Teaching Surf Instructors to Teach

National Surf Schools and Instructors Association

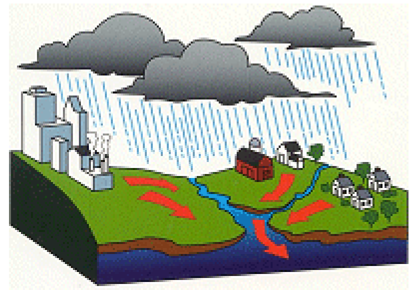
Instructors and Coaches Training Manual

NATIONAL SURF SCHOOLS & INSTRUCTORS ASSOCIATION
NSSIA
Established 2005
PROTECTING INDUSTRY & STUDENTS

Beach Environment

Part 3

Our Environment – Where does it start?



A watershed is the drainage area where soil is deposited into a given body of water. This body of water can be a creek, pond, river or ocean. In general, the larger the body of water, the larger its watershed. The watershed provides the initial route for sand as it migrates from the land, to the coast, and then into the ocean.

Coastal Management

The coastal zone plays a vital role in the lifestyles and livelihoods of surfers. Used wisely, coastal resources can continue to contribute to the livelihoods and lifestyles of all surfers for generations to come. However, like many resources, they have been subject to pressure from population growth and human activity in modern times. The complex nature of the coastal zone requires careful management to ensure that its most valued elements are protected and conserved.

These coastal management plans operate with other instruments to preserve our coastal resources. They…

- provide for the protection, conservation, rehabilitation and management of the coast, including its resources and biological diversity; and
- have regard to the goal, core objectives and guiding principles of an ecologically sustainable development in the use of the coastal zone; and
- provide, in conjunction with other laws, a coordinated and integrated management and administrative framework for the ecologically sustainable development of the coastal zone; and
- encourage the enhancement of knowledge of coastal resources and the effect of human activities on the coastal zone.

Natural Environmental Impacts

The beach-ocean system can be considered to be in a dynamic equilibrium. Sand that is moved off-shore by winter storms, leaving steep narrow beaches and ocean sand bars, is returned to the shore by the gentle waves of summer, creating wide, gently sloping beaches without ocean sand bars. However, the reality is that an equilibrium situation does not exist. Beaches do not qualify as a closed system because sand is regularly being lost from the system.

Coastal erosion occurs when wind, waves and long shore currents move sand from the shore and deposit it somewhere else. The sand can be moved to another beach, to the deeper ocean bottom, into an ocean trench or onto the land side of a dune. The removal of sand from the sand-sharing system results in permanent changes in beach shape and structure.

Forces that are constantly changing beaches combine with forces such as rising sea level and human activity, to create several concerns regarding the shape and future of the shoreline on the coast.

Issues such as erosion control, restoration of beaches and preparation for catastrophic events need to be dealt with by coastal communities. The response to the challenge varies from locality to locality, with local, state and federal governments each having a part in the final action plan that is implemented.

Dunes

Most people use the word 'beach' when they refer to the sandy area that separates the sea from the land. However, this sand area is only a part of the beach system which begins in the sand dunes above the high tide mark, and stretches out to sea past where the waves break.

Vegetated sand ridges called dunes back most beaches. These dunes are very effective coastal protection features. They absorb the erosive energy of waves generated by cyclones or storms and are reservoirs of sand to replenish the beach during periods of wave erosion. Vegetation on the dunes traps and holds sand blown from the beach aiding dune build-up and stopping sand from being blown inland and lost from the active beach and dune system. Dunes are built up by dry beach sand blown inland and trapped by plants and other obstructions. As sand accumulates, the dunes become higher and wider.

Plants play a vital role in this process, acting as a windbreak and trapping the deposited sand particles. A characteristic of these plants is their ability to grow up through the sand and continually produce new stems and roots as more sand is trapped and the dune grows.

Stable sand dunes play an important part in protecting the coastline. They act as a buffer against wave damage during storms, protecting the land behind from saltwater intrusion. This sand barrier allows the development of more complex plant communities in areas protected from saltwater inundation, sea spray and strong winds. The dunes also act as a reservoir of sand, to replenish and maintain the beach at times of erosion.

Dunes are Vulnerable

Frontal sand dunes, which are closest to the ocean shore, are vulnerable. The vegetation can be destroyed by natural causes such as storms, cyclones, droughts, fire, or by human interference such as clearing, grazing, vehicles or excessive foot traffic. If the vegetation cover is damaged, strong winds may cause 'blowouts' or gaps in the dune ridge. Unless repaired, these increase in size, and the whole dune system may sometimes migrate inland covering everything in its path. Meanwhile, with a diminished reservoir of sand, erosion of the beach may lead to coastal recession.

To avoid this, protecting the vegetation is vital. The beach, between high and low tides, is resilient but the sensitive dunes which we cross to reach it must also be protected. For this reason, damaged and sensitive dunes might need to be fenced off with access paths for vehicles or people. For the sake of our coast, we must care for the dunes.

Plants on the Beach

Vegetation on the beach and dunes tends to occur in zones, according to the degree of exposure to harsh coastal conditions. Closest to the sea is the pioneer zone, extending landward from the debris line at the top of the beach in an area called the foredune or frontal dune.

Only specialized pioneer plants can colonize areas exposed to salt spray, sand blast, strong winds, and flooding by the sea. They are often protected by waxy or hairy coverings on stems and leaves and grow low to the ground, offering little resistance to the wind. They have strong root systems and spread rapidly; creating a mesh of creeping stems so if one part is buried in shifting sand or uprooted another part can continue growing. They thus serve to stabilize the sand, forming and building dunes.

Behind the frontal dunes, in areas protected from windy and salty conditions, vegetation depends on local circumstances. For example, freshwater swamps can be dominated by paperbark tea trees (*Melaleuca* spp.) whereas on higher, better-drained ridges, woodlands of *Eucalyptus* and *Acacia* species or low rainforest (beach scrub) develop.

Yet these zones are not fixed. As plants grow taller or create humus, and dropped leaves accumulate, exposure to sun and soil conditions change. The soil becomes richer and holds more water. This enables scrub and woodland plants to move in, changing the type of vegetation type by a process called succession.

Background on Beach Controls[1]

Seawalls, groins, jetties and other shoreline stabilization structures have had tremendous impacts on our nation's beaches. Shoreline structures are built to alter the effects of ocean waves, currents and sand movement. They are usually built to "protect" buildings that were built on a beach that is losing sand. Sometimes they are built to redirect rivers and streams. Other times they are constructed to shelter boats in calm water. In many cases, seawalls, jetties, breakwaters and groins have caused down-coast erosion problems with associated costs that have greatly exceeded the construction cost of the structure.

Dana Point, CA before the Army Corps blocked its great waves, polluted its waters, and destroyed a rivermouth wetlands area.

Every surfer knows that there are groins and jetties that have incidentally improved wave riding. However, in many other areas shoreline construction has ruined wildlife habitat, destroyed surfing waves and caused beaches to erode. Instructors as well as surfers need

1 This section was derived from Surfrider Foundation Materials. It is made available to the NSSIA as a courtesy.

Surfrider Respect Our Beach Program

to understand the consequences of shoreline structures so that we may be able to effectively influence decisions on the impacts, placement or necessity of these structures

Erosion

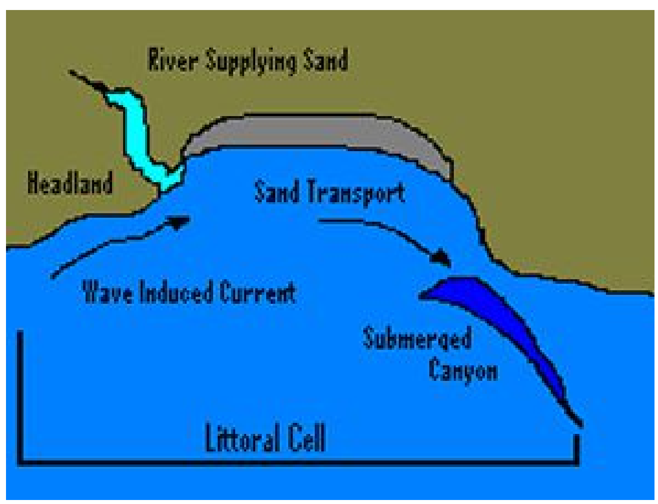
Every winter, the newspapers show pictures of oceanfront buildings falling into giant surf. Beaches are not static piles of sand. Ocean currents cause beaches to move constantly. Beach sand is primarily a product of the weathering of the land. Sand can also come from ocean organisms such as coral. As well, sand can come from the erosion of coastal bluffs. However, most of the sand along the world's beaches comes from rivers and streams. When natural processes are interfered with though, the natural supply of sand is interrupted and the beach changes shape or can disappear completely. For example, sand production stops when coral reefs die from pollution, when coastal bluffs are "armored" by sea walls and when rivers are dammed upstream for flood control and reservoir construction. The sand that collects behind upstream dams and reservoirs is often "mined" and sold for concrete production, never making it to the beach.

In the face of eroding beaches, owners of beachfront property will often try to use their political influence to demand that "something be done." The intelligent action would be to move the building away from the ocean. Unfortunately, what has often been done in the past has been to armor the coastline with rocks, concrete and steel. This does not protect or maintain the beach, it only protects the buildings.

Millions of taxpayer dollars have been wasted subsidizing beachfront construction. Federal flood insurance and expensive Army Corps of Engineer projects have done very little to make oceanfront buildings safe and have hastened beach erosion. In many cases, it would be more cost-effective for taxpayers to have the government buy the coastal property, condemn the buildings and allow the area to act as a buffer between the ocean and the remaining buildings. In urbanized areas with expensive real estate, a more cost effective and environmentally sound alternative to shoreline structures is to periodically "nourish" the beach with sand.

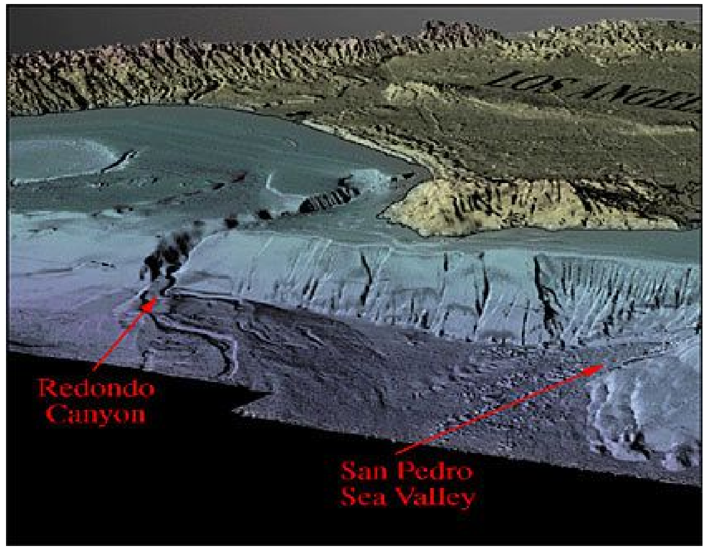
The Littoral Cell

On the West Coast of the U.S., beach sand moves from river mouths to the beach. It then moves along the coast in the direction of prevailing currents and eventually it moves offshore. This sand transport system is called a littoral cell.



When waves break at an angle to the shoreline, part of the wave's energy is directed along the shore. These "longshore currents" flow parallel to the shore. Surfers call this the "drift". This current will move sand along the shore and a beach will be formed; the same current that transports a surfer down the beach from the point of entry will also move beach sand down the shoreline. When this longshore current turns seaward, it is called a rip current.

Some areas have underwater canyons near the beach. These submarine canyons were prehistoric river mouths. Sometimes the longshore current will be interrupted by one of these canyons. In this case, the sand is lost from the beach in water too deep to be returned to shore. The littoral cell system, from the river mouth to the underwater canyon, will always lose beach sand. If the sand supply from the river is cut off, the beach will lose sand causing the beach to become narrower.



This picture shows the Submarine Canyon in Santa Monica Bay and San Pedro (image from Dartnell, and Gardner, 1999, U.S. Geological Survey Digital Data Series DDS-55 (CD-ROM).

On the East Coast of the U.S., the shore formed differently. Sand comes from the erosion of headlands, bluffs and cliffs. The underwater coast (continental shelf) of the east is broad and flat. East Coast beaches are generally wider. In addition, barrier islands run along the coast. In contrast to the West Coast, submarine canyons are rarely near the beach and seldom act as conduits for sand loss. A notable exception is the Hudson Canyon at the southwest end of Long Island, New York. Sand that moves south here is lost down the canyon.

On the East Coast, sand "loss" is primarily from the movement of barrier islands. Barrier islands naturally migrate landward due to sea level rise, but this migration is accelerated during storm events. Powerful hurricanes deposit sand inland by washing it over the dunes. On the other hand, sometimes these storms will create strong ocean currents that take sand too far offshore for it to return to the beach. The depth where sand is moved so far offshore that it cannot return is known as the "closure depth". The precise depth is under scientific debate and varies with time, wave and weather conditions. Overall, when humans try to interfere with the natural migration of barrier islands, it is usually at their long-term peril.

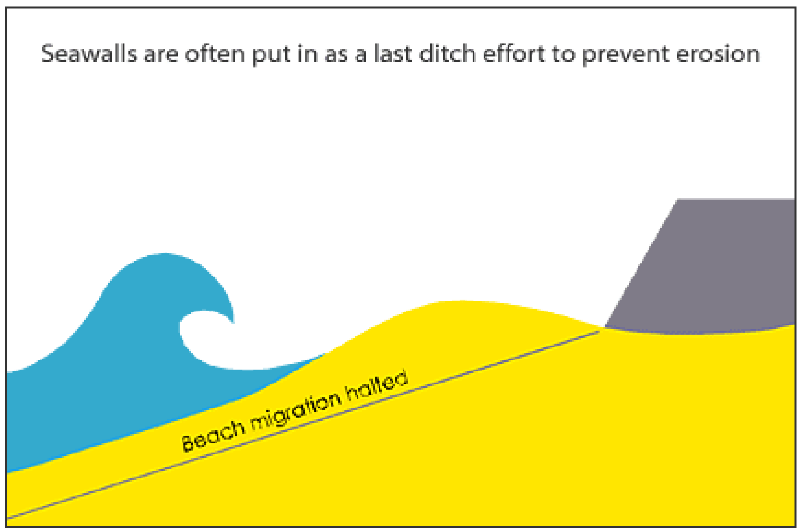
Erosion is a Process

Beaches are dynamic and natural. Buildings, bridges and roads are static. The problem occurs when there is a static structure built on a dynamic, moving beach. If buildings and roads were not built close to the shore, we would not have to worry about shoreline structures or sand erosion.

Seawalls – A Response to Erosion

When coastal buildings or roads are threatened, usually the first suggestion is to "harden" the coast with a seawall. Seawalls are structures built of concrete, wood, steel or boulders that run parallel to the beach at the land/water interface. They may also be called bulkheads or revetments. They are designed to protect structures by stopping the natural movement of sand by the waves. If the walls are maintained, they may hold back the ocean temporarily. The construction of a seawall usually displaces the open beach that it is built upon. They also prevent the natural landward migration of an eroding beach.

When waves hit a smooth, solid seawall, the wave is reflected back towards the ocean. This can make matters worse. The reflected wave (the backwash) takes beach sand with it. Therefore, both the beach and the surf may disappear.



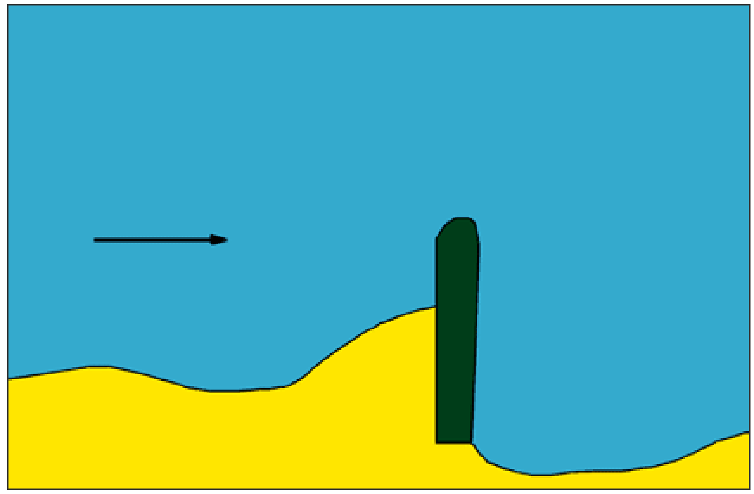
Seawalls can also cause increased erosion in adjacent areas of the beach that don't have seawalls. This so-called "flanking erosion" takes place at the ends of seawalls. Wave energy can be reflected from a seawall sideways along the shore, causing coastal bluffs without protection to erode faster. When it is necessary to build a seawall, it should have a sloped (not vertical) face. Seawalls should also have pockets and grooves in them that will use up the energy of the waves instead of reflecting it.

Usually the most cost-effective, environmental solution is to move the structure away from danger. Building seawalls will buy time against natural processes, but it will not "solve the problem" of erosion by waves.

Groins

Groins are another example of a hard shoreline structure designed as a so-called "permanent solution" to beach erosion. A groin is a shoreline structure that is perpendicular to the beach. It is usually made of large boulders, but it can be made of concrete, steel or wood. It is designed to interrupt and trap the longshore flow of sand. Sand builds up on one side of the groin (up-drift accretion) at the expense of the other side (down-drift erosion). If the ocean current direction is constant all year long, a groin "steals" sand that would normally be deposited on the down-drift end of the beach. The amount of sand on the beach stays the same. A groin merely transfers erosion from one place to another further down the beach.

Groins occasionally improve the shape of surfing waves by creating a rip current next to the rocks. However, the rip can also divert beach sand onto offshore sand bars, thereby accelerating erosion. Groins can also ruin the surf. If the waves are reflected off the rocks, the waves may lose their shape and "close-out."



As soon as one groin is built, property owners downdrift of it may start clamoring for the government to build groins to save "their" beach. Eventually, the beach may become lined with groins. Since no new sand is added to the system, groins simply "steal" sand from one part of the beach so that it will build up on another part. There will always be beach erosion downdrift of the last groin.

Breakwaters

A breakwater is a large pile of rocks built parallel to the shore. It is designed to block the waves and the surf. Some breakwaters are below the water's surface (a submerged breakwater). Breakwaters are usually built to provide calm waters for harbors and artificial marinas. Submerged breakwaters are built to reduce beach erosion. These may also be referred to as artificial "reefs."

A breakwater can be offshore, underwater or connected to the land. As with groins and jetties, when the longshore current is interrupted, a breakwater will dramatically change the profile of the beach. Over time, sand will accumulate towards a breakwater, and downdrift sand will erode. A breakwater can cause millions of dollars in beach erosion in the decades after it is built.

Beach Nourishment

In recent years, the hard structures described above have fallen somewhat out of favor by communities due to the negative impacts we have discussed. Beach nourishment is becoming the favored "soft" alternative. Beach nourishment is simply depositing sand on the beach in order to widen it. Although paid for by all taxpayers, it is frequently undertaken to protect private oceanfront buildings. Occasionally the taxpaying public is refused access to beaches that they have paid to protect. But sand nourishment is a costly, temporary solution. The projects are not intended to have a long life span and must be re-nourished on a regular basis, creating a cycle that will go on until the money runs out or shorefront buildings are relocated.

There are many considerations that must be addressed when designing a nourishment project. If the grains of sand are not exactly the same size as that of the natural beach, the newly nourished beach may erode faster than the natural beach was eroding. Furthermore, beach nourishment can cause bottom organisms and habitats to be smothered by "turbid" water that has sand and mud suspended in it. The shoreline is moved seaward into deeper water, causing the beach to drop off quickly, posing a hazard to swimmers. This may also impact the surf for a period of time, causing the waves to break as shore break, until the beach and sandbars can reestablish a level of equilibrium.

Environmental Impact of Structures

Before a shoreline structure is built, the local community must be informed of its environmental impacts. The US National Environmental Protection Act (NEPA) mandates that an Environmental Impact Statement (EIS) must be prepared to identify environmental impacts of the project. This document must spell out all effects that a new structure will have on the surrounding area.

The EIS process allows activists to educate the public about the project's impacts on the environment. Written comments on the draft EIS are crucial for legal purposes. Oral comments at hearings are even more important because they are picked up in the media, which allows more of the public to become informed.

"Hard" shoreline structures also have severe environmental impacts on the longshore current and the natural processes of beach sand distribution. On the other hand, "soft" solutions like sand nourishment are expensive and temporary. Therefore, major projects such as marinas should be built in natural harbors away from the energy of the waves.

Overall, shoreline construction means that taxpayers pay the bills when the ocean behaves as expected. Whether it is fire department rescues, the Public Works Department placing sand bags, the police guarding vacant buildings from looters or the Army Corps of Engineers spending millions to "correct the problem," taxpayers are the ones who pay. Shoreline protection is, often, "welfare for the rich."

Understanding Waves

The very first thing an instructor or student sees when they get to the beach is the waves. When you first get to the beach and look at the lineup, you try to "read" the people already out in the water. Try and understand what type of rider each of them is and how they might interact with your students. If there are aggressive surfers in the water, move down the beach a little.

For your students, you want to make them feel safe. Therefore, when the lesson starts, one of the fist areas to cover on the beach is waves and where they come from. Wind can have a tremendous effect on water, especially when it blows for a long time. Waves are made by 'something' causing water to be displaced, and that 'something' is wind with storms causing the biggest waves.

Energy Transfer and Wave Physics

Basically, waves are formed when wind blows across the ocean surface in areas called 'fetch zones' to form chop. When the chop moves out of the fetch zone it can form into lines of swell. These lines of swell then travel across the ocean in groups called sets. The swell becomes waves that break when they move into shallow water such as a reef, beach or headland. Waves are pulsing bands of energy that travel across the ocean until they break. When a wave breaks it is releasing energy, and it is this energy that surfers utilize for surfing.

Energy can only be transferred from one point to another through two methods: through a particle, or through the interactions of particles. The latter is the process used by the wind to transfer energy to ocean water, and is known as the process for creating a wave. When energy is transferred through water friction into a wave, the particles themselves do not move, they only vibrate in place. The wave as a whole moves, because one vibrating particle will transfer this energy to a particle next to it, which will in turn transfer to the next, and so on. The wave itself is the energy in motion.

Waves require a material medium to travel (air, water, ropes, etc.). These waves are divided into three different types:

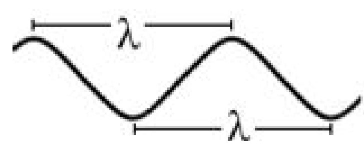
- Transverse waves cause the medium to move perpendicular to the direction of the wave.
- Longitudinal waves cause the medium to move parallel to the direction of the wave.
- Surface waves are both transverse waves and longitudinal waves mixed in one medium.

For surfaces waves (like ripples on water), the particles move in a circular pattern, giving both longitudinal and transverse properties. These conditions tend to break many formal wave rules. However, continuous energy transfer in one direction, due to the friction from wind, will generate more energy in the direction of the wind.

Frequency is the number of complete cycles of a periodic process occurring per unit of time. A period is the time interval between two successive occurrences of a recurrent event or phases of an event; a cycle. The wave period in seconds is equal to 1/frequency.

The actual distance between two peaks or compressions is known as the wavelength. It can be correlated with frequency and speed with the equation.

$P = 1/f$ $\qquad\qquad \lambda = s/f$



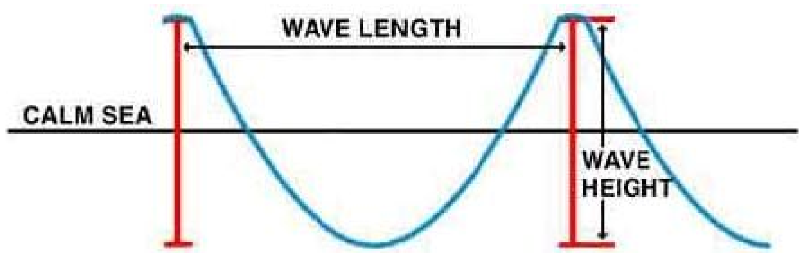
Velocity (or speed) equals the frequency times the wavelength (lambda).

The shortest distance between peaks (the highest points) and troughs (the lowest points) is the wavelength.

In surfing, we normally think in terms of period and speed. Frequency is defined in cycles per second. Therefore, period P is simply 1/f. or seconds per cycle. The energy of a wave is proportional to its frequency and proportional to the square of its amplitude. If velocity is defined as feet per second, then its amplitude will be in feet. However, energy calculations generally use meters for velocity. Note also that speed and velocity are used interchangeably.

Parts of a Surfing Wave

Waves have a crest, trough, length and a height as shown in the figure below. Surfers also use the terms lip, whitewater, and face when describing waves. The highest part of the wave is called the "crest." The lowest part of the wave is called the "trough." Waves can be described by their height, wavelength, and wave period. The wave-height is the vertical distance from the crest to the trough. Wavelength is the horizontal distance between the crest of one wave and the crest of the successive (next) wave.



The wave period is the time it takes for two successive (one after the other) waves to pass a fixed point. Wave period is used to classify waves. Typically one will hear waves described like, "It's 5 ft. @ 13 seconds." What this means is that the average height of the largest 33% of the waves are 5 ft. and that the average period (time between wave crests) of the most prevalent swell is 13 seconds.

Waves traveling in water deeper than one-half their wavelength are called deep-water waves. Waves traveling in water shallower than one-twentieth of their wavelength are called shallow-water waves. Shallow-water waves interact with the ocean floor through a drag at the bottom of the energy cell. As waves enter shallow water their speed and wavelength decrease, but their height increases.

The ocean produces larger waves than a lake or pond because it has a larger fetch area. One fast-moving (velocity) gust of wind will not create large waves, but the same fast-moving wind over a sustained (long) period of time will. A slow-moving wind over a long period of time will not create large waves.

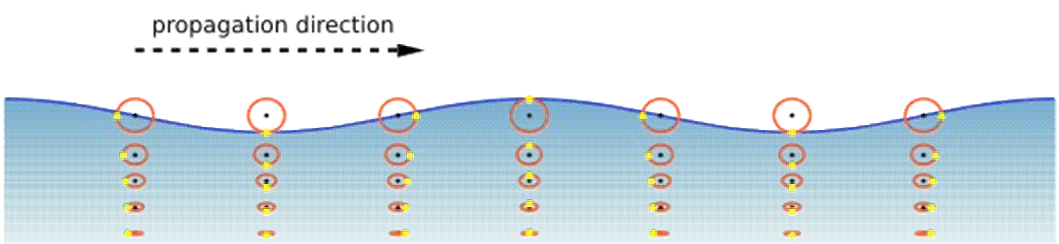
Wave Energy and Momentum

Momentum is defined as a measure of the motion of a body equal to the product of its mass and velocity, also called *linear momentum*. Both momentum and velocity have the same direction. When an object is moving, it has a non-zero momentum. If an object is standing still, then its momentum is zero. The symbol for momentum is a small **p.**

Intuitively it seems a mechanical wave doesn't carry momentum since there's no mass flow. A cork on the surface of the sea just bobs up and down. Surfing requires interaction with the drag force from the sea bottom near the beach as the wave breaks, but that doesn't necessarily mean a water wave carries momentum. A surfer pushed by an ocean wave, near the shore, will gain linear momentum, but this is not a transverse wave traveling with constant **v**. It might seem theoretically that the only true momentum is generated by the water flowing back from shore having already washed in when a wave breaks. However, in reality the motion creating momentum is called orbital motion.

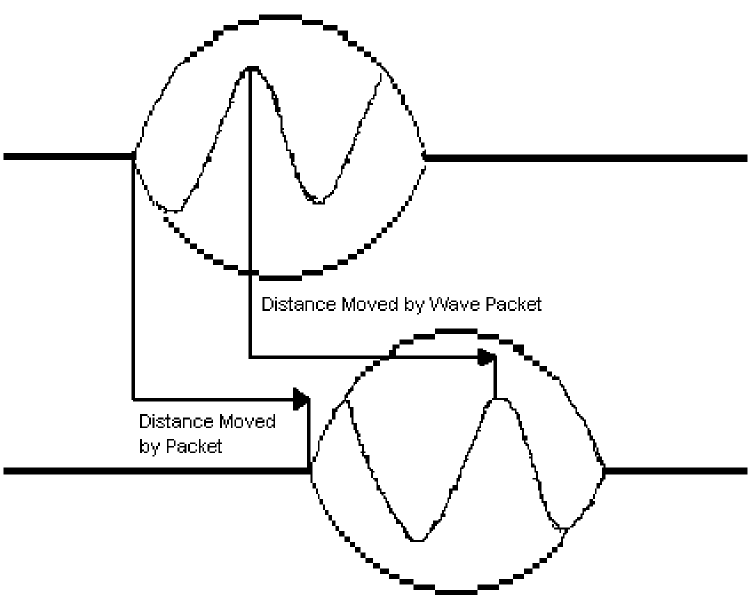
Airy Wave Theory is the name of the theory often used in ocean engineering and coastal engineering to describe how energy moves in the ocean. Underneath the surface there is a fluid motion associated with the free surface motion. While the surface elevation shows a propagating wave, the fluid particles are in an orbital motion. Within the framework of Airy Wave Theory, the orbits are in deep water closed circles, and in finite depth closed ellipsoids — with the ellipsoids becoming flatter near the bottom of the fluid layer. So while the wave propagates, the fluid particles just orbit (oscillate) around their average position. With the propagating wave motion, the fluid particles transfer energy in the wave propagation direction, without having a mean velocity. The diameter of the orbits reduces with depth below the free surface. In deep water, the orbit's diameter is reduced to 4% of its free-surface value at a depth of half a wavelength.

In a similar fashion, there is also a pressure oscillation underneath the free surface, with wave-induced pressure oscillations reducing with depth — in the same way as for the orbital motion of fluid parcels. The figure below from *Wikipedia* shows orbital motion existing under linear ocean waves. The yellow dots indicate the momentary position of fluid particles on their (orange) orbits. The black dots are the centers of the orbits.



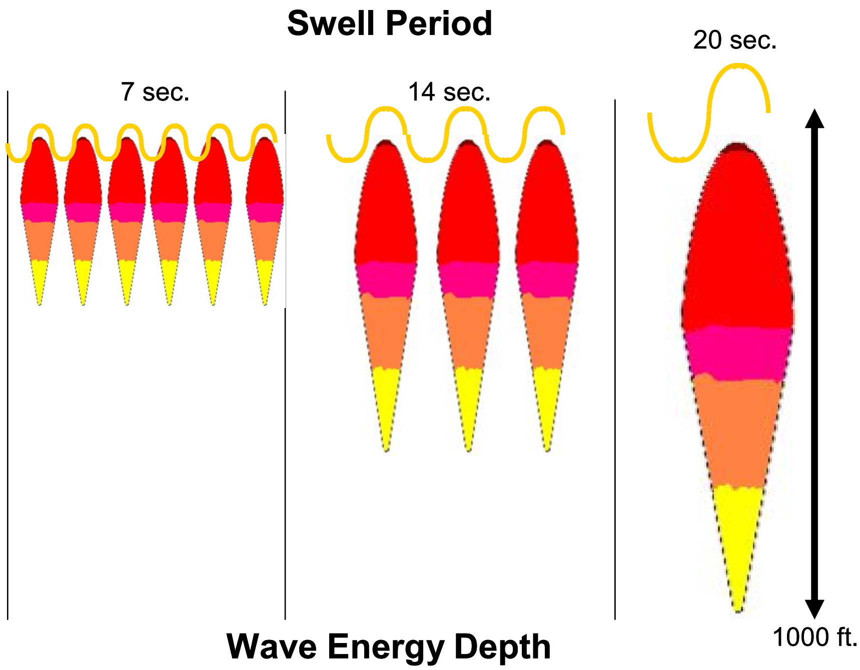
The speed at which wave energy travels is not, in general, the same speed at which wave peaks and wave troughs move. Energy moves in parcels called wave packets with a velocity called the group velocity. Wave peaks and trough move at the phase velocity.

The figure shows that the velocity of peaks and troughs on the surface (the phase velocity) of the ocean doesn't always equal the velocity of the wave packets (the group velocity) beneath. Energy travels with the wave packets. What this means is that what you see on the surface in open sea does not necessarily reflect the true energy traveling with the wave.



As the wave packet moves along the surface of the water, the leading trough is gradually overtaken by the crest behind it. Thus the trough moves out of the packet which now has a crest leading it. This crest also moves faster than the packet and soon disappears to be replaced by a trough and so on.

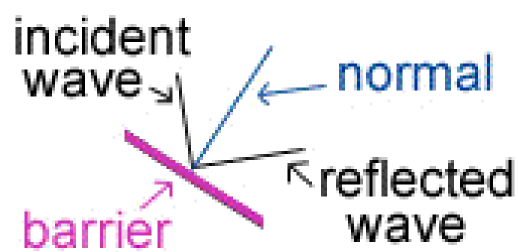
The energy of an ocean wave extends well below the surface of the water. This is because of the weight of the water and the ease in which energy is transferred between individual water particles. As was indicated, this energy relates directly to the period of the wave, with longer period waves extending deeper into the ocean as shown in the figure.



When two waves mix or interact with each other, the resulting displacement is a simple sum of the two initial displacements. This means that if two waves intersect in phase, the compressions/peaks are lined up, they experience constructive interference, and the resulting wave is larger. If the two waves are in phase, but one is inverted (upside down), the waves experience destructive interference, and the resulting wave is smaller. If the two waves are out of phase, are different frequencies, or traveling in different directions, the resulting wave amplitude and direction is difficult to judge, as will be the energy pattern.

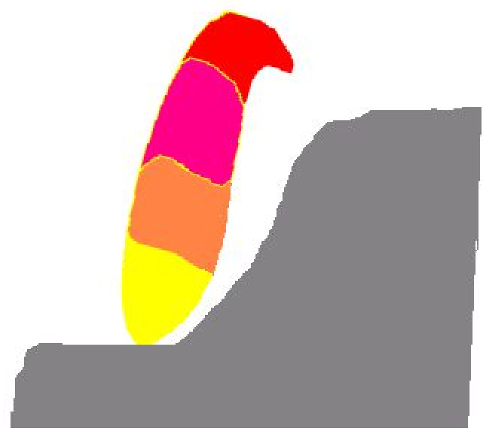
Besides energy, waves also have momentum, and whenever a wave encounters an obstacle, it is reflected by that obstacle. When a wave propagating through a medium hits a different medium, some of the wave is absorbed, and some is reflected. This "reflection" of the wave can be analyzed in terms of momentum and energy conservation. If the collision between wave and object is perfectly elastic, then all the incident energy and momentum is reflected, and the wave bounces back with the same speed. If the collision is inelastic, then the object absorbs some of the incident energy and momentum and the wave does not bounce back with the same speed.

When a wave hits a barrier, it will be reflected depending on the direction of the barrier (normal). The angle between the incident wave and the normal is the same as the angle between the normal and the reflected wave. When a wave enters a different medium at a non-perpendicular angle, the direction of the waves change. This change is called

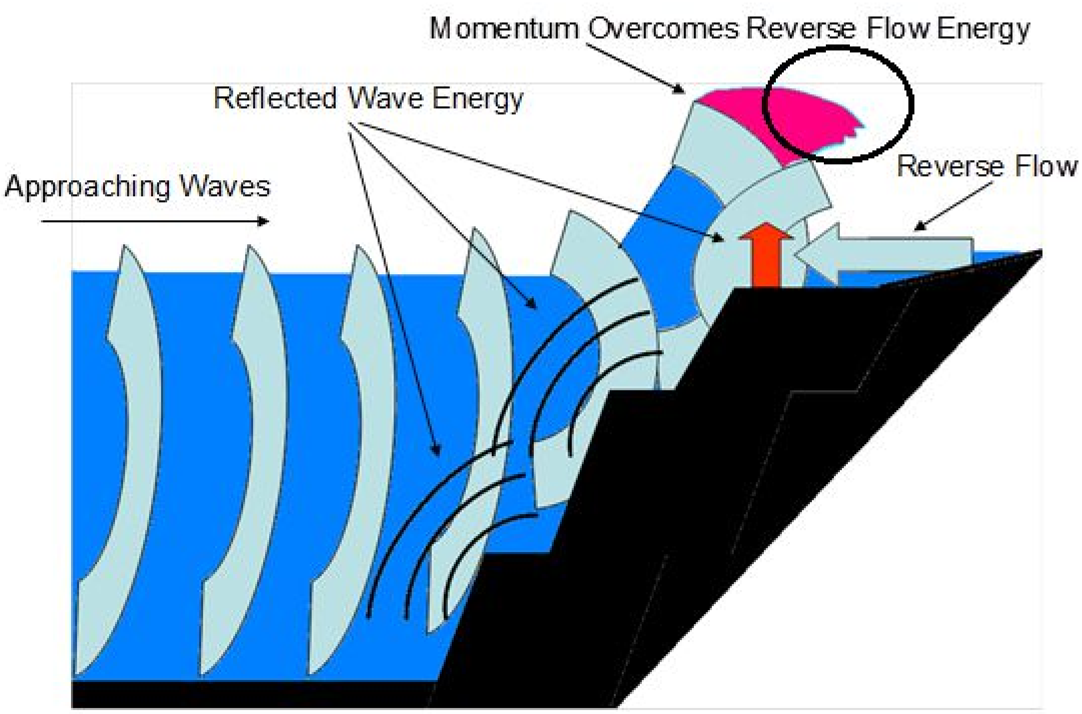


refraction. Refraction is a crucial factor in determining the characteristics of any surfing break: it can make the waves bigger, smaller, longer, shorter, faster, slower or hollower. When a wave travels through a small hole/area in a barrier, it bends around the edges. This is called diffraction.

As waves approach the shoreline and shoal (interact with the ocean floor) they transform drastically in several ways. Waves can be refracted, reflected, diffracted, and they can break. In the case of a water wave hitting a rock, sand bar or reef, the density is significantly different than water; most of the wave energy will reflect. The reflection of this energy is dependent on the angle of the reflecting surface with respect to the approaching wave's direction. The first figure below shows the wave energy starting to deform as the bottom parts of the wave start to reflect, increasing energy in the top of the wave, and forcing the top of the wave upward.

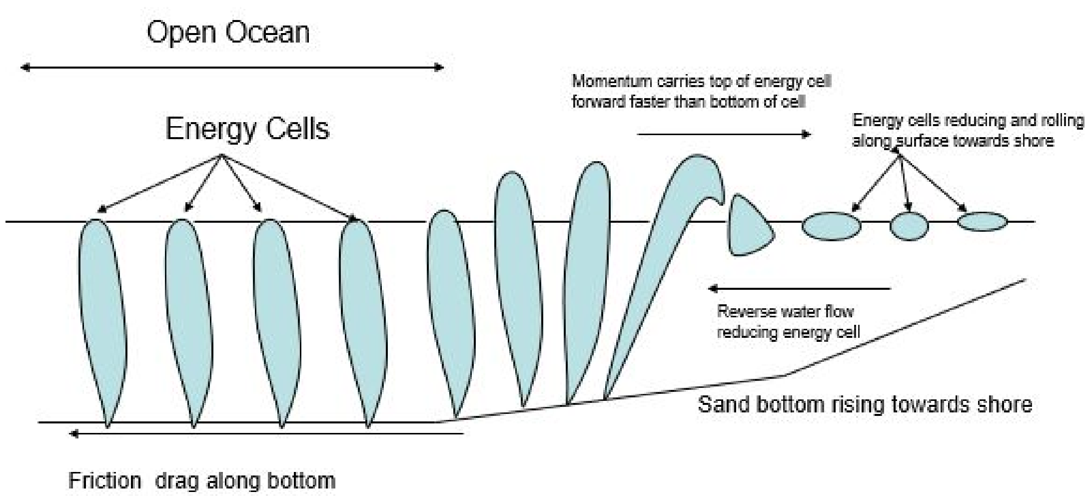


The second figure depicts a wave reflecting from various bottom obstacles back on oncoming waves with the resulting energy of each wave shown as enlarging the peak. Additionally, the outgoing wave after breaking at the beach, etc. will also enlarge the peak even further. The red area represents the highest energy points of the wave. The third figure shows the waves from above.

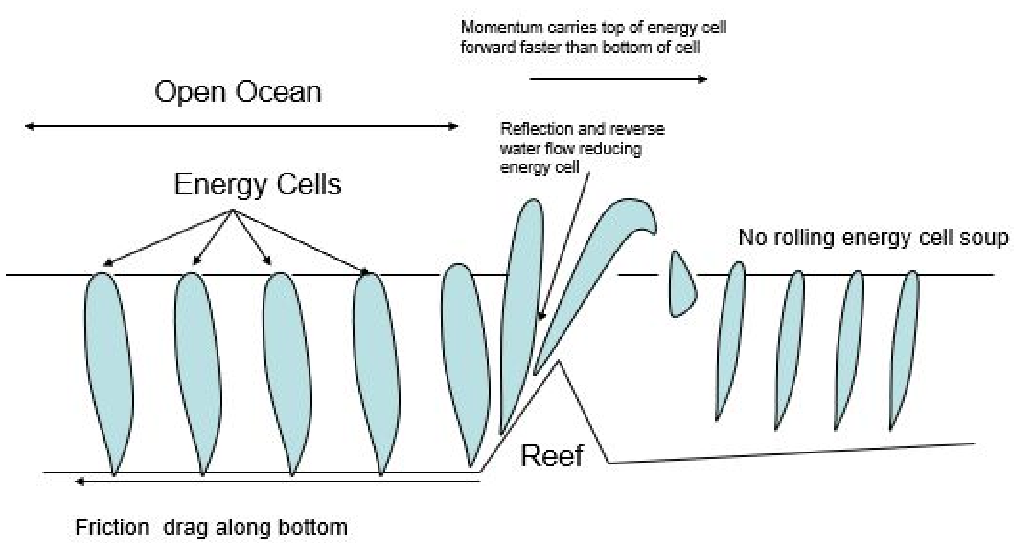


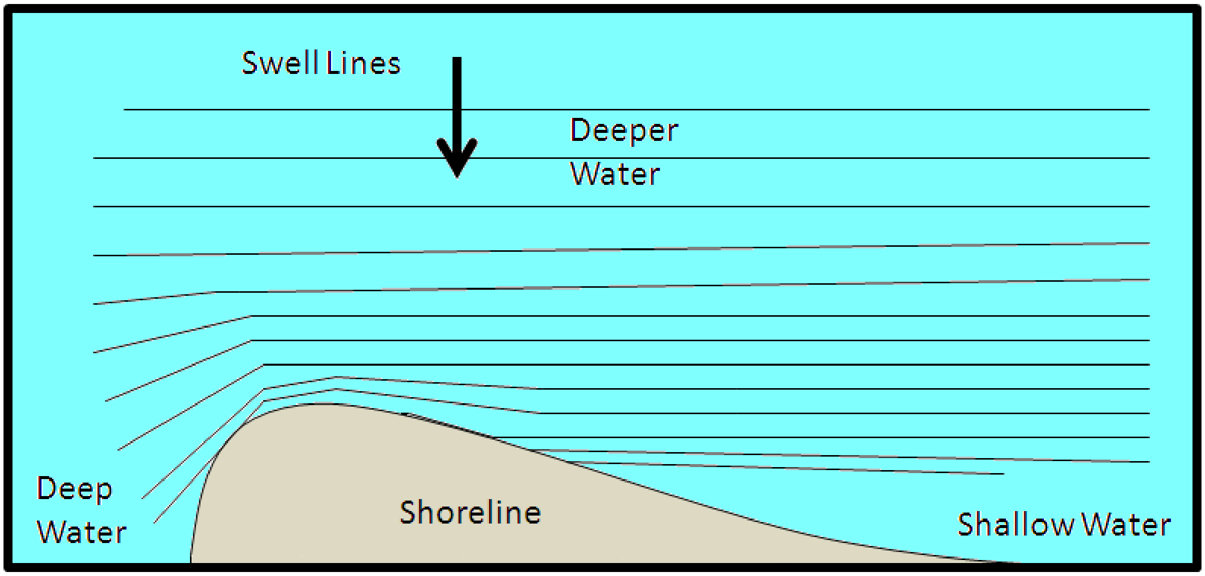
Now let's see how wave energy changes when the wave hits a reef versus when it rolls towards a sand bottom beach. This is the area where lessons are normally given. Notice that with a sand bottom, energy in the form of soup rolls a considerable distance after the wave breaks. This is why a leash in necessary to prevent a lose board from hitting someone inside. With a reef break, the board won't travel far since the soup dissipates quickly. Remember this is for a normal smaller wave where lessons are given.

Energy Transfer With Shore Break

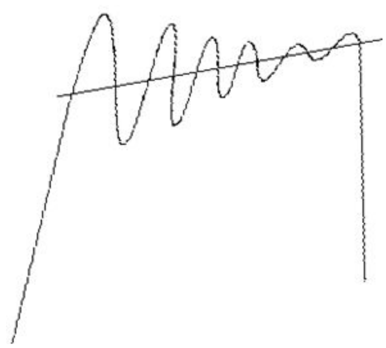


Energy Transfer With Reef Break



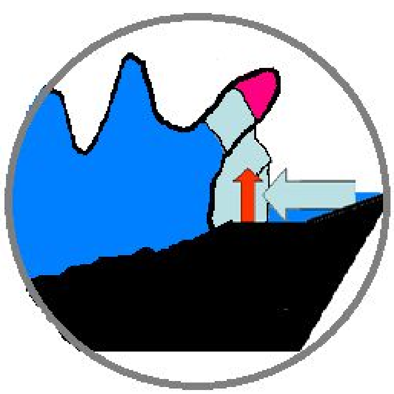


Where Do Sets Come From



Another important concept to understand is that in the real world is that changes in the direction of the energy can't happen instantly.

Since energy can't instantly change state in the real world, it reaches its final state through a series of slowly dampening sinusoidal movements making up the pulse that take place at the top (or bottom) of the pulse. Since the bottom of the pulse is dragging on the ocean bottom, the top of the pules is really where the dampening exists. Therefore, as the wave front moves it starts to skew as shown. When a pulse reaches the coastline, you have a set with the cleanup wave usually the largest and last wave. The picture below is the circled area in closer detail.



What distinguishes a good wind wave from just a bunch of chop?

Wind waves, though rideable and often present, are not the optimal type of wave one likes to ride. Swells are much better. Wind waves are only the raw material. Wind waves lose energy and height after they move away from the wind that produces them; such waves start degenerating once they move away from the wind source that created them, unless enough underlying energy is present to transform the wind wave into a swell. Not enough energy and it will dissipate due to the surface tension of the calm water.

Wave Intensity Classification

The geometry of tube shape can be represented as a ratio between length and width. A perfectly cylindrical vortex has a ratio of 1:1, while the classic almond-shaped tube is nearer 3:1. When width exceeds length, the tube is described as "square".

Classification parameters

Tube shape defined by length to width ratio

- Square: <1:1
- Round: 1-2:1
- Almond: >2:1

Tube speed defined by angle of peel line

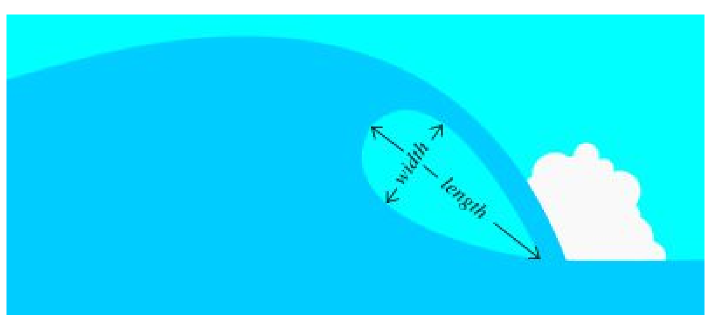
- Fast: 30°
- Medium: 45°
- Slow: 60°

Wave Intensity Table

	Fast	**Medium**	**Slow**
Square	The Cobra	Teahupoo	Shark Island
Round	Speedies, Gnaraloo	Banzai Pipeline	
Almond	Lagundri Bay, Superbank	Jeffreys Bay, Bells Beach	Angourie Point

What conditions are best for making swells?

There are three factors that influence the level of energy contained in swells**. Wind velocity, wind area (fetch), and duration**. That is, the speed of the wind, the amount of ocean surface area affected by wind blowing in the same direction (also known as **fetch**), and the amount of time those winds blow over the same part of the ocean. Ideally, to make a huge swell, one would want strong steady winds blowing at maximum velocity over thousands of miles in the same direction (fetch aimed towards your beach) for days.



As a wind wave moves away from a storm, the choppy components dissolve, leaving only the pure swell energy to travel. However, if windy seas heading towards a shore ceased close to land (say 500 nautical miles or so), only some of the bump would have time to dissipate, and a combination of chop and swell energy would hit shore. But if the storm faded 2000 nautical miles from shore, all chop would fade and clean swell energy would result (assuming there weren't local winds to create new chop to contaminate the swell). Such swells are known as **ground swells**, which often create ideal surf conditions.

Significant Seas and Swell

In general, if you have a choice between obtaining significant sea or swell data, use swell data. Significant seas don't exist in the real world from a surfing perspective. "Seas" are the combined sum of the heights of all waves present at the reporting station or buoy. Think of it as the average wave north, and a 3 ft. swell coming from the south; it would be reported as a 6 ft. sea. ('Seas' are actually the square root of the sum of the squares of all wave energy present). Add in a bunch of open-ocean chop and it really starts to skew the results. Surfers don't typically ride two separate waves coming from two different directions simultaneously. So the seas measurement actually overstates actual wave size.

Ocean chop tends to have a period ranging from 3-8 seconds. That is, there is anywhere from 3-8 seconds between each wave crest. Wind waves range from 9-12 seconds. Ground swells range from 13-15 seconds, and strong ground swells have a period anywhere from 16-25 or more seconds.

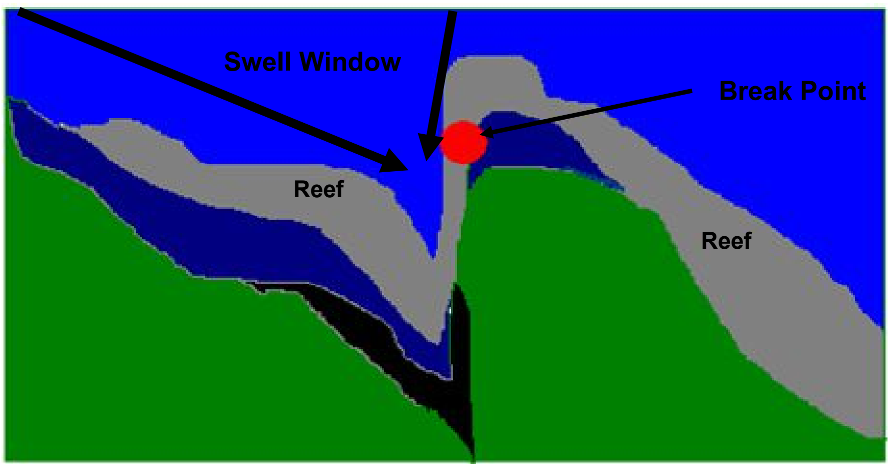
A longer period swell affects water much deeper in the ocean than short period swells. Long period waves move faster and deeper. In short, swell period is more important than height. Also, swell speed is directly proportional to its period. It's a linear relationship. As period increases so does swell speed. Additionally, all swells of the same period travel at the same speed, regardless of size. A 2 ft. swell with a 20 second period moves the same speed as a 25 ft. swell with a 20 second period. If you can predict the period of a forecasted swell, and know how far away the storm is from your location (in nautical miles), you can accurately determine the arrival time of the swell, regardless of its size.

The Big Waves

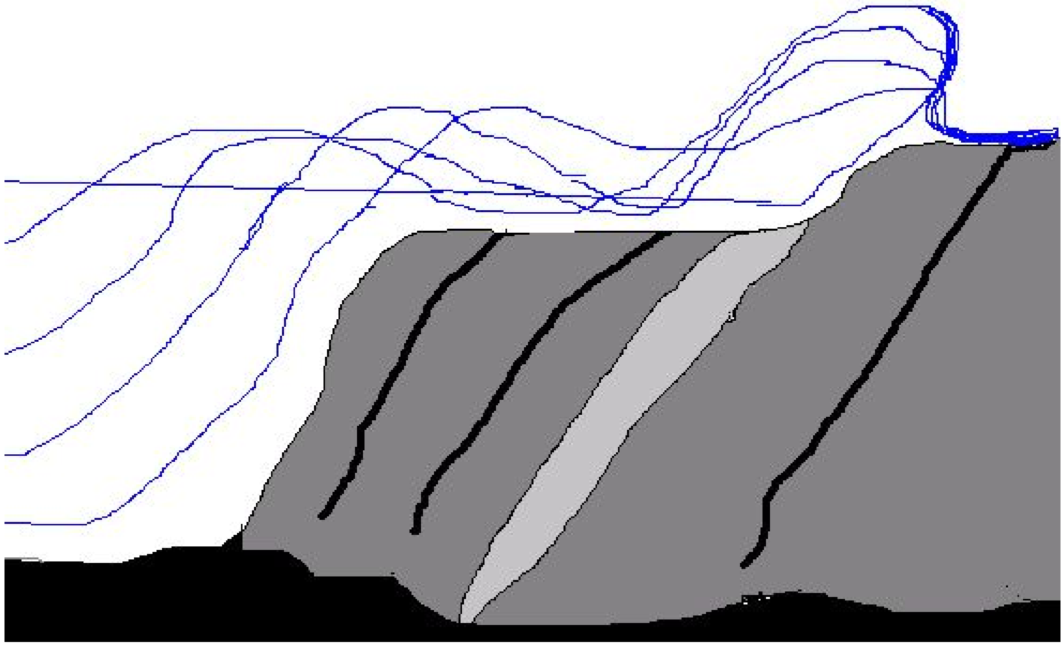
Perhaps the largest wave an average surfer will ever encounter on any particular day happens when a ground swell and a locally generated wind wave coming from the same direction converge. But ground swells have more energy, and are easier to catch, so they will be what most surfers ride. If both a swell and reasonably long period wind waves are present, then the upper limit one might experience could approach the significant sea height. Surfers and boaters notoriously overestimate the size of the waves they encounter, and statistically, significant sea measurements help sustain that practice. But, a far better measure of unbroken waves is the swell height and period. Swell height is the 'average' height of the highest 1/3 of the most energetic swells present at that reporting station (a buoy), and is most likely what one would ride if surfing near that location. Likewise, swell period is the average period of the most energetic swells. Use swell data whenever possible.

Obviously, there are locations where the various reflecting surfaces and oncoming waves can generate massive wave heights. Such places include Waimea Bay, Jaws, Mavericks, Cortes Banks and Todos Santos. It takes a couple of conditions to generate these massive waves. First, you need a swell that approaches the breaks from an almost perpendicular direction. We call this the swell window. Next, you need the bottom structured in such a way that the maximum amount of energy is transferred directly up towards the wave surface rather than reflecting into the wave in such a way as to diffract part of the wave's energy, thus reducing its forward momentum.

The figure below is typical of one type of big-wave generating bottom contour. In the case shown, similar to Jaws below, an underground canyon tends to channel the wave's energy, keeping it from dispersing back towards the open sea.

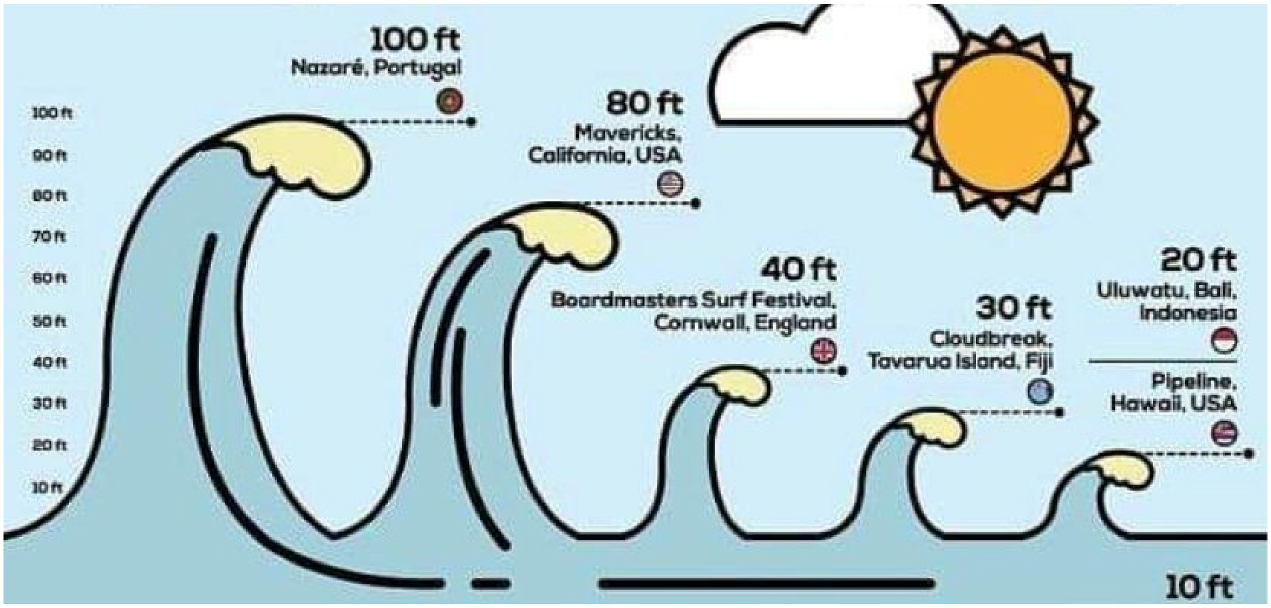


For another type of bottom, such as the Cortes Bank off the California Coast, an underwater mountain rises steeply from the ocean floor. In this case, a large swell approaching the mountain has no other place to transfer its energy, pushing the wave up to significant heights. A picture of a surfer at the Cortes Banks is below the figure.




SPAIN
PORTUGAL
NAZARÉ
LISBON
PRAIA·DO·NORTE
PREVAILING·SWELLS
DANGER·ZONE
PHOTOGRAPHER'S PERCH
LIGHTHOUSE
BIGGEST·WAVES
ATLANTIC·OCEAN
NAZARÉ
NAZARÉ·CANYON
CANYON·SWELLS
FISHING·BOATS
WAVE·BUOYS
MILES
0
1/2
1

Big Wave Breaks



Artificial Reefs

The emergence of artificial reefs to enhance existing surf conditions has generated significant worldwide interest (and concerns) in recent years. Some attempts have proved useless when storms have destroyed what was created. Still other attempts have not proved as successful as they were first advertised. Advances in materials and designs will help refine newer reefs as they are developed. This section presents a brief review of how waves break plus it provides an overview of the basic concepts behind current artificial reefs that exist today.

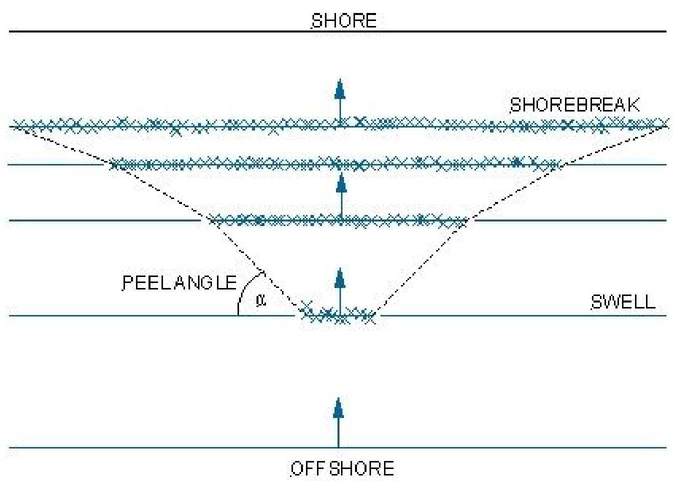
The bottom line is that artificial reefs, regardless of their specific design, will cause a wave to bend and break irregularly. While almost any simple shallower bottom beach area with a large swell window will work as a base, the most functional artificial reefs are designed to refract and direct swells into longer lasting angled breaks regardless of their direction. Therefore, the major concern with installing an artificial reef is not so much that it will create a surfable wave, but rather how the reef might impact sand erosion, drift, and other environmental concerns.

Background

As a review, when a wave moves in the open ocean, the sea bottom has virtually no effect and the wave energy moves based on its period. However, when a wave approaches the coastline, the shallower water causes the bottom of the wave to drag along the ocean floor. How much of a slow down and how the wave is formed is dependent on the water depth and irregularity of the bottom contours.

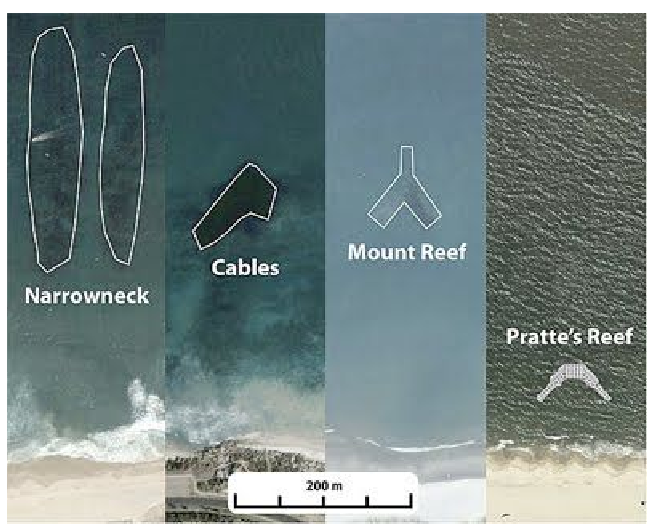
If a wave hits a steep incline into shallow water over a short distance, the wave height increases substantially, resulting in very large wave faces. This is because the first waves to hit the incline slow down while the following waves are still approaching at their open water speed. The energy in the waves starts to compress and combine with other waves since these waves are now closer together. This combined energy pushes the top of the wave up, while the combination of gravity and momentum at the top of the wave causes the top of the wave to break forward.

Refraction is the primary controlling factor in how the shape of the wave is formed and also how long the breaking wave might last. Waves break in a progressive manner. Since the contour of the ocean bottom is not uniform, one part of a wave crest could have more drag than other parts causing the slower moving part of the wave to bend slightly. Refraction always turns the waves towards the slower moving water (the shallower area).



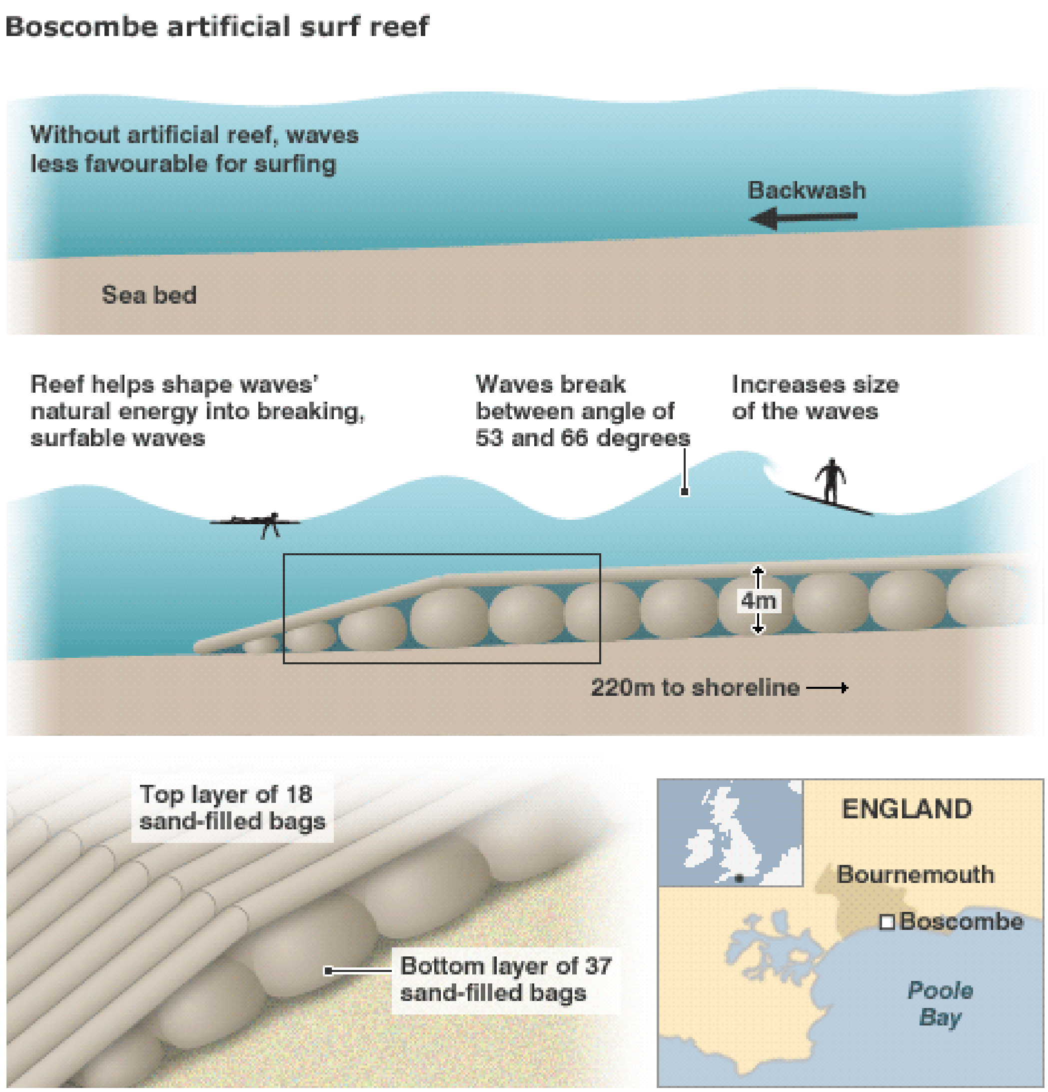
A good description of how a wave progressively breaks is available from Artificial Coastal Management. According to their web site, "peel angle (see their figure) is related to the wave breaking location, which is determined by water depth and wave characteristics. Generally, waves start to break when the wave height is approx. 1 to 0.7 times the water depth. Thus, a 1m wave will break in approx. 1 to 1.4m of water. If the seabed at this depth has contours which are parallel to the direction of the wave crests, the wave will break almost simultaneously along the crest and the wave will 'close out' [i.e. peel angle is close to zero]. If the wave encounters a variable depth along the length of the crest [as is the case for oblique swells, desirable bar formations and natural or artificial reefs], the wave will break at the shallow point initially and then progressively along the crest as the wave moves onshore, creating ideal conditions for surfing."

The figure at right, from http://oceanswavesbeaches.blogspot.com/2009/08/do-artificial-reefs-work-vol-4-track.html#, provides a shape comparison for four artificial reefs. The reef at Cables near Perth, Australia, was built in 1999 by lowering granite blocks from a barge onto the ocean floor. The reef is shaped like a boomerang and measures 140 meters from north to south. The whole structure sits between 1 and 2½ meters below the surface, on an existing limestone reef, which was originally up to 6 meters deep.



The importance of Cable Stations (left) is that it was built before research into artificial reefs was advanced, and there was not a consensus as to whether an artificial surf reef would work or not. If the intent was to create a surfable break on a beach that doesn't have a rideable wave, or to create an additional break in an area overpopulated with surfers, then it was hugely successful. If the intent is to create a world-class break on a beach with no or irregular surfable waves, then building an artificial reef will mostly be a failure.

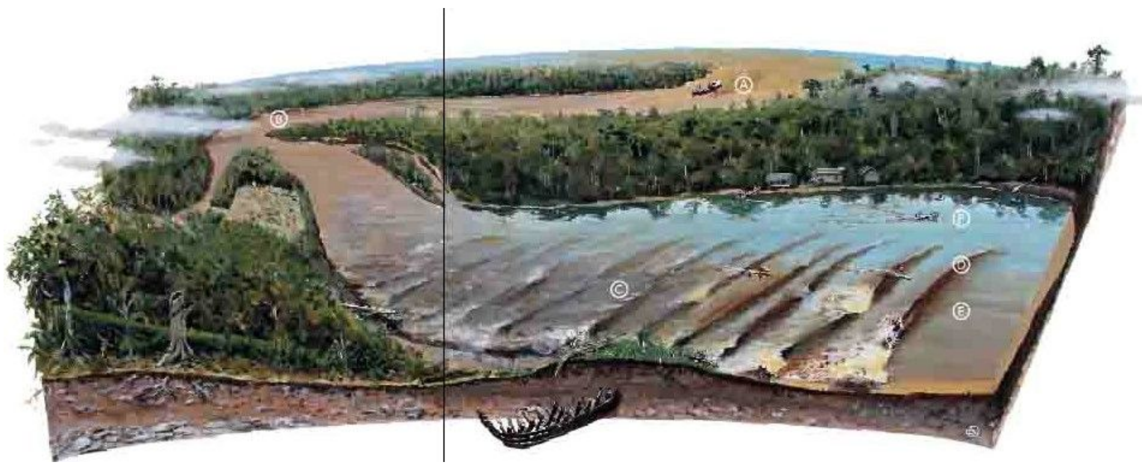
The Boscombe figure below represents a simple design using sand bags to break up the existing wave pattern and increase wave size on a flat bottom beach. Since sand exists already, it represents less of an environmental risk than other materials previously used to



build artificial reefs. One issue with using sand bags has been the gaps in the newly created reef that often develop when the bags break down over time or are subjected to rough surf conditions. These gaps can deteriorate the quality of the break they create. However, technology is improving and this may become less of an issue as time goes on.

Tidal Bores

Tidal Bores take place when the leading edge of the incoming tide forms a wave (or waves) of water that travels up a river or narrow bay against the direction of the river or bay's current. They are rare, normally where a wide area funnels into a shallow, narrowing river or lake during the incoming tide. There can be a single wave front or multiple waves. Generally speaking, these locations do not make good locations for instruction.



Predicting the Waves

In planning surfing classes, base your next day's surf prediction on two sources, the winds and the weather patterns. On the East Coast, for instance, you really can't rely on how long a swell will last, but you are safe to predict on a day-to-day basis. A small swell can easily be blown down to nothing, once the winds switch to offshore. If the winds blow sufficiently onshore for an extended period, you are always going to get something rideable. Most of the time you will get a big offshore storm that hits on one day with messy slop, switching to clean surf the following day. And then, it all goes away on the third day.

Check out the winds the night before a class, and check how strong they will be, in case there is no swell. If the winds are strong enough, a location that will take a straight onshore wind swell can be used, if all normal spots are flat. If there is the slightest hint of a swell, with or without the winds, classes can be run at the normal surf break. Swell criteria for lessons are anything bigger than 6 inches, and strong enough to push a board to the beach. As long as a student has enough time to jump up on the wave, we do class.

Another way to check if you are going to get a swell is by checking with other surf shops or schools, either up or down the coast. If there is surf in the south on one day, and the storm or front is moving northward, you can predict that the swell will hit you soon after.

Two other important items to consider are swell direction versus the direction of your beach and tide. It will be tough to teach lessons at peak high tide during a very small swell unless your bottom conditions can handle it. By the same token, if you try to teach a group lesson during low tide and even a slightly active swell, chances are good that your students can get pounded by a shorebreak wave or get caught in a rip and pulled out quickly. Plan accordingly for such conditions.

Teaching In Various Surf Conditions

In order to conduct business, surf schools must be able to deal with four types of situations regarding surfing conditions. They are as follows: **1) big, ugly, nasty surf ; 2) small, tiny surf; 3) perfect surf 4) no surf.** Perfect surf can be any size, depending on whom you are teaching.

If at all possible, it is best to assess the surf situation in advance, by checking out all the available teaching locations and making your choice before you meet the student. It is always far better to actually drive to the location, rather than depend on wave cams. Many times, a wave cam can be deceiving, showing no surf when there is surf. Some instructors will cancel a class based on checking a wave cam or listening to someone else, when they should have run the class.

For the average novice students, a range from 1-3 feet, with no rip tide and light off shore winds, would be **ideal.** Finding a surfing break with a slow, sloping face is preferred, compared to a steep, fast wave. Most beginners feel better in a shallow beach break with a sand bottom, rather than a rock or reef situation. If a rock or reef break is desired, always provide booties for the students.

Big and ugly surf should always be avoided, unless you think that the student is advanced enough to either handle it, or be challenged by it. Nevertheless, avoid making a choice based on what the student says. Almost all the time they will tell tall tales of their expertise, and an instructor will regret listening to them, once the student is outside the shorebreak. Base your decision on previous history with them, or treat them as beginners if it is their first class with you.

It is much better to find a miniscule wave at a secluded break, rather than taking out students in heavy surf. Maybe one in one hundred would enjoy this situation. If there is no recourse but to go out in this type of wave, the safest choice is to keep the students in the white water. Paddling outside could lead to problems, especially if a beginner is unable or unwilling to paddle or ride back in to the beach. In this situation, no one should be forced to go out, if they do not want to.

Small, tiny surf is fine, as long as a student has enough wave power to push his or her surfboard into the beach. Even if the wave is only a foot or less, as long as there are consistent swells moving into the shore, teaching a class should not be a problem. In this type of situation, having them catch many waves, and paddling more than they would in good surf can challenge students.

Many advanced surfers have competed in professional contests in waves that were barely one foot. If a contest can be run in those conditions, and thousands of dollars in prize money handed out, a beginner should have enough surf to take a lesson in the same conditions. Remember…avoid refunds!

No Surf is always a challenge. Remember that if you cancel the class, it is less likely that the student will reschedule. Often times, a surf lesson is a spontaneous act, and if it doesn't go off, chances are it will never happen. Therefore, if at all possible, do the lesson anyway. If the student is insistent about doing the class, despite flat surf, do it anyway.

In this type of lesson, plan on extending the beach lesson and pre-surf stretching and conditioning. A long paddling session can follow, detailing and analyzing paddling strokes and technique. Obviously, running a surf class in totally flat conditions is probably the biggest challenge of a surf instructor.

Surf Lessons with Beginner Waves

The most popular wave for a beginner lesson is an easy wall that is soft and gentle yet just steep enough to allow trim on the face if the skill level warrants. There is usually enough white water to ride for the absolute novice. Ideally, the wave is breaking in 3 feet of water, deep enough to be safe, yet shallow enough to make it easy for the instructor and student.

Perfect Waves for Learning

The perfect dream wave for teaching/learning, after the basics are understood, is a small left and right peak. This wave has an easy wall available to both goofy and natural intermediates. The water should be 2-3 feet deep, providing enough water to not injure students when they wipeout, yet shallow enough to make it easy for the instructor. This wave is still powerful enough for a clean run into the beach, yet also good for whitewater practice. As well, the whitewater ends in a small channel just before the shore to prevent students from running their boards straight into the sand and risking hurting their ankles. Above all else, there are no crowds to contend with.

Tides

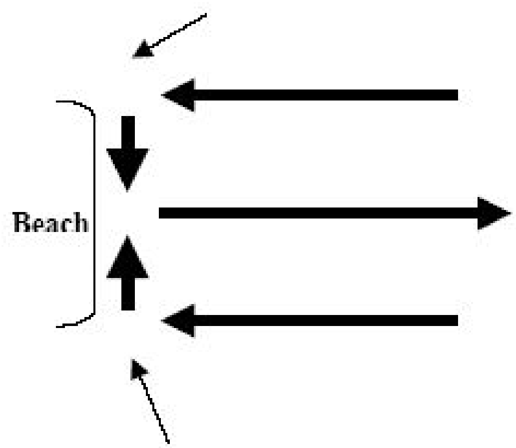
Tides are caused primarily by the combination of the sun's and moon's gravity, and also by the earth's rotation. Here are a couple of key elements to remember:

- The moon has a greater tidal effect than the sun.
- Spring tides occur when the sun and moon are lined up.
- Neap tides occur when the sun and moon are at right angles.
- Extra high tides occur (40% higher) during spring tides when the moon is closest to the earth.
- Many surf breaks are better when the tide is low to mid as the higher tides often cause the waves to mush out.

Rip Currents

Rip currents were discussed previously. These currents exist all the time on most surf beaches, and are particularly noticeable when there is a swell. When there is a strong swell and the tide is outgoing, the rip's speed increases dramatically, quickly becoming dangerous to swimmers.

The currents associated with a rip are shown in the figure below. Rip currents normally form at low spots or channels in sandbars, and also near beach structures such as groins, jetties and piers. Their width and extension can vary but usually extend to the line-up just beyond the breaking waves.



Identifying Rip Currents

One way of identifying a rip while sitting on a board is based on the constant need to keep paddling back to your line-up point on shore or to constantly paddle towards the beach. The following list describes some visual tell-tale signs that a rip current exists:

- The water color looks a little different or even less clear.
- Chop seems to be more pronounced when the surface is calmer after a wave.

- Foam from breaking waves or debris is moving steadily seaward.
- A place where there is a break in the incoming wave pattern and it's easier to paddle out.

Surfers often take advantage of rips to quickly paddle to the outside in heavy surf conditions. You should teach beginners about how to use rips as well as to always wear a leash and be knowledgeable about dealing with swimmers when they get caught in rips.

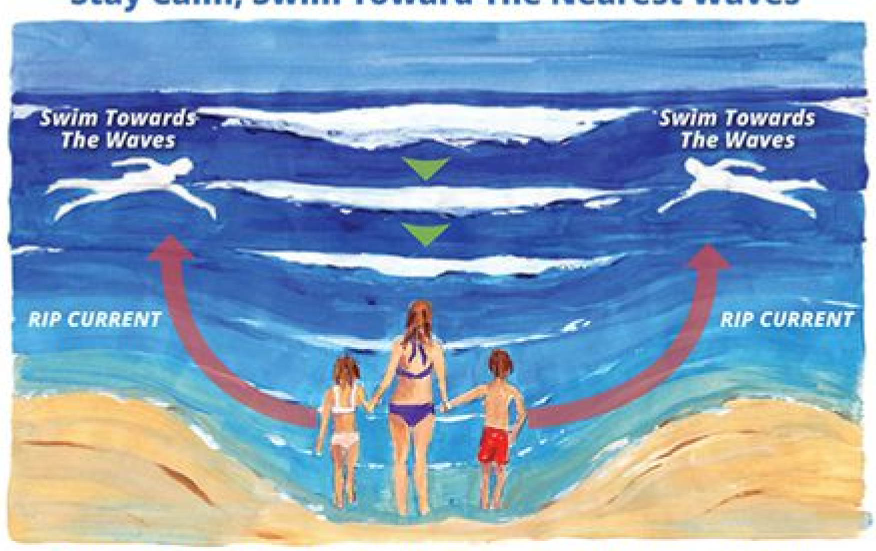
How to Escape a Rip Current (By permission from the Willis Brothers)

To escape a rip current the Willis Way, stay calm and swim toward the nearest waves. Ocean waves are nature's escalator of energy moving towards the shore. When it comes to powerful rip currents there is only one way a swimmer can make it back to shore with out the aid of a lifeguard, jet-ski or helicopter and that is to come in with the incoming waves. There is no other way. This technique specifically targets "self-rescue" when and or where lifeguard assistance is not available.

How to Avoid a Rip Current

To avoid rip currents the Willis Way, simply wade or swim in front of the waves. Rip currents are nature's escalator of energy going away from the shore and returning to the sea. Rip currents can be difficult to spot even for the most trained water safety experts. Many times inexperienced beach goers look for the calm areas were waves aren't breaking to go bathing or swimming. This is where danger can begin. While the calm water may appear to be a safe to swim it's actually where rip currents happen. Science shows out going rip currents occur along side or in-between waves. Thus, to avoid rip currents bathers need to stay in front of incoming waves. The primary concern for beginner surfers is to stay calm if they are caught in a rip, conserve energy, and simply paddle sideways with the current until they are out of its grip.

Escape a Rip Current The Willis Way
Stay Calm, Swim Toward The Nearest Waves



Ocean waves are nature's escalator of energy moving towards the shore.