Chines: fashion, form or function?

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We have probably all read the claims about why chines are so good. Some claims are true, others have elements of truth, and some are just marketing words.
There is little doubt that chines can work well on a modern high performance racing yacht. For a given beam (often controlled by a handicap rule), the chine adds stability and hence sail-carrying power, and the associated flat under-surface makes planing a lot easier to initiate. However, cruising boats are not restricted by handicap rules and almost all of them are too heavy to plane (as distinct from just surfing down waves momentarily). So why do they appear on cruising boats? Is it just fashion or are there some genuine benefits? Is it the chine itself that generates those benefits, or is it some less obvious knock-on effect?

What is a chine?

The technical description of a chine is a bit convoluted; it is a discontinuity in the rate of change of curvature of the section shape. In other words, if you look at the boat from astern, you will see a kink in the shape somewhere between the keel and the deck.
There are really two different sorts of chines: those that run the full length of the boat as often seen in steel or plywood boats; and those which tend to start above-water around amidships and run through to the transom. The latter is the more modern version (or perhaps not, see later in this article), seen on many production cruisers these days.
The opposite of a chine shape is a round bilge shape, where the hull is a smooth continuous curve from the deck edge down to the centerline.

Comparing apples with apples – the naval architect's dilemma

In order to assess the validity of the claims made about chines, we have to take a few steps back and identify just what is being changed when comparing a chined section to a round bilge section. The problem with comparing a chine boat with a round bilge one is that so many parameters can change at the same time that you do not know which ones are the cause of any resulting performance or space change. This is a dilemma faced by naval architects in almost all facets of hull shape.
What exactly are we varying? Consider figure 1 which is a section near the transom. The round bilge shape is the solid blue line. We can compare it with a chine hull of at least two different shapes. The dotted black line keeps the same angle of deadrise, resulting in a very low chine; or the chain dotted red line results in an increase in deadrise and a higher chine.
You can also look at the problem the other way round, by comparing a particular chine shape with two different round bilge shapes, as in figure 2. Each of these shapes has different stability and performance characteristics, and also different internal volume. So it depends on which chine shape you are comparing the round bilge hull to.
Those initial examples in figures 1 and 2 consider only changes near the transom, and already the question has become quite difficult to pin down. Most modern chines continue forward to about amidships so we also need to consider a section somewhere near, say, the forward end of the cockpit (figure 3). The way we draw the chine here not only affects the chine height as it did at the transom, but now it also changes the waterline beam and the underwater volume of the hull. If the chine does change performance, is it due to the change in volume, the change in waterline beam, or just the introduction of the sharp

corner of the chine? It's getting even more complicated, and I have not yet mentioned multihulls! Deciding what shapes to compare is one reason why the pros and cons of chines are not clear-cut. I am going to present the analysis for one comparison: the higher chine v the round bilge of figure 1, redrawn in figure 4 for clarity. I have gone through the same analysis for the other shape variations, but in order to keep this article down to a publishable size I will present just the findings.

Design analysis

The chine in figure 4 has introduced volume outboard and low down, but the upright underwater shape has not been changed much. Let's consider how these changes affect the design attributes. I give a brief explanation of the effect, then give the low chine a score from -5 (worse) to +5 (better), compared with the round bilge shape.

Upright stability.

Stability when upright does not affect performance but it does affect the tippiness in light winds and the tendency to roll at anchor. For very small heel angles the upright stability of the chine boat is the same as the round bilge boat, so it gets a score of 0.

Windward stability

As the boat heels over the chine starts to immerse, generating more righting moment (due to the centre of buoyancy shifting further outboard) and hence more power to carry sail. The low chine scores well on this, I'll give it +3.

Speed

This is a really difficult one to quantify as a single entity, as there will be changes to speed in light airs, heavy airs, upwind and downwind. Most of the effects of a chine are felt on upwind and reaching legs, so the guiding factor is power to carry sail (windward stability). This is tempered by any increase in underwater surface area, which increases friction drag and reduces speed in light airs. I am assuming the chine is not accompanied by a change in underwater volume (hence boat weight). The chine itself can slow the boat down if it is not aligned to the water flow, causing extra turbulence and hence a lot more drag. It is difficult for a designer to work out the direction of water flow at the chine. Experience is a big help provided it is backed up by some kind of measurement. Computational Fluid Dynamics (CFD) can provide guidance in the right hands, but the best measure is probably model towing tank tests using wool tufts or dye streaks. Very few cruising yacht designs undergo towing tank tests. On the basis that the low chine gives more upwind power but more heeled surface area I will score it +1.

Tracking upwind

This is a a very complicated, multi-faceted aspect of boat performance, but some insight can be gained by a simple analogy with an arrow. The feathers on an arrow are at the back in order to make it go in a straight line (try throwing a dart feathers-first and it will turn round in flight until the feathers are at the back). Profile area at the back of a boat has the same effect e.g. if you add a skeg it will help make the boat track in a straight line like an arrow. A chine, when heled over, acts a bit like a long, shallow skeg, helping to keep the boat on track. Don't take the arrow analogy any further, it only works up to a point (pardon the pun). So the low chine should improve tracking; score +2.

Balance

Balance is the tendency toward weather (or lee) helm. It is related to, but different from the amount of effort required at the tiller or wheel. As with tracking, this is a multi-faceted topic for which the science is still playing catchup with the art. As a general guide, a boat with a very narrow forebody but a very wide aft body will be difficult to balance; and a shape which changes that relationship with heel angle will be even more difficult to balance. Having a chine sticking out in the aft part of the boat will tend to create imbalance if not executed carefully, though the improved capacity to fit twin rudders on the chine shape may help address some of the imbalance. So lots of "if"s and "but"s in that analysis, but the chine shape is probably more difficult to balance; I'll give it -2.

Room in the aft cabin

The chine gives you a bit more room, the question is whether that room is useful. If it enables you to put a wider berth in, that is useful. If it just gives you a sliver of extra volume under the cockpit, it's not much of a gain in the overall scheme of things. This low chine gives a bit more beam where the berth top might be, depending on the size of boat etc. Score +2.

Cockpit area

The cockpit area tends to be determined by beam at the deck unless there is a very rapid decrease in beam at the floor level. This shape doesn't affect cockpit volume much unless the floor is very low, so a score of +1.

Hull volume

This is really the same analysis as for aft cabin and cockpit, extended through to amidships. The chine will probably add useful above-water hull volume right through to the main cabin, so score +3.

Wave slap

Wave slap is the loud thumping sound in the aft cabin when the waves are coming from behind the boat – usually when it is either moored alongside or when at anchor with waves and wind (or tide) in opposite directions. Very little research has been done on wave slap (none that I can find). An investigation of the scientific literature on the physics of hull slamming and underwater acoustics suggests that the slapping increases as the angle of the hull to the water decreases, and also as the amount of section curvature decreases. This is also what seems intuitively correct. So the low chine is bad news for wave slap – the angle to the water is the same but it presents a wider, flatter area. Score -3.

Findings

If we add up all the scores given above, we end up with an answer to the question: is the low chine better or worse than the round bilge shape? I have done this for all the shapes compared in figures 1 and 2, the results being presented in Table 1. Be very wary of the conclusions for two reasons:

- Firstly, as I have tried to point out, there are lots assumptions and approximations made in the analysis. If you are looking at a specific hull, it would be wise to re-examine the analysis for that individual design shape.
- Secondly, and perhaps more significantly, adding up the individual scores assumes that every design attribute is equally important. This is clearly not the case; the relative importance is a fairly subjective matter. For example, many cruisers might

consider wave slap to be more important than speed. These two attributes can bring out the worst and the best in chines, so their weighting is critical to the overall finding.

Look at table 1, but don't say you haven't been warned!

attribute	**Figure 1 high chine (red chain)**	**Figure 1 low chine (black dotted)**	**Figure 2 high bilge (blue solid)**	**Figure 2 low bilge (black chain)**
Upright stability	-2	0	0	+3
Windward stability	+2	+3	-1	-1
Speed	+2	+1	0	-2
Tracking upwind	+1	+2	-1	-3
Balance	0	-2	+1	-3
Aft cabin room	-3	+2	-1	+3
Cockpit room	-2	+1	-1	+3
Hull volume	-3	+3	-1	+3
Wave slap	0	-3	+1	0
totals	**-5**	**+7**	**-3**	**+3**

Table 1: Rating of different section shapes

Conclusions

The findings suggest that a low chine is good, but a low bilge is also quite good. It also suggests that a high chine is bad, and a high bilge is also quite bad. In other words, it is not the chine itself that is creating the differences, it is the height of the turn of the bilge. What we can perhaps imply is that it is easier to draw an efficient low turn of the bilge if there is a chine.

Nothing is new

Whilst the subject of chines is topical, they are certainly not a recent phenomenon. The half-length chine of today's yachts didn't really appear until 10 or so years ago. Or did it? Figures 5 and 6 are photos taken nearly 40 years ago, showing glass fibre racing yachts with a half-length chine. They happen to be model yachts, designed by professional model yacht sailor Graham Bantock. They were very fast, putting me in the top 10 of the world championships in my first and only season of model yacht racing. It just goes to show there is nothing new in yacht design, just old ideas applied to new situations.

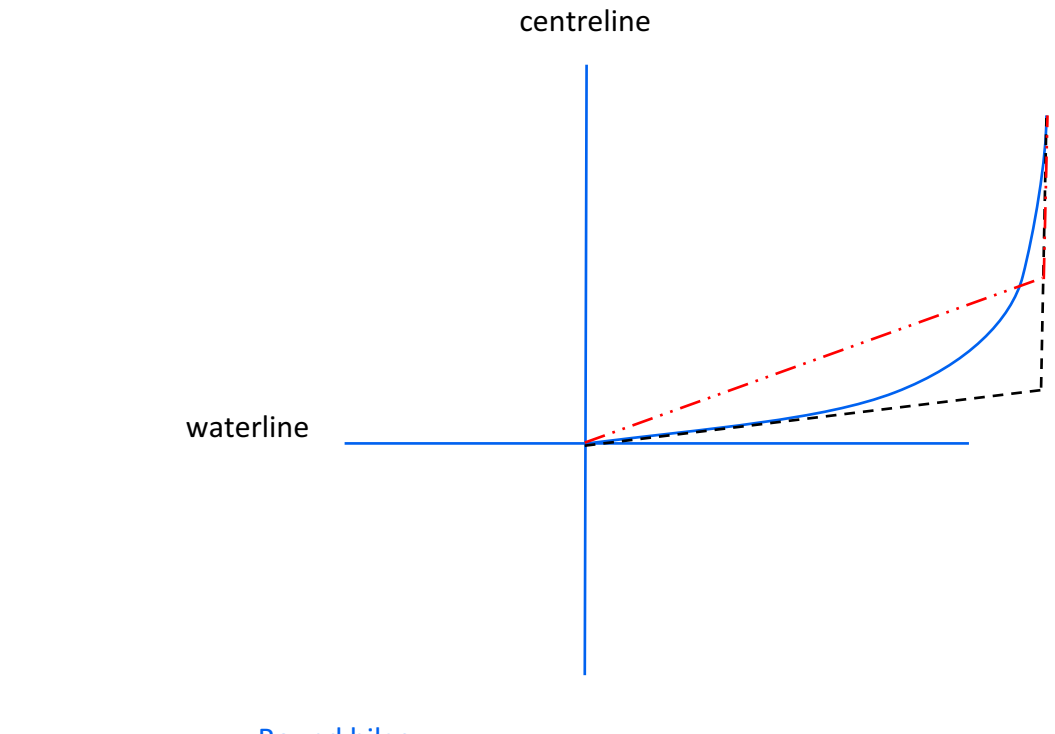

Figure 1

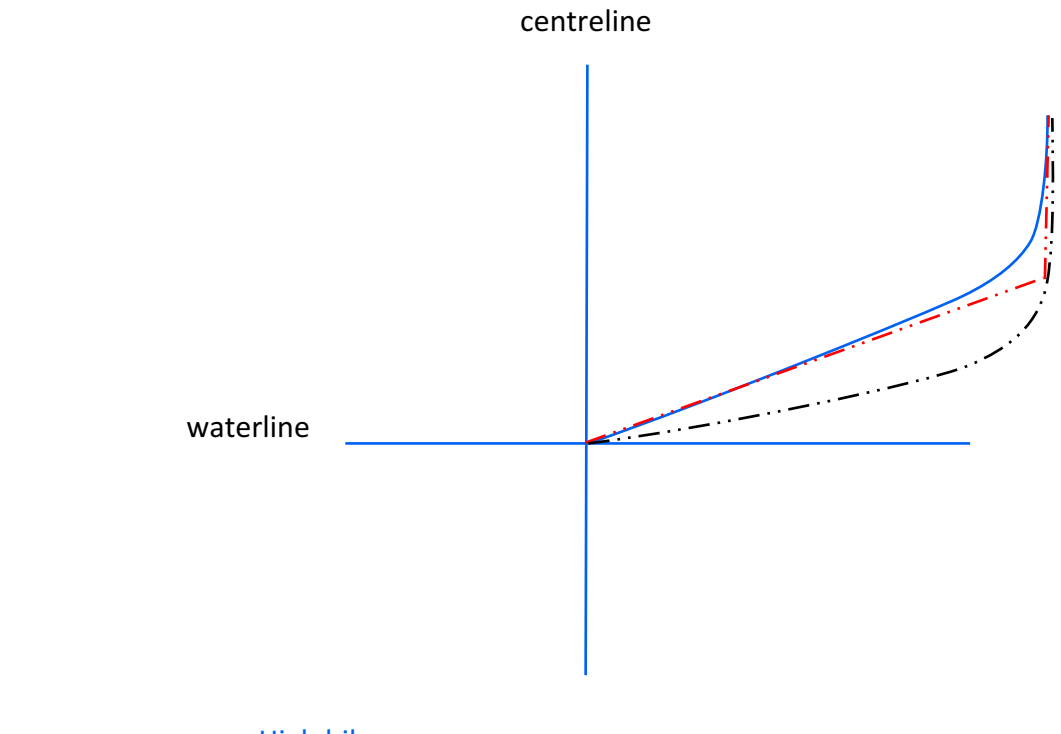

Figure 2

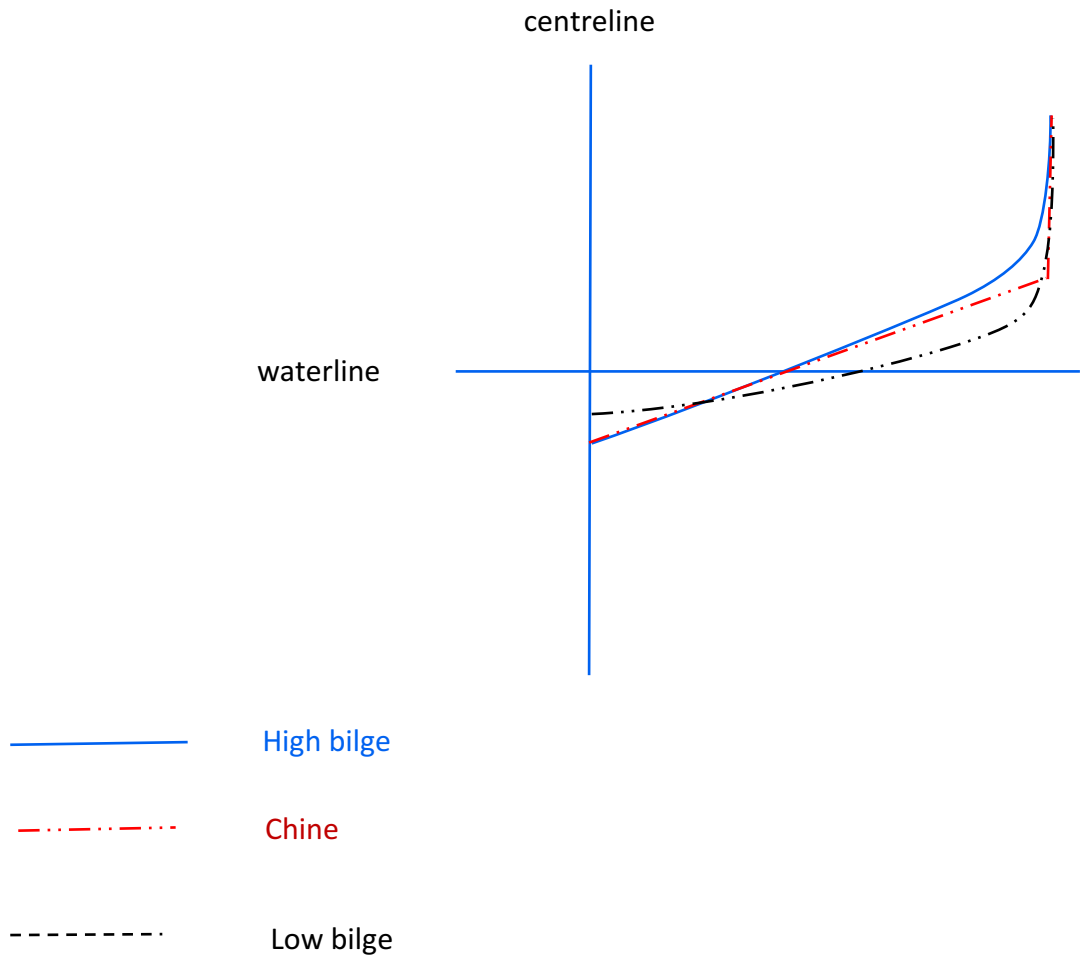

Figure 3

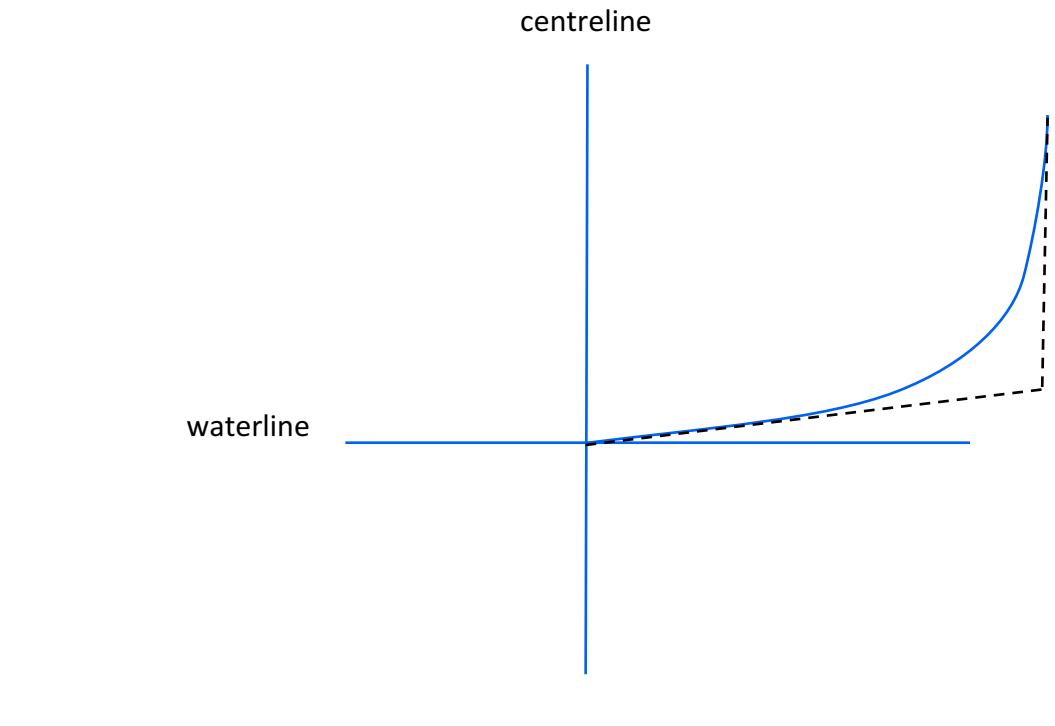

Figure 4

Figure 5

Figure 6