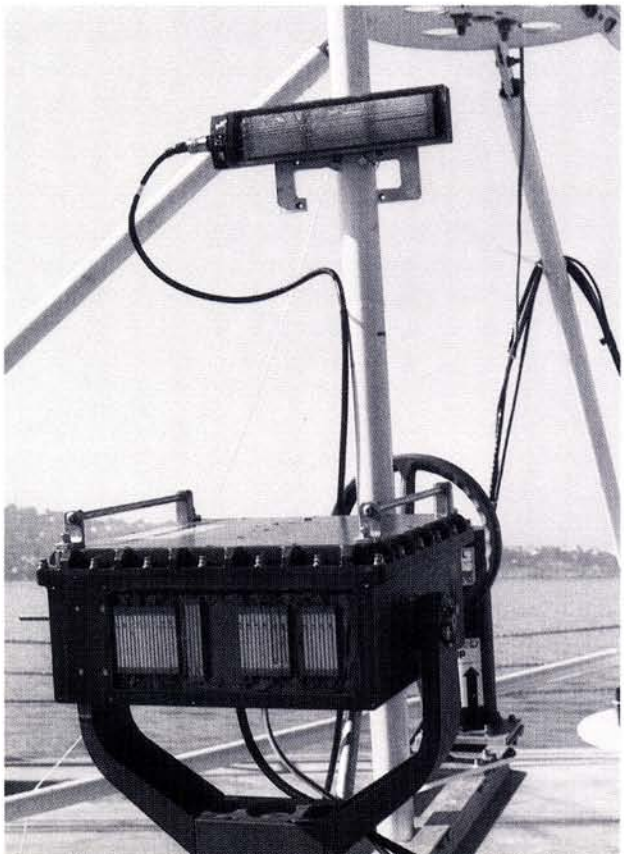
in different directions, the system can take a velocity measurement every half second in a pie-shaped section of water that covers more than 850,000 square feet.

The data are transmitted at a rate of about 300,000 bytes per second over a fiber-optic cable to a computer equipped with a digital signal processing card. To help scientists visualize the rip currents, the data are then converted into a color 'movie' that appears on the computer screen.

As part of the experiments conducted off of Scripps Pier, John Largier, a researcher in the Center for Coastal Studies, swam in the rip currents using a hand-held CTD and optical backscatter sensor. The instruments measure the salinity, temperature, and turbidity of the water as a function of depth.

"The rip current water tends to be a different temperature and generally more turbid than the offshore water, so the CTD and the optical backscatter surveys allow you to map out the shape of the rip current and the extent of the water being ejected from the surf," Largier said.

The sonar system, located at Scripps Pier, emits high-frequency sounds or 'pings' every half second and then records the returning echo (created when the sound bounces off of tiny bubbles in the water).



Results of their experiments will be published in an upcoming issue of the *Journal of Geophysical Research*.

"The two main things we discovered are that, first of all, rip currents are highly erratic," Smith said. "They are not continuous and they don't recur periodically–they just occur randomly. Judging from our analysis, they also must be a fairly major contributor to onshore-offshore mixing or exchange of water because of the large volume of water that is carried offshore."

Such mixing is important for sustaining life in coastal waters and for dispersing pollutants that are dumped into the water along the coastline.

In the region of Scripps Pier, the rip currents occur as often as several times an hour, with each rip current usually lasting for several minutes.

"They can get going within a couple of minutes," Smith said. "So, it goes from essentially no current to two knots–that's a pretty fast current. You have to be a strong swimmer to keep that up for very long."

Smith said that in the future the new device could be used as a means of detecting rip currents along beaches frequented by swimmers.

"If we used a lower frequency, which would go farther, we'd be able to cover a much larger area," he said. "So, for example, an instrument at the La Jolla Cove might be able to monitor the whole beach along La Jolla Shores. You could see where the rips are and you could see how strong the longshore currents are."

The sonar was originally developed by Pinkel to investigate currents within cracks, called leads, in the ice cover of the Arctic Ocean. The huge fractures are believed to play a potentially critical role in global climate. Because Arctic winter air temperatures are typically about 70° Fahrenheit (21° Celsius) colder than that of water protected under the

Arctic ice, the air-sea temperature difference in the leads is as great as anywhere on the planet. This clash of temperatures causes clouds of steam, or 'sea smoke' to rise over the surface of fresh leads.

Designing an instrument to withstand the harsh Arctic environment posed a considerable challenge to Scripps engineers Eric Slater, Lloyd Green, Michael Goldin, and Christopher Neely.

"We needed an instrument that could endure temperatures more than 40° Fahrenheit below zero, that was compact enough to fly in a helicopter, and that could float if dropped in the water," Pinkel said. "Those were stiff requirements for a prototype."

In spite of the atmospheric pyrotechnics associated with Arctic leads, the fluctuations in current found within them are relatively small, only a few centimeters per second. Because the sonar was designed to detect these subtle variations, it could easily detect the more energetic motions of the rip currents along Scripps Pier.

Jerome Smith stands at the shoreline in front of Scripps Institution of Oceanography.

Go With the Flow

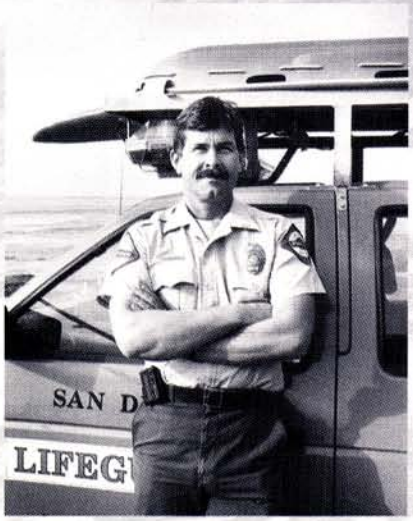
People being caught in rip currents trigger approximately 90 percent of ocean rescues made each year by San Diego city lifeguards according to Lt. Brant Bass of the San Diego City Lifeguard Service.

If you find yourself caught in a rip current, don't try to fight it. Instead, swim parallel to shore until you are out of the rip. Then swim into shore. If you become very tired or are being carried seaward by the current, Bass advises to simply ride the current out until you are beyond it, and then swim back to shore. Of course, if you are swimming in an area protected by lifeguards (which Bass strongly advocates), signal them for help.

"The important thing is not to panic," Bass said. "Wave your arm over your head and we'll come out and get you."

Rip currents often occur in areas where the natural flow of water is interrupted by structures, such as seawalls. In La Jolla, for example, the perilous currents are frequently seen along the sea wall at Children's Pool.

"Rip currents tend to be most dramatic in spring and fall because the sand is either being carried out to sea by waves or being returned to the shoreline," Bass said. Such changes can form a depression or trough in the sand under the water, which concentrates and strengthens the rip current. The fast-moving currents then compound the problem by removing more sand from the floor of the trough and making it even deeper.



San Diego city lifeguard Brant Bass.