Freak Waves, Tidal Waves and Tsunami

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The tsunami disaster in Papua New Guinea in 1998 initially led to a sudden intense community debate on what can be done to warn of these types of events and what could be done to minimise death and damage associated with them. This debate escalated just after the Indonesian (Aceh) event of 2004. Out of this arose an elaborate Pacific and Indian Ocean Ocean observing network and a forecasting centre based in Australia. This is operated by the Bureau of Meteorology in conjunction with Geosciences Australia. It was recently tested by the Chilean event of 27th and 28th February 2010.

Even this day and age, there is considerable confusion on what freak waves, tidal waves and tsunami actually are. It seems appropriate to look at various types of hazardous waves and see what can be done to maximise safety in their presence.

The scientific agencies that investigate these phenomena are faced with conflicting needs to avoid unnecessary jargon that baffles the public while using accurate terms so that communities that could be affected by similar disasters in the future are better prepared. There are three terms widely used (and more widely abused) when referring to a range of different naturally occurring but unusual oceanic waves. These are freak waves, tidal waves and tsunami.

Tsunamis are rare events triggered by a range of geological causes. These can be any of the following: earthquakes (typically with a magnitude of 7.0 or more on the Richter scale) that have their epicentre out to sea, underwater volcanic eruptions; underwater landslides; or, rarest of all, meteorite / comet impacts. Tsunamis typically arrive in sets of from three to eight waves. They are particularly dangerous because they travel so fast – up to 1000 km/hr across the deep open ocean, and because a tsunami is a wave that marks the sudden arrival of an increase in sea level. Yachts and ships on the open ocean will not normally notice the passing of a tsunami – unless the sea is sufficiently shallow to cause the wave to build up and possibly break. Their impact on the coast is determined to a large extent by the shape and depth of the ocean floor. Under water valleys leading towards the coast will lead to a concentration of the energy of the tsunami, particularly if it approaches in the direction of the valley. Tsunamis are most common around the Pacific rim countries, although small tsunamis have affected the Australian coast in recent decades, the most recent impacting on North West Cape in June 1994. Sydney was affected by a 1 metre tsunami in May 1960 which was generated by a major earthquake off the Chilean coastline. The wave took 17 hours to cross the Pacific Ocean – about the same time as a jumbo jet would take!!

Currently there are some methods of predicting these ominous waves but nevertheless they can rather elusive at times. These methods and sophisticated computer forecasting models are being improved all the time. Luckily they are rare phenomena that are unlikely to be encountered in most areas. There has been an international system in place that provides an alert to countries bordering the Pacific Ocean that a tsunami may have formed following a major earthquake or eruption. The Pacific Tsunami Warning Centre in Honolulu sends top priority messages to the Bureau of Meteorology/Geosciences Australia and its counterparts in countries around the Pacific, which are immediately passed on to emergency services and the media. Should you ever hear one of these alerts, the judicious thing to do is stay well away from the coastline. On the ocean the best approach is to sail out to sea over the deepest water available. Avoid any shallow and V-shaped bays or inlets. If you are on one of the south Pacific

Islands and you experience a major earthquake, head for the highest ground immediately. There may not be a tsunami generated, but if there is you will have very little time to act. You should also remember that tsunamis travel in groups of 3-8 waves and there can be anything from 15 minutes to 1 hour between successive waves. The largest wave is often the third or fourth in the series so it is wise to stay away from the coast for several hours after the first wave arrives.

Tsunamis are frequently referred to as tidal waves, or even storm surges. True tidal waves (waves generated by tides and more accurately described as tidal bores) are a daily occurrence in some parts of the world and are generated by the gravitational forces of the moon and sun. They reflect changes in sea level associated with the incoming or outgoing tide. They are found in narrow inlets in regions where there are large differences in sea level between high and low tides. One spectacular example is found in a narrow inlet along the Kimberley coast of Western Australia. A waterfall develops at the entrance to the inlet with each outgoing tide. These tidally induced features are regular and at their peak strength midway between high and low tides.

Not so benign or harmless are storm surges. Storm surges are the rise in sea level along the coast that are experienced whenever persistently strong gale, storm or hurricane force winds (typically sustained winds of 64 knots or stronger) blow onto a coastline. The largest storm surge on record in Australia occurred at Bathurst Bay when the sea level rose approximately 10 metres above its normal level during a land-falling tropical cyclone in 1899. Less dramatic storm surges have been experienced in other Australian gulfs and bays, including Geographe Bay and Exmouth Gulf in Western Australia and St Vincent's Gulf in South Australia. Much of the tropical coastline that is subject to tropical cyclone impacts have received a storm surge at some time in their recorded history. The marine community might note that storm surges are likely to see moored vessels dragged tens of metres above the normal high water mark. Also, the increase in sea level reduces the protection from large waves offered by naturally occurring fringing reefs or man-made break waters. The best protection from storm surges, which may be alluded to in tropical cyclone or storm warnings issued by the Bureau, is to go well upstream, or to moor in the lee of a significant island. Windward lagoons with fringing reefs offer little protection from major storm surges.

Next we take a look at freak waves, often caused by swell waves or a combination of sea and swell. (Sea waves are those waves of short wavelength that are formed by the wind blowing locally. Swell waves are those waves formed by a persistent wind in one area that have moved well away from their point of origin. Shorter wavelength waves decay quickly once the wind speed drops, leaving only the longer undulating waves that have become known as swell.) Waves have their origins firmly entrenched in the wind, although it may not be windy where they are observed. They are also far more common than most people would think and are not a freak occurrence. There are several common causes.

In any strong wind event, the winds generate a range of waves of varying heights, known as a wave spectrum. A typical spectrum is illustrated in Figure 1. There are a few very small waves rising to the average wave height then trailing off gradually to a few very large waves. The typical person on the water will estimate the wave height as the height of the highest third of all the waves, slightly higher than the actual average height of the waves. To use a technical

term that you may come across, this height is known as the significant wave height. There will be a small percentage twice this height – occurring only once or twice per day. These very large outliers are the ones that catch people out, whether they are rock fishing, anchored over shallow water or crossing over a shoal or sand bar. The best precaution is to be aware of their existence and make an allowance for these larger waves when crossing shallow waters or operating near rocks. You must also remember that tidal changes can alter the bottom depth quickly so that a given wave height that is harmless one hour could break in the same location an hour later.

Another cause of freak waves is the combination of waves from two different sources. The effects are most dramatic when assisted by an island or an underwater feature such as a shoal or reef. As an illustration, assume you are sailing to the east of Bass Strait. It would be common to have one wave train moving eastward out of the Strait and another northward from the southern Tasman Sea. The waves from these two different sources will add together to form a complex wave pattern. Remember that both wave trains will have their own range of big and small waves. When a large wave from each train coincides, a “freak” wave will be generated. These waves will be very hard to pick in advance, as they will not come from the direction of either of the wave trains. They will appear to approach from a direction midway between the two. In the case just given, this will be from the southwest. Be particularly careful when crossing waters that are the junction of two large seas.

Waves opposing a strong, narrow ocean current will also form much steeper faces than normal. Examples of this would include waves formed by: a southerly wind in the middle of the East Australian current; a southerly or southwesterly wind opposing the Leeuwin current off the Western Australian coast (remember that the sea breeze off the WA west coast tends to be a south to southwesterly); or a south westerly wind against the Agulhas Current which sets south off the South African coastline. If you encounter this situation, the steepest waves will generally be in the strongest part of the current. The best option is to sail at a sharp angle out of the current.

The final type of freak wave is even more difficult to predict. If there are seabed valleys in shallower parts of the continental shelf that converge as they approach land, they will cause approaching wave fronts to be concentrated at these locations. The extent to which this happens depends on the combination of the water depth, the wavelength (distance from one wave crest to the next) and the angle that the waves are approaching the coast. If in unknown waters near the coast it is safest to remain over deeper waters.

Now that some of the mystery has been removed from these ogres of the oceans, you can enjoy your next sailing venture without unnecessary worry.