The WAR Report

Waves Are Resources

by Surfers Against Sewage

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Credit Al Mackinnon

1. Introduction

Waves are everywhere. They form a part of every single aspect of our lives, every day. The sound hitting our ears, light hitting our eyes, the heat from the Sun, the changing weather patterns, the radio signals spewed out by our mobile phones and wireless routers and the ones received by our televisions; even the motion of our cars in a traffic jam – all are waves of some sort.

As surfers, we are able to use waves in a very special way. A miniscule proportion of the energy reaching the Earth as electromagnetic waves from the Sun, through a long series of links involving planetary waves, atmospheric waves, wind-driven waves and wave-wave interactions, eventually reaches us in the form of clean, rideable swell. We then bleed off a tiny part of that energy to boost us along for a few seconds. Most of us have dedicated a considerable part of our lives to the quest for more and more of that liquid energy. To us, waves are much more important than they are for the rest of the population. They rule our lives. Without waves, the concept of being a surfer would be totally meaningless.

It goes without saying that, as surfers, we have good reason for stopping other people destroying or degrading the waves. However, if we want to persuade others not to ruin the waves, we need a stronger argument than just a surfing one. The coastal developers, coastal engineers and politicians responsible for schemes which destroy or degrade surfing waves tend to find the 'intrinsic' value of natural things hard to understand. They only understand the concept of enjoyment if it is bought with money. This document therefore sets out to explain the wider implications of over-interfering with the waves, including how it can make some people lose out financially.

The 'spin-off' effects due to the existence of a surfing wave can affect the lives of people who might not even know or care about surfing. For example, a surfing wave in a particular area might attract a lot of money-spending people to that area, which benefits the local non-surfing residents by making them richer. If that wave were suddenly removed, so would that particular source of money. For that and other similar reasons, waves are 'resources' and are worth saving, even if you are not a surfer.

Another potentially much more serious effect of over-interfering with the waves is that, by making the waves dissipate their energy on the coast in a different way, or by extracting too much energy from the waves, the natural system might be thrown out of balance. Experience shows that when any part of the natural functioning of the planet is significantly disturbed, we invariably end up with more problems than we know how to solve. So this is definitely something we need to avoid.

In this report, we start off by explaining a few basic things about waves, how they are valued by us surfers, how they can be valued by non-surfers. We then go on to describe different ways in which waves can be destroyed or degraded. We pay particular attention to the subject of generating electricity from the waves, something that has great potential but which we need to be careful about in the future. Finally, we outline ways in which waves can be protected, which will ensure that everybody comes out better off in the end.

If you are a surfer, other coastal water user or just someone who loves the coast or Nature in general, and you already appreciate the 'intrinsic' value of waves, this publication will be very useful to you. It will be particularly useful if you have had experience of a surf spot that has been threatened, degraded or destroyed, but you weren't quite sure how to stop it happening in the future. It might give you a little more ammunition when coastal developers and politicians try to present strong opposing arguments. If you are actually one of those coastal developers, engineers or politicians, or any member of the public for that matter, this publication will also be very useful to you. If you are open-minded enough to read it, you will learn how valuable waves really are, not just to a bunch of hippy surfers, but to a significant proportion of the population.

2. What are waves and what are they for?

2.1. Definition of a wave

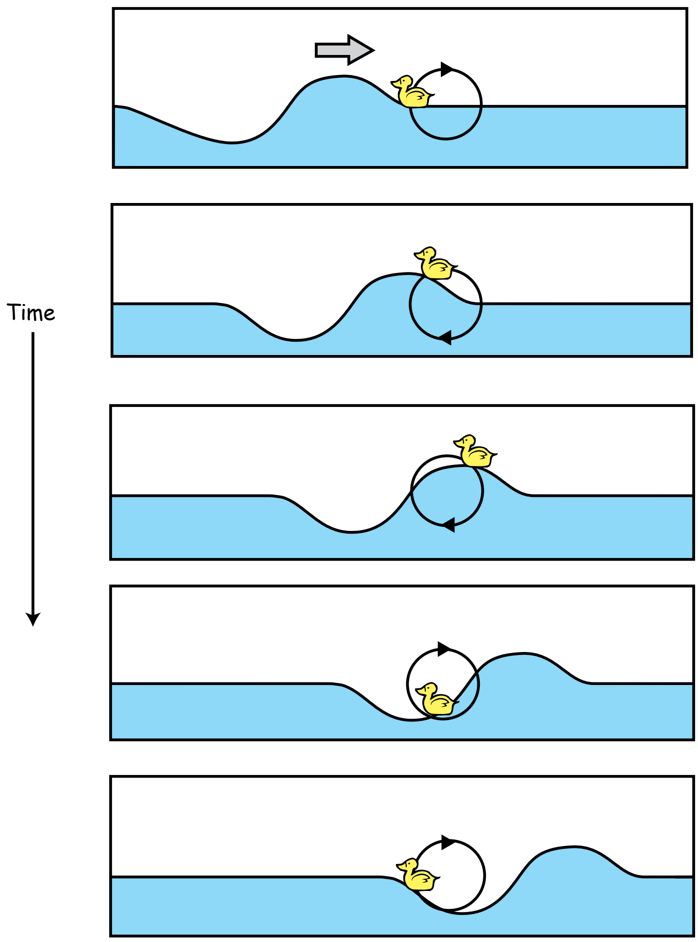
So, how would you go about defining a wave? Well, waves are such complicated things that it's not even a simple matter to define the word 'wave'. For example, Webster's dictionary says this:

"A disturbance or variation that transfers energy progressively from point to point in a medium and that may take the form of an elastic deformation or of a variation of pressure, electric or magnetic intensity, electric potential, or temperature."

That definition is not strictly correct for some types of waves: for example standing waves which don't transmit energy in a single direction, or electromagnetic waves that don't need a medium through which to propagate. But for the waves we ride, namely those generated by the wind on the surface of the ocean, that definition is pretty accurate. Wind-generated ocean waves transfer energy from one place to another through up-and-down motions of the ocean surface.

2.2. Basic properties of waves

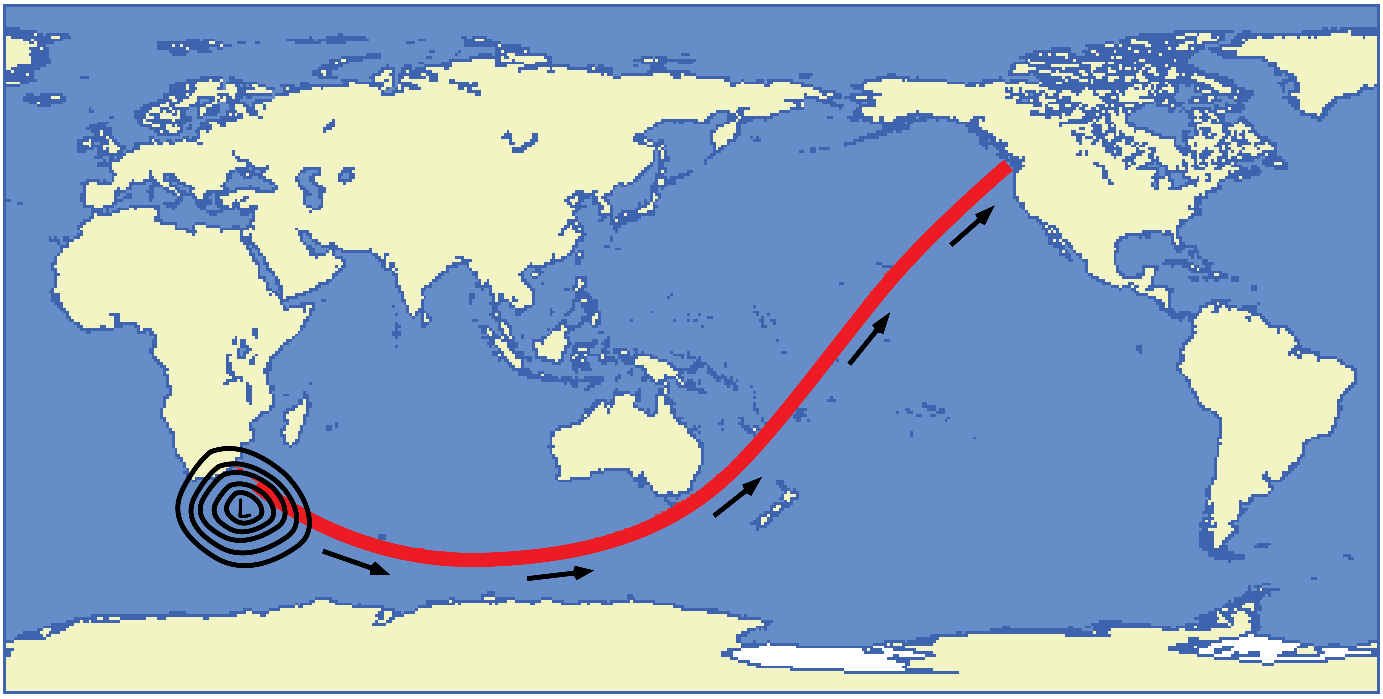
Perhaps the most important thing to understand about waves on the open ocean is that they transmit energy through the medium, but the medium itself doesn't go anywhere. As long as the wave isn't just about to break, a particle on the surface will describe a complete circle as the wave passes through it.



In deep water the particles on the surface move in circles as a wave passes; the water isn't actually transported anywhere

Another important characteristic of ocean waves is that they are *dispersive*. This means that, as the wave is travelling along in deep water, its velocity depends upon its period (the length of time between the passing of successive wave crests past a fixed point); the longer the period, the faster the wave. This has profound effects on the way swell propagates away from a storm and what happens when it arrives at the coast. A mixed up sea full of different periods will gradually sort itself out as it freely propagates away from the storm centre – because the longer, faster waves progressively outpace the shorter slower ones. That is why, at coastlines that receive long-travelled swell from storms thousands of kilometres away, the longest waves of a new swell always arrive first.

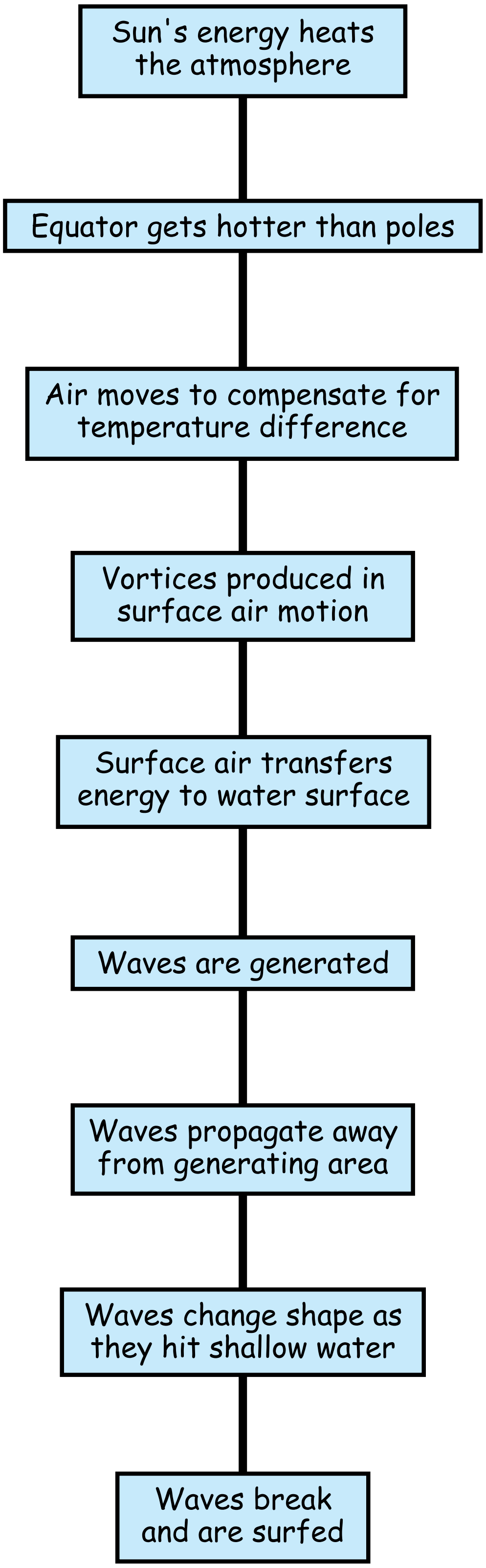
Lastly, ocean waves can propagate immense distances without much energy loss. Deep-ocean swells follow *great-circle* routes around the world. A great circle is the shortest path between two points on a sphere, such as the Earth. In theory, a swell could travel as far as a great circle route would allow it before it hit a continent. Probably the furthest a swell could travel in theory would be about 22,000 km – more than half way around. This would be generated from a storm just off South Africa, which would send a swell on a great-circle route all the way to Vancouver Island, Canada, passing Tasmania, tracking through the Tasman Sea, brushing past New Zealand and hitting Fiji and Hawaii on the way.



Ocean waves travel great distances without much energy loss. In theory, a swell generated from a storm just off South Africa could reach the west coast of Canada, 22000 km away.

2.3. Where do waves come from?

So, where do the waves we see breaking on the coast actually come from? Well, coastal ocean waves are not just a local phenomenon; they are connected to every other natural element on the planet through a chain of physical processes. The sun's rays hit the equator more directly than the poles, so the equator tends to heat up more than the poles. To compensate for this temperature differential, the air covering the planet moves. Because of the Coriolis force, which exists due to the rotation of the planet, vortices are produced in this moving air. The air that moves along the surface of the sea transfers some of its energy from the air to the water, which generates waves, or windsea. When these waves leave the generating area they travel freely, no longer receiving energy from the wind. The resulting swell spreads out radially and circumferentially, and the waves form themselves into groups. Then, when those waves start to approach the coast, they change shape according to the contours of the sea bed (the bathymetry) before finally breaking on the shore. This is when the waves are surfed.[1]



Flowchart showing the basic processes behind every wave that breaks on the shore

2.4. What are waves for?

Ocean waves were not created for our benefit alone, nor are they some redundant appendage of Nature, serving no apparent purpose in the grand scheme of things. Waves are a very important and necessary part of the workings of our planet. Just like everything in Nature, waves evolved along with all the other elements of the planet, therefore they must have a purpose. Otherwise they would have been ‘evolved out’ and wouldn’t exist.

First of all, ocean waves, particularly long-travelled swells, are a very important element in the complex web of mechanisms that control the heat balance of our planet. Oceanic storms are a result of atmospheric circulation patterns constantly trying to equalise the equator-to-pole temperature difference. In addition to driving the oceanic currents, the surface winds generated by these storms produce oceanic swells which, although don’t actually transfer water from one place to another, transfer enormous amounts of energy from one part of the planet to another.

Once the waves reach the coast, this energy is converted into water motions which contribute to the ever-changing shape of the coast. The waves impart their energy upon the coastal material, and change its shape. If the shape of the coast changes, this changes the way the waves break, which, in turn, alters the way those waves change the shape of the coast. In other words, there is a *feedback* loop between the water and the land. If the coastal material is rock the changes are relatively slow, but if the material is sand or stones, the changes are much more rapid, and, of course, very difficult to predict.

2.5. What would happen if we took all the waves away?

So, you can see that ocean waves are not just important for us; they are essential for the correct functioning of our planet. If you took all the waves away, clearly something would go wrong with the natural energy balance of the planet. Of course, there is no way of knowing exactly what would happen, but there would probably be some kind of re-adjustment to achieve the same energy balance, without waves. This might mean radical changes in atmospheric circulation patterns, ocean currents, cloud cover, precipitation or even seismic activity – who knows? Whatever the case, the Earth would quickly adjust itself to a stable state and be ‘happy’ again. We, as a species, on the other hand, might find it impossible to exist.

3. Waves for surfing: types of surf spots

Waves for surfing come in an almost infinite variety of shapes and sizes. Surf spots can be categorized into different types according to what the sea floor is made of and how it got the way it is. Inevitably, each type can then be split into a whole hierarchy of sub-types until you get down to individual surf spots having their own unique signature and being universally recognizable (for example, see the iconic photo of Pipeline below). Here we are just going to keep it simple and have a look at beachbreaks, reefbreaks and rivermouths. In the UK, the majority of surf spots are beachbreaks, followed by reefbreaks, and a smaller number of rivermouth breaks.

The iconic Pipeline

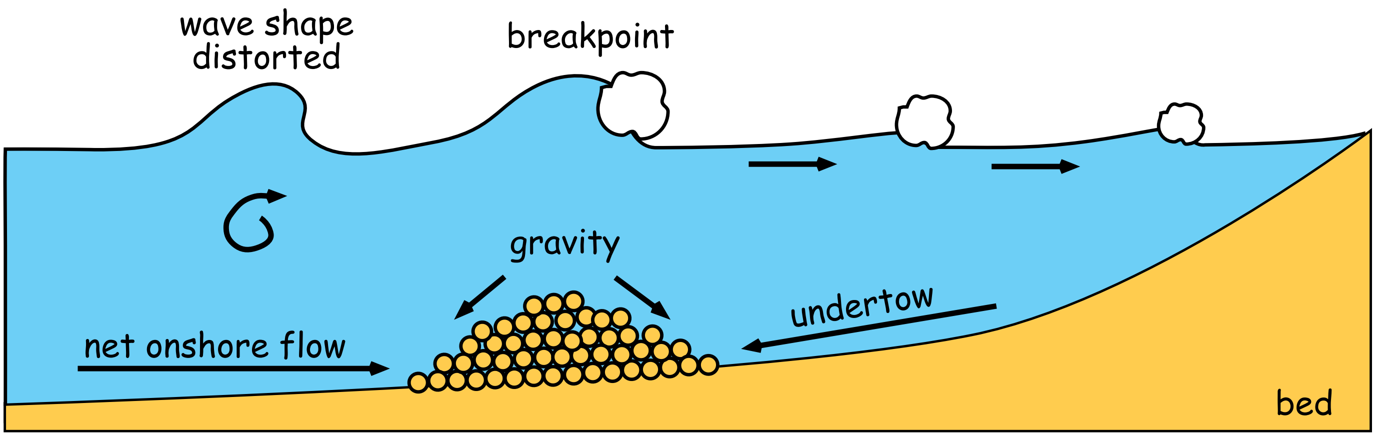
3.1. Beachbreak

A beachbreak is, as the name suggests, a surf spot where the waves break on a beach. Beaches might seem very simple on the face of it, but they are, in fact, one of the most complicated and unpredictable systems in Nature. Surfing beachbreaks is often a game of cat and mouse, discovering a good peak one day only to have it disappear the next.

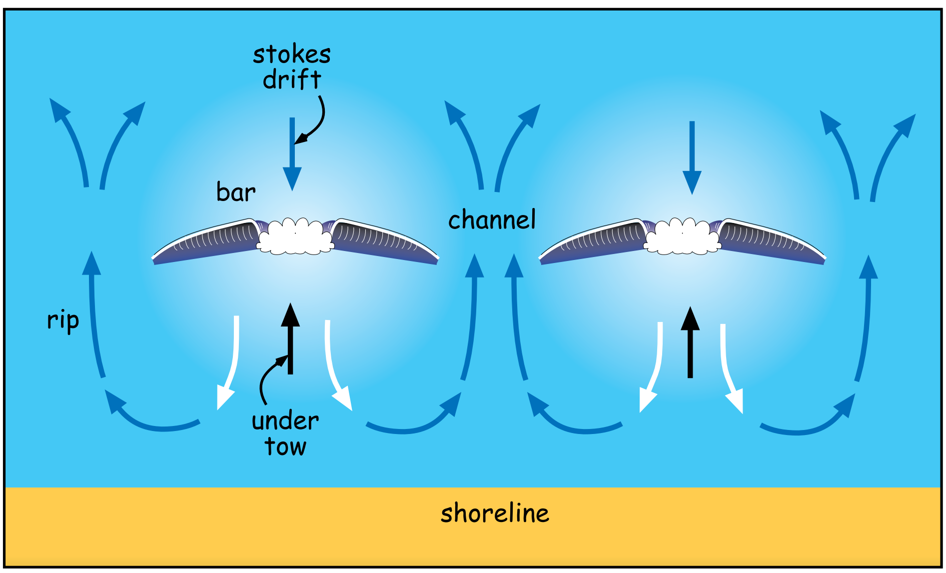
The main feature of a beachbreak is that the wave-breaking platform is mobile. The waves move the sediment around and the resulting shape of the sea floor then changes the way the waves break, which, in turn, moves the sediment around even more. Again, it is a feedback loop where both things depend on each other. Whether or not there are good sandbars for surfing depends upon that complex interplay between the waves and the sandbars.

If we consider just the movement of sediment in an onshore-offshore direction, we can get a general idea of how this works. Beyond the breakpoint, the action of the waves coming into shallow water tends to move sediment onshore through a mechanism called *Stokes drift,* and inside the breakpoint the *undercurrent* tends to move sediment offshore. The action of both these mechanisms causes sediment to accumulate on the sandbar at the breakpoint, which makes the waves break more strongly at that point. If the waves break more strongly, the sediment-transport mechanisms are reinforced, which builds up even more sand at the breakpoint, which further reinforces the mechanisms, and so on. A point is eventually reached where the sandbar cannot physically get any steeper, and gravity starts to pull the grains back down again.

Of course, sediment is transported along the shore as well. On good beachbreaks there is usually a sandbar system consisting of a series of humps and dips, the waves breaking on the lumps but not in the dips. Imagine a sandbar lying parallel to the shore, with only slight variations of height along its length. Any incoming waves are naturally focused towards the humps and away from the dips. This brings into play the onshore-offshore mechanism described above, which starts to make more sand accumulate below the breakpoint, making the humps higher. As the humps grow and the waves become stronger, the water from the broken waves starts to flow back out to sea in between the humps, creating rip-channels and making the dips lower. In summary, on a real beachbreak there are so many different mechanisms interacting with each other that the shape of the waves and the shape of the sand are extremely difficult to predict.



Two-dimensional illustration of how a sandbar is formed below the breakpoint



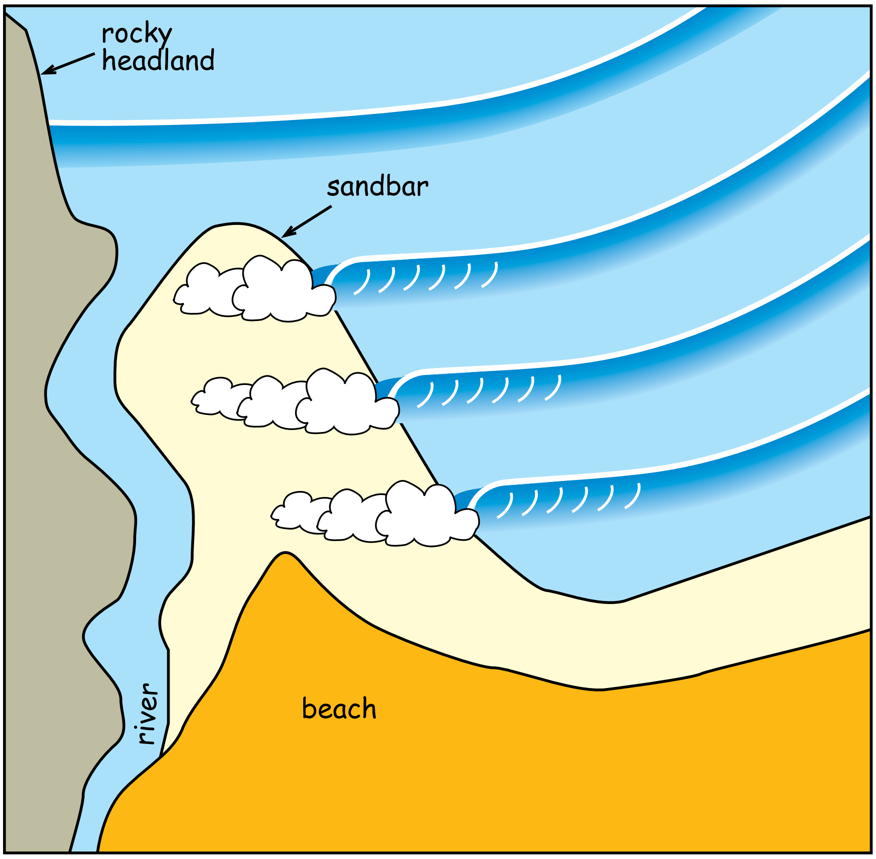
Three-dimensional beachbreak setup, showing how sandbars are formed along a stretch of coast

3.2. Rivermouth

A rivermouth break is a surf spot where the waves break on a sandbar at the mouth of a river. It could be referred to as a special case of a beachbreak because the waves break on sand, but it has a number of unique characteristics. At a good rivermouth break, the wave itself looks very much like a pointbreak, peeling down the edge of the sandbar instead of down the side of a rocky headland. The sandbar is a semi-permanent feature, kept in place by the sediment-transport mechanisms of the estuary. Given the right conditions, rivermouths can produce some of the most perfect waves in the world. However, they are very sensitive to any factors that might alter the shape of the sandbar, and typically only produce really good waves at certain times of the year.

A rivermouth sandbar forms where the width of the river increases, which is also where the speed of the water flowing into the sea decreases. The formation of the sandbar is intimately linked to the speed of the water flow, which controls the transportation of sediment down the river and the deposition of that sediment on the bar. Some distance up the estuary, the water is flowing fast enough to produce turbulence. This turbulence suspends sediment from the bed and allows the water to carry that sediment down the river. At the mouth of the river, the extra width causes the water flow to spread out, which makes it slow down. At some point, the turbulence will no longer be strong enough to keep the sediment in suspension, and it will 'fall out' onto the sea bed. This is the point where the sediment accumulates on the bed to form a bar.

The building up of the bar usually works best during summer when wave heights are relatively small. Large waves breaking on the bar tend to erode the bar away and spread the sediment around into irregular shapes, making the waves break less perfectly. Therefore, at many rivermouths, the shape of the bar is at its best just after the summer or after a long stretch of small or flat surf.



Typical rivermouth break setup

3.3. Reefbreak

A reefbreak, in its broadest definition, is a surf spot where the waves break over a rigid, immovable sea floor, rather than a movable one in the case of a beachbreak. Usually, the material making up the reef takes many years to change, whereas the sediment beneath a beachbreak or rivermouth can shift around daily or even hourly.

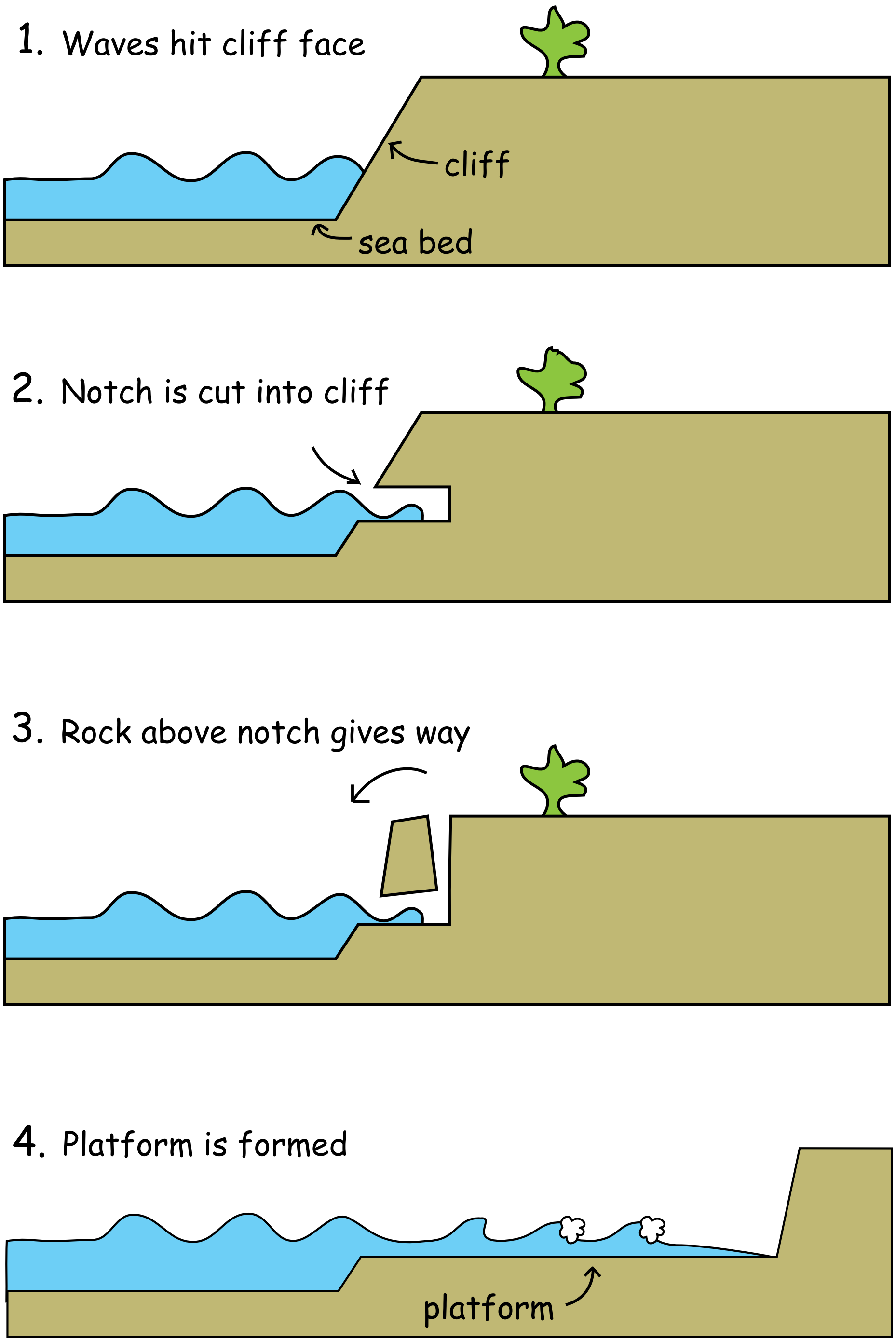
Reefbreaks can take many different forms, depending on the local coastal geology and the material that makes up the sea floor. The waves that break on them can be of every possible type, from long, slow point-type waves, to suicidal sucking 'slabs', or large-scale offshore big-wave spots.

Perhaps the simplest way to distinguish reefbreaks from each other is by the type of material they are made of. For example, in higher latitudes such as around the British Isles, the majority of good surfing reefs are made of sedimentary rock such as limestone or sandstone. But then on volcanic islands such as the Canaries, most surf spots are made of solidified magma that spewed out of the volcano, and in tropical zones, the best reefbreaks are usually made of coral.

Reefbreaks made of sedimentary rock are formed over millions of years as layer upon layer of sediment is built up and gradually compressed under its own weight. If the coastline has not been subject to any geological deformation since the rock was formed, the rock strata will be horizontal and the reefs will be fairly flat. If, on the other hand, there was some traumatic geological event, the coastal rock strata might be folded and twisted. In this case, the reefs will be much more uneven, sometimes consisting of rows of jagged rock sticking up vertically like giant saw blades

Traumatic geological events shaped the jagged reef at Porthleven. Photo Greg Martin

Sedimentary-rock reefs are often found at the bottom of cliffs. A rock platform below a cliff is known by geologists as a wave-cut bench. The idea is that the cliff is gradually being eroded away by a continuing process. First, the action of the *waves cuts* a notch in the bottom of the cliff; then the part of the cliff above the notch starts to become unstable and falls into the sea. Most of the sediment that falls down gets washed away by wave action. Finally, what remains is a platform at the bottom of the cliff, just below the water surface.



The formation of a sedimentary rock reefbreak at the bottom of a cliff

4. Surfing waves around the British Isles

4.1. Introduction

Apart from a section of northwest England and southwest Scotland facing the Irish Sea, and the west coast of Scotland inside the Hebrides, most of the coast around the UK contains some kind of rideable surf, and is surfed on a regular basis. Of course, the quality of the waves hitting the coast varies enormously from area to area, from clean, long-travelled swells to short-period, locally-generated windseas (sometimes known as windswell1[†]); as does the quality of the set-ups, from flat, kelp-covered reefs and pointbreaks to poor-quality closing-out beachbreaks.

Also, the number of surfers in each area varies greatly, but not necessarily in proportion to the quality of the waves. The number of surfers at a particular break depends heavily on the density of the local population or the ease with which people can travel to that break from the main population centres. Consequently, you find that relatively poor-quality waves in places like the south coast of England are a lot more popular than much higher quality waves in more inaccessible places like northern Scotland. In *both* cases the waves are valuable.

4.2. Principal surfing areas around the UK.

South-West England – South Coast

Medium quality, medium consistency, very high popularity. Receives occasional long-period swell from the North Atlantic in the winter, and short-period windseas generated in the English Channel. Prevailing winds are west or southwest, onshore at spots exposed to long-period swells. A mixture of beach and reefbreaks

South-West England – North Coast

High quality, high consistency, very high popularity. Receives long-period swell from the North Atlantic throughout the year. Prevailing winds are west or southwest, offshore at north-facing spots. Mostly beachbreaks and a smaller number of reefbreaks. Probably the most consistently surfed area in the UK

South Wales

Medium quality, medium consistency, very high popularity. Receives long-period swell from the North Atlantic, mostly in the winter. Prevailing winds are west or southwest, onshore at spots most exposed to the swell, but there are a variety of spots facing different directions. A mixture of beach and reefbreaks

Pembrokeshire

High quality, medium consistency, high popularity. Receives long-period swell from the North Atlantic, mostly in the winter. Prevailing winds are west or southwest, onshore at spots most exposed to the swell, but there are a variety of spots facing different directions. Mostly beachbreaks with a smaller number of reefbreaks

West and North Wales

Medium quality, low consistency, medium popularity. Receives long-period swell from the southern North Atlantic in winter, along with locally-generated windseas. Prevailing winds are west or southwest, onshore at spots most exposed to the swell, but there are one or two sheltered spots. A mixture of beach and reefbreaks

[†] The term 'windswell' is a bit confusing because 'swell' by definition is the opposite of 'windsea'. Swell means free-travelling waves that are no longer being fed by the wind, and 'windsea' means waves that are still growing in the storm, being fed by the wind.

Northern Ireland

Medium quality, medium consistency, medium popularity. Receives long-period swell from the northern North Atlantic, most of the year, apart from west or southwest swells. Prevailing winds are west or southwest, offshore at most spots. Mainly beachbreaks, some of which are of high quality

Hebrides

High quality, high consistency, very low popularity. Receives long-period swell from the North Atlantic, all year. Can get very stormy in winter. Prevailing winds are westerlies, but usually more than enough swell to get into sheltered spots. A mixture of beach and reefbreaks. Remains partly unexplored

North coast of Scotland

Very high quality, medium consistency, low popularity. Receives long-period swell from the northern North Atlantic and the northern North Sea. West swells struggle to get into many spots. Prevailing winds are south-westerlies, so offshore at most spots. Mainly reefs, some of which are world-class

Orkney Islands

Very high quality, high consistency, very low popularity. Receives long-period swell from the North Atlantic and the North Sea. Can be very stormy in winter. Prevailing winds are westerlies, but usually enough swell to reach sheltered spots. Mostly reefbreaks, some of which are of high quality. Remains largely unexplored

East Scotland

Medium quality, low consistency, medium popularity. Receives long-period swell from the northern North Sea and shorter-period swell or windsea from the mid and southern North Sea. Prevailing winds are westerlies, offshore at most spots. Mostly beachbreaks, with one or two reefs

North-east England

High quality, low consistency, high popularity. Receives long-period swell from the northern North Sea, and short-period swells and windseas from the mid and southern North Sea. Mostly flat in summer. Prevailing winds are westerlies, offshore at most spots. A mixture of beach and reefbreaks, with a few high-quality breaks

East Anglia

Low quality, low consistency, medium popularity. Receives most short-period swells and windseas from the mid and southern North Sea and some rare long-period swell from the north. Mostly flat in summer. Prevailing winds are westerlies, offshore at most spots. Mostly beachbreaks, some of which are affected by man-made structures

South coast of England

Low quality, low consistency, very high popularity. Receives mostly short-period windseas with occasional long-period swell from the North Atlantic. Mostly flat in summer. Prevailing winds are south-westerlies, but many spots are sheltered by man-made piers. Mostly beachbreaks, but one or two high-quality reefs.

Channel Islands

High quality, medium consistency, high popularity. Receives long-period swell from the North Atlantic, mostly in winter. Prevailing winds are westerlies, but there are a variety of spots facing different directions. A mixture of beach and reefbreaks

5. Value of waves to surfers

5.1. Introduction

To us surfers, waves are extremely, if not infinitely, valuable. Without any waves at all, the whole concept of surfing would be meaningless. But some waves are more valuable to us than others, and that depends on a number of different factors. Even though 'personal' the value of a particular surf spot varies according to whether you are a longboarder, bodyboarder or big-wave surfer, there are obvious examples of surf spots that are universally considered good or bad.

The overall value of a surf spot to surfers doesn't just depend on the quality of the wave; it also depends to a certain extent on the consistency and the number of people affected if that wave were taken away. In this section we are going to have a brief look at what might make us, as surfers, value one type of surf spot over another. Of course, the only time we would have to do this is if we were presented with a 'devil's choice' of having to choose one spot to sacrifice in order to save another. Ideally, *all* surfing waves should be worth saving and we should never have to face this dilemma. Nevertheless, it is interesting to have a look at, even if only as an academic exercise.

Note that, in this section, we are only talking about the 'intrinsic' value of waves to surfers themselves, not the 'extrinsic' value of a surf spot to a local community through secondary effects such as the influx of tourists and the money they bring. This will be covered in section 7.

5.2. Personal preference

The way we value some waves over others varies from person to person. Probably the most important factor in determining the personal value of a particular type of wave is the suitability of your preferred surfcraft to that wave. For example, longboards are designed to make the most of long, slow pointbreaks; so this type of wave would be highly valuable to longboarders, but of very little value for bodyboarders or bodysurfers. On the other hand, bodyboarding or bodysurfing especially comes into its own in heaving shorebreak waves that are far too steep for most other types of surfing; so this type of wave would be practically worthless to a longboarder. The personal value of a wave also depends to a certain extent on how the difficulty of that wave matches your own level of skill. In general, the more surfing skill you have, the more you will appreciate more challenging waves.

5.3. High and low quality waves - generic

However, some types of waves are clearly worth more than others, but to everybody, not just to a particular subset of the surfing population. Certain qualities of a wave are universally sought after; for example, length of ride, smoothness of the wave face, lack of close-out sections and, for most surfers, a tube. A pointbreak with a 200-metre barrel and constant offshore winds is generally considered better than a mushy semi-closeout with backwash and a rip running through the middle of it. Given a 'devil's choice' of which of these two waves to sacrifice, if they had to, most surfers would sacrifice the semi-closeout; which implies that the other one is worth more.

Around the coastlines of the world, poor-quality surfing waves are far more abundant than high-quality ones. In fact, as the quality gets higher and higher, the abundance gets less and less. The very best waves in the world – those considered 'world-class' – could almost be considered freaks of Nature, the result of a combination of offshore bathymetry, coastal geology and prevailing wind and swell patterns found almost nowhere else in the world. It is easy to see that these 'world-class' waves, just like other unique natural feature of this planet, perhaps should be protected above all others, and, therefore, are worth the most. But perhaps that isn't always the case.

5.4. Consistency

Most of the time, the consistency of a surf spot affects its value to surfers. For example, consider two surf spots each containing a mediocre left hander with a 50-metre ride. One of these spots is in an area that picks up consistent swell of the right size, has prevailing offshore winds and is surfable 300 times a year. The other one is in an area that rarely picks up enough swell, is plagued with onshore winds and is surfable about 20 times a year. Ignoring any other factors, which one would you choose to sacrifice? Well, if everything is equal apart from the consistency, then obviously the more consistent spot would win over the other one.

Now, what would happen if you were given the choice between a very mediocre spot that is surfable almost every day, or a booming world-class pointbreak that only breaks once a year? This is a bit more of a difficult question. On one hand, it is tempting to put more value on the world-class spot even though it only breaks once a year, because it is more unique and it would be a shame if it disappeared. On the other hand, the poor-quality spot might actually have a higher *practical* value. The majority of surfers are of intermediate standard and probably don't need really high quality waves to get stoked. Any break that allows people to get out there and surf on a regular basis might produce a lot more wellbeing among the local surfing community than a world-class pointbreak that only goes off once a year. Not everybody would agree with this of course, and it remains a subject for debate. One thing that is clear though: the inconsistency of a high-quality surf spot should never be an excuse to degrade or destroy it.

5.5. Number of surfers affected

Another factor that is important while trying to assess how much a wave is worth to the surfers themselves is the actual number of surfers that would be affected if that wave were destroyed or degraded. Crudely, the value of the wave goes up as a function of the number of people that surf it. For example, the same wave would probably be considered to be worth more if it were in an accessible part of the UK with a regular surfing population than if it were in an inaccessible part of the Namibian desert. However, at the high-quality end of the scale, it is not quite so straightforward. Very high quality waves are generally considered more valuable than others, even if almost nobody surfs them. A world-class wave such as some of those found in Northern Scotland might be practically unknown to the surfing world and only surfed by a handful of people, but that is not a valid argument to destroy it.

As far as numbers of surfers are concerned there is another complication: the sheer number of surfers in the water starts to affect the quality of the wave from each individual surfer's point of view. At first, there is plenty of room for everybody, and adding more people doesn't affect the surfing experience of the people already in the water. But then the spot begins to become saturated, so that each person's individual enjoyment goes down slightly every time another surfer enters in the water. In this case, you could say that, at the beginning, the wave becomes more valuable as more people enjoy it, but then its value levels off as it surpasses its natural crowd-carrying capacity.

Again, don't forget we are talking about the 'intrinsic' value of the wave to the surfers themselves, not the amount of money that the wave might bring in to local shops, bars and hotels. That is another matter altogether, which we will discuss in section 7.

5.6. Summary

In summary, the value of a particular surf break to the individual surfers who surf there is not as simple as you might think. It is a complicated function of a number of interrelated factors, some of which are difficult to define and difficult to assess objectively. These include the quality of the wave, the consistency of the spot and the number of surfers who would lose out if that wave was taken away. Here, all we have done is tried to identify the factors involved and guess how they related to the value of the wave from the individual surfer's perspective. As we stated earlier, there really ought to be no excuse for destroying any surf spot, no matter how poor quality, how inconsistent or how few people surf there.

"Natural surf breaks should be treated as world heritage sites, and should never be destroyed no matter what the reason"…and…"We really can't allow any existing surf breaks to be taken down, for whatever reason." (Yvon Chouinard, founder and CEO of Patagonia, Inc.)

5.7. Value of waves to surfers: putting a monetary value on a surfing wave

Using the criteria above, it would be interesting to see which waves were the most and least valuable to surfers, for example, around the British Isles. This would be just a 'relative' value, or you could call it a *qualitative* analysis. But if we wanted to try to compare the value of waves with the value of something else, we would have to try to determine 'absolute' values, or do a *quantitative* analysis. This would involve an independent unit of measurement, such as money.

But is it really feasible to try to put a monetary value on a surf spot or a surfing wave? After all, waves provide us with things like happiness, laughter, physical exercise and good vibes – things that 'money can't buy'. So perhaps it would seem absurd, and somehow wrong, to try to put a monetary value on something that is, really, beyond value.

Nevertheless, marketing experts have made attempts at actually putting monetary values on things that are generally considered beyond value. These are called *non-market evaluations* because they refer to things that are worth something to us in some way, but are not normally bought and sold in the market place. They include things like clean air, forests and natural habitats – and, of course, waves for surfing.

The way the experts try to put a value on these things is to try to work out a kind of 'surrogate' value. This can be done in two different ways. The first is called *revealed preference*, and is based on how much money it costs us to perform the activity that allows us to enjoy the resource (i.e. surf those waves). This means, how much it costs us in fuel to drive the car or take a plane to a surf destination, how much we spent on boards, wetsuits, leashes, wax or any other equipment and how much time and effort we spent organizing our surfing. Every surf session costs us something, whether it be a boat trip to the Mentawais or an early-morning surf at our local beach before work. The second method is called *stated preference,* and is based on how much money we would hypothetically pay to stop that resource (i.e. a surf break) from being taken away.[2]

If our local break was threatened because, say, somebody wanted to build a breakwater through the middle of it, it would be interesting to see how much we would be prepared to pay towards a campaign that would eventually stop them. Similarly, to see how much we might be willing to pay to bring back a good surfing wave that has already been destroyed or made inaccessible. There are plenty of examples of this around the UK, but the one that stands out the most, worldwide, is the now seriously degraded world-class big-wave pointbreak at Ponta Jardim in Madeira (see section 6). How much would the surfers who rode it before the sea wall was built be prepared to pay to restore it to its former quality?

5.8. Surfing waves are not for sale

Putting a monetary value on a wave is probably best done just for curiosity or as an academic exercise, as it carries a huge risk of being taken the wrong way by the wrong people. As soon as you put a specific value on a surf break, some people will start to imply that it is potentially for sale. Otherwise, why would you have put a value on it? This then will encourage coastal developers to perform cost-benefit analyses, whereby the value of a surf spot is numerically balanced against the potential income from some scheme that includes destroying that wave. For example, what would happen if we decided that a certain surf spot was worth, say, £10,000 a year, and somebody wanted to build a yacht harbour that would generate an estimated income of £15,000 a year but would destroy that wave in the process? Who decides what to do? Are the developers then in a position to 'buy' that wave from the surfers? More about this kind of thing in section 7.

6. Ways in which surfing waves can be lost

6.1. Introduction

Surfing is one of those activities that make direct use of a natural resource without depleting that natural resource. There are other examples such as walking across a mountain without destroying the flora on the mountain, paragliding without affecting the atmosphere, or diving without killing all the sea life.2[†]

The majority of things that people do are not like that, however. Either in order to make our lives more comfortable or to make us happier (or *believe* we are happier), we rely on artificial infrastructures built using some mineral extracted out of the ground and converted into fuel or material goods, which we pay for with our money. Examples of these activities include driving around in a new car or motor boat, drinking beer, owning a large television, owning a luxury apartment overlooking the beach, or having a lot of money in the bank. People tend to think of these types of activities as being more important and more 'serious' than something as simple as surfing.

Now and again, in order to enjoy activities like the ones above, people end up destroying surf spots or polluting the water, or restricting our access to the waves. There are many ways this can happen; below are just a few examples.

6.2. Solid structures

Solid concrete structures built sticking out of the coast into the sea represent the most common method by which surfing waves are destroyed, and the most permanent. If somebody builds a large concrete breakwater or sea wall which destroys a surf spot in the process, that surf spot is gone forever.

In the past, we knew a lot less about coastal erosion and waves than we do now. We modified the coastline with concrete structures and we built houses, hotels, car parks and walkways, right on the coastline. Nowadays, some of these structures are being eroded away by the waves, and others are still causing knock-on erosion effects at some nearby stretch of coast. Ideally, we should just let Nature take its course and let the sea erode them away.

Of course, that's easier said than done, because some of these structures have people living in them, and others are so firmly fixed that removing them would be virtually impossible. So, in these cases, building some structure to protect some other structure we erroneously built in the past is almost excusable. If it involves the destruction of a surf spot, it might be a complicated issue to try and stop it.

However, most surfing waves are destroyed by new structures designed to protect something artificial. A common example is a pier or breakwater to stop the waves eroding an artificially-widened beach at a popular tourist resort. A scheme like that supposedly benefits a lot of people because it allows them to lie on the beach and burn their skin before spending their money in the local bars and restaurants. Are those activities more 'important' than surfing?

Another example is the building of a breakwater to stop the wave energy entering a certain area where people want to keep their boats. In some cases this might be a port containing fishing boats, which is excusable because fish is food and food is essential; but most fishing ports were already built hundreds of years ago. Normally the problem nowadays is a yacht harbour where people keep their expensive motor boats. In the summer they drive those boats around, consuming large amounts of hydrocarbons and making a lot of noise, but having fun at the same time. Again, is this more 'serious' than surfing?

[†] Obviously to surf or paraglide you need to buy a board and wetsuit which need to be manufactured from raw materials. But there is a difference: here we are talking about the enjoyment derived from the actual performing of the activity, not the pleasure derived from the buying or owning of the equipment

In the UK, coastal urbanization schemes that threaten to destroy surf spots often crop up. One recent example is the wave known as Custard Point at Brighton Marina – ironically a surf spot enhanced by a man-made structure, but nevertheless one of the most popular spots on the south coast of England.

In 2008 local surfers and residents were made aware of a proposed scheme to create a new four-story building containing 8000 square metres of office space, nine luxury flats and two cafés. This would have involved driving 186 concrete piles into the seabed and beach alongside the eastern edge of Brighton Marina, which almost certainly would have degraded the wave. The local population protested. The response they got from the developers was no better than what you would expect anywhere in the world:

"Surfers would not be banned and could continue to surf slightly further east."[3]

However, in December 2008 the local council rejected the planning application. A major influence in this decision must have been the massive public opinion against the scheme, including thousands of petitioners and letter-writers, not just from Brighton, but from as far away as Melbourne, Australia. This example shows that, at least in a country like the UK, public opinion counts.

In other countries, including those belonging to the European Union, things are not so easy. In Madeira, which is part of Portugal, a number of very high quality surf spots have been destroyed for no good reason. Ponta Jardim, before 2003, was considered one of the world's finest big-wave pointbreaks. However, in 2003, developers working for the local government built a large sea wall and road sticking out directly in front of the peak, which seriously degraded the surf. Before the wall was built, the natural volcanic platform provided the most efficient wave-energy dissipater or a buffer zone, where the broken waves progressively lost power. Now, the waves hit a row of concrete blocks at full force without any dissipation, causing extreme backwash and making surfing in big-wave conditions virtually suicidal.

According to the developers, the reason the wall was built was to 'protect' the small village of Jardim do Mar from the waves. How could the village suddenly need protecting? Waves of all sizes have been dissipated by the natural volcanic platform for thousands of years. The wall has not only seriously damaged one of the world's best surf spots, but it has also artificially modified a previously natural coastline, which could set of a chain of events leading to instability and erosion in the future.

Before *After*

Ponta Jardim was one of the world's finest big-wave point breaks before it was ruined by the sea wall. Photo Will Henry.

6.3. Dredging

Dredging a rivermouth to make the water deeper so that boats can come in and out is also a great way to destroy or degrade good surfing waves. Although this method isn't always permanent and doesn't actually involve building a solid structure, it does physically alter part of a natural system. Waves that break on rivermouth sandbars are usually very sensitive to changes in the shape of the bar, and often only work well at certain times of year or at certain stages of the tide. Physically removing the sand from the bar is a sure way to ruin the wave.

The worst cases of surfing waves lost due to dredging are those where somebody builds a yacht harbour or shipyard somewhere upstream, or enlarges an existing one, so that the sandbar has to be dredged at regular intervals to allow those people to get their boats in and out. In these cases, as soon as the bar starts to build up again and the wave almost begins to recover naturally, the perpetrators come along and dredge it again.

Sometimes, a rivermouth is dredged at intervals that allow the bar to recuperate, or perhaps the amount of sand removed is not quite enough to ruin the wave. But sometimes, a larger-than-normal boat needs to be brought in or out, and more sand than normal is removed from the bar. At best, this will temporarily degrade the wave; at worst it will permanently throw the entire system out of balance and ruin the wave for ever.

In the UK there are relatively few rivermouth sandbar breaks compared with other types of wave. Therefore we have had very few, if any, problems of this type in the past. However, just across the Bay of Biscay, in Northern Spain, a serious problem occurred recently.

In 2003, the world's most famous rivermouth wave, Mundaka, almost disappeared off the map for good. The wave at Mundaka was reduced from a world-class pointbreak to a poor-quality beachbreak, almost certainly triggered off by the shifting of some 243,000 cubic metres of sand by a local shipbuilding company to facilitate the removal of a large ship. Dredging the channel to float ships out had been done many times in the past, with very little noticeable effect on the sandbar. This time though, they went over the top, removing far more sand than ever before. As a result, the course of the river was diverted, which starved the original sandbar of sediment and built up a new bar in the wrong place and at the wrong angle. It stayed like this for three years, during which time local surfers were getting more and more worried that it would never come back. But then, miraculously, some time in 2006, the bar did actually recover.[4]

Something – we don't know what – managed to flip Mundaka back to its original state. Complicated natural systems like estuaries seem to obey the laws of chaos, where they exist in one of many stable states called 'attractor' states. If you force the system too much it tends to flip into a different state and it becomes very difficult to flip it back again.[5] Luckily, the position and shape of the bar at Mundaka is a very resilient state and that dredging wasn't quite enough to change it permanently.

For 3 years we lost Mundaka, one of the world best waves due to dredging. Photos Roger Sharp

6.4. Pollution

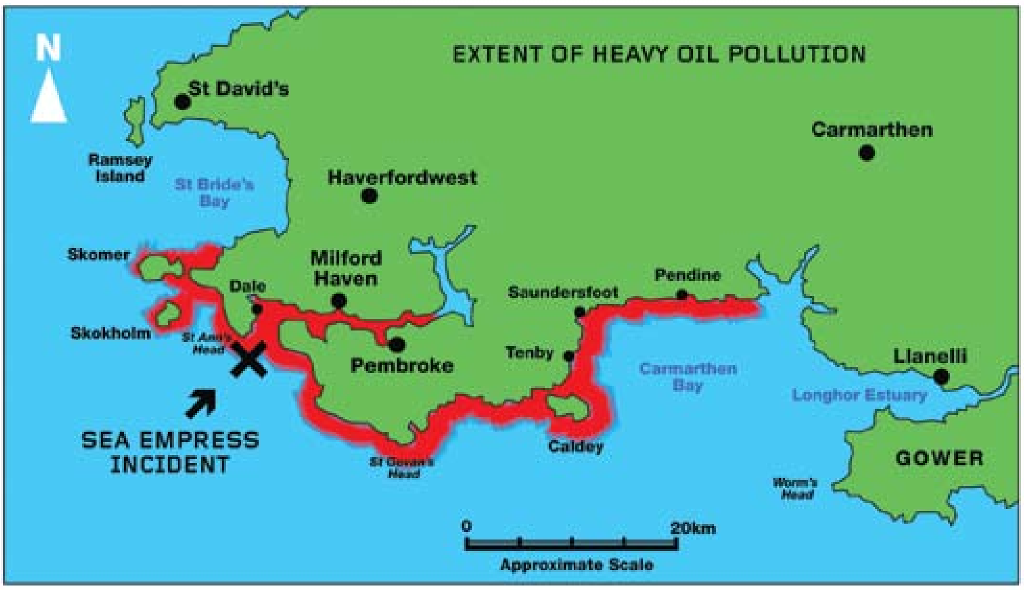
If somebody introduces a pollutant into the sea where there is a surf spot, we risk being affected if we go into the water; which could mean anything from an uncomfortable experience to serious illness or permanent disability, or even death. Contaminating the water alters the waves chemically, but not physically – so you might still be able to see them breaking perfectly, but you can't get in the water to surf them. Pollutants that people put into the sea include things like lead, mercury, zinc, pesticides, fertilizers, hydrocarbons, nuclear waste and, of course, sewage. Contamination 'events' can either be semi-permanent, like the pumping of toxics into the sea from inadequate sewage treatment systems or factories installed near the coast, or they can be one-off events, like an oil spill or perhaps the sudden release of sewage into the sea from an overflow system that is bursting at the seams.

6.5. Oil spills

The distribution of crude oil and other oil-derived substances into coastal waters and onto the coast, by people who allow it to escape from their ships is another common way to pollute the line-up. This can stop us surfing along huge stretches of coast for several months.

One of the worst oil spills to happen in the UK was also the first of its kind: the *Torrey Canyon*, which went aground on the Seven Stones Reef off Land's End in March 1967. The Torrey Canyon was carrying 120,000 tonnes of oil, all of which leaked out[6] and spread up the Bristol Channel and along the English Channel, seriously contaminating the coasts of England, Wales and France. Many of the most popular surf spots in Cornwall were under a thick blanket of oil and a no-go zone for months afterwards. Detergent-based dispersants were sprayed onto the oil, which produced an even more toxic sludge than the oil itself.[7]

More recently, in February 1996, just off the entrance to Milford Haven in Wales, the *Sea Empress* spewed out 73,000 tonnes of the 130,000 tonnes of crude oil it was carrying, and contaminated around 200 km of coastline. The disaster occurred in the Pembrokeshire Coast National Park, which is one of the most sensitive wildlife and marine conservation areas in Europe. Fishing and the collection of edible plants was banned between St David's Head in Pembrokeshire and Worm's Head on the Gower Peninsula, and oil was still being removed from beaches in this area over a year later.[8] The coastline affected by the Sea Empress spill is also one of the most heavily-populated surfing areas in the UK.



Map showing the extent of the heaviest pollution caused by the Sea Empress disaster

Probably the oil spill which stopped more people surfing than ever before was the *Prestige,* which sunk off the Coast of northwest Spain in November 2002. Inspections in Holland and the U.S. had already detected structural fatigue in the hull of the Prestige, but it was considered seaworthy in the Bahamas, whose flag of convenience it was flying. The ship let go of at least 50,000 of the 77,000 tonnes of heavy fuel-oil oil it was carrying. The slick gradually worked its way along the entire north coast of Spain, down into Portugal, up into France and even as far as the English Channel. For the entire winter, line-ups in France, Spain and Portugal were empty, and throughout the following summer (2003), the oil-covered beaches were seriously affecting bathers and tourists.[9] The oil still didn't go away into the autumn and throughout the next winter, and can still be found on some rocky beaches over seven years later.3[‡]

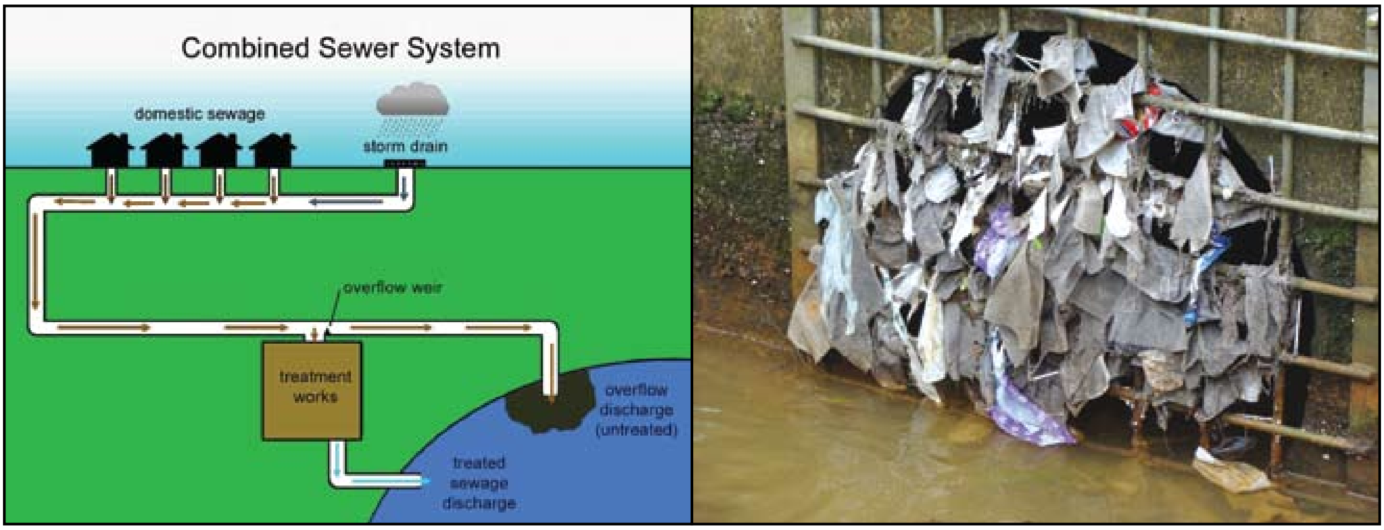
In April 2010 a massive oil spill occurred from a sea floor oil gusher in the Gulf of Mexico, as a result of an explosion on board a drilling rig called the Deepwater Horizon. At the time of writing, the disaster is ongoing, with the amount of oil spilling into the sea being estimated at between 3000 and 13,000 tonnes per day[10]. On average, that's roughly one Prestige every 11 days.

The Torrey Canyon was the world's first major oil disaster off Cornwall in 1967. Photo Getty images

6.6. Sewage

In the UK, the biggest problem with pollution is sewage. This is precisely why SAS was set up in the first place in 1990. Since then, SAS has been a major influence in improving the UK's sewerage systems. In those last 20 years, over eight billion pounds have been spent, and the continuous discharge of raw sewage into the sea has practically disappeared. Raw sewage is extremely poisonous, and carries pathogens such as hepatitis A, ecoli 0157H, gastro enteritis and many other nasties.

However, we still have a long way to go. The major threat nowadays is the Combined Sewer Overflow (CSO) and its misuse by water companies. The CSO is a kind of emergency outlet for the sewerage system, which discharges raw sewage and wastewater into rivers and into the sea when the system is overloaded. They are designed to function under extreme conditions, in other words sudden heavy rainfall, which is when they open up and relieve the pressure off the main system. They should normally function around three times during a bathing season, which is not ideal, but just about acceptable as long as the public are warned. Unfortunately, this is not the case. Because the UK's sewerage system is badly overloaded, water companies are not using CSOs in the correct manner; they are allowing them to discharge raw sewage into the sea hundreds of times a year. This blatant abuse of CSOs has resulted in the European Commission (EC) taking the UK to the European Court of Justice.



The UK's combined sewerage system and a Combined Sewer Overflow (CSO) that has recently discharged

According to the water industry itself, the number of CSOs around the UK is around 22,000. Many of these are completely unregulated, which means they can discharge an unlimited amount of raw sewage without any risk of the water company being prosecuted. At the moment, for the vast majority of CSOs, there is no way of knowing when the discharges take place, how long they last or how much sewage is discharged each time.

Surfers Against Sewage are working hard to solve the problem related to CSOs. In the short term, we are demanding that the public be better informed as to when a CSO is about to go off, so that they can decide whether to risk entering the water or not. In the long term, we are calling for water companies to increase the capacity of their systems so that the number of CSO discharges can be brought down to three per bathing season.

We believe that the funding for these improvements should not come from increases in water bills. The companies are already making enough profit to considerably increase the amount of money they reinvest into improving their systems, and hence protecting the health of their own clients. For example, in 2009, during a recession, the UK water industry registered a profit of almost two billion pounds.

Sustainable Urban Drainage Systems (SUDS) can take a great deal of pressure off the sewerage system by absorbing rainwater instead of letting it go down drains and overload the system. Surfers Against Sewage are calling on local politicians and urban planners to consider installing these systems, which could go a long way to reducing the number of CSO discharges.

Lastly, the public still needs to be made more aware that clean water is a valuable resource. Sensible use of water around the home and at work can make a lot of difference if we all contribute. Letting clean water flush down the drain unnecessarily is, literally, throwing money down the drain. Since we pay the water companies for the water we use, the more we waste, the richer they get.

So, what can you do to help? For a start, if you spot a potential pollution incident call the Environment Agency Pollution Hotline: 0800 807060, and then call the SAS Pollution Hotline: 01872 555950. Then, if you want to do more, you can sign up to the SAS Adopt a CSO campaign, to help us reduce the raw sewage discharges at your local beach. For more information see: www.sas.org.uk

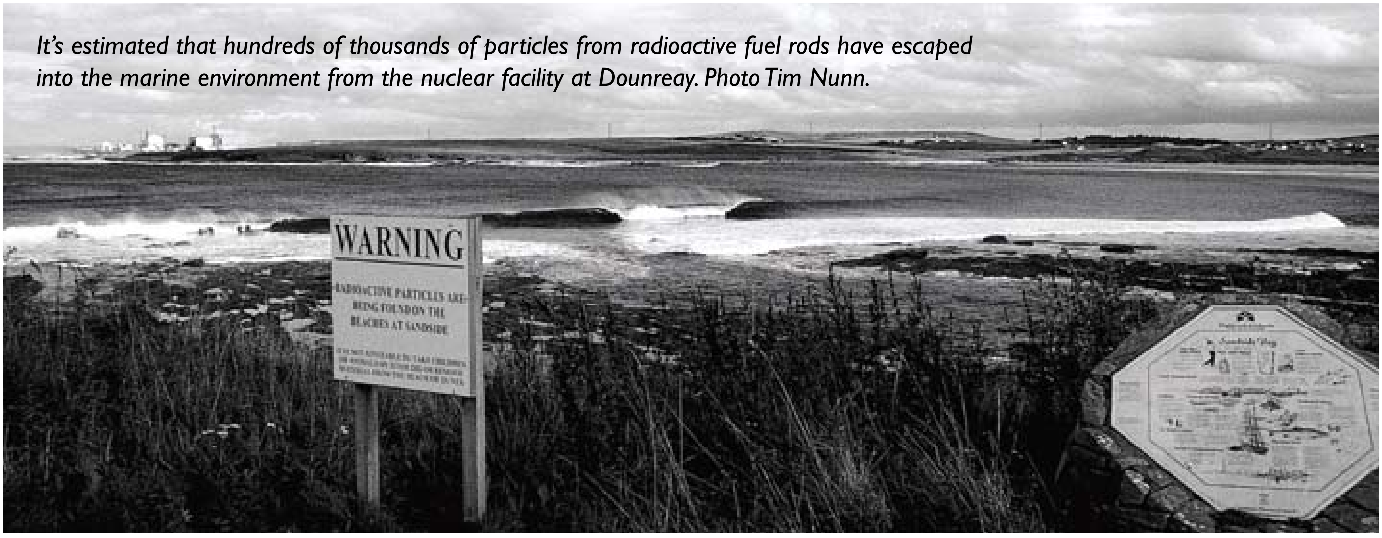
6.7. Nuclear waste

Exposure to radioactive material can be very harmful. Depending on the amount, it can cause nausea and vomiting followed by fever, dizziness, disorientation, low blood pressure, then hair loss, infections, bloody vomit, and death. Sustained low doses of radiation can also cause death by cancer.

Nuclear reactors need a lot of water to cool them down. So, as you can probably imagine, people tend to put them where there is already a lot of water, such as on the coast. If this is near a good surfing wave, then there is a real possibility that radioactive material will end up on the beach and in the line-up.

Sandside, in northern Scotland, is a high-quality left-hand pointbreak less than three kilometres from Dounreay nuclear power station. Nuclear material is regularly found on the beach at Sandside. Recently, it has been revealed that a tunnel dug under the seabed intended to remove nuclear effluent from the power station never functioned properly, with perhaps hundreds of thousands of pieces of fuel rod being washed out to sea with the liquid. The sea bed is now covered with radioactive particles over an area covering hundreds of square kilometres.[11]

Since it was put into action around 1959, Dounreay has had a poor safety record. For example, in 2007 UK Atomic Energy Authority pleaded guilty to three charges of allowing nuclear fuel particles to be released into the sea from Dounreay and one charge of disposing of radioactive waste at a landfill site.[12] In 1994 the plant was shut down, and is now under the control of the Nuclear Decommissioning Authority. They estimate that it will take until the year 2336 before it becomes reusable as an industrial site.



It's estimated that hundreds of thousands of particles from radioactive fuel rods have escaped into the marine environment from the nuclear facility at Dounreay. Photo Tim Nunn.

6.8. Non-polluting contamination – litter

Another type of contamination which is not always hazardous to our health, but which definitely tends to make our beach and surfing experience extremely unpleasant, is unnatural objects abandoned by people in the marine environment. In other words, litter. This typically includes rubbish that people throw on the beach, objects put into the sea from commercial ships and fishing vessels, industrial waste and agricultural runoff entering the sea via rivers, and solid items that people put down the toilet entering the sea via sewage outlets. Most of these things are simply uncomfortable; but some of them, such as syringes and broken glass, can be very dangerous.

About half of all marine litter is plastics, whilst the remainder consists of materials such as polystyrene, rubber, metals and glass. Plastic is not biodegradable and takes a very long time to degrade, particularly in the marine environment. For example, a plastic bottle may persist for more than 450 years if left on a beach.

A dirty beach not only costs thousands of pounds a year to clean up, but also is less attractive to surfers and other water-users, which in turn makes the waves less valuable. Imagine if there were two beaches each containing exactly the same types of waves that worked in the same swell and wind conditions, but one had seagull droppings and seaweed on the beach and the other had coke tins, cigarette ends and pizza boxes all over the beach and condoms and tampons floating in the line up. Which one would you prefer?

Surfers Against Sewage is campaigning on a number of different levels to tackle the torrent of marine litter that washes up and gets deposited on UK beaches every year.

6.9. Access

The last example of how surfing waves can be taken away from us is when we are simply denied access to them. In this case, the waves themselves might remain undamaged, but somebody decides that we are not allowed to surf them. In most cases, this is because the area of coast and adjacent ocean containing the waves has been claimed by somebody as their private territory.

In the UK, in theory, everybody is granted free access to the coast. If the only way to access a certain section of the coast is through somebody's territory, the owner is normally obliged to provide public right of way to the coast, typically in the form of a footpath. The Marine and Coastal Access Act 2009, gives people a right by law to be able to access all the beaches around England, and also provides the right to walk around the entire coast of England via a coast path[13].

There appears to be one exception though: the military. Ministry of Defence training grounds and firing ranges are often placed at or near the coast, and, of course, access is either permanently closed to the public or closed when the army are practicing blowing things up. The reef/pointbreak at Broad Bench, Kimmeridge is one of England's best waves, surfed by a large number of people. It is also just on the boundary of a MoD firing range, and is out of bounds to the public when firing is taking place. In 2008 the military decided to increase their firing exercises and completely close off Broad Bench for 228 days a year. Crucially, the Bench is closed during the winter, which is normally the only time it receives surfable waves. The time it is available to surfers is during July and August, which is practically useless.

This world class wave lies on the outer limits of an MoD firing range

In mainland Europe, access to the coast is also restricted in a lot of places due to the military. In southwest France, there is a military zone running from Biscarosse to Mimizan – a distance of about 30 km. Access to the beach is completely forbidden along this stretch, which contains some of the best beachbreak setups in the world.

In California, a controversial issue regarding access to the coast at the Hollister Ranch has been going on for decades. The Ranch contains a number of classic reefs and pointbreaks along a 14-km stretch of coast, but the land is owned by private individuals who don't let members of the public pass through their territory. State laws do, however, permit the public to pass anywhere seaward of the high-tide line, which means that surfers must either walk in at low tide or arrive by boat. The landowners do not encourage outsiders and have been known to vandalize boats or intimidate visiting surfers in the water.[14]

There are many other examples around the world of private landowners restricting access to good surfing waves, but two particularly stand out. The first is in northern Peru, where at least 200 km of coastline containing several world-class left-hand pointbreaks have been declared a 'private nature reserve' by the owners of the land[15], and the other is in the Northern Cape of South Africa. The area between the Namibian border and the Buffels River, a 150-km stretch of coast aptly named the *Diamond Coast* is a forbidden zone, controlled by the DeBeers diamond mining company. The Diamond Coast contains a large number of world-class reef and pointbreaks which have only been ridden by a handful of surfers over the years, most of whom have been DeBeers employees.

6.9.1. Summary

Finally, what would happen if the situation were reversed? What would happen if a group of surfers, by simply riding the waves, somehow took away another group of people's rights to watching TV or drinking beer? The difficulty in simply trying to imagine how this could possibly happen makes you realize how unbalanced the whole thing is. Surfing very rarely stops other people doing the activities they like by taking away their 'resources', while other activities *do* stop us surfing by taking away the waves.

Over 300 surfers and waveriders protest with SAS for 100% access to the Bench

7. Value of surfing waves to non-surfers

7.1. Introduction

The existence of a surfing wave near a place where people live can bring money into the local economy. This adds an extra, indirect value to that wave over and above the *intrinsic* value of just being able to surf it. The surf spot is an attraction to outside visitors who come to the area not just to enjoy surfing the wave, but also to watch other people surf it, or to accompany somebody who will be surfing it.

For example, when there is an important international contest you sometimes get a huge influx of people into a small coastal town – not just spectators, but photographers, movie-makers, journalists, competitors' friends and family and, of course, the competitors themselves. All these people need to eat, drink, sleep, drive around and put wax on their boards while they are in that area. They bring money that was earned somewhere else, and spend it in local hotels, bars, restaurants, car-hire agencies, car parks and surf shops. If the surf spot were not there, these people would not come. They would take their money and spend it somewhere else.

7.2. Examples of tourism values

Not many studies have been made into just how much money is brought into local economies due to the existence of surfing waves, but the evidence suggests that it is considerable, and that it compares favourably with other activities such as boating and golf. Below are just a few examples, starting off in the UK:

A survey was carried out in 2004, commissioned by Cornwall County Council and the South West Regional Development Agency, results of which showed that the overall turnover from the surfing industry in Cornwall was about 20% more than the sailing industry, and about twice as much as the golf industry. Results also showed that the average visiting surfer spends about 8.5% more in Cornwall than the average visitor.[16] The number of businesses relating to surfing in Cornwall is extremely high considering the population. In Newquay, for example, the combined number of surf shops and surf schools reached a recent peak of over a hundred, which has declined slightly due to the recession, but is still a very large number for such a small town.

In Mundaka, northern Spain, the existence of the famous rivermouth wave generates a lot of money for the local economy, mainly because of the large influx of surfers to the town every time the wave breaks. A 'surfonomics' study, published in 2008, revealed that surfing in Mundaka contributes up to 4 million euros (£3.4 million) per year to the economy of the town and supports up to 95 jobs.[17] That's a lot, considering it only has about 2000 permanent residents.

Meanwhile, in California, it has been estimated that surfers visiting the break at Trestles contribute up to US$13 million (£9 million) a year to the local city of San Clemente.[18] In Costa Rica, a market survey carried out in 2006 suggests that surfing-related activities account for around 25% of the country's tourist economy. This puts surfing ahead of coffee and second only to bananas as the principal money-bringer to Costa Rica.[19]

Large international contests can mean a lot of money for local businesses. For example, the Boardmasters contest held at Fistral Beach in Newquay was estimated in 2001 to be worth around £17 million to the local economy.[20] On the Gold Coast of Australia, it was estimated in 1998 that a single high-profile event was worth over AU$2 million (£1.3 million)[21], and in Hawaii the organizers of the Hawaiian Triple Crown surfing tournament estimate that, during the two months that the tournament runs, up to US$9 million (£6 million) is generated for businesses on the North Shore of Oahu as a direct consequence of the event.[22]

7.3. Who benefits?

So who benefits from all this money being brought in to the local economy? The answer is the people who own or work in any of the establishments where the visitors spend their money. A lot of these people might themselves be surfers, especially if we are talking about surf shops, surfboard manufacturers or surfing schools. If the spot is destroyed, polluted or degraded for some reason, the surfers in the town will not only suffer because they won't be able to surf it, but they might also suffer because their jobs depend on that wave bringing money-spending tourists into town.

But the people who benefit don't necessarily have to be surfers. They can be hotel managers, shop owners, ice-cream sellers, politicians or anybody else. In fact, they don't even have to like surfing or know anything about it; they might simply tolerate it because they know it brings them money. Instead of getting pleasure out of riding the waves, their major source of satisfaction in life might be something completely different. The money they gain because there happens to be a good surfing wave in their town might be spent on watching TV, drinking beer or owning a new motor boat. If the wave is degraded or destroyed, their income will go down; which might mean less beer, TV or motor-boat fuel.

Often it is the second group of people I've just mentioned – those who don't know or care about surfing – that have more influence than the surfers themselves over whether or not some scheme, such as a concrete structure, dredging operation or sewage works will cause a detrimental affect on the waves. Therefore, it is essential that these people be convinced that, just like yacht harbours, golf courses and factories, surf spots can also be a source of money.

Experience shows that most people responsible for a scheme that ruins a surfing wave do not understand the value of that wave in the same way that we do. They don't understand the intrinsic value of the wave; they can only see the *extrinsic* value – that the wave is a means of generating money which will be subsequently spent on something other than surfing. Unless the value of the wave is spelled out to them in monetary terms, they will think it is valueless.

Therefore, the most effective way of making sure surf spots don't get destroyed or degraded is to simply point out that they are an important means of bringing money into the local economy and a lot of people might 'suffer' if the waves were taken away. Surveys and 'surfonomics' studies like those mentioned above are gaining momentum. A body of literature is beginning to build up in scientific journals, conference proceedings and other publications, which will be read by coastal engineers, coastal planners and other potential wave-ruiners.

7.4. The dilemma

There is one problem with the above approach: what happens if a world-class surfing wave exists in an area where virtually nobody comes to visit and there are no international contests? In this case, the surf spot would have no extrinsic value and therefore be apparently worthless to those people who might decide to ruin it.

Spots like this do still exist. Some have only recently been discovered, and others are either too cold or inaccessible to ever be popular with surfers, even though they have been known about for years. In the UK, the prime example is the north of Scotland and the Orkney Islands. Here, the quality of the reef and point setups really is world-class, but the number of surfers has always remained much smaller than in other parts of the British Isles. The area contains a very low permanent population, is freezing cold and dark in winter, tricky and expensive to get to, and swell and wind conditions are very difficult to predict.

As of the time of writing, nothing has happened to any of those world-class breaks, but there is a plan in place to install hundreds of wave-energy converters (WECs) off the coast of northern Scotland and the

Orkneys. The developers are largely unaware of the quality and uniqueness of the breaks, so we need to keep a close eye on what is happening.

The other classic example is just a few hundred miles away in Madeira. Even though Ponta Jardim was undoubtedly a world-class wave and perhaps one of only a handful of true big-wave pointbreaks on the planet, the surfing world was largely unaware of its existence. That is, until it was too late. The fact that Ponta Jardim was generating almost no money for the economy of Madeira meant that it was worth nothing to the local government, who blatantly destroyed it. Just to see what we are up against, according to Carlos da Silva, Associate Secretary of Tourism on Madeira: *"We don't believe that tourism on the island will depend ever on surfing."*

8. Electricity from the waves

8.1. Introduction

Just as we can tap off a small amount of wave energy to push us along on our boards, we can also extract energy from the waves and re-direct it to generate electricity. Electricity from the waves is a renewable and clean source of energy, and is being considered, along with other forms such as solar energy and wind energy, as a viable replacement for fossil-fuel and nuclear based generators. In this and the following section (9) we will talk about the different ways in which waves can be used to generate electricity, and why we should be careful that it doesn't cause any adverse affects on the waves themselves.

The fact that waves can be used in this way automatically puts a value on them. However, this is not quite the same as their value to us for surfing or their value as natural elements, because waves don't need to be protected so that they can be used for electricity. In fact, waves might need to be protected *from* being used for electricity so that they can still be used for surfing or so that their natural function isn't interfered with. In the future, there probably won't be many cases of an electricity-generating wave suddenly being degraded or destroyed by a yacht harbour or dredging operation.

Before we begin, a note on the units of electrical power we will be quoting in this section. The term 'power' means the *rate* of energy use. This means the amount of energy used per unit time. For example, if your neighbour uses up twice as much electrical energy every second, every day or every year than you do, his power consumption will be twice as much as yours. Energy is measured in joules (J) and power is measured in watts (W). One watt means that the rate of energy consumption is one joule of energy per second. A kilowatt (kW) is a thousand watts, a megawatt (MW) is a million watts and a terawatt (TW) is a million megawatts. The average home in the UK needs roughly between 1 and 3 kW of power to run. In other words, it burns 1000 to 3000 joules of energy per second, or between 86 and 259 million joules per day. A power-generating device that produces a megawatt is approximately enough to supply 400 homes in the UK.

Just to confuse things, most energy companies talk about kilowatt-hours (kWh), which is their particular way of measuring energy. Then, they sometimes quote power consumption in kilowatt-hours per year. This is totally unnecessary, as power consumption should really only be quoted in watts (1 kW = 8760 kWh per year), so, here we are going to forget kWh and just talk in terms of watts. That way, we can compare apples with apples, not apples with bananas.

8.2. Renewables - general

Most people now accept that we can't continue to burn fossil fuels (hydrocarbons) to generate electricity. We are going to have to stop doing it pretty soon, otherwise (a) all the fuel will run out and (b) our atmosphere will get so polluted that global warming will have serious impacts on the entire planet. Fossil fuels need to be replaced by alternative forms of energy generation that (a) are 'renewable' so they won't run out and (b) are 'clean' so that they don't pollute the atmosphere.

So what do we mean by 'renewable'? Well, hydrocarbons are continually being generated in the Earth from dead organic material, but at a rate thousands of times slower than the rate at which we are extracting and burning them. Therefore, if we keep burning them at the present rate, they will run out. Put in more general terms, the energy source we have chosen to use is one that is 'replaced' by Nature at a rate too slow for the rate we want to use it. It would be much better if we could choose a different source of energy: one that was 'replaced' by Nature at the same speed as we used it. Energy from sources such as the Sun, the wind and the waves are theoretically 'renewable' in the sense that, as soon as we use some of the energy, it is immediately replaced by Nature. The idea is that the amount of energy contained in the atmosphere or in the ocean is so vast that every time we extract some for our own use we make such a small dent in it that Nature fills up that dent straight away.

And what do we mean by 'clean'? Traditional carbon-based energy sources convert matter into energy and matter. We use the energy, but the matter (the pollution) goes up into the atmosphere. Other energy sources such as solar, wind, tide or wave-based ones already start off as energy. They convert that energy into energy and matter, but the amount of matter produced is so tiny it is almost insignificant. Therefore, these sources are much 'cleaner' in the sense that they produce virtually no pollution. No pollution means no contribution to global warming.

8.3. How much wave power does the ocean contain?

It has been estimated that the total combined wave power in all the oceans of the world is between one and ten terawatts.[23] It has also been estimated that about two terawatts of wave power is theoretically available to us in the form of waves that break on the coastlines of the world.[24]

Practical issues mean that we couldn't possibly harness anywhere near that. But even if we could, we really wouldn't want to. Part of the reason that waves exist is to help with the natural energy transport around the globe, and removing a significant proportion of that energy transport might just throw something out of balance. The Earth would need to redirect the energy somewhere else, which might trigger off changes in the climate, which would bring us right back to square one.

So, whatever the case, the amount of power we could, in theory, harness from the waves is somewhat less than 2 TW. But how does this compare with the amount of power we will eventually need to replace all that power we are presently getting from fossil fuels? Well, in 2008, the average global power consumption was about 15 TW, between 80 and 90 percent of that (i.e. about 12 TW) being derived from fossil fuels.[25] Clearly then, if we continue to consume the same amount of power worldwide, we won't be able generate all that power from the waves. But don't forget there are many other clean renewable energy sources such as solar power and wind power, each providing a useful contribution along with wave power.

8.4. Best places for WECs around the world

Number of kW per metre of wave crest[27]

The places where there is most wave power are not necessarily where the biggest waves occur, or where the waves are suitable for surfing. Instead, you need somewhere where the coast is constantly being battered by lots of waves and plenty of energy. To find out how much power there is available along different stretches of coast around the world, we can look at estimates of the amount of power in kilowatts per metre length of wave crest.[26] The places with the highest average wave power throughout the year are those subjected to the constant westerly winds found between thirty and sixty degrees north and south. In the west of Scotland, for example, the average wave power per metre is 70 kW. Other high-power areas are the southwest tip of Australia with 60 kW per metre, and Cape Horn with 70 kW per metre. The places where people surf the biggest waves in the world tend to have relatively small overall wave power figures. The coast around Northern California, for example, only has about 30 kW per metre.

8.5. Types of WEC

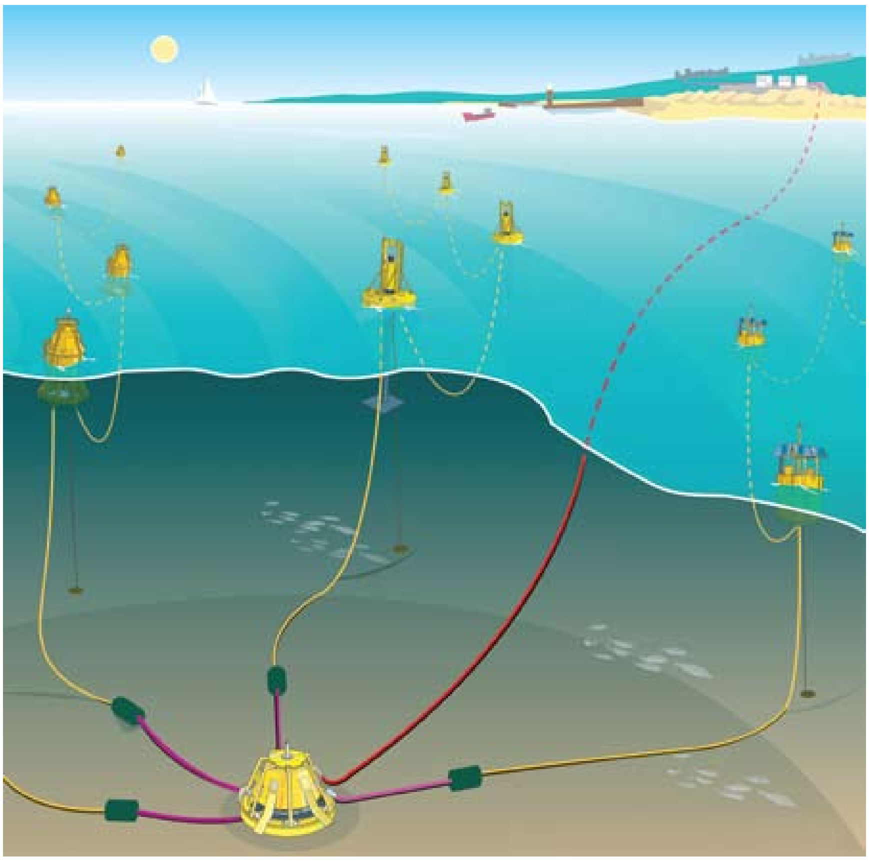
So why haven't we already replaced all those smelly old coal-fired power stations with nice, clean renewable energy devices? Well, one problem is that we are still getting to grips with the technology. Before any device can be connected up to the National Grid to supply homes and factories with electricity, it has to be designed, developed and tested.

Companies and research departments are working hard to get these devices designed, tested and operational. The European Marine Energy Centre (EMEC) is a wave and tidal power research centre in the Orkney Islands, which includes an on-site test facility for WECs at Billia Croo. Here, four high-voltage cables have been installed from an onshore substation to four different locations between one and two kilometres offshore, to enable developers to connect their devices for testing.

Another test facility, at the opposite end of the country, at Hayle in Cornwall, is the Wave Hub. This is a central distribution point, almost like a giant multi-way adapter, where wave energy converters are 'plugged in', in order to be tested. The hub will be deployed about 18 km offshore, mounted on the sea bed and connected via a high-voltage cable to a substation at Hayle, which, in turn, is connected into the National Grid. The Hub has four 'slots' each to be allocated to a separate company to allow each of them to test their particular apparatus. The cable allows a maximum of 16 MW, or 4 MW per company. At the time of writing, the Wave Hub is just beginning to be installed.[28]

There are a bewildering array of wave energy capturing devices currently under development.[29] No less than 113 companies around the world are working on their own versions, 23 of which are in the UK.

Below is a description of some of the most likely devices to be used in the future, around the UK. Six different generic categories of device have been identified by EMEC.[30] Here we will just describe the most advanced and perhaps most likely-to-succeed version of each category.



Cornwall's Wave Hub will act like a socket allowing wave energy converters to plug in and test devices in arrays. Image courtesy of South West RDA.

The Pelamis:

This is the best example of an *attenuator*. It is basically a series of giant floating tubes, linked end-to-end by hinged joints, very much like a string of large floating sausages. The commercial version is 150 m long by 3.5 m in diameter. It is designed to lie semi-submerged in the water and go up and down in tune with the swell. To allow it to function properly it orientates itself perpendicular to the wave fronts. As the sections move independently of each other, hydraulic rams inside the tubes pump hydraulic fluid into electrical generators. One interesting feature of the Pelamis is its ability to be 'tuned' to the characteristics of the waves, helping to enhance the power extracted in small seas. It can also be 'de-tuned' out of phase with the waves to avoid damage in large seas. The combined effect is to make the overall power output over long periods of time more constant, especially in places where the wave height is more variable throughout the year.

Each Pelamis produces a maximum output of 750 kW, and is designed to be moored in water at least 50 metres deep.[31] At the time of writing, three of these machines have already been installed five kilometres off the coast of Aguçadoura in northern Portugal, and the power has been successfully supplied into the local electricity grid. At the EMEC test centre in Orkney, two second-generation Pelamis devices are being tested, and there are plans for wave farms to be installed off the Shetland Islands, and off the Western Isles of Scotland, each containing up to 26 devices. Negotiations are also taking place for a future wave farm containing more than 50 devices off the north coast of Scotland. The developers have been recently awarded a lease for a large area of ocean near Torresdale on the north coast.

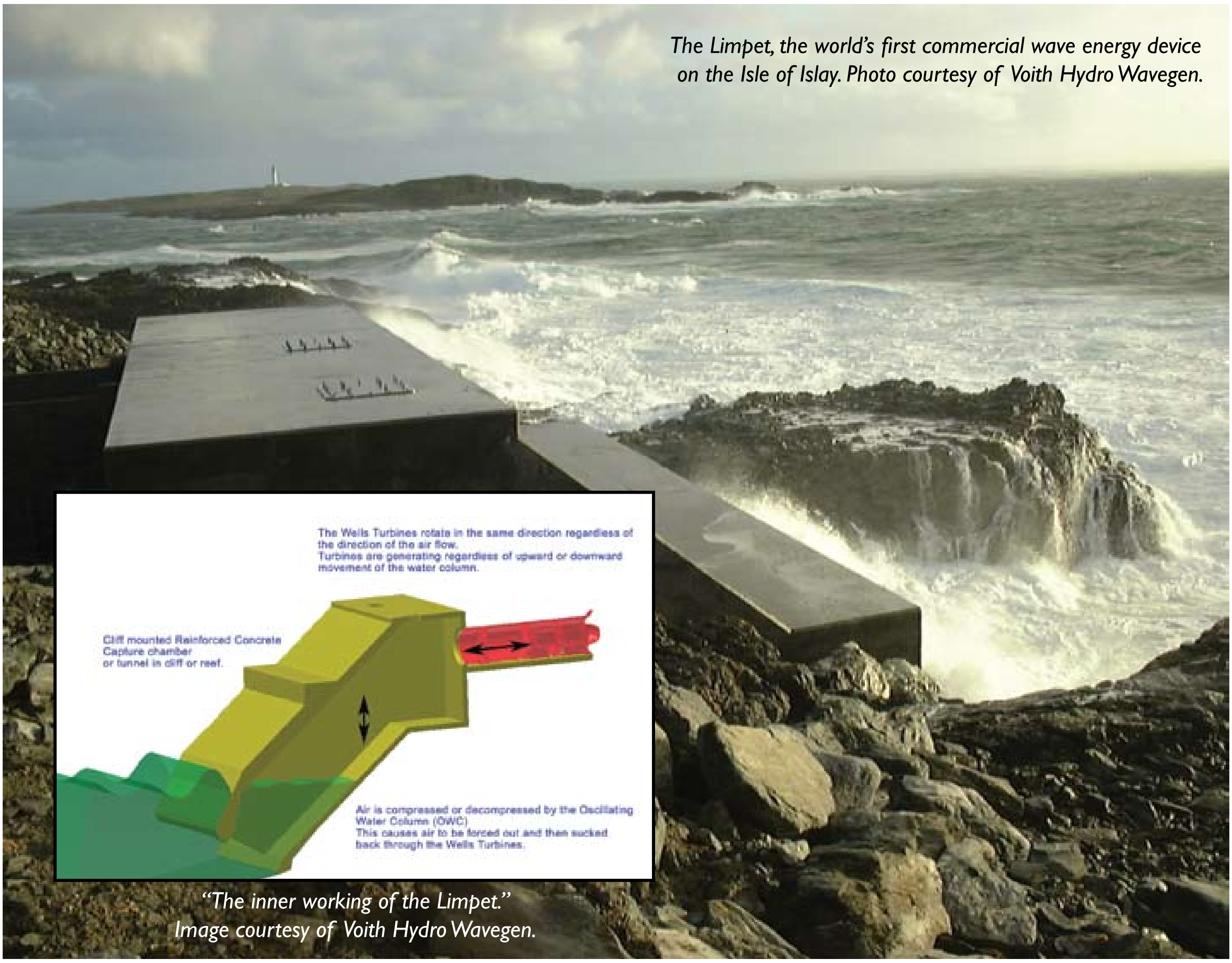
A Pelamis machine ready to convert wave energy into sustainable electricity. Image courtesy of Pelamis Wave Power

The Limpet:

The Land Installed Marine Powered Energy Transformer (Limpet) belongs to the class of devices called the *Oscillating Water Column*. The principle behind this system is reminiscent of a natural blow-hole found at the top of low cliffs or overhangs, where the wave action forces air up through the hole causing a fountain of spray to shoot up, amusing children and adults for hours. The device consists of a half-submerged hollow tube mounted vertically on the side of a natural cliff or on the end of a man-made breakwater. The water in the bottom of the tube rises and falls with each wave, compressing and decompressing the air in the top of the tube. The air is then forced through an electricity-generating turbine at high velocity. The principle is remarkably robust and simple. An interesting feature is the *Wells Turbine*, which allows electricity to be generated from air travelling in both directions, which effectively doubles the efficiency of the device. Benefits of this device compared with others include better survivability in storms and much easier access for repair and maintenance.

In 1990 a small prototype device was installed on the Scottish island of Islay, and tested for a number of years, before a fully-operational unit was commissioned in 2000, which continues to supply up to 500 kW of power to the local grid.[32]

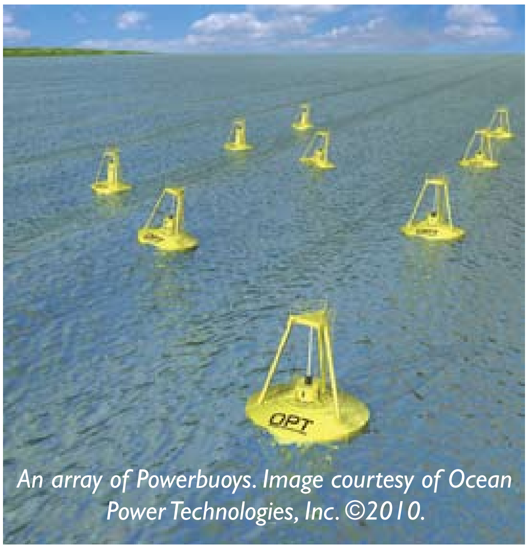
Future projects include the installation of a Limpet-type system on a breakwater at Mutriku, northern Spain[33], generating up to 300 kW. Another project is proposed on the island of Lewis in the Outer Hebrides, consisting of a breakwater located 350 m offshore and containing up to 40 oscillating water columns. This would generate up to 4 MW of power.



The Limpet, the world's first commercial wave energy device on the Isle of Islay. Photo courtesy of Voith Hydro Wavegen.

"The inner working of the Limpet." Image courtesy of Voith Hydro Wavegen.

The Powerbuoy



An array of Powerbuoys. Image courtesy of Ocean Power Technologies, Inc. ©2010.

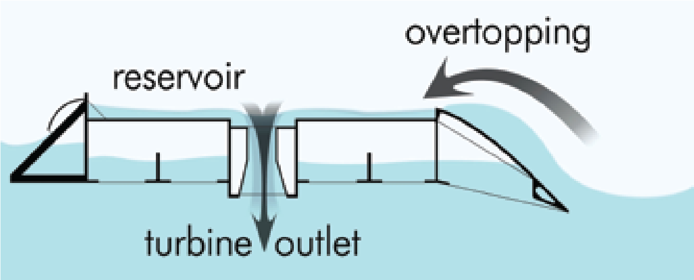
The Powerbuoy is a *point absorber*. These work in a similar way to a normal wavebuoy, but instead of converting the up-and-down surface motions into measurements of wave height, they convert those motions into electrical energy via pistons that pump hydraulic fluid into electrical generators. An interesting feature of the Powerbuoy is that it has sensors to continuously monitor the performance of the system and the surrounding wave conditions, with the data transmitted in real time to a shoreline receiving station – again, very much like a wavebuoy. In the event of very large waves, the system automatically shuts down to avoid damage.

The latest version of the Powerbuoy generates up to 150 kW of power. The buoy is 10 m in diameter, sticks up 10 m above the waterline and protrudes 34 m below the surface. At the time of writing, a smaller 40 kW version has already been tested at a site near Santander, Spain, and another 150-kW unit is being connected to the National Grid via the EMEC test facility in Orkney.[34] An array of devices will also be connected to the National Grid via the Wave Hub testing facility at Hayle in Cornwall, with an eventual capacity of up to 4 MW.

The inner workings of the Powerbuoy. Image courtesy of Ocean Power Technologies, Inc. ©2010

A Powerbuoy machine is capable of producing 150KW of power. Image courtesy of Ocean Power Technologies, Inc. ©2010

The Wave Dragon:



The inner workings of the Wave Dragon.
Image courtesy of Wave Dragon

The Wave Dragon is an *overtopping* device. Normally, overtopping is an undesirable effect that occurs on sea walls and breakwaters, where the water sloshes over the top of the structure after the wave has hit it. The Wave Dragon is designed to purposely induce overtopping. It first focuses the waves onto a steep ramp in the centre of two large, parabolic-shaped reflector arms. The water from the magnified wave then runs up the ramp, over the top and into a reservoir. Since this water has been forced higher than sea level, it has potential energy which can be converted into electricity. This is achieved by allowing the water to flow out again through holes in the reservoir, via electrical turbines. The arm-span of the smallest commercial version of the Wave Dragon is 260 m, with the arms sticking out of the sea surface by over 10 m and a maximum output of 4 MW.[35]

A scaled-down prototype of the Wave Dragon was installed at Nissum Bredning in Denmark in 2003 and functioned successfully until 2005. The unit was 4.5 times smaller than the proposed commercial model and produced 20 kW of power.[36] A full-scale device is planned to be deployed about four kilometres off Milford Haven in Wales, which will be connected to the local grid while being tested for a period of three to five years.

Note that the industry is beginning to move away from this type of device, mostly through concerns about the survivability of the device itself in large wave conditions. For us, this is good news because, as far as causing interference to the waves, the Wave Dragon is potentially the worst machine out of all those described here.[37]

Wave Dragons manipulate swell to 'break' and can create a large wave shadow.
Image courtesy of Wave Dragon

The Oyster:

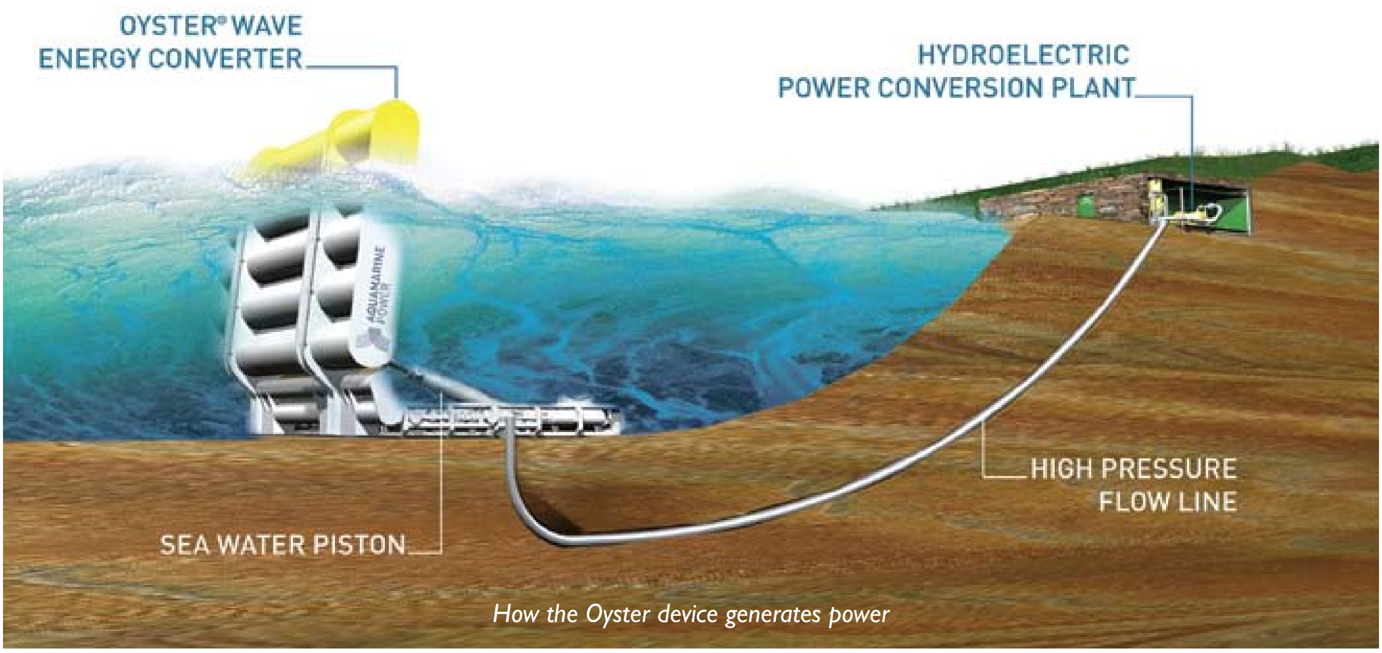
A full scale Oyster device awaiting deployment.

The Oyster belongs to a class of device called the *Oscillating Wave Surge Converter*. It consists of a large flap mounted vertically and perpendicular to the prevailing wave direction. The device is attached to the sea bed and the flap is hinged at the bottom so that swings backwards and forwards with the wave action. The movement drives hydraulic pumps which push water through pipes to an electricity-generating turbine on the shore.

The flap is 26 m wide by 13 m high and sticks out of the water up to about 3 m. Each Oyster device is capable of generating around 650 kW of power.[38] It is designed to be deployed at distances of the order of 500 m from the shore, in water depths of about 10 m.

In 2009, the first Oyster was installed at the EMEC test centre in Orkney[39], which is, at the time of writing, generating electricity for the National Grid while being tested at the same time. A second-generation device, the Oyster 2, is being developed, three of which are planned to be installed at EMEC. These will be linked together and connected to a common onshore generator.

Future plans include the deployment of over 100 Oysters in 'small clusters' along the Orkney coastline from Costa Head in the north to Neban Point in the southwest. In the long term, the developers are hoping to install extensive arrays of Oysters off the UK and Irish coasts, with a total maximum output capability of 1000 MW.[40] One of the first instalments is proposed near Brough Head at Marwick in the Orkneys, just offshore of a number of very high-quality surfing waves. Surfers Against Sewage are extremely concerned that, if these devices are installed, they will seriously degrade the waves. Installing them at a different site along the coast, away from any surfing waves, would be the best solution for everybody involved.



How the Oyster device generates power

9. Harnessing wave energy without interfering

9.1. Introduction

By definition, devices that produce electricity from the waves are removing energy from the waves. If a significant amount of that energy was supposed to be used for some other purpose, and we are 'stealing' it, then there might be a problem. We suggested earlier that, in theory, if the number of wave energy converters installed around the coasts of the world became large enough, the Natural energy flow carried by the waves would be redirected in a different way, which might conceivably produce some adverse local or even global climatic effects. The number of devices that we can practically deploy will probably never reach anywhere near those numbers. So, within the general scheme of things, the amount of energy we are 'stealing' will be insignificant.

However, this tiny amount of energy, if removed from the ocean near to a coastline where there are surfing waves, can make all the difference if you are a surfer. A few megawatts of power extracted from the waves just beyond the breakpoint can, in some cases, mean a big difference in wave height. Also, even if wave energy converters deployed near to surfing breaks don't noticeably reduce the height of the waves, they might still ruin the actual shape of the waves by causing interference. Lastly, if the devices change the characteristics of the waves breaking on a shoreline, and that shoreline consists of moveable sediment, you might interfere with that complicated feedback loop between the sediment and the waves.

Surfers Against Sewage are fully in favour of renewable energy sources such as WECs. But the priority must always be that they are installed without interfering with the waves. We have produced a comprehensive guide aimed at developers of offshore renewables[41]. The first document to promote the surfing community as an important stakeholder in this sector, it works within the existing Environmental Impact Assessment (EIA) process, highlighting sites of special surfing interest that developers should avoid. If used effectively it could help speed up the consent process for suitable offshore developments.

9.2. Specific effects from devices

First, let's have a look at the various different ways each device mentioned in the previous section might potentially affect the waves for surfing. Very little or no studying has been done on this, so the following are just 'educated guesses' based on the size and shape of each device and how it is deployed in relation to the surf spot; particularly how far it is deployed from the breakpoint. In the end, of course, we won't know until extensive simulations have been made by independent researchers. Even then, some effects might not be able to be predicted.

The Pelamis will be deployed in arrays consisting of several tens of devices over an area of one or more square kilometre. At the test site in Portugal, they are moored 5 km from the shore, which is a lot further offshore than, say, the Oyster. Also, a major advantage is that they are designed to be orientated in the same direction as the wave approach rather than present a lateral barrier to the waves.

The Limpet is the least offensive of all the devices, as long as it is deployed on the side of a cliff, like the one in Scotland, or, even better, on an existing breakwater. Breakwaters are at best very clumsy devices that try to dissipate unwanted wave energy by making the waves slam up against the side of a concrete structure. Basically, all that energy is wasted. Converting some of it to electricity not only helps to perform the function of the breakwater by removing unwanted energy from the waves, but also redirects that energy into something we can use. As long as the breakwater was there in the first place, the installation of the Limpets onto the breakwater cannot cause any interference to nearby surfing waves.

The *Powerbuoy* has been environmentally assessed in Hawaii by the U.S. Office of Naval Research, which concluded:

"Minimal impacts on shoreline conditions, no alteration to currents of wave directions and no adverse effects on shoreline erosion or change in sand deposition patterns"

However, at only 150 kW each, to produce a decent amount of power you would need a lot of them (see below), which, if clustered together, could seriously affect the waves. One advantage is that they must be deployed in fairly deep water to make room for the 34-metre section sticking downwards below the surface; hence they would be a reasonable distance from the shore.

The *Wave Dragon* is a 300-metre long wall sticking out six metres from the sea surface, mounted across the incoming wave approach. If you didn't know what it was, you might mistake it for a breakwater. Obviously several of these monsters could have a drastic effect on the waves if deployed close enough to the shore. The test version planned off the Welsh coast is going to be 4 km from the shore. Whether this is far enough away for the effects to be tolerable, we don't know.

The *Oyster*, although a much smaller device than, say, the Wave Dragon, is designed to be mounted very close to the shore, so the effects on the waves will be very sensitive to the particular location along the coast. If a number of Oysters are mounted directly behind a surf spot, for example, the waves will be undoubtedly affected; but if they are mounted perhaps a few kilometres along the coast where there isn't a surf spot, the effects will be concentrated into that area and the surf spot will remain unaffected.

Some computer simulations have already suggested that the Oyster will cause significant wave height reduction.[42] Even if this turns out to be acceptable, the presence of the devices in the water could cause all sorts of interference to the waves, similar to what happens when you have rocks sticking out of the water just beyond the breakpoint. Reflection and refraction could cause the wave faces to become lumpy, the waves to interfere with each other, double-up, close out, back off or peel at the wrong speed, or the tube to shut down. All these effects are probably too subtle to be resolved by current computer modelling techniques. So, the best thing is to not even consider putting any Oysters near a surf spot.

An Oyster device in the water.

9.3. How many WEC's to harness all the energy?

What sort of numbers of wave energy converters are we talking about if we want to seriously think about using wave energy to replace the energy generated by fossil fuel burning power stations?

Just to get a ball-park figure, the average power output of a coal-fired power station in the UK is about 1600 MW.[43] From section 8, the maximum power output of each device quoted by the manufacturers is:

Pelamis: 750 kW

Limpet: 500 kW

Powerbuoy: 150 kW

Wave Dragon: 4 MW

Oyster: 650 kW

However, these figures are the *maximum outputs*. The assumption made is that the devices are working at full output all the time, which is not the case because the output varies according to wave height. For example, the full 750 kW from a Pelamis is only achieved in wave heights of at least five metres. Most of the time it will be much lower, and will vary from season to season. What we really need is an estimate of the *average* output of the devices throughout the whole year.

Off the coast of northern Scotland and the Orkney Islands, for example, the mean annual significant wave height is about 2.2 m.[44] According to the manufacturers of the Pelamis, the output of the device in wave heights of 2.2 m is around 200 kW (27% of its maximum output) at the optimum period of 8 s, and even less at periods either side of this.[45]

We couldn't find any similar data for the other devices, so, let's assume that they are more efficient than the Pelamis and produce an average of 50% of their maximum output throughout the year.

We can now calculate how many devices we would need to match the power output of a 1600-MW coal-fired power station in the UK, and hence be able to shut that power station down (which is the result we are after):

7900 Pelamis, or

6400 Limpets, or

21,000 Powerbuoys, or

800 Wave Dragons or

4800 Oysters

In general it would be better if the manufacturers quoted a realistic average output of each device alongside the theoretical maximum output in the largest waves that the device can handle. Note that a significant amount of energy will be provided by WECs, but a large proportion will also be supplied by other sources such as wind and solar energy.

9.4. Conclusion

In summary, predicting whether wave energy converters are going to ruin our waves is not straightforward and should always be assessed on a case-by-case basis. Let's look at two different scenarios:

A Pelamis wave farm is installed 5 km or more offshore in an area containing long stretches of beachbreak, such as the north coast of Cornwall or southwest France. This causes a minimal reduction in wave height spread over a large stretch of coast, and does not affect the shape of the waves or ruin any particular spot.

A number of Oysters are installed a few hundred metres offshore of one or more high-quality reefbreaks, perhaps unique in the world. This causes a large reduction in wave height together with backwash on the waves, lumpy faces and shutting-down sections. A world-class surf spot has been reduced to poor or mediocre.

There really is no excuse for situations like 2 above. There is a vast amount of coastline in the world that receives huge amounts of wave energy, but where the waves are not even remotely surfable. If devices such as the Oyster are going to be used, then they could easily be deployed away from surf spots. After all, nobody wants to slow down the development of renewable energy sources, particularly us surfers, who will be among the first people to notice the impacts of climate change.[46] The developers just need to be made aware of the value of surfing waves, not just to surfers but to the entire community. Until now, none of the companies proposing to deploy wave energy converters have had much of an idea of the value of surfing waves, or how their devices might affect them.

Marwick is under threat from a proposal to deploy an array of Oyster devices close to this great wave. Photo Al MacKinnon.

10. Protecting the waves

10.1. Ways in which we can protect the waves

If you have read this far you will have realized that waves have a value, and people (not just surfers) will suffer if they are destroyed or degraded. Therefore, we must protect them. But how?

In order to protect the waves, the first thing that needs to be done is to make the general public more aware of the problem; make them aware of what a coastal ocean wave actually is and why such a thing should need protecting. Next, the people likely to degrade or destroy a wave should be educated and made to realize that doing so might be detrimental to many other people apart from just a small group of surfers. Then there are more permanent ways of protecting waves such as groups like SAS becoming proper stakeholders in the planning of coastal modification schemes, or the passing of actual laws to protect waves. There is also the concept of *surfing reserves* which has already become reality in Australia and is currently getting off the ground on a global basis. Below is a brief summary of each those methods:

10.2. Increase public awareness

The general public still finds it very difficult to understand what a coastal ocean wave actually is, let alone recognize its value or the fact that it must be protected. Objects such as mountains and rivers are the easiest things for people to envisage as elements that should be protected, because they are more or less fixed.

A species of animal is not quite so easy because it is the individual animals that belong to that species that really exist as physical entities, not the species itself. But people still tend to get the idea.

The concept that a particular 'wave' needs protecting is, however, much more difficult. One reason for this is that when we refer to a 'wave', we don't really mean just one wave. We really mean the circumstances that come together to make waves break at a particular spot on the coast, in a particular way. Saying that we need to protect the 'right-hander at Thurso East' is a bit like saying we must protect the '09:50 from Paddington to Oxford'. In reality we are not protecting just one train; rather we are protecting the circumstances that allow that service to run.

Because of the difficulty I have just described, public awareness of waves needs to be increased as much as possible through documents such as this one, and through campaigns such as Protect Our Waves.

Also, the people who are most likely to degrade or destroy the waves need to be made aware that their actions might affect a much wider group of people than just a small band of surfers. The existence of a good surfing wave in a particular area might have important spin-offs such as an increased number of visitors to that area, attracted by the wave, which then boosts the local economy. This concept, because it involves money, is much easier for politicians and coastal planners to understand than the intrinsic, natural value of a surfing wave.

Therefore, more 'surfonomics' studies need to be done, showing how much money a surfing wave can generate, and they need to be published in journals that will be read by coastal planners, coastal engineers and politicians.

It must also be recognized that the above method fails to protect surfing waves which could be extremely high quality but which exist in areas where some other factor inhibits the influx of people from outside. The easiest waves to protect are the ones where surfing is the most popular. But in some cases, for surfers' voices to be heard, the wave needs to be so popular that the sheer number of surfers reduces the value of the wave for the surfers themselves. By the same token, the most vulnerable spots are those which are only just being discovered.

Therefore, a better way must to be found to solve this paradox than simply over-publicising a previously uncrowded surfing wave, just to attract enough surfers to mount an effective campaign.

10.3. Become stakeholders

If surfers and other coastal water-users could have an official voice within the politics of a country, in other words, become official *stakeholders,* this would ensure that we were taken that much more seriously. A breakthrough has been recently been made in Scotland, as a direct result of considerable lobbying by SAS.

In February 2010, the Scottish Government recognised recreational water-users' need for a voice on Regional Planning Partnerships within the Scottish Marine Bill. The amendment was forwarded by Member of Scottish Parliament, Robin Harper Green, on behalf of Scottish water-users. A seat on the regional planning partnerships gives recreational water-users the platform to voice any concerns relating to the marine environment and recreational wave resources.

Achievements like these set a great precedent, which can be used as an example when justifying that water-users should become stakeholders in other countries. After all, if it can be done in Scotland, what is different about England, Wales or anywhere else in Europe?

10.4. Surfing reserves

Another way to protect an area containing good surfing waves is with a *surfing reserve*. If implemented in a similar way to a bird sanctuary or other type of nature reserve, the surfing reserve could make sure that, at least, certain 'iconic' surfing waves are protected forever. The concept was first introduced in Australia way back in 1973, when Bell's Beach became the first surfing reserve. More recently, since 2005, the idea has really taken off in Australia, with classic surf spots such as Angourie and Margaret River being declared surfing reserves.[47] At the time of writing there are 12 surfing reserves in Australia, with more on the way. Also, an organization called World Surfing Reserves (WSR) is beginning to nominate iconic surf spots world wide.[48]

Even though declaring a spot a surfing reserve in theory won't stop somebody coming along and destroying a wave if they really wanted to, the high-profile recognition of a spot will make a lot more people sit up and take notice if something negative starts to happen. Instead of going virtually unnoticed by the outside world until it's too late, a surf spot that has already been declared a surfing reserve will make developers think twice, especially if there is an alternative that will cause them less grief.

"The bubble provided by the WSR designation should act like a semi-permeable membrane, enabling certain kinds of activities and sustainable developments while resisting the intrusion of others (like landfills, mining operations, trawlers, and the grosser monoliths of unchecked development). The simple existence of the WSR acts as a tactical wedge that inserts itself into every future discussion concerning the fate and destiny of the reserve area." (Drew Kampion, former editor of Surfer Magazine and The Surfers Path).[49]

In the UK, surfing reserves could be integrated into sustainable development practices managed alongside the environmental, societal and economic fabric of local communities. It is envisaged that surfing reserves will encompass a wider field of activities than the original ones designed for Australia. For example, as well as the main focus of making sure nobody destroys or degrades the waves, they should promote the following key principles:

Conserving and enhancing natural and cultural heritage

Sustainable use of natural resources

Understanding and enjoyment of the environment through recreation

Sustainable social and economic development of local communities.

Recently, SAS put forward a proposal for surfing reserves to be included in the Scottish Marine Bill (see above). This has not yet been included, but we will continue to campaign for the adoption of surfing reserves, both in Scotland and in the rest of the UK.

Finally, most of the places where surfing reserves are easy to implement and are welcomed by the local community are those very places where surfing reserves are least needed. In Australia, even without surfing reserves, it would be much more difficult to come along and build a breakwater through one of the best surfing waves than it would be in the UK, and even worse places with poor track-records of coastal management like Spain, Portugal or Mexico, even though the quality of the waves and the numbers of surfers affected might be just as high. In the latter countries, setting up something like a surfing reserve would be much more difficult bureaucratically, and, if it were achieved, surfers and other members of the public would be powerless against unscrupulous developers and corrupt government officials.

10.5. Laws to protect waves

Last but not least, if laws were passed to specifically protect surfing waves, this would not only make it extremely difficult for someone to destroy a surf spot, but it would also help to further raise public awareness. In the UK, developers already have to go through an expensive and time-consuming process to get planning permission, and this includes passing an Environmental Impact Assessment (EIA). If there were proper laws stating that surfing waves cannot be interfered with or destroyed, it would be in the developers' own interest to avoid putting their concrete in the wrong place.

At the moment, no law exists in the UK to protect surf spots, but it does in one country: Peru. This might sound surprising, but Peru has a history of surfing culture that goes back almost as far as Hawaii, and surfing is seen as a respectable and worthwhile pastime, unlike in many parts of Europe.

In 2000, *La Ley de Preservación de las Rompientes Apropiadas para la Práctica Deportiva* (roughly translated: law for the preservation of appropriate waves for the practice of sports) was approved by the Peruvian Government, and would be put into action as soon as a list of surf spots was drawn up by the Peruvian Surfing Federation and submitted to the Peruvian Navy.[50]

So, we need a law like that in the UK, but how do we get one? Well, before a new law is made or existing laws changed, the people with the power to change the law need to know about the problem. This requires a large amount of high-profile campaigning with really solid justifications that such a change in law will be of overall benefit to everyone, perhaps with petitions containing the signatures of thousands of people. The fundamental first steps are the following:

- List all surfing waves around the country, where they are and under what local authorities they fall.
- List any past incidents going back as far as possible where a surf spot has been threatened, degraded or destroyed as a result of coastal urbanization, dredging or pollution.
- List any currently threatened waves or proposed schemes which might potentially result in a wave being threatened in the future.

10.6. The POW campaign

The SAS Protect Our Waves (POW) campaign has been running for about a year, at the time of writing. In its first year of operation the campaign has achieved the following:

- Securing a seat for water-users in the regional planning partnerships within the Scottish Marine Bill. This is a major success, and it is the first time recreational water-users have had this level of legislation to protect their waves.
- Producing a comprehensive guidance document aimed at developers of offshore renewables. It is the first document of its kind anywhere in the world, explaining how developers should go about making sure their devices are properly tested for any adverse effects on the waves for surfing.
- A high-profile petition protesting against the access restrictions at Broad Bench, a world-class surf spot on the south coast of England. The petition was signed by over 1000 supporters including a number of legendary surfers including Kelly Slater, Rabbit Bartholomew and Jeff Hakman.
- A peaceful protest involving over 300 surfers in the water at Broad Bench – the largest action event ever undertaken by SAS.

10.7. What you can do

Surfers Against Sewage is a small team of passionate campaigners. We work tirelessly to represent surfers at the highest level, because we are surfers too, and what is important to you is important to us.

If you help us to become more powerful, we will be able to make your voice heard more clearly on issues that concern all surfers and recreational water-users. This is what you can do:

- Become a member of SAS
- Sign up to our Facebook page
- Follow us on Twitter
- Become active and engage in campaigns
- Contact us immediately if you see or hear of anything that could threaten the waves.

11. Conclusions

The fact that waves are valuable to surfers for surfing, and the fact that waves can be valuable to other people due to the knock-on effects of surfing such as the income of tourist money, is already reason enough to protect them. But there is that other, more fundamental reason why waves are important and should be protected. In section 2 we explained that waves have a purpose within the functioning of our planet, principally as an energy-transfer mechanism. Therefore, if they were significantly disturbed, the planet would simply adjust to compensate, which might then cause detrimental effects on us as a species.

Of course, the effect of taking a wave out here and there or modifying the coastline a little bit is, as far as we know, far too small to make any difference. But we still have to be careful because we don't know where the threshold is; we don't know how much we can modify the system before it goes out of balance. After all, by burning too many fossil fuels and by removing too many trees – both of which we also thought were insignificant – we have succeeded spectacularly in seriously altering the atmosphere.

We need a change of attitude towards the coast and the waves, and towards Nature in general. We need to recognize that we are nothing but another component in Nature just like our fellow animals and plants, the atmosphere, the rocks, the ocean and the waves. If we excessively modify any of the other elements, we will only cause more problems for ourselves in the future. We continue to ignore this philosophy, even though it is by no means new:

"Man's attitude towards nature is today [1963!] critically important simply because we have now acquired a fateful power to destroy nature. But man is part of nature and his war against nature is inevitably a war against himself." (Rachel Carson – June 1963)[51]

We also need to realize that it doesn't have to be an 'I-win-you-lose' situation. At the moment, just because of a lack of communication and a lack of understanding, we are constantly battling against coastal developers and politicians; they think we are taking away their money and we think they are taking away our waves. We don't care about their money and they don't care about our waves. Well, it doesn't have to be like that. If we just thought about things a little more, the coast and the waves – as resources – can be used to benefit everyone in a sustainable and stable way.

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