To lay me down

The best place to sit out seasickness

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Leaving aside the old adage that the best place to overcome seasickness is to sit under a tree, where is the best place to put a seasick crew member? Seasickness is caused by many factors and every person responds differently to each factor. Ventilation, odours, warmth and ease of access are all significant elements when deciding where best to place a seasick person, but one of the most important, yet least understood, is where the point of least motions is. Lateral movement can cause seasickness, but the most influential movement is usually vertical acceleration. There are three types of motion that create vertical movement:

- Roll motion - rotation from side to side
- Heave motion - up and down
- Pitch motion – rotation fore and aft

Rolling

When the yacht is rolling, if you are on the centreline there is no up and down acceleration; you only feel the rotational movement. However, if you are on the side deck or in a berth well outboard, you will experience quite a lot of vertical acceleration due to rolling. Roll motion is usually greatest when sailing downwind, so an outboard berth is perhaps not the best option for a seasick crew in these conditions. The cabin floor can become a preferred option.

Pitching and heaving

Pitching and heaving have to be considered together, as we shall see in a minute. Heaving is the simple up-and-down motion caused by the wave, with no rotation involved. Heave motion occurs at all points of sail and it is of the same magnitude everywhere on the boat (Figure 1). You might therefore think that it plays no part in finding the place of least motion, but you would be wrong. To explain why, we first need to look at pitch motion.
As a wave approaches the boat the bow starts to lift and the stern starts to drop. This is the rotation due to pitching motion. The acceleration will be upwards at the bow but downwards at the stern (Figure 2). Because a boat pitches about a point just slightly aft of amidships (see side bar), there is slightly more upward motion at the bow than there is downward motion at the stern. You might then think that the best place to put a seasick person when pitching into waves is at the pitch point just aft of amidships. On a typical production cruiser this is usually at the bulkhead between the galley/nav area and the main saloon. However, you would be wrong; this is where heave motion comes into play. As the boat pitches it also heaves, and the total vertical motion is the combination of the two individual motions. If the boat heaves upward as the bow pitches upward, the vertical heave motion will add to the upward vertical motion at the bow due to pitch, but it will subtract from the downward motion at the stern due to pitch (Figure 3). If, on the other hand the boat is heaving downwards as the bow pitches up, the opposite occurs i.e. the vertical motion at the bow is reduced by the heave motion and increased at the stern. So in order to find the point of least motion we need to know not only the magnitude of each motion, but

also when in time each motion occurs relative to the other. In naval architecture speak this is the "phase angle" between the two motions (those with a background in engineering might recognise the term). The only way to calculate the phase angle between heave and pitch is to carry out complex seakeeping calculations, rarely done for sailing yachts. To further complicate matters, the phase angle changes as the period (length) of the wave changes. Fortunately we can make some simplifications and generalisations. The result is that, when the motion is most severe, the bow is going up at roughly the same time as the heave motion is upward. This means there is much less vertical motion at the stern than there is at the bow. The net result is the point of least motion is quite a bit aft of the pitch pivot point. On a typical cruising boat it is just behind the bulkhead dividing the cockpit from the cabin. If you do not believe the theoretical explanation above, observe for yourself a yacht sailing to windward in waves. Have a look at where it *seems to be* pitching about; you will be observing the point of least motion and the chances are it is somewhere near the forward end of the cockpit. So when sailing to windward, a good place to put a seasick person is near the forward end of the cockpit, or down below in an aft cabin berth.

Catamarans

A brief note on catamarans; they are different! The phase angle between pitch and heave is different, so the point of least motion is usually further forward, quite close to amidships. Therefore, when a catamaran is pitching into waves a berth well forward of the cockpit has least motion – perhaps at the front of the main saloon? (Figure 5)

The vertical accelerations in a catamaran tend to occur at a higher frequency (a quicker motion), which alters their influence on seasickness – usually, but not always, it reduces susceptibility This advantage of less seasickness from the vertical motion is offset by the lateral accelerations being more rapid and severe than on a monohull (the "train ride effect"). So they come into play more strongly than on a monohull when considering seasickness. The lateral motions are more or less the same wherever you lie down on a boat, so there is no strategy available for minimising them.

The rolling motion on a catamaran is also very different, but the general aim of avoiding outboard berths still applies; near the centreline in the main saloon again looks promising.

Conclusions

From the perspective of placing a seasick crew where the motion is least, for a monohull a berth under the cockpit is a good option when sailing to windward, provided it has good ventilation. When rolling downwind a berth close to the centreline is good. Overall, if on deck a secure location at the forward end of the cockpit is often best. For catamarans the best option might be to lie down at the forward end of the saloon. And for all types of vessel if all else fails, sit under a tree….

Pitch pivot; the three centres of motion

Great debate rages in naval architecture about where a boat pivots when pitching. This is because there are three forces acting, each with its own point of action.

Gravity

The centre of gravity is probably the easiest point to imagine. It is the point through which the weight of the boat acts. Every object has a centre of gravity and you can find it very easily, right now… take a pencil or pen and try to balance it across a finger so that it does not fall off. The point you are supporting it at when it is balanced is directly under the centre of gravity. The principle is the same for a boat; imagine taking the boat out of the water and chocking it up on just one narrow block of timber (don't try this!). When the timber is in just the right place for the boat to sit precariously in level trim on top of it, the centre of gravity is directly above the chock. Clearly this is not a practical way of finding the centre of gravity, so yacht designers adopt another approach whereby they estimate the mass of every item on the boat (including the hull, keel, engine, etc.) and their location, then take a weighted average. It is a tedious process and one that is prone to error, which is why some boats do not float horizontally when launched – the designer's estimated position is a bit out. It is important to recognise that the centre of gravity of the yacht does not change whether the boat is ashore or afloat; it has nothing to do with the water.

So the weight of the boat acts downwards at the centre of gravity. Weight is the first of the three important forces.

Buoyancy

Now let us put the boat back in the water, but only for a moment. Imagine the boat is not in normal water, but some kind of gloopy stuff (sand maybe?). Pull the boat out of the sand/water and look at the shape and size of the hole that has been left in the gloop/water. This shape will have its own "centre of gravity". It is not the centre of gravity of the boat because that is a characteristic of the entire boat, not of the shape we have just created. What we have here is the centroid of the water displaced by the boat. It is called the centre of buoyancy because it is the point at which the upward buoyancy force acts (Archimedes' principle etc.). Buoyancy is the second of the three important forces.

Change of buoyancy

This last one is a bit different. Consider a boat sitting happily in its pen with the crew all standing at the longitudinal centre of buoyancy. What happens if they all move to the bow? The boat trims down by the bow and up by the stern (trim is just the word used for pitch when the boat is not bouncing around). So there is a wedge of extra buoyancy added in the forward part of the boat, and a wedge of buoyancy removed from the aft part of the boat (Figure 4). The two wedges must be equal and opposite in volume because we have not changed the weight or displaced volume of the boat, merely shifted it around. However, the forward wedge is long and slender whereas the aft wedge is short and fat. The point where the two wedges join will therefore be the pivot point for trim. Surprisingly it is not at either the centre of buoyancy or the centre of gravity. Imagine taking a chainsaw to your boat and hacking it off exactly at the waterline (again, do not try this!). Now look down at the resulting shape; it will have its own centre. Because most boats are fatter aft at the waterline than they are lower down the hull, this centroid will usually be a bit further aft of the centre of buoyancy (the centre of buoyancy can be thought of as the weighted average of the centroids of lots of shapes generated by lots of such horizontal chainsaw cuts, each at increasing depth below the flotation waterline). This third centroid is called the centre of flotation, and it is the point about which *changes* in buoyancy due to trim or pitch will act.

Putting it all together

When considering the motion of a boat there are three forces – weight, buoyancy and change of buoyancy - each with their own centre of rotation – centre of gravity, centre of buoyancy and centre of flotation. To put a bit of the real world into this explanation, the centre of gravity and centre of buoyancy are each typically about 3 % of waterline length aft of amidships, and the centre of flotation is perhaps 6% aft of amidships. For a 10m waterline boat this puts the centre of flotation about 0.3m aft of the other two centres. The pivot point will be some kind of weighted average of the three positions, depending how much of each force is acting at any particular instant. It follows that the pivot point will change position as the boat passes over the wave. And we haven't even begun to consider where the wave forces act on the boat! Even if you are able to work all that out, it is still only the pitch pivot point, not the point of least motion.

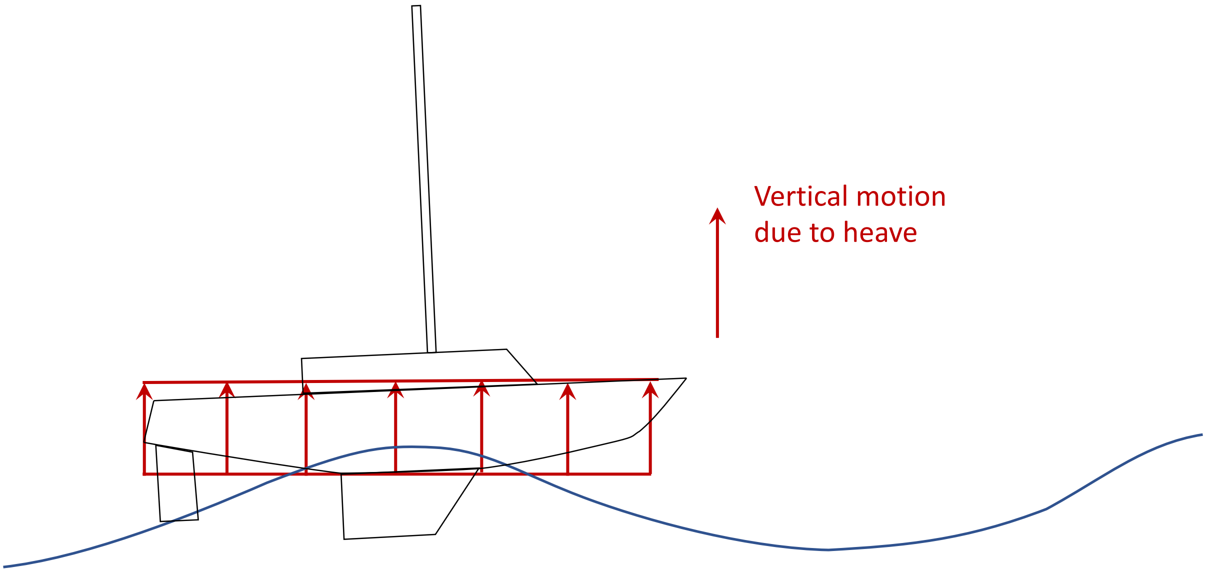

Figure 1 Heaving motion

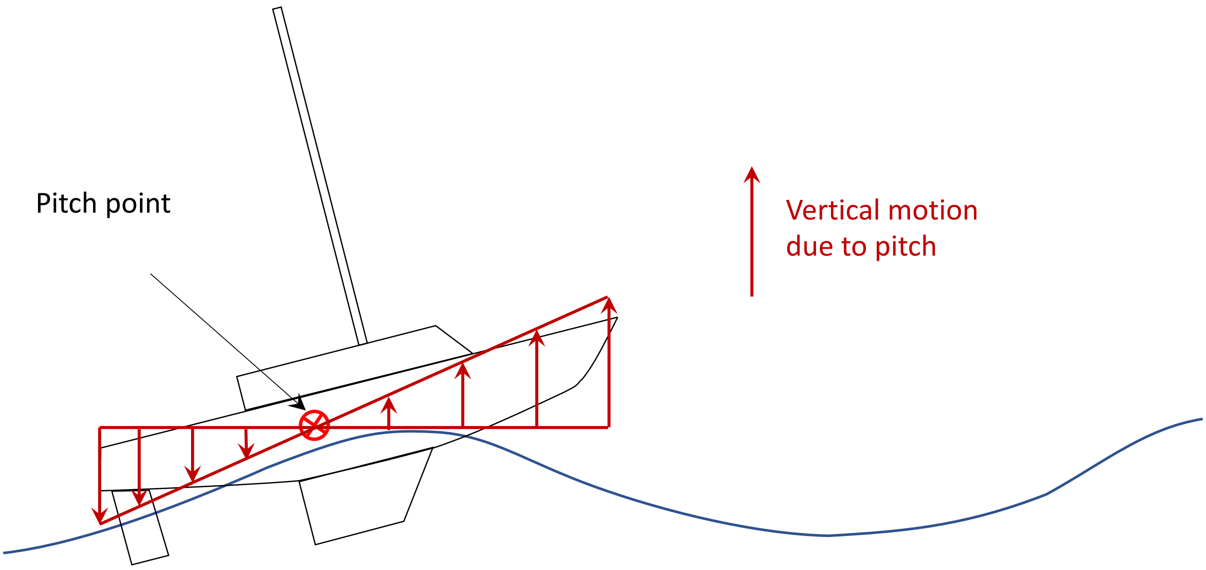

Figure 2 Pitching motion

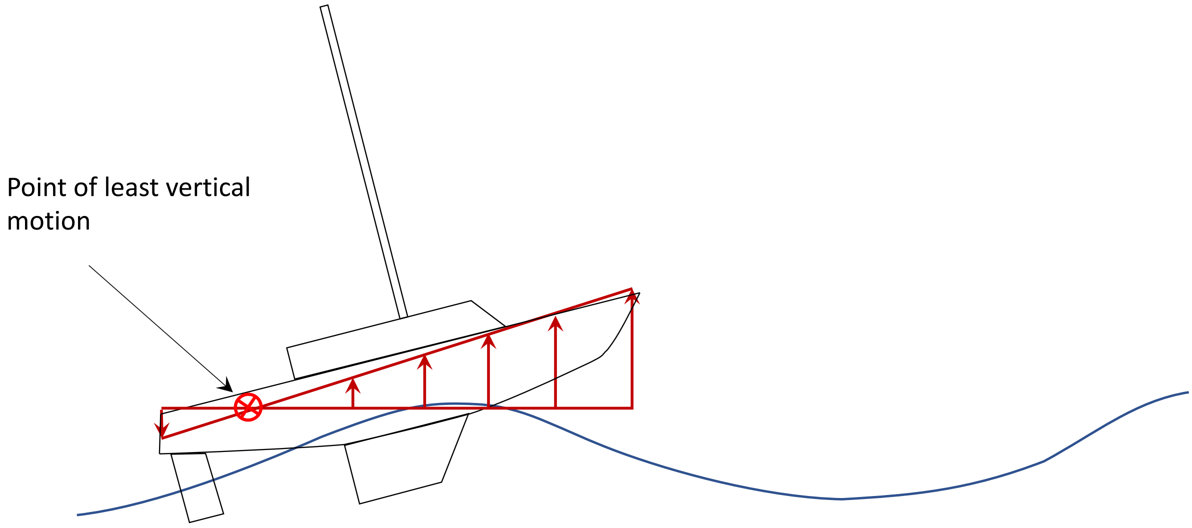

Figure 3 Motion due to pitch and heave combined

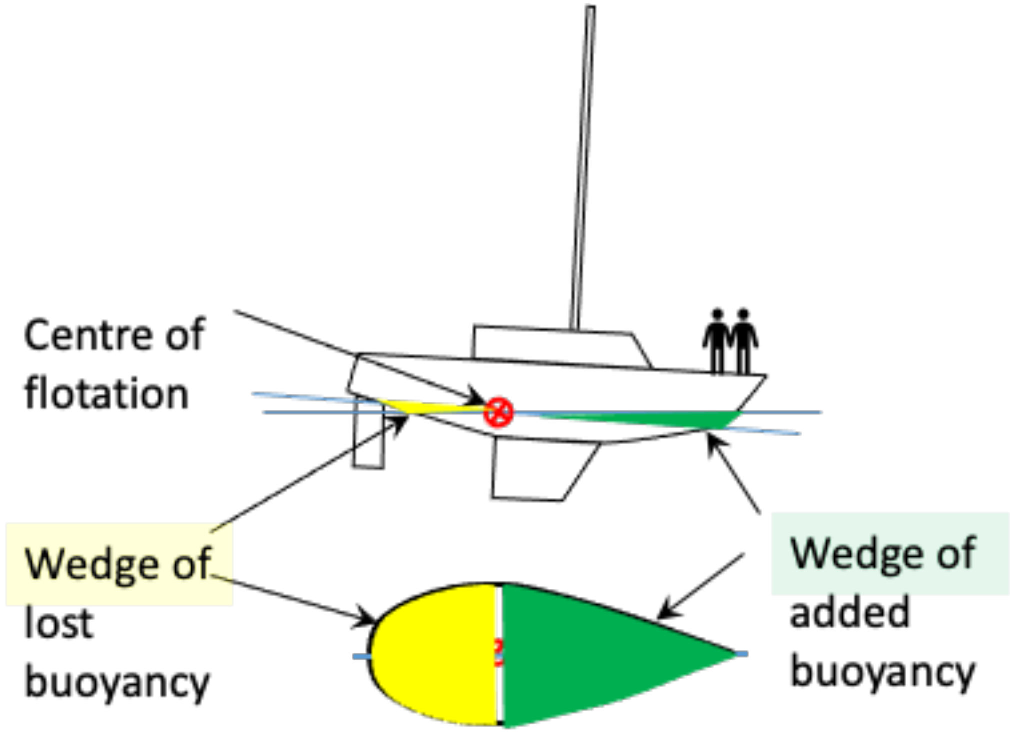

Figure 4 Centre of flotation

Figure 5 The main saloon may be the best place on a catamaran