Gybing boards – how they work…

…And a look at a few other things along the way.

By Strangler -I do not claim to be an expert. There may well be mistakes in the detail but hopefully the general principals are near enough correct. Comments on a postcard.

'Foil' is the common term for centerboards, rudders, keels and wings (the type on airplanes, not 49ers!). To the aerodynamicist and hydrodynamicist they are all the same. This term is used here where relevant to centreboards and rudders.

THE BASICS and non-gybing boards.

A centreboard [CB] that is passing straight through the water does nothing for a sailboat [Fig 1] except cause drag (and decrease roll - if the hull rolls from side to side water has to slosh from one side of the board round to the other [Fig 2], this slows any rolling motion). CBs work by meeting the oncoming water at an angle (leeway angle) like an airplane wing, thus creating lift.

So what does a CB do? If those nasty race officers did not make us slog our way upwind CBs would be of far less importance. But as it is, they are one ingredient in the witches brew that is the Black Art of sailing

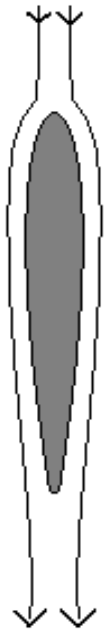


Fig 1

Foil at 0° angle of attack -water flows past causing only drag.

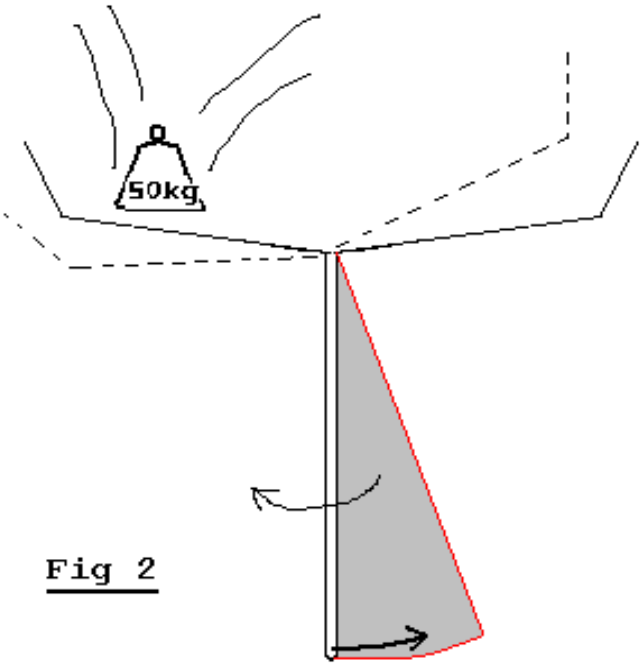


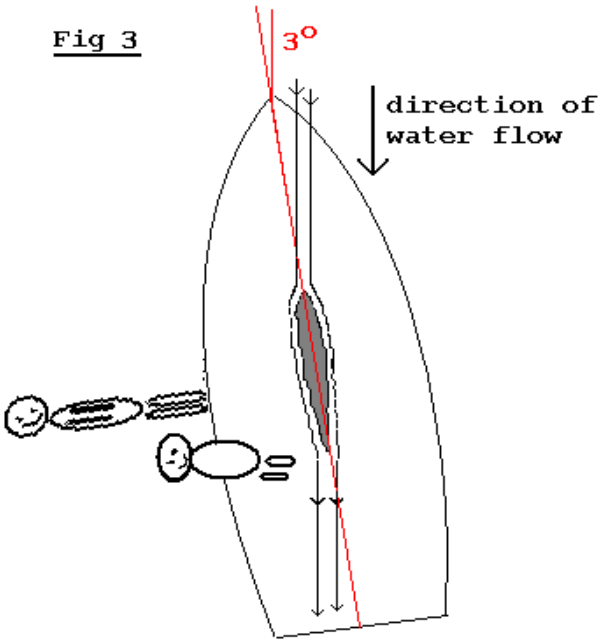
Fig 2

upwind fast. The underwater shape of a CB is designed solely with beating in mind – thats when the CB is needed most, when the side forces from the rig are greatest. The effect it has is like putting the boat on rails, making it go forwards rather than sliding sideways. Imagine a sailboat beating to windward, the sails are sheeted right in with the boom almost on the centreline. Its amazing the boat does not just slide sideways. Well, if you were to suddenly sheet the sails in whilst stationary the boat will just slide sideways. That's because the CB can only work if water is flowing past – just as an airplane wing only works at speed, if the plane slows too much it falls out of the sky. This is one reason why we get speed up after a tack, so the foil is working properly again before whacking the sails in tight, and is a reason for sheeting the sails out a little and going for speed in light winds.

Show us ya foils, Rob!

As already said, a centreboard has to meet the oncoming water at an angle [Fig 3]. This means the hull must also meet the oncoming flow at the same angle, generally around 3º (exaggerated in the diagram). The boat, on port tack is pointing toward the left hand margin, but tracking straight up the page. The CB will now create 'lift' and counteract the large side force from the sails allowing just the small forward force to be utilised. With water being a thousand times denser than air a relatively small foil will cancel out the loads from the large sail area. Just as well with all those sandbanks at Starcross!

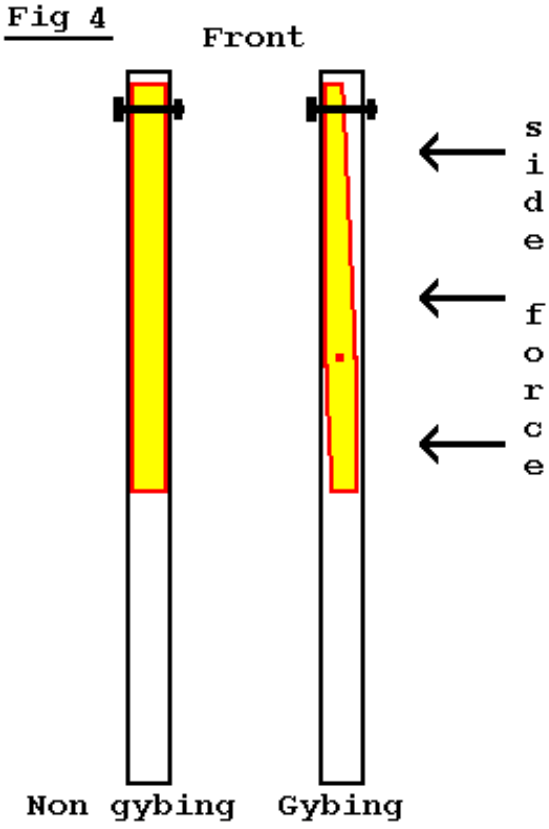
Fig 3



Gybing Boards

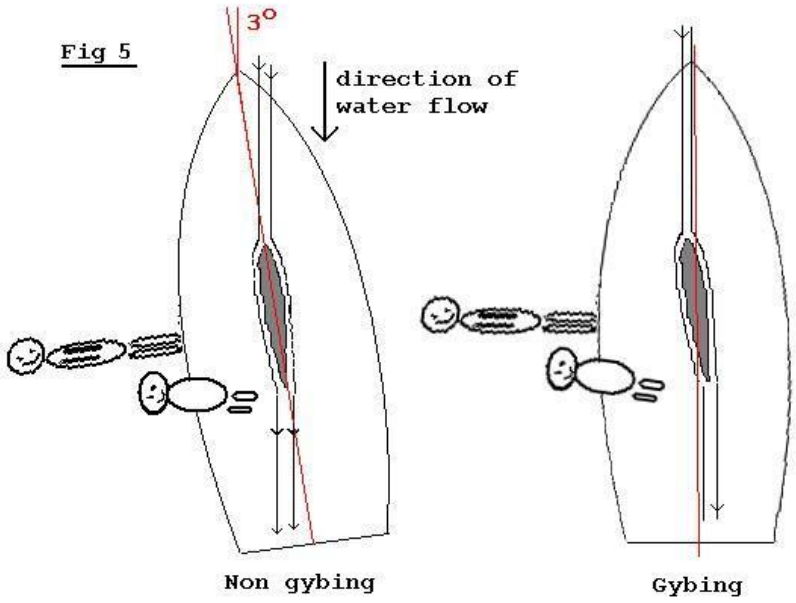
When a gybing board [GB] is fully down it can rotate a few degrees within the case thanks to a special diamond shaped stock [Fig 4]. It will pivot on the widest point about two thirds back- see dot in diagram. Staying with the port tack example, the side forces have more surface area in front of the pivot point, so the boards leading edge is pushed to windward. If you think about it (but not too much!), its similar to gybing a mainsail – the pivot point is the mast, wind coming down the page, the leading edge of the GB is the leech of the sail. Hence the name.

Fig 4



Jane and Tim hiding more than just their foils.

The effect on the hull is shown in fig 5. The first obvious difference is the hull now meets the oncoming water at the right angle. You may think this is THE big advantage of a GB with the hull creating less drag. Yes it does create less drag but there are disadvantages too. More of that later.



THE really clever bit is what happens to the rig. Both boats are tracking in the same direction (note the 2 CBs are parallel) but the GB boat's bow has rotated 3º off the wind and the sails have done the same - they can therefore be sheeted out a tad and so you go faster. The speed differential will be more marked in light to medium winds, and if you are going faster the foil is therefore more efficient (water flowing past a greater rate – more lift generated) so you can point a little higher – but speed first, pointing second. If you merely point higher you are more likely to stall the GB. That's slow!

In waves and/or stronger winds the speed advantage of a GB is negligible or even negative. It is then usual to raise the board slightly which will align it into a non-gybing position. You may think this puts you back on equal terms with CBs, especially if its windy enough for them to be kicking the board back a bit too. But there is a problem. GBs are generally built to a slightly different shape – thicker and a blunter leading edge. You will not now have the optimum shape so may be a gnats tad slower.

Foil shape. Thicker foils are more foregiving, ie. can cope with greater angles of attack before stalling, at a cost of a tad more drag. As speed increases foils become more efficient and the leeway angle reduces (about 1.5° for a 49er), so faster boats have thinner foils.

Comparing non-gybing and gybing boards.

Going back to comparison of hull alignment in Fig 5, the hull of the non gybing boat helps the CB a little with resistance of the side forces, but will not in the GB example. This means the GB has to work harder. I guess the result is that it will be a little less forgiving and more prone to stall, probably a reason why not so effective in waves/strong wind.

Another disadvantage according to Bethwaite [High Performance Sailing], is the effect on the rudder. Look at the transom of each boat. You will see that the 'wash' from the non gybing board exits near the port quarter, whereas with the GB it passes through the rudder area. Bethwaite suggests this causes abnormally high drag in the upper part of the rudder foil.

So why have some classes [with open rules] had love affairs with gybing boards and others kept well clear. I found this explanation on a boat design internet forum-

Gybing boards work best in flatter bottom hulls without pointy stems. ie they don't work well in boats that use the narrow bow sections to help with lift. So not used in Cats, low rider Moths, National 12, Merlin Rocket, but work ok in 5o5, Fireball.

What the authors say:

Dave Ullman [Championship Dinghy Sailing- pub. 1978], 470 World Champion '77 & '78.

I don't think you can get away more than about 2.5º of gybe. Most classes seem to respond best to 1º to 1.5º. and in every class that allows a GB, it is imperative to have it……. In 14s, 5o5s, and FDs, you can hardly race without a GB…… you may gain 20-30 lengths on one leg.

In the Coronado 15, you are permitted to have a total of quarter inch of gybe….we took the whole quarter inch and put it on starboard tack….gave us an angle of about 3º and were absolutely untouchable on starboard tack, neutral on port.

Frank Bethwaite [High Performance Sailing- 1993] Aeronautical engineer and sprogged three World Champion sailors.
Don't run your rudder blade in the wake of the centreboard, ie. think twice before you use a gybing board. (Oh, he is a killjoy!)

Lawrie Smith [Tuning your dinghy- 1985] Fireball & Enterprise Word Champion.
The effect of a GB can be dramatic and, and if it works correctly, the board will help the boat point higher. If however the board is gybing too far, the section will stall and an increase in drag will occur.

In conclusion.

You pays ya money and takes ya choice.

Disclaimer- Resemblance to any Hornet sailors in the diagrams is purely coincidental.