TUNING THE 505 RIG by Steve Taylor

Retyped from
505 Great Britain No.16
Summer 1980

World champion Steve Taylor describes the functions of the 505 rig and the effects rig controls have on sail shape and overall speed.

You've fitted out a well-rigged hull with a good board and rudder, and you're on your way down to the club with newly acquired sails, ready to step the mast and attempt to transform your magnificent efforts with wallet and toolbox into speed on the race course.

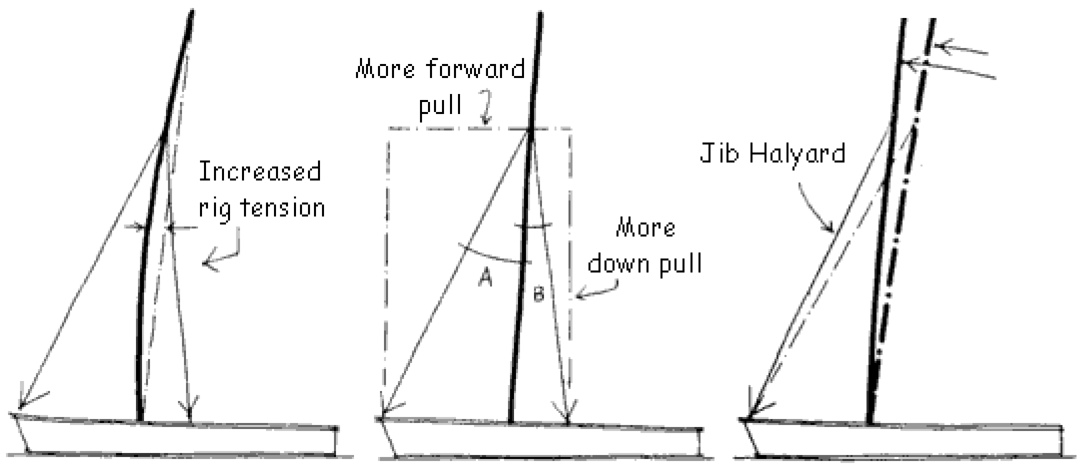
Naturally, every time you touch a control line, it moves effortlessly, with no friction, and whatever it controls works beautifully - you just don't know quite where to set it. Lots of practice in the old boat has given you some idea where to start and certainly means that your boat handling is smooth, your steering second nature and your relationship with your team-mate gracefully established. Ever since your last frostbite season your starts have been good and your tactics consistent. Now the problem is to learn to think a little more clearly about how to set up your rig in all conditions, how to adjust it quickly as the conditions change and how to see what shapes are produced in your sails as you make these adjustments.

On 505s and any other boat in which the loads of the rig and the mast are supported by the luff wire in the jib, the headstay, if there is one, is generally left slack when sailing and is only used to hold the mast up in the parking lot. Once the shrouds are fixed, increasing tension on the jib halyard does two things:

1) it straightens the rake, pulling the mast forward, and
2) it pulls against the shrouds and increases rig tension (diagram).

Because the fore-and-aft angle of the jib luff to the mast is much greater than that of the shrouds (diagram), a small change in jib halyard length will affect rake more than rig tension; likewise, a change of equal length in the shrouds will affect tension more than rake (diagram). A good way to start thinking about your rig is to consider the jib halyard as your rake control and the shrouds as your *tension* control.

Jib halyard tension reduces rake and can also increase rig tension



Angle A, between the jib luff and the mast, is much larger than angle B, between the shrouds and the mast. This causes the jib luff tension, to be the dominant factor in rake, and shroud length to be the dominant factor in rig tension.

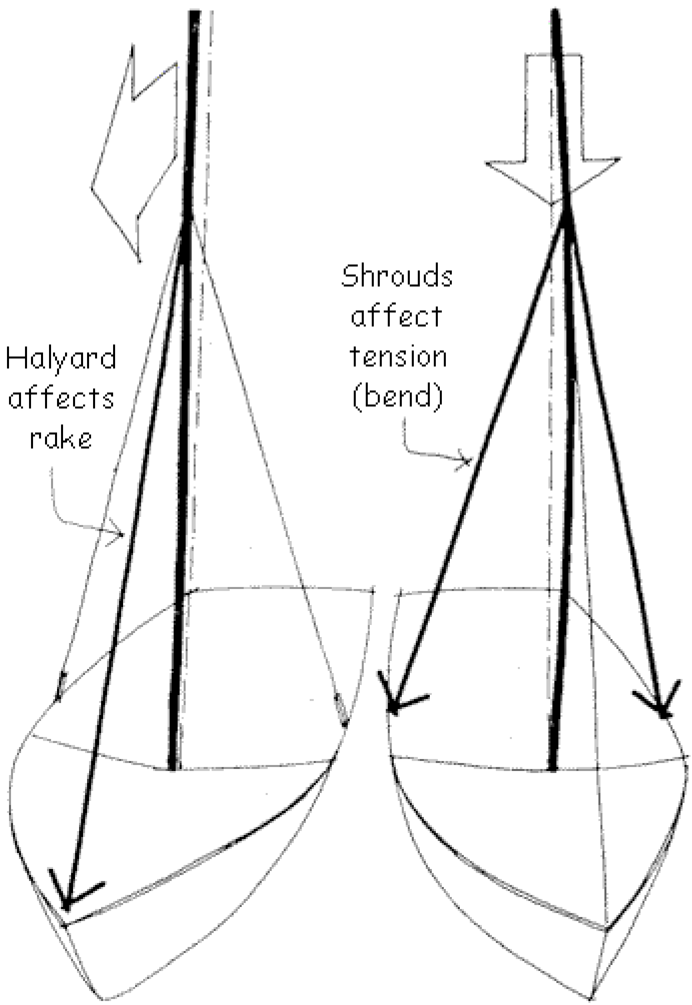
Both rake and tension are important adjustments, but with the exception of the FD, which uses rake to control the genoa lead, tension is usually the more important of the two. Therefore, for simplicity's sake, you can first choose a basic rake setting and set your jib luff to that point. Then, if your shrouds are adjustable, you will be able to regulate tension easily with a control line. If your shrouds are fixed by chainplates with rows of holes, to effect tension change you may have to first release the jib halyard, then change the shroud pin location and finally put the jib halyard back in the desired position. In any event, remember that it is shroud length that makes the tension difference - the jib halyard is for rake.

The two most important effects of rig tension are jib luff sag and mast bend, both of which control, to a large degree, the shape of the sails to which they are attached. The table shows how jib luff sag affects jib shape.

The Effects of Jib Luff Sag on Jib Shape

	Too Much Sag	Correct Sag	Too Straight
Draft	draft too far forward	draft in correct position	draft too far aft
Fullness	sail too full, especially head	depth correct	sail too flat, especially entry
Leech	upper leech too close to mainsail when sheet is trimmed	leech twist balanced with sheet and lead	upper leech too open relative to sheet and lead
Luff	loose luff may 'pump' in seas, causing rapid shape variations	luff stable, but forgiving	rigid luff unforgiving and prone to stalling -entry too fine
Steering Groove	steering groove too wide, can't get accurate course from telltales	steering groove reasonable, telltales normally responsive	steering groove too narrow, telltales too nervous - both leeward and windward flutter at once.

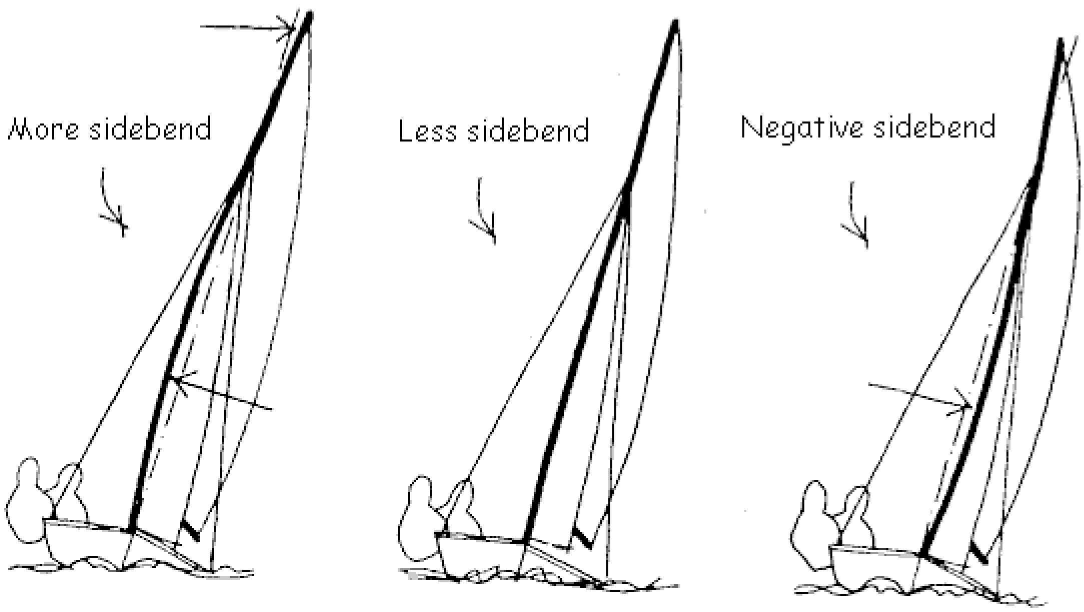
Understanding how rig tension affects the shape of the mainsail through mast bend is a bit more involved. First, tension affects bend primarily through the spreaders, especially if the shrouds intersect the mast at about the same place as the jib halyard at the hounds. Unlike jib luff sag, which happens in a direction roughly aligned with the wind, mast bend can be controlled and thought of in two different directions - fore and aft or sideways (diagram).



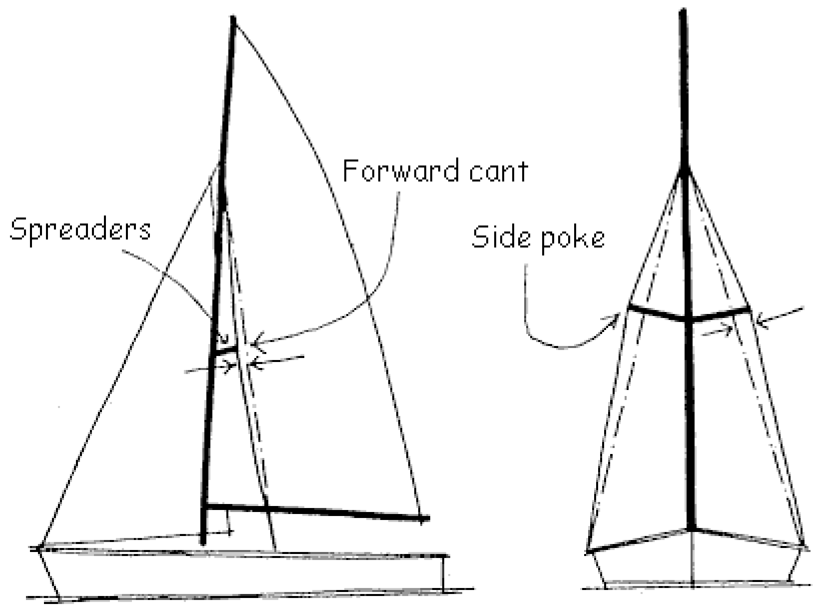
More forward cant on the spreaders, coupled with more shroud tension, causes less fore and aft mast bend. A reduction in either cant or tension will allow more fore and aft bend. If the spreaders are swept aft of a neutral position, increasing tension will induce more fore and aft bend.

At this point, it should be mentioned that this is true only while the mast is still basically in column, or only up to the point where further shortening the shrouds ceases to add tension. At some point after the mast is bent like an archer's bow, shortening the shrouds will not add tension, but actually reduce it or leave it constant as the mast buckles out of column and simply bends more in whatever direction it had already begun. It very rarely pays to sail with the spar set up this way, and particularly with stiff boats and powerful rigging systems, care should be taken not to attempt to 'tighten' the rig past this point of 'no return'.

Sideways bend is controlled largely by the degree to which the spreaders deflect the shrouds outboard position, or poke. For the purposes of this discussion, *more side bend* means the middle of the mast comes to windward and the tip to leeward; *less side bend* means the mast is straight sideways; and *negative side bend* means the middle of the spar depresses into the slot to leeward - regardless of whether the tip is also to leeward (S-bend) or is held straight, or to windward, through either natural stiffness or very high trapeze wires (diagram).



Longer spreaders, or more poke, tends to reduce side bend and can even force it negative. Shorter spreaders allow more side bend. Changes in tension work to increase or decrease the effect of the spreaders correspondingly - more tension and the spreaders do more work.



Having established, to a degree, how tension and spreader adjustment control mast bend, the important questions become, how does mast bend affect sail shape, and what do you want when?

The table shows:

The Effects of Fore and Aft Bend on Mainsail Shape

	Too Straight	**Correct Bend**	**Too Much Bend**
Draft	draft too far forward	draft in correct position	draft too far aft sail perhaps inverted
Fullness	sail too full	depth correct	sail too flat
Leech	leech too tight, even when sheet and vang eased	leech twist balanced with sheet and vang	too much twist, even with tight sheet and vang
Steering Groove	staying in groove very difficult and/or overpowered	boat powerful but forgiving	boat underpowered, no punch through seas
Stalling	sail prone to stalling, stopping boat, too much side force, no acceleration, pointing too high going slow	sail on verge of stalling, but working nicely, points and foots well	can never stall sail, can't point

Although sideways bend also affects the entire shape and twist of the sail in very similar ways to the table on fore and aft mast bend, it is important to discuss it separately in terms of twist and the effect on the size of the slot between main and jib. Twist in a sail is defined as the change in the angle of attack of the cross-sectional shapes of the sail in progression up from the foot (diagram). A chord is the imaginary line between luff and leech, at any height, and if these lines change their angles to the wind, then the sail has twisted. When the leech is tightened, the aft ends of the chord lines move to windward and twist is reduced. Likewise, if the middle of the mast moves to leeward (negative side bend), the front end of the chord line (a point on the luff) moves to leeward, and again, twist is reduced.

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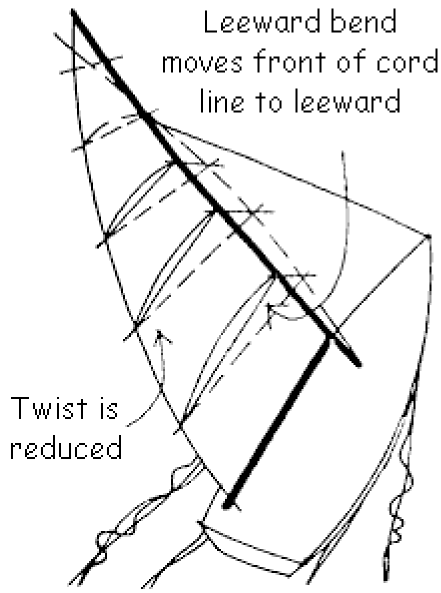

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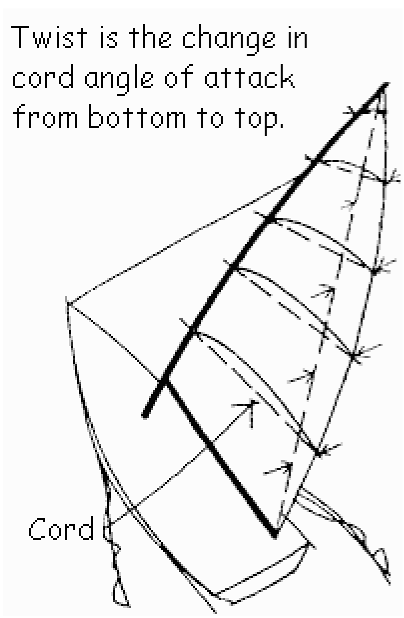


Because twist (angle of attack) is perhaps the *primary* determinant of how much power (and drag) a sail develops, and because side bend has a linear relationship to twist, side bend is a very powerful variable in rig control. One-half inch of sideways movement of the luff at spreader height will make a far greater difference to your performance than one-half inch of fore and aft bend.

The 'slot' effect is also important, particularly in terms of preventing interference between the jib and main while retaining maximum useable power in a given condition. Although traditionally held ideas about the slot working as 'Venturi' are not especially accurate (which will be left to the aerodynamicists to explain), there is no question that the jib/main relationship is important.

Most critical is the ability to open the slot in heavy air without sacrificing pointing ability (which happens if you simply go to extremes of twisting or easing the jib). Getting the middle of the mast to come slightly to weather in a blow can be extremely fast, and the resulting twist in the main, as well as the opening of the slot, work together as an efficient means of depowering, often allowing great increases in speed with little or no loss of pointing.

Conversely, it is very important to hold the mast straight in lighter conditions, and accomplishing these things is largely a matter of correct spreader length and rig tension. Spreaders which, are simply too long will never allow enough side bend in a blow - those too short will give way too early. On 505 rigs which allow the side bend tendencies to be balanced by the height of the shrouds' attachment point to the mast, it is possible to have a mast which will go through the following routine with regard to side bend:

- *very light air* - stands straight because static rig tension dominated wind load.
- *fully hiking air* with boom on centreline, little twist in main - mast bends negatively sideways due to high-mounted shrouds; less twist, more power.
- *fully trapezing air* stands straight as thrust from boom slightly off centreline coupled with more twisted main pulling tip more sideways and less aft, which counteracts tendencies of high-mounted shrouds to produce negative bend.
- *heavy air* - bends to weather in middle, opening slot, twisting main; this is caused by boom well off centerline thrusting mast to weather in loose mast partners and well-twisted sail pulling tip even more sideways to leeward, less aft. Short spreaders offer little resistance to this tendency while still working effectively to limit fore and aft bend as desired.

The 505 offers nearly ideal opportunities for controlling side bend, due to the optional height of the shrouds. Some other boats (420, 470) require that the shrouds be so low that longer spreaders are required to keep the mast from developing too much side bend too early; therefore, it is impossible to attain negative bend in power conditions without spreaders so long that the mast will never open up in a breeze. The best compromise on these boats is to hold the mast straight up until you get in heavy air (fairly long, but not extreme spreaders), then let some side bend into the rig when the wind qets really heavy.

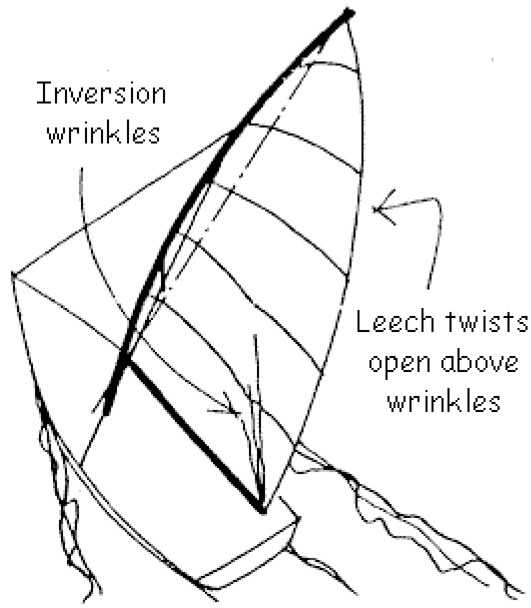
Extreme conditions often require special attention to keep the sails working well. In very light air, no tension can be put on the mainsheet or vang without over-tightening the leech. Therefore, there are no natural forces to bend the mast. The luff curve in the main, which is necessary for more wind, will hang lifeless behind the mast, and the sail will be much too full, with the draft forward and leech tight (slow). Something must be done to force bend without pulling on the leech. If the bend is attained with aftcanted spreaders and rig tension, the jib sag is undoubtedly too straight, the jib entry too fine, etc. So the mast must be 'pre-bent' by pushing or pulling it forward at or above deck level with blocks, wires, 'mighty screws', struts or something. Once pre-bend is attained, proper draft and twist will fall into the mainsail, the jib will sag appropriately and speed becomes possible.

The jib luff is standing up straight but the mast appears to be bending to leeward which closes the slot between jib and main when it is very windy.

Light air usually requires the mast rake to be a little less (more vertical), and it is an unfortunate trade-off to have to ease the jib halyard to attain sag - better to ease the shrouds.

In short, boats which are allowed variably adjusted shrouds really ought to have them - it is also very fast downwind to be able to let the rig lean forward.

Heavy air often requires more rake and also, more tension, again calling for a change in the shrouds and not simply easing the jib halyard. In particularly heavy air, extremes of mast bend can sometimes be very fast.



A mainsail which is 'inverted' (bent beyond its luff curve) develops large diagonal wrinkles that run roughly from clew to spreader (diagram), almost as though the back of the boom was bent off to leeward. This can provide a means of depowering without easing the sail too far outboard, retaining pointing ability.

In fact, very good control over the angle of the bottom batten (lower leech) can be had in some sail designs even before the inversion wrinkle develops. More lower mast bend can help open the leech if the sail is right as well. This can extend the effect of opening and closing the lower leech into more moderate as well as very heavy air.

There are very few magic numbers which will solve all one's problerns. Even with a specific suit of sails for a given boat, for which some guidelines could be offered (most sailmakers do), changing sea conditions will grossly alter what shapes you want, even for the same wind velocity. However, knowing how your controls affect your shapes, and arranging your boat so that the controls work easily and within the range you need, will allow you to make decisions as you sail and try them out. Experience will let you know what works and what doesn't, but it's important to know what's going on (and why) as things change or you change them.

Most importantly, it is vital to practice enough to develop a ready feel for what you need to do as conditions vary; otherwise, you'll find yourself off beyond the layline while you fiddle with the rig.