Rip currents

Researching a natural hazard

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Rip currents (often incorrectly referred to as rip tides) are a serious hazard for sea bathers. This article describes new research carried out by the authors, in partnership with the RNLI, to better understand the nature of rip currents. It explains why the currents occur, why they are so hazardous, and how the results of the research can be used to help protect the public from risk. If you are studying coasts or natural hazards — or if you swim in the sea — you should read this article

Photograph 1 On Perranporth beach in Cornwall sand bars show up as regions of breaking waves or shallow water, and the deeper channels are dark blue streaks. All the bathers are in the sand bar region, not in the dark blue streaks which represent rip currents

Have you ever wondered how beach lifeguards decide where to place their red and yellow flags to indicate safe-swimming areas? On sandy beaches with large waves there are often sand bars (shallower areas) under the water (Photograph 1). Deeper channels between these bars either run along the beach or cut across the sand bars. The complicated shape of the bars and channels, referred to as the bar/channel morphology, causes complicated wave refraction patterns.

Strong currents can be present in the channels and when the flow is away from the beach, towards the sea, these currents are called **rip currents**. Flow velocities in rip currents often exceed the speed at which people can swim and can easily drag

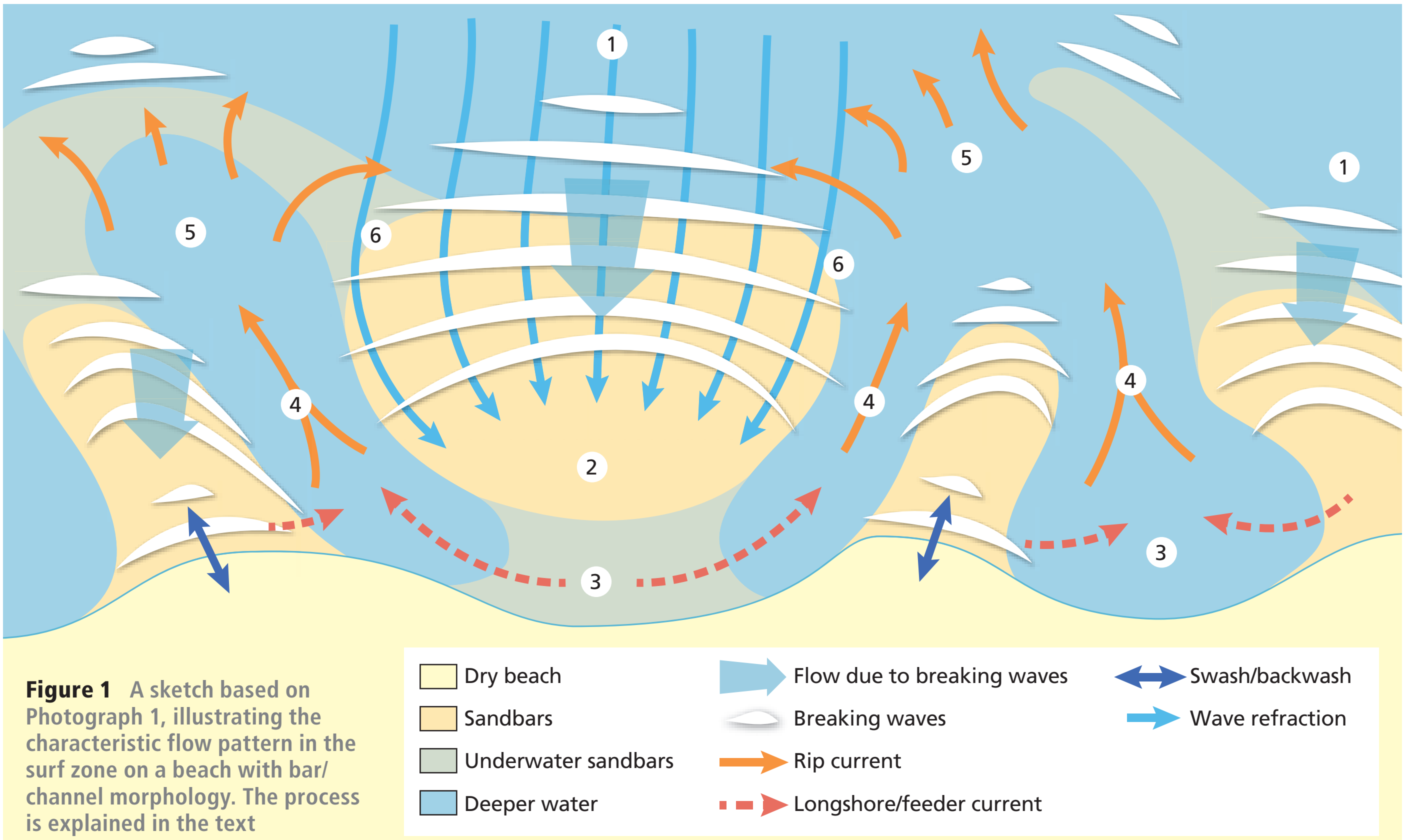

Figure 1 A sketch based on Photograph 1, illustrating the characteristic flow pattern in the surf zone on a beach with bar/channel morphology. The process is explained in the text

unsuspecting swimmers out to sea. So beach lifeguards place their flags away from rip currents and near the shallow sand bars where bathing is safest.

Rip hazard and risk

Rip currents are a natural hazard and can become a risk when people are exposed to them.

- In the southwest of England, two-thirds of all the incidents attended to by beach lifeguards of the Royal National Lifeboat Institution (RNLI) are due to rip currents (a total of 2,504 a year).
- It is estimated that 35 accidental coastal drownings a year in the UK (out of a total of 153) are due to rip currents.
- In Australia (80 people a year) and Florida (50 people a year) rip currents are the main cause of accidental drownings.
- More people in the USA drown in rip currents (100 a year) than in floods, tornadoes or hurricanes.

Almost all rip-related drownings occur on beaches without lifeguards. As there are few lifeguards in developing countries, especially outside tourist areas, the number of people who drown each year due to rip currents must be in the tens of thousands worldwide. Anecdotal evidence from a single beach on the Mombasa coast, Kenya, suggests there were four drownings a month until the RNLI trained a basic local lifeguard service. Since then, there have been no recorded drownings.

What causes rip currents?

Figure 1 is a diagram based on Photograph 1. It shows the complex flow of currents and water motions generated by breaking waves when a beach has sand bars and channels. The rip current is only one part of the pattern.

In the surf zone the waves travel and refract towards the shore, then break on the shallow sand bars (1). The breaking waves push large amounts of water towards the shore (2). This

Photograph 2 Drifters are carried into the surf zone on Perranporth beach (a, b) to be released at various locations on the bar and in the channels. Once released (c) they are taken by the surf zone currents

is the flow that knocks people over when a breaking wave hits them, and allows body boarders to enjoy long rides.

So-called rip feeder currents (3), also referred to as longshore currents, run from the regions of wave breaking along the shore towards the rip channels. Where there is a gap between sand bars, the feeder or longshore current turns away from the shore and water starts to flow out to sea. The fastest seaward current occurs where the rip channel is at its narrowest and this is referred to as the **rip neck** (4).

The flow can now do two things depending on wave conditions and the configuration of the sand bars and channels:

- When the rip current 'breaks through' the sand bars and the line of breaking waves, the flow spreads out and weakens in the region referred to as the **rip head** (5). Eventually the flow disappears altogether.
- Alternatively, the rip flow turns back towards where the waves are breaking (6) and joins the onshore flow caused by the breaking waves. This flow pattern is referred to as **recirculation**.

Regardless of the final destination of the rip flow (rip head or recirculation), the rip current returns the water that was originally moved onshore by the breaking waves back to the sea. Rip currents are therefore driven by breaking waves — without waves breaking on the sand bars, there will be no rip currents.

What happens to swimmers

If you were a bather, passively floating with the currents, you might follow the same flow pattern as described above. Starting from the sand bar, you would be pushed towards the beach by the breaking waves. You could be pushed on to the beach and end up in the region of swash and backwash, but you could also drift along the beach in the feeder or longshore current, before turning seaward into the rip channel.

You would probably notice a sharp increase in your travel speed as you entered the rip neck, before you either popped out behind the breaking waves in an area of calmer water or moved sideways over the bar to re-enter the surf zone.

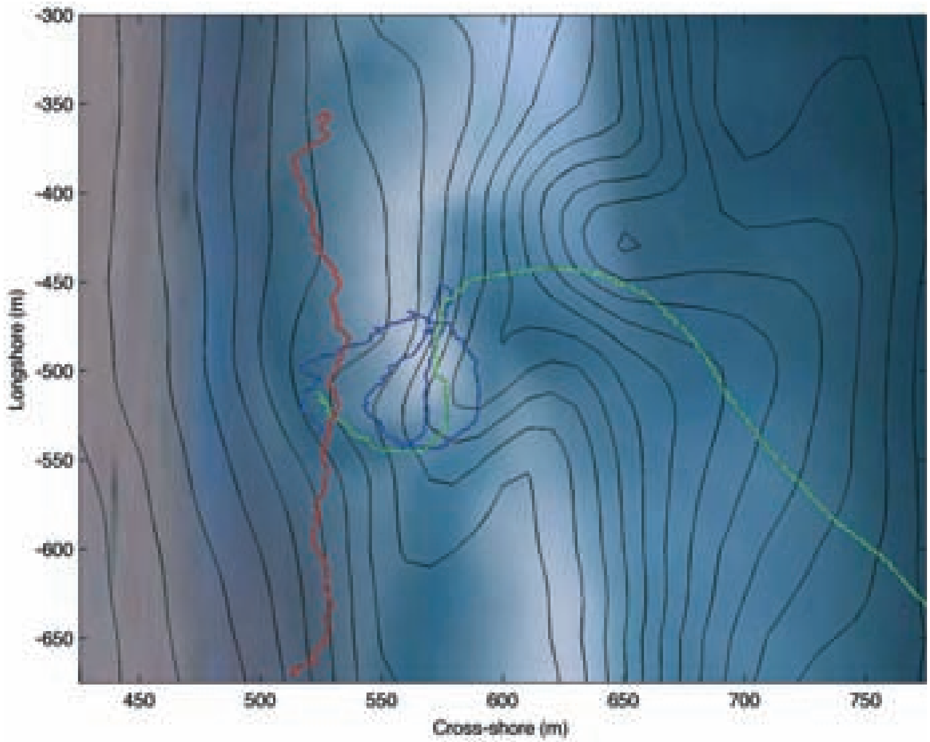

Figure 2 Movement of three drifters at Perranporth, showing the various types of circulation. The green track shows the drifter exiting the surf zone and moving out to sea, the blue track shows the drifter making a number of rotations and the red track shows a simple alongshore movement

Spatial characteristics of rip currents

Figure 1 shows the water flow circulation in the surf zone, but is this flow pattern real and can it actually be measured? Because the type of circulation pattern has implications for beach safety, researchers from all over the world have been trying to measure the water motion in rip currents. As you can imagine, it is difficult to record such a complicated flow pattern, and a number of techniques have been used.

Dye release investigations

One method used, especially in Australia, is injecting a colourful dye into the surf zone to visualise the rip current (Google 'dye release rip current' and you will find images, reports and video clips). The problem with this method is that, although it shows the location of the rip very well, it does not provide any information on current velocities and only gives a snapshot of the flow pattern.

GPS tracking

Another method for measuring the rip flow pattern is to use GPS-tracking devices. Drifters — large buoyant PVC tubes that mimic the behaviour of floating people — are released on the sand bar and in the channels and their movement is recorded with small on-board data loggers using GPS technology (Photograph 2). By combining the data from a large number of these drifters, a detailed picture of the rip current circulation can be obtained (Figures 2 and 3). Note that the background of Figures 2 and 3 has been obtained using video cameras. The zone of breaking waves shows up white in the picture and the beach is brown.

This work has confirmed that there are three distinct circulation patterns:

- an **exit pattern**, where the rip current leaves the surf zone (pattern 3-4-5 in Figure 1)
- a **recirculating pattern** where the rip current is often unable to extend beyond the surf zone and turns back onto itself in the form of a large circulating eddy (pattern 3-4-6 in Figure 1). Some of the drifters were left out in the surf zone for 2 hours and were found to rotate more than 10 times over this period
- an **alongshore pattern** where the surf-zone flow is dominated by a strong longshore current. This pattern is particularly common when alongshore winds are strong and generate a large down-wind drift

The implications for beach safety should be clear: the exiting rip flow pattern will take swimmers out to sea, the rotating pattern will bring swimmers back in and the longshore pattern will move swimmers alongshore.

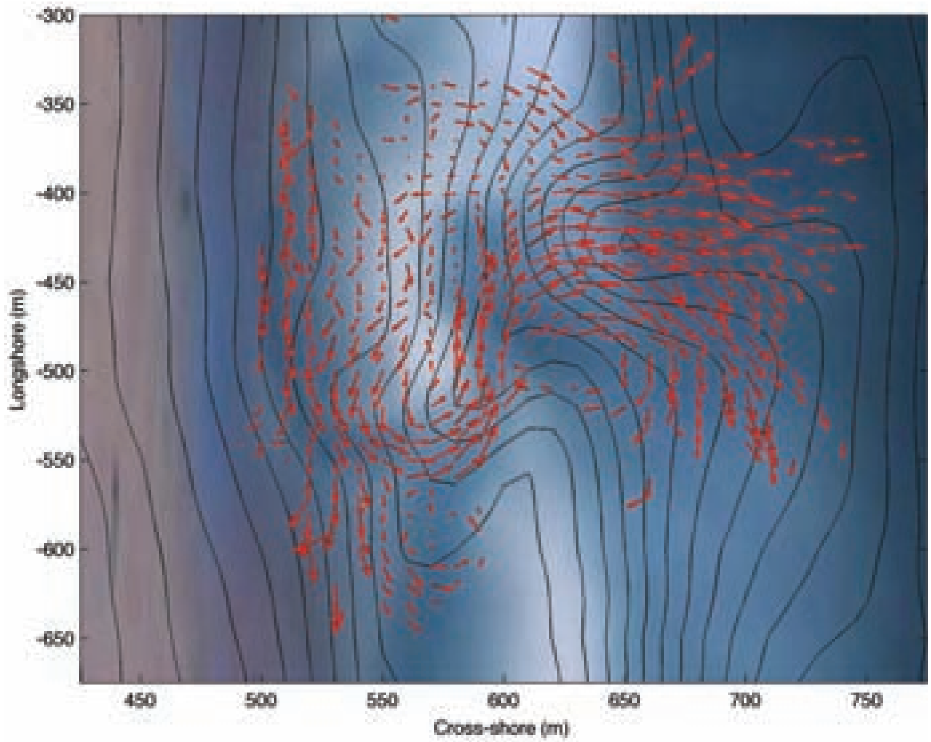

Figure 3 By deploying a large number of drifters over an extended period of time, the mean flow field in the surf zone can be mapped. The red arrows show the direction and speed (length of arrows) of the average current field determined from 164 separate drifter deployments over a 4-hour period around low tide. Most drifters exited the surf zone, quite a few displayed a rotational flow pattern, and several drifters moved alongshore

Temporal characteristics of rip currents

As well as their spatial patterns, rip currents also vary over time, particularly on UK beaches, which have a large tidal range — usually more than 4 metres. The water level varies hugely during the day and the surf zone and water line move up and down the beach with the tide. Beaches along the French Atlantic coastline show a similar tidal variability. Recording water levels and current velocities at the same location but over an extended time period requires a different method: deployment of fixed instruments placed on the sea bed (Photograph 3). Figure 4 shows the results of such measurements.

Recordings of current speed in the rip and feeder channels on beaches with a large tidal range reveal an interesting phenomenon: rip and feeder currents are 'turned on and off' depending on the water level. This may be where the incorrect term 'rip-tide' comes from — although tides are important in controlling when rips are active, rip currents are not caused by water leaving the beach during the falling tide.

Box 1 Saving lives

It is important that new knowledge and understanding resulting from any kind of research benefits society. Scientists therefore need to collaborate closely with so-called end users — the people who apply the new science to real-life problems. The authors of this paper are all researchers at Plymouth University and the rip-current research they are involved in occurs in partnership with the RNLI. Such collaboration is essential for ensuring that the new knowledge and understanding on the dynamics of rip currents is being used on the beach to help save lives.

We find that the feeder and rip currents are strongest at low tide, when waves are breaking on the sand bars and transporting water towards the beach. Velocities are up to 0.7–0.8 m s^{-1}, which is almost 3 km h^{-1}. This is a relaxed walking pace, but faster than the swimming speed of even a good swimmer. At mid and high tide, however, waves no longer break on the sand bars and the rip current ceases to operate.

Implications for beach safety

The motivation of the work described in this article is to make beaches safer for people (Box 1). So, can our findings be used to achieve this?

Education

The first step is to educate the general public (you!) to recognise rip currents and the hazard they represent. This should lead to fewer people entering the sea near a rip current.

Training lifeguards

The second step is to pass on our enhanced understanding of rip dynamics to the lifeguarding community, through training workshops and material, so they can better

Photograph 3 (a) A fixed instrument rig being carried into the surf zone at low tide on Perranporth beach. (b) At low tide it is above water level, but as the tide rises, the instrument is under water (c) and starts recording current velocities

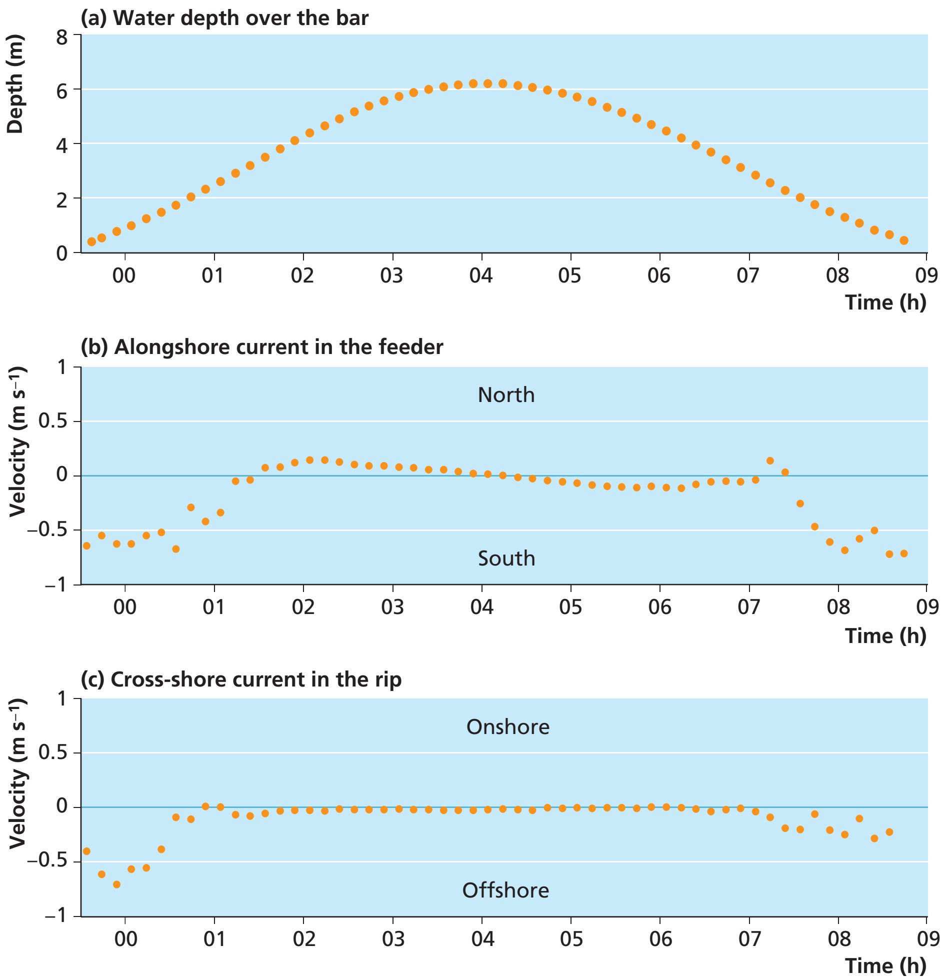

Figure 4 (a) Water depth over the bar (location 2 in Figure 1), and current velocity recorded in the channels of (b) the feeder (location 3 in Figure 1) and (c) the rip (location 4 in Figure 1) over a single tidal cycle

manage the risk to bathers. For example, in some countries the advice when caught in a rip is to 'swim parallel' to the current. As you will have seen from this article, the appropriate behaviour depends on the circulation pattern of the type of rip current you are caught in (as well as your strength as a swimmer). 'Swim parallel' may be sound advice when caught in a rip that is about to drag you out to sea, 'go with the flow' may be more suitable for competent swimmers who find themselves in a rotating rip current.

Forecasting risk

Finally, as the relation between rip-current dynamics and wave/tide/wind/beach conditions is better understood, it should be possible to make predictions of rip-current activity and therefore rip risk to bathers. If reliable rip-risk predictions are available, lifeguards and local authorities can allocate resources where and when required, and even close down beaches that are too hazardous.

In the near future, regional predictions of rip-current hazard could be published on the Met Office website, like forecasts of pollen count and UV intensity. These predictions would also allow agencies like the RNLI to issue regional rip-current warnings when high-risk conditions are likely to coincide with people flocking to the coast on sunny weekends.

Further reading

More information is available from the project website: **www.ripcurrents.co.uk**.

The project featured on BBC's *Bang Goes the Theory* **www.youtube.com/watch?v=z8SIxiGD2O8**

For an Australian perspective on rip currents, there is a very good YouTube clip, put together by Dr Robert Brander, locally known as Dr Rip, from the University of New South Wales: **www.youtube.com/watch?v=-hCZuYzNujI**.

Questions for discussion

1 What would be the best advice for bathers caught in a rip current? (Note: there is no single right answer — it all depends on the type of rip current, swimming ability, wave conditions, etc.)

2 What are the key factors that control rip current occurrence, velocities and circulation pattern?

Gerd Masselink is professor of coastal geomorphology at the University of Plymouth. Together with **Professor Paul Russell, Dr Martin Austin** and **Dr Tim Scott**, and in collaboration with the RNLI, he is investigating the dynamics of rip currents. The project is funded by the NERC.

Key points

- Rip currents are strong seaward-flowing currents that occur on sandy beaches with near-shore sand bars. They are natural hazards that may drag unsuspecting swimmers out to sea and are responsible for thousands of drownings per year worldwide.
- The flow velocities in rip currents are generally strongest during low tide and this is when they represent the greatest risk to bathers.
- There are three distinct water-flow patterns in the surf zone: an exit pattern where the rip current leaves the surf zone, a circulation pattern where the rip current turns back onto itself like a giant merry-go-round and an alongshore pattern where the surf zone flow is dominated by a strong longshore current.
- A better scientific understanding of rip currents can help beach lifeguards to better manage the risk they present to bathers, and save lives.