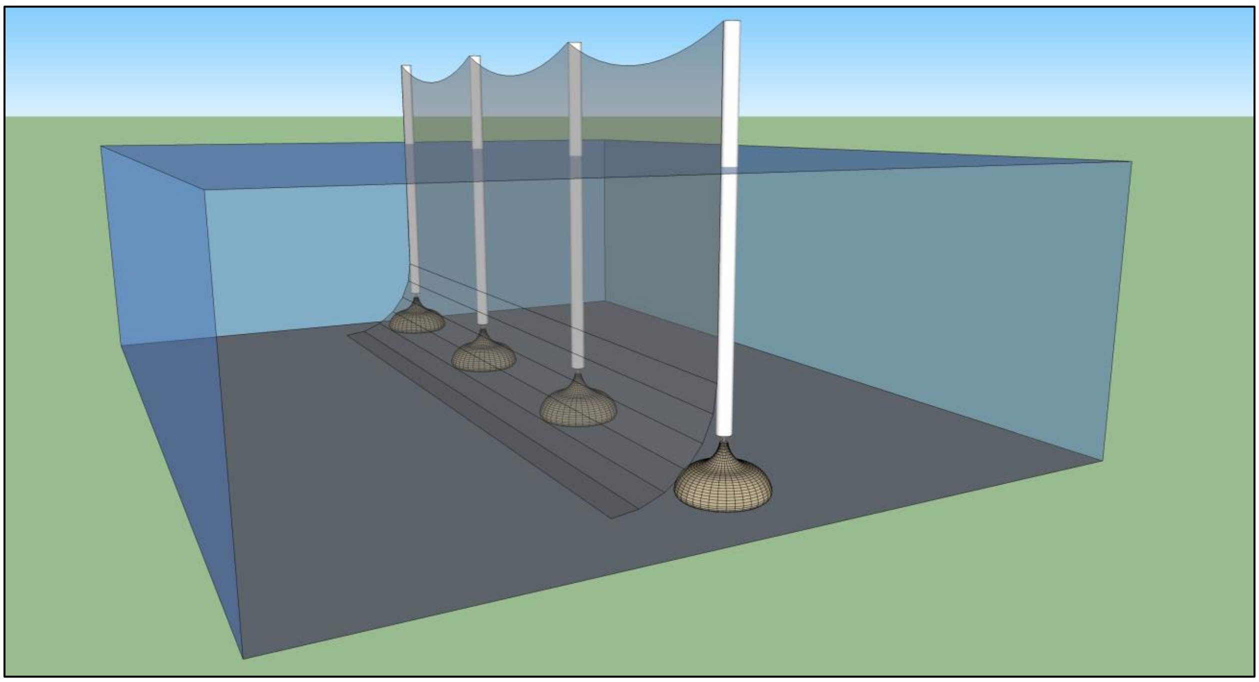
Shark-proof enclosure for surf breaks

Submission to the Senate Standing Committee

inquiry into shark mitigation and deterrent measures.



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I am a surfboard maker, having made boards for several world champions over the last 25 years, and a designer of other products and systems in the surfing realm. I am the majority shareholder of the wave pool company *Liquid Time Pty Ltd*., which received a grant from the *Australian Research Council* to develop the method of making surfing waves using Kelvin Wakes.

It is obvious that there is a need to separate human activity at beaches from the presence of sharks. Concerns over the wellbeing of sharks or mammals that might become caught in shark nets has effectively blocked our capacity to protect the public and so this net system is designed to adapt to the varying conditions of tide, swell and wind, and also cause no injury or death to any shark or sea mammal.

This net system is not designed to catch sharks but completely block them from swimming into the beach area.

Common netting systems that are used to enclose swimming areas are not viable for the open beaches. These nets are held in place with a weighted lower edge, often by steel chain, and one or more anchored points external to the netted area. The upper edge of the net is attached to a string of floating elements or a continuous air filled tube or boom, in order to keep the net suspended from water level to sea bed. Tidal movements are accounted for by using enough net material in the vertical plane at high tide, which then merely goes slack and hangs to the sides when the tide is at its lowest.

When this standard net boom approach is considered for open ocean environments the combination of wave action and onshore winds would undermine the efficiency of the system since the slack in the net would be taken up as the floating elements are pushed by wind and chop towards shore. The net would be taught and angled to its limit, the floats being nearer to shore with the weights being further out to sea. Larger waves could then crest and spill over the top of the net, thereby allowing sea creatures that might be on the tops of waves to enter the netted area.

PARTIALLY SUBMERGED BUOYANT POLE SHARK NET

This alternate method does not place the floating elements on the water surface but within and above the water. The netting is held firm with the sea bed by chain, the buoyant poles are held in position by sand filled geo-textile bags, and the poles and netting extends above water level being attached to the poles throughout their entire lengths. This means that no matter how the net is influenced by wind and waves it can be angled to a high degree and still have netting above the water level. The strong buoyancy of the hollow and sealed poles keep tension on the entire system, allowing for a small degree of movement with those forces. This system is neither at the mercy of these forces nor is it trying to totally defy these forces. It bends just to the degree that is necessary, in order to allow the water movements to pass through the net system.

KEY FUNCTIONAL DESIGN CONSIDERATIONS

1) The ratio between the submerged part of the poles and the part that extends above water level should not get below 1/1. In other words the design will function best with more than half the pole under water. Any force acting upon the tops of the poles from the crest of crashing waves when onshore winds are strong, will be resisted to a high degree by the lower portions of the poles that will naturally have high drag since the lower parts of the wave have much less actual physical water movement. This dynamic will keep the poles substantially upright with the waves passing through with the netting with little effect on the whole structure..
2) The upwards force due to the buoyancy of each air filled pole needs to be less than half the relative mass of each sand bag that they are fixed to, or the whole net system could be moved too easily by wave action. The mass of sand is 1.52 tonnes per cubic metre and water is 1 tonne per cubic metre so the relative mass of the sand bag under water is about 0.5 tonnes per cubic meter. The buoyancy of the poles is about 1 tonne per cubic meter of air inside the poles below sea level, and so a ratio of 6 cubic metres of sand per 1 cubic meter of pole buoyancy is ideal. 6 cubic metres of sand above water weighs 9 tonnes but has a relative weight of 3 tonnes underwater and so the bag will have a mass about triple that of the buoyancy of the pole and so would be stable due to this differential. Higher proportions of sand could also be used.
3) Net material with a mesh size of less than 5cm is desired so that no large sea creatures could get entangled within the net. Stiffening elements can be attached to the net transversely between the buoyant poles to further limit the sag that could happen as larger creature bump into the net structure. In addition small reflective discs could be attached to the net in sufficient number to add to the physical presence of the net so that sea creatures will sense the entire surface as an obstacle and thereby avoid running into it.

Note: Non critical functional aspects to consider would be the placement of solar panels and batteries, on top of each pole to power signal lights for shipping and boating purposes. Submerged video cameras could also be powered by the same means, so that the nets can be monitored for damage or to assess how sea creatures are relating to the structure to allay the fears of any who might be concerned for the wellbeing of any sea creature that might encounter the net system.

CONSTRUCTION AND INSTALLATION

Materials:

The entire system can be made with 4 off the shelf components.

(1) Poles: Poles can be made from PVC storm water piping with capped ends.

(2) Netting: There is an almost infinite range in netting.

(3) Sand bags: Geotextile bags have been used for decades in the marine environment.

(4) Chain: Stainless steel chain is standard in floating boom structures used for a variety of functions.

Method:

PVC piping can be end capped and thereby water tight, using standard chemical welding. A series of polypropylene or stainless steel belts would be attached to the poles onto which a linear belt would be sewn or attached using industrial methods. This linear belt would run the entire length of each pole. The netting would then be sewn into each linear belt. Or if required eyelets could be placed within the linear strip and stainless rings used to attach the net to the belt. The lower end of the poles would be inserted into a sleeve which would be glued onto the outer surface of the pole. Belts around the outside of the sleeve would add to the securing method. There are a myriad of ways of attaching net to pole and pole to sand bag, these are just some obvious methods.

Installation:

Option 1. The entire system is made on land and floated into place on one or more barges. The advantage of option 1 is faster deployment.

Option 2. The entire system barring the sand filled bags is made on land and when in position the bags are filled onsite by the use of a dredge. The advantage of option 2 is that the mass of the system is vastly lower with unfilled bags.

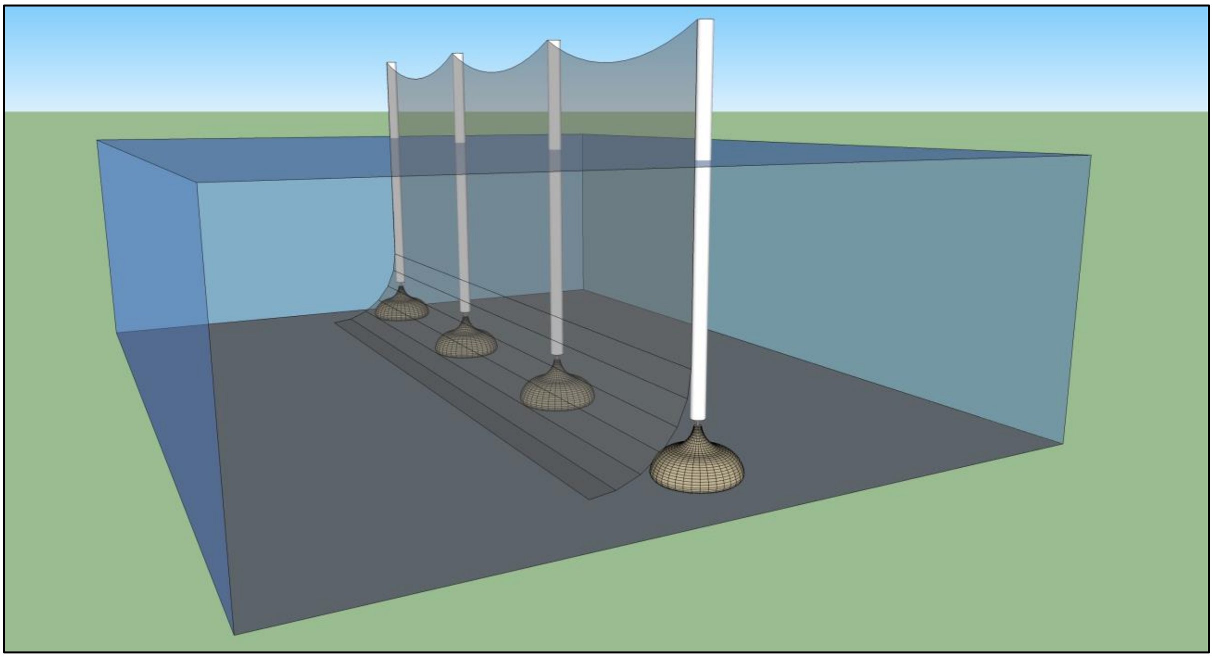


Figure 1. Netting above water level allows for tidal variations. Low water resistance from the buoyant poles and netting allow wave energy to pass through the net and support structure with minimal deflection of structure.

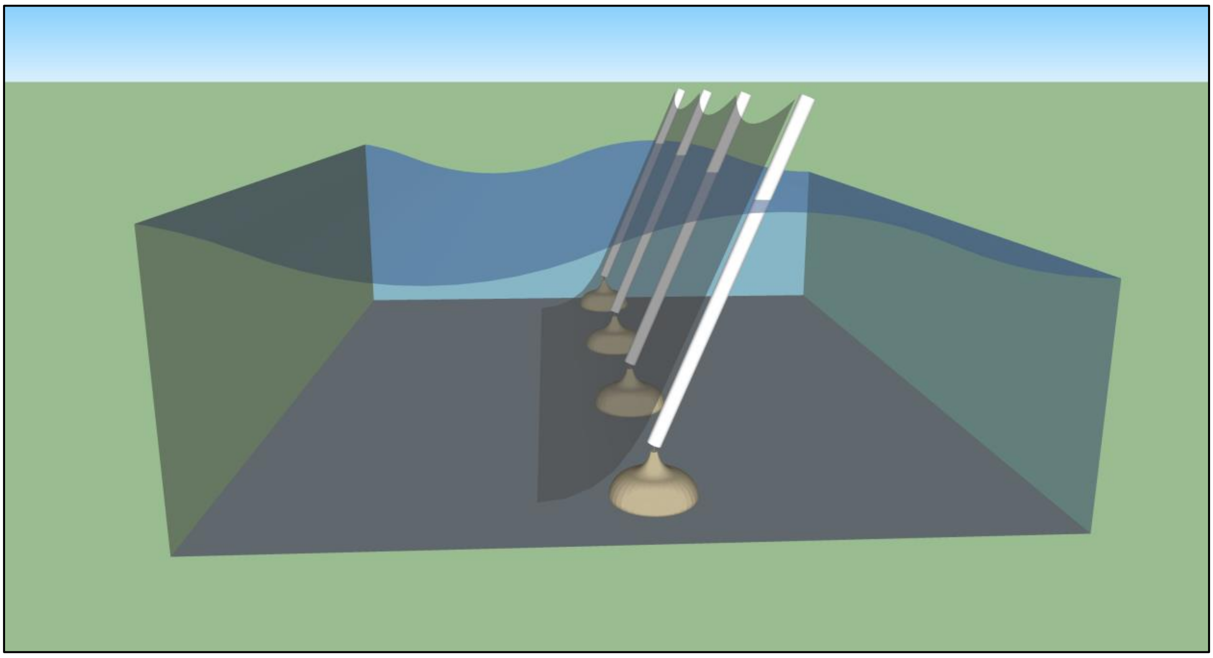
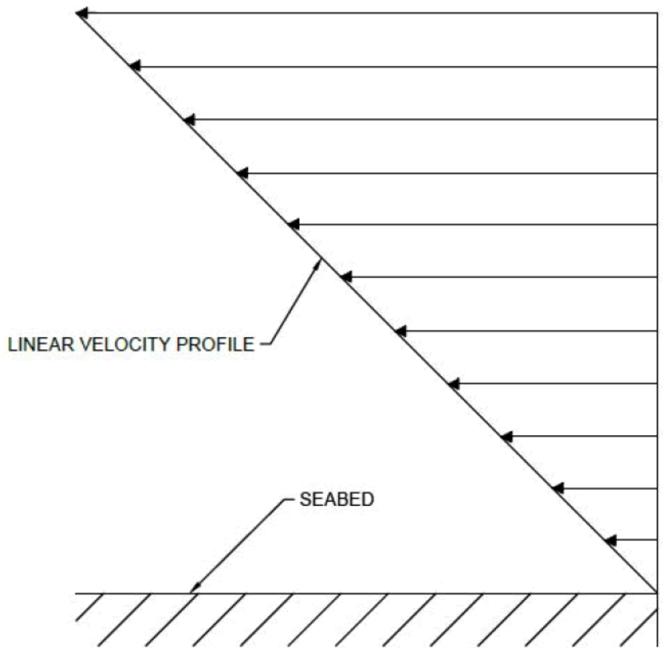


Figure 2. As the structure tilts back and forth due to larger swells, the drag decreases as the angle increases, so that it will not tilt over to the point that the net passes underwater. The submerged portions of the poles resist any force applied to the upper parts of the poles.

Shark Net Force Balance

A simple force balance was conducted with 500 metres of net leaning over at an angle of 30° from vertical in a mean water depth of 12m to determine the buoyancy force and therefore size of upright pipes to counter the drag force on the net and upright pipes. The tide range was estimated to be 2 metres; 1 metre above the mean waterline at high tide and 1 metre below the mean waterline at low tide.

The velocity profile of the water passing through the net was assumed to be linear as illustrated below, with the minimum velocity of 0 m/s occurring at the seabed and the maximum velocity occurring at the water surface. Integrating this velocity profile over the water depth equates to a resultant velocity equal to half the maximum velocity acting at two thirds of the water depth.



Following shallow water wave theory, wave velocity is purely a function of water depth as shown in the equation below, where C is wave velocity and h is water depth. A water depth of 13 metres (high tide) yields a wave velocity of 5.65 m/s whilst a water depth of 11 metres yields a wave velocity of 5.19 m/s.

The drag and buoyancy forces were calculated assuming a drag coefficient of 0.47 for the pipes and netting (which is common for circular profiles) and a seawater density of 1025 kg/m3. The buoyancy force was assumed to act at the centroid of the submerged pipe. The moment created by the buoyancy force from each pipe acting at the centroid was compared against the moment created by the drag force acting at two thirds of the water depth above the seabed. In the low tide case, the moment from the buoyancy force came to 42162 kN and the moment from the drag force came to 24803 kN. In the high tide case, the moment from the buoyancy force came to 60909 kN and the moment from the drag force came to 41557 kN. It is clear in both the high tide and low tide cases that the buoyancy moment is much greater than the moment from the drag, which means that the net and vertical supports will be leaning at an angle of much less than 30° from vertical. It is also evident that in the hypothetical case where the net does achieve an angle of 30 degrees from vertical, the restoring moment created by the buoyancy of the net is much greater than the drag moment which means that the net will spring back to a resting position of much less than 30°.