The Shock of the Old

Part 9: Just don't point that thing at me.

Why boats have bowsprits, with Moray MacPhail

For centuries – maybe millennia – ships did without bowsprits. From about 1200 they were quite commonly fitted to square-rigged vessels but mainly to stay the foremast or to hang a square 'watersail' beneath them. Maybe because dipping – and later, balanced – lugs developed from squaresails, most lug-rigged working craft did not have bowsprits.

But the development of gaff rig and standing lugs around 1600 brought with it the need for bowsprits to extend and balance the sailplan. This applied both to working craft – smacks, pilot cutters and the like - and to yachts. For different reasons these types shared the need for speed which a big rig could provide, though the limitations of available materials for rigging until the late 1800s meant that the sailplans were long and low.

Working boats were early and enthusiastic adopters of mechanical

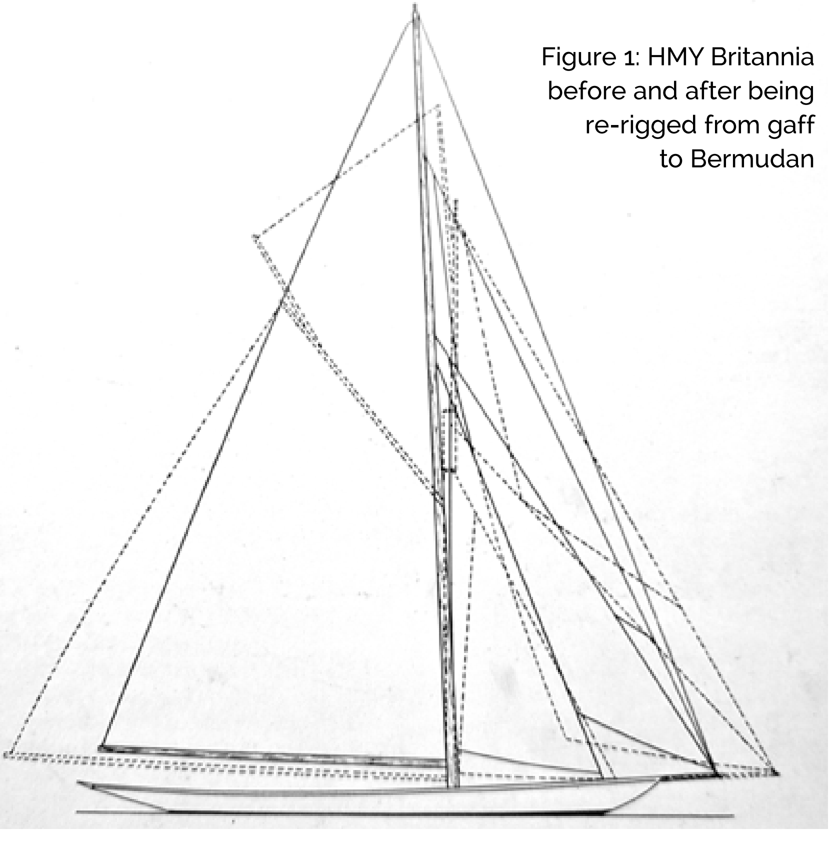
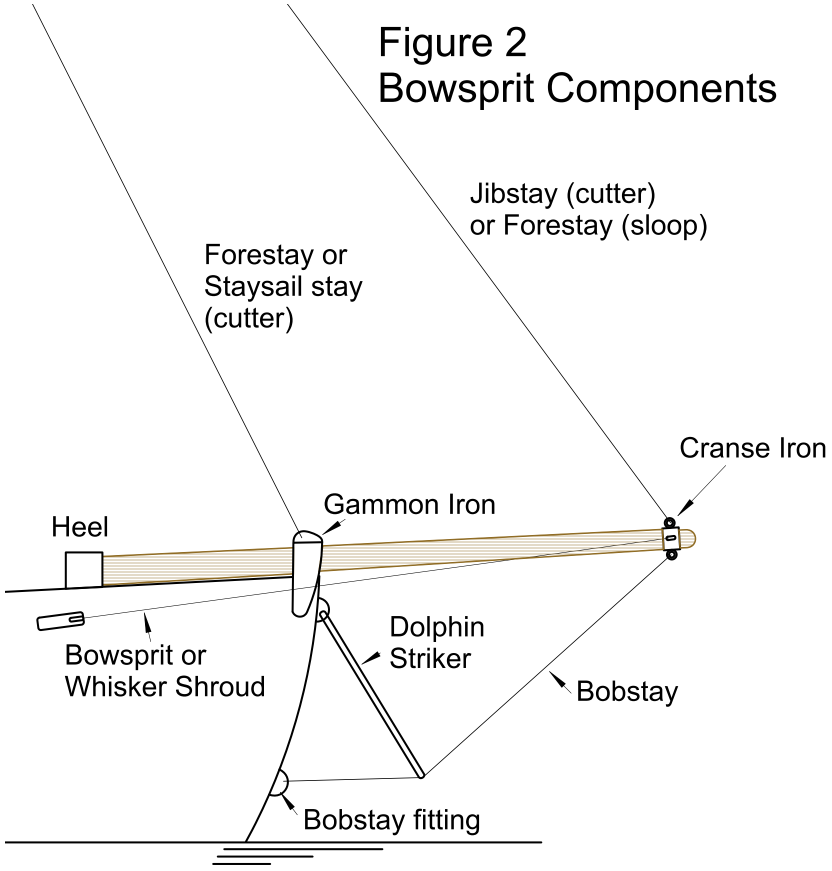


Figure 1: HMY Britannia before and after being re-rigged from gaff to Bermudan

power, so the change to Bermudan rig in the early 20th century didn't affect them so much, but the increasing adoption of that rig for pleasure craft together with better materials for stays, meant that rigs became taller and narrower. A good example of a yacht making the transition is *HMY Britannia* whose re-rig in the 1930s is shown in Figure 1. Bowsprits were either eliminated completely or a good deal shorter.

They do however gather about them some wonderful terminology as seen in Figure 2 and still have a place in traditional rigs.



Bowsprit Loads

I'm going to make the bold assumption that in W149 we made a good estimate of the size of the wire stay attached to the cranse iron, and hence the maximum load which that stay can exert on the bowsprit and bobstay. Those can be related to the forestay load by resolving the forces, as we looked at in W142.

The angles of the forestay α and bobstay β will give the design load for the bobstay; see Figure 3 where:

$$B \sin\beta = F \sin\alpha$$

From that we get Figure 4 which shows how the loads on the bobstay vary with changes in forestay and bobstay angles

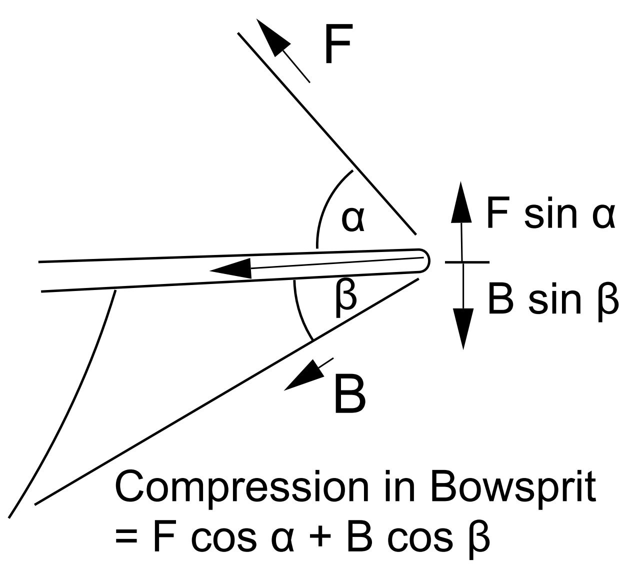
It is pretty easy to get to factors of 2.5 or more, particularly with shallow bobstay angles, hence the use of dolphin strikers to increase the staying angle. In our case α is 62˚ and β is 21˚giving a factor of just under 2.5. Using our rule of thumb in W149 for the maximum load on wire of 770 x its diameter squared gives 49kN for an outer forestay using 8mm (5/16") wire. So that's 120kN bobstay load which makes for a 12mm (1/2") bobstay.

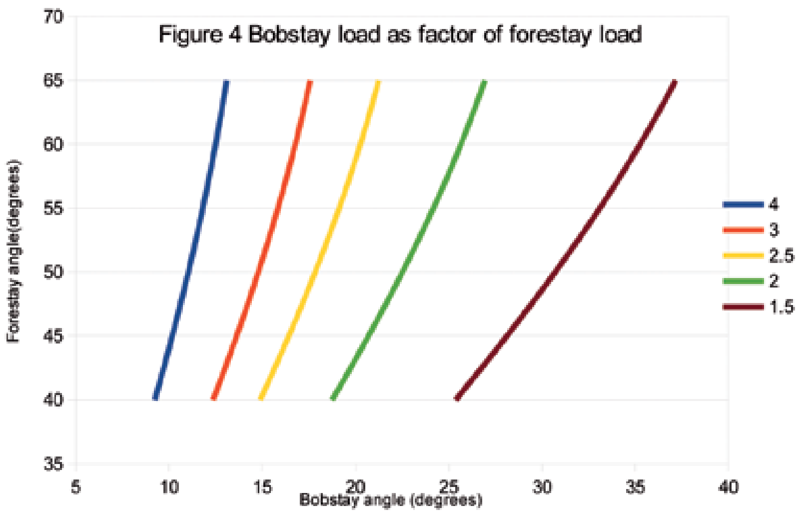
We can work out the compression in the bowsprit, shown in Figure 5 as a factor of the forestay strength. Because the curves are nearly vertical it means the result is mainly driven by the bobstay angle. So a reasonable approximation of the bowsprit load factor (C) is

$$C = 4.7 - 0.083\beta$$

with β the bobstay angle in degrees. For our example of β at 21˚, gives a factor of 2.95. Doing the sums properly – meaning with all the sines and coses – gives 2.8, so it's a fair result.

Figure 3 Bowsprit loads





That gives us just over 13 tonnes compression in the bowsprit. Note that even on an 8 tonne boat with a moderate bowsprit, we have bowsprit and bobstay loads a good deal greater than the displacement of the boat.

Now we have a design load we can size the bowsprit. Remember we are effectively carrying forward the factors of safety from the mast sizing exercise so we don't need to add in any more.

Bowsprit Arrangements

Like masts, bowsprits are usually columns in compression, the stay loads on the cranse iron being transmitted to the bowsprit heel, where they are then taken into the hull.

In W147 I mentioned briefly how a sideways load on a pole in compression can cause early buckling, which you can easily try for yourself by pushing down on a thin stick and then tapping it sideways. So ideally bowsprits should 'float' within the gammon iron once the sails are pulling. Like a mast, this is achieved by using stays: the bobstay running from cranse iron to a point on the stem somewhere around the water-line and whisker shrouds from cranse iron to plates mounted at deck level.

In practice there are three main variants for bowsprits:

• Fixed at the heel and cranse iron, floating at the gammon iron.
This is usually the scheme adopted if the bowsprit is regularly retracted or raised and needs bowsprit shrouds to take the lateral loads. You treat it as a pinned or pinned strut over the whole length of the bowsprit. The K factor in the buckling sum – see W149 – is 1.

• Fixed at both heel and at the gammon iron – or onto the deck – but without bowsprit shrouds.
While this is simple, it tends to be a permanent arrangement. As a column, this is treated as fixed one end – at the gammon iron or stemhead – but free at the cranse iron. It's not pinned because even though there is a forestay and bobstay, it can still trip sideways. The effective length is the part of the bowsprit outboard of the stem and the K factor for buckling is 0.25.

• Fixed at the heel and gammon iron, with shrouds.
This is like the lower part of a deck-stepped mast – see W149 – fixed at one end and pinned at the other. Again the effective length is the portion of the bowsprit which is outboard. The K factor in the buckling equation is 2 for this arrangement.

To illustrate the options the table opposite shows the critical load for bowsprits made from 100mm (4") diameter Douglas Fir of varying length. In all cases the bury – the portion on deck – is 1m (39").

What can we get from this? Firstly if the outboard projection of the bowsprit is less than the bury inboard, then you are better off with a fixed bowsprit, probably without whiskers. In any event with such a short bowsprit you are less likely to be concerned with retracting it. If on the other hand the bury is less than half the outboard projection – as it usually is – and you want to be able to retract or raise it – as people often do – then you are better off with a floating bowsprit with whiskers.

If you don't need to retract or raise the sprit – perhaps to save on marina charges – and it projects out more than half the total length, then fixed with shrouds can be a good way to go so long as you can firmly fix the bowsprit to the foredeck. Wedging the sprit into the gammon iron may not count if all you are doing is creating a hinge point.

You are probably tired of graphs and

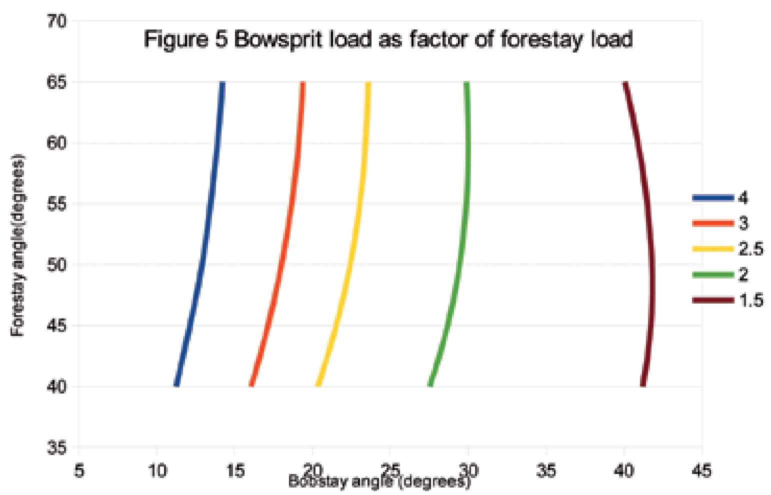


Table 1 Critical Load (tonnes) for a 100 mm (4") Diameter Douglas Fir Bowsprit 1 metre on deck					
Outboard length (m)	0.5m	1	2	3	4
Loose, with whisker shrouds	26.5	14.9	6.6	3.7	2.4
Fixed, no whisker shrouds	59.6 (Note 1)	14.9	3.7	1.7	0.9
Fixed, with whisker shrouds	476.9 (Note 1)	119.2 (Note 1)	29.8	13.2	7.5
Note 1. Maximum Compressive Load 37.7 t, so these configurations are unrealistic					

things by now, so I have put some up on the website to show, based on round Douglas Fir bowsprits, the critical load in tonnes. For example a 10 tonne load on a 5m (16') bowsprit with 20% of its length inboard would need a 140mm (5½") diameter if floating; 180mm (7") if fixed without whiskers; and 105mm (a tad over 4") if fixed with whiskers.

I should emphasise here that I am simply considering loads from the stays here, so ignoring unexpected ones like driving into a quay which you can't design for. I'm also ignoring the sideways loads from the sails which are always small by comparison with the vertical loads. Why are they small? Well rather as in the case of deflecting a highly loaded jib sheet – see W142 – a small lateral load from the sail will create much larger tensile loads in the forestay.

A bowsprit doesn't have to be circular in section, of course. Let's return to the K factors which are directly related to the critical load a column can withstand before buckling. In the case of a fixed bowsprit without shrouds, K is 0.25. In the case of a fixed bowsprit with shrouds K is 2, in other words a factor of 8.

In the vertical direction, the resistance to buckling is the same in both cases because there is the bobstay and forestay to restrain it. It is the sideways direction which is different. So for a fixed bowsprit you can effectively mimic the effect of shrouds by doubling the width of the section since that will increase the section inertia by a factor of 8 – it's W142 again! Hence plank bowsprits, and less commonly, bowsprits of oval section In either of these cases, fitting shrouds will do nothing structurally for you, though they might also be fitted for reasons like supporting netting. Back now to our example gaffer of previous issues on which the bowsprit is 4m long with 1m bury (13'/3'4"), supported at heel and cranse, with whisker shrouds. From which we get a diameter of 138mm (5½"). For comparison, the size if fixed on the deck, would be 169mm (about 6¾") diameter without whiskers and 100mm (4") with them.

Bumkins, stubby stern bowsprits, can be treated the same way. Start from the backstay wire size to determine the maximum load, resolve using the relevant geometry to get bumkin stay loads, hence bumkin loads. Being short and not often retracted they are usually fitted without shrouds, and fixed where they pass through the hull. Finally you can do the same for spreaders, jumper struts and diamond stays. I have to confess I have never done that. Perhaps I should!

So, we finally have mast and bowsprit sizes, shroud sizes, and stay sizes for rig configurations which might apply to the kinds of craft we are talking about. And you'll probably agree that's enough esoterica. Now we can tackle the practical aspects of rigging and fittings, but at least we now have a good feel for what we want them to do. Next time, wires and rope for standing rigging.

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