TOC
Last Chapter
Next Chapter
Help!

A 120-percent-overlap working jib on a Deerfoot 74.The sheet lead has been moved forward from the beating position for reaching, resulting in an even luff shape all the way up the sail.

CRUISING SAILS

Choosing the right sail inventory to carry on a cruising sailboat is a difficult process. You are beset by a series of conflicting requirements and compromise-inducing factors.

First, while we all want performance, none of us is especially keen to work hard at changing sails every time apparent wind is up or down or switches direction. So the sail inventory needs to be versatile in the wind ranges and angles it will handle. The modern sailor is in luck here, because new fabrics and construction techniques yield much more versatile sails than were possible even a few years ago.

Second, we have the problem of storage. Sails have to compete with inflatable dinghies, dive gear, and toilet paper for precious space aboard. There's also the question of how the sails are packed. When sailing shorthanded, with a trunk cabin probably in the way, folding a sail isn't always possible offshore. Some sail inventory will inevitably find its way below in bulky condition.

Third, there's the question of budget. A versatile inventory that keeps you moving without a lot of sail changes and that stores easily is also easier on the wallet.

Fourth, the type of sailing you plan also has an impact on needs. Where the local cruiser can get away with a more modest inventory, tailored to his specific area requirements, the offshore sailor must take into account a wider range of conditions. Another consideration is backup. If one sail fails on the offshore boat, there has to be something in the inventory that can serve until the damaged sail is repaired.

Fifth, a good cruising sail should be long-lived and tolerant of abuse. It's not unusual to see a well-constructed suit of sails circumnavigate and still be in good condition, provided they are kept covered when not in use to protect them from ultraviolet radiation, and perhaps recut once or twice as their shape alters with age.

HEADSAIL ISSUES

There are some non-speed factors that must be taken into account in the name of seamanship. Visibility is of paramount importance on a shorthanded cruising yacht, so low-cut, deck-sweeping headsails are out, at least for work in traffic. A higher cut is also desirable to keep the sail from scooping up the bow wave on a reach. This last factor is related to size. The smaller the yacht, the more clearance is required to avoid scooping water.

The geometrical shape of sails also has a big impact. For example, high-aspect headsails are very fast when beating and close reaching, but they impose more load on the sail, requiring heavier, stiffer cloth which is more difficult to handle and store. On the other hand, sails with

TOC

Last Chapter

Next Chapter

Help!

The padded luff on this roller-furling jib (left) creates bulk when the sail is rolled, which in turn tends to flatten the sail. (North Sails RI photo)

Smaller freestanding roller furlers (above) work well for light-air staysails, free-flying reachers, and mizzen jibs. One of the problems is how to secure the drum control line. Harken has solved this problem with a built-in camcleat. (Harken photo)

lower aspect ratios and more overlap of the shrouds are more difficult to tack. High-aspect sails also have a narrower performance groove, demand more precise sheeting angles, and are tougher to sail with. On the benefit side they have a lower center of area. This means the lower-cut sails will tend to heel the boat less, translating into better boatspeed and more comfort.

With all these factors under consideration, the first place to start making a decision is in storage space.

Intermezzo had a small forepeak that took up the first 5 feet (1.5 m) of the bow. This was blocked off from our double bunk by a bulkhead with double doors, a fairly common arrangement on most cruising yachts. We decided that our headsail inventory would have to fit into the forepeak when the sails were folded. And they did, barely. On the other hand, offshore, more often we would have one or two headsails on deck in use or at least stowed on their respective headstays, and this left room below for a stuffed, as opposed to folded, sail or two. It also made it possible to dig out a sail from the bottom of the pile with less difficulty than when everything was tightly packed.

Roller-Furling or Jib Hanks?

It's a question that isn't debated much anymore. Roller-furling jibs are now the norm. But just in case you don't already have roller-furling on your headstay, consider the following from the sailmaker's perspective.

Using a roller-furling jib forces the sailmaker to lift the clew higher than he might otherwise have done, reducing sail area and efficiency upwind. The typical roller-furling system causes a loss of around 3 feet (0.9 m) of headstay length — that's a good chunk of the most efficient part of the sail (and you cannot make the sail area back by going for a longer overlap, as this makes the sail harder to sheet and less efficient overall). Obviously roller-furling eliminates the use of battens, thereby forcing the sailmaker to substantially hollow out leech and foot shape, another loss in efficiency and sail area.

The overall impact? You probably lose an easy 5 percent or more in pure upwind boatspeed compared to a better cut of sail.

Of course, there are other considerations, like storage space, working on the foredeck, and visibility when the sail is stowed (a hanked-on sail bagged on the forestay is sometimes difficult to see around). In the end you need to weigh the convenience of a roller-furling headsail against the performance of one that is attached with hanks or that fits into a luff groove.

Another significant impact of roller-furled jibs is their weight aloft. Between roller-furling gear and the sail, a 40-footer (12.2m) can easily add 120 pounds (54.4 kg) to rig weight.

Working Headsails

With storage area established and the question of roller-furling debated, the next consideration is a primary upwind headsail. Modern yachts have tended away from the large overlapping genoas of the CCA era for good reason (headsail overlap is expressed as a percentage of the forward triangle. This is typically measured by dividing the perpendicular distance from the clew to

An ideal cruising jib layout. The clew is raised off the deck so the sail will sheet efficiently when reaching, and overlap is very moderate. The sail would set better at this wind angle if the sheet lead were moved a bit forward. This would add more tension on the leech and improve the shape at the top of the sail. (Port Townsend Sails photo)

A two-ply working jib, with the extra ply sewn onto the foot and leech, where loads are heaviest. The cloth in this type of construction must be carefully matched for stretch characteristics, or serious wrinkling and unfairness will develop.

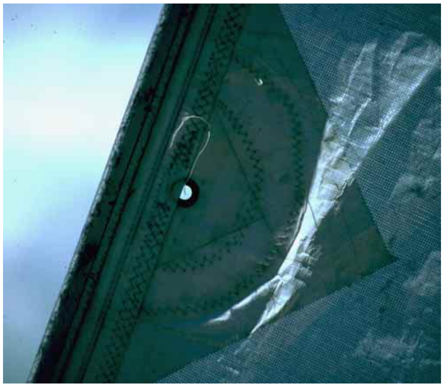
Dark sailcloth has two major advantages. First, it is much easier on your eyes in bright sunlight. Second, it is much more visible at sea. (Port Townsend Sails photo)

the headstay by the "J" measurement (or distance from mast to headstay fitting on deck). Beyond, say, 120 percent, the small potential increase in speed that comes with the extra sail area in light airs is more than offset by difficult handling and loss of speed as soon as the breeze builds. As cruising yachts become larger, the headsail overlap should be less. On *Intermezzo II* and *Sundeer* we've found a 105- to 110-percent overlap ideal as an all-around sail. Sea conditions and the preponderance of reaching work will dictate clew height. The higher the clew, the easier the sail is to sheet when sailing off the wind, although as stated above you do lose efficiency with the higher clew when beating. Lifeline height is a minimum. For heavy reaching, perhaps 3 to 5 feet (0.9 m to 1.5 m) above the lifelines should be chosen.

In your discussion with the sailmaker, establish the wind range in which you want the sail to operate. I like to have a high top end. This means less sail changing but reduces boatspeed at the lower end of the windspeed spectrum. Eight to 18 knots of true wind speed (about 22 to 24 knots apparent) makes a good compromise for a primary upwind sail.

You'll want to have aboard at least one, but preferably two, smaller working headsails. These will fill in as the wind pipes up. They should have a higher clew for sea clearance and to make them more usable off the wind. Eighty-five and 65 percent of the foretriangle area fit the bill nicely. If you choose one of the two, go with the smaller sail. It's almost always better to be underpowered than overpowered when it's blowing. The small difference in size will make the boat a lot easier to handle, while having a nominal impact on heavier air performance.

TOC
Last Chapter
Next Chapter
Help!



A reef point sewn into the luff of a working jib. Reefable headsails look good on paper but rarely work out in the real world. We've had two and only used the reefs once or twice.

Reefing Headsails

Another consideration is reefing headsails. If you're sailing with a hanked-on jib, having a second set of clew, tack, and reefing cringles installed makes sense in some cases. On the plus side, this eliminates one size of sail aboard. On the negative side, the sail must be heavier to handle the higher wind ranges and is therefore more difficult to stow and move. Also, it won't set as well in lighter airs. We've used reefing headsails on a number of occasions with success. But I think their usefulness is limited to vessels under 40 feet (12.2 m) in length.

There are two approaches to the headsail reefs. One is to have a second clew but the same tack position. This reduces area somewhat and gets the clew higher and out of the bow wave area. The other approach is to raise both the tack and the clew, reducing area even more and enabling you to lift the entire bottom of the sail clear of the deck.

Another view of the CCA reaching rig, this time with a 170-percent light #1 genoa and deck-sweeping staysail.The lower clew forces the lead forward and hooks the genoa in toward the boat.

The Light Genoa

A large, light genoa, probably about 125 to 135 percent of forward triangle area, will be a help in lighter wind ranges where most cruising is done. To keep the sail compact when stowed and to give it a good bottom end, we should probably specify a 14-knot apparent-wind range (going to windward). This isn't going to be super-efficient in drifting conditions, but it will do well motorsailing and probably keep us moving reasonably well in 6 knots of true wind. For optimum performance to windward, the clew should be kept low at about lifeline height. But this is too low for beam reaching in a breeze with a sea running and is difficult to fly from the pole. For all-around use, the clew should be raised 3 to 6 feet (0.9 m to 1.8 m) above the deck.

Yankee Jibs

If you're sailing with a traditional doublehead rig, a yankee jib will have to be cut to work with the staysail. The clew on the yankee should be about a quarter of the way up the leech of the staysail. The draft of the yankee should be a bit farther forward than usual to help open the slot between it and the staysail. A yankee cut in this fashion has a number of advantages. Along with working well with the staysail, its high clew keeps it clear of the seas on a boiling reach. It's also ideally suited for flying from the end of the whisker or spinnaker pole when you're broad reaching or running. Finally, pulpit chafe off the wind is minimized.

Yankees are very popular in some quarters. Our experience with them, however, has been mixed. The high-cut yankee has a higher center

TOC
Last Chapter
Next Chapter
Help!

TOC

Last Chapter

Next Chapter

Help!

Intermezzo II's sistership, *Pegasus*, had a traditional double-head rig with a high-clew yankee jib and staysail underneath. While this rig did break up the sail area, it was very inefficient and difficult to keep properly trimmed. Note the top two battens of the mainsail. They are full length to prevent the sail from hooking under the cap shroud when jibing and to assist with sail shape.

A "traditional" CCA-era reaching rig — 150 percent jib top with deck-sweeping staysail below. This rig is a bit faster in light-reaching conditions than a 120-percent working jib, maybe as much as 5 percent faster. However, it is a real pain to handle and of doubtful value on a short-handed cruising vessel on which storage space and budget are at a premium.

of effort than a conventional working jib and is smaller in area for the same amount of overlap. We've found that there is a lot more heel angle associated with a yankee than with a lower clewed jib of the same area.

A yankee will do better if you reduce its size and use it as a heavier, smaller jib in conjunction with a low-cut staysail. Overlap and interference between yankee and staysail are reduced with this method, and overall efficiency goes up. When we're sailing in higher latitudes where the weather is changeable and prone to breezing up, we like to use this combination. It is not as efficient as a single larger headsail, but it is easy to change down by dropping one sail or the other as conditions dictate. Also, should the primary headsail be damaged, this is a sailplan with which you can make reasonable progress in lighter wind rages, albeit at a reduced pace.

Cutter Double-Head Rig

With cutter-rig proportions, where the main mast is moved aft and the forward triangle is enlarged, the combination of staysail and yankee jib can be a bit more efficient than we've previously discussed. The mainsail is smaller, and the two-headsail approach keeps things more manageable in the forward triangle. Aboard *Intermezzo II* we went this route for the handling ease it presented. Instead of carrying a heavy #1 genoa of 950 square feet (88.3 square meters), we had a 400-square-foot (37.2-square-meter) staysail and 600-square-foot (55.8-square-meter) jib. The two sails presented a less formidable opponent on the foredeck. Today, we'd go with a larger full-batten main and smaller forward triangle, obviating the necessity of a double-head rig for handling.

If you are sailing a true cutter, then the headsail choices are definitely going to be along the lines of yankee/staysail configuration, with perhaps a drifter or reacher thrown in for light-air sailing.

The clew on this big drifter is too low, resulting in a hooked lead, clearly visible here, when sailing free. If the clew were raised the sail would lead further aft and be much more open. This would result in a faster sail and less tendency to heel the boat, reducing weather helm at the same time.

Drifters

Another approach is to go with a drifter or very light genoa, sewn on its own luff wire that is hoisted free of the headstay on the spinnaker halyard or extra jib halyard. This sail will be made of light nylon or light Dacron and about 135 percent of the forward triangle. It will be extremely useful in light airs to windward (up to 4 knots true), reaching (6 knots true), and off the wind for as long as you have stability to carry it. If the clew is lifted so the sheet leads through the end of the main boom when broad reaching, it becomes a part of a very effective twin-headsail rig. With the drifter sheeting through the boom and the main fully hoisted, the jib is flown on the pole to windward. Because of its light weight, this sail takes less than half the storage space of the genoa.

Reachers

Once you've taken care of your primary upwind sails you'll want to look at a good reaching headsail. These are easier to design and build since they have much lower loads. Aboard *Intermezzo* we carried a 3.25-ounce reacher built from a soft cloth. It was compact, easy to store, and saw many thousands of miles of use. A good reacher will have a clew that is high enough to be flown efficiently off the whisker or spinnaker pole for running, or from the end of the main boom when broad reaching. This is usually 8 feet or so off the deck. If made from slightly heavier material, and if the luff can be tightened by halyard or backstay tension, the reacher can often function as a light #1 genoa. If you've got good-size spinnaker halyard gear, you can also make the reacher free by flying using a wire or Spectra type of luff. The sail can then be roller furled (the same applies to the drifter).

Be sure to have chafe patches sewn around the tack where your downwind sails will tend to rub on the pulpit rails.

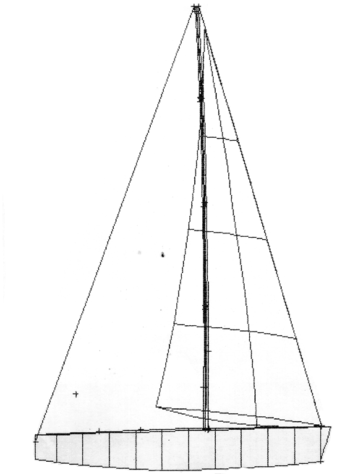
If a choice has to be made between a drifter and reacher, we go with the reacher; we feel it is a better all-around sail, given the higher top windspeed in which it can be used.

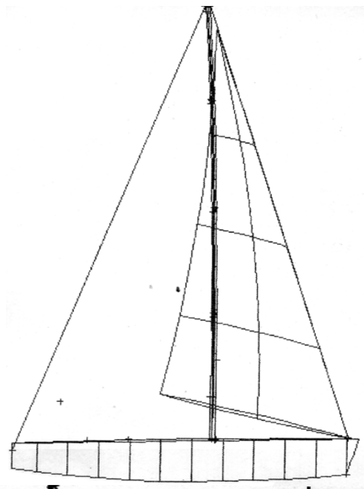
Jib Battens

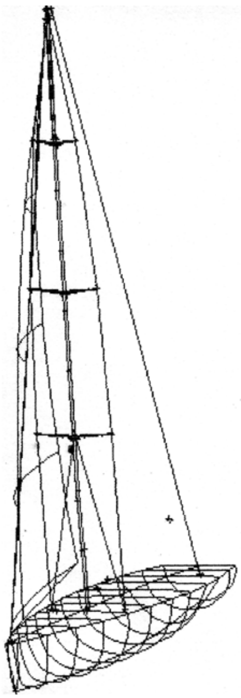
If perchance you've opted for a hank-on headsail in lieu of roller-furling, then you should consider adding battens to the leech of your non-overlapping jib.

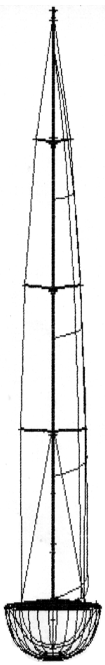
A single, full-length batten placed just above the cutter stay will have a huge impact on the efficiency of your sail and will add to its life. Even better is to have a series of short battens below the top full length batten. However, these can sometimes make the sail difficult to stow, so we usually go with just the one at the top.

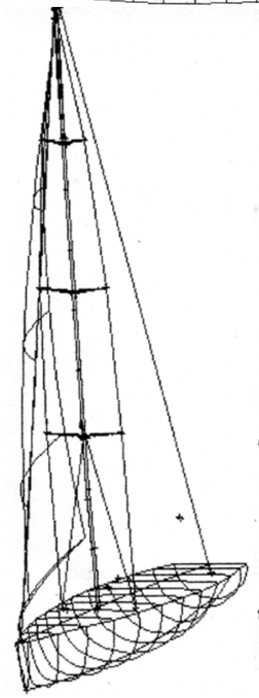
If the reacher is sewn to a 1x19 wire luff, it can be flown from the spinnaker halyard on a free-flying roller-furler system. This allows you to drop and stow it when it's not needed, avoiding excessive weight and windage aloft. Notice how compactly it stows when furled on the stay.

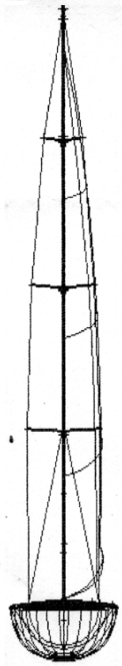








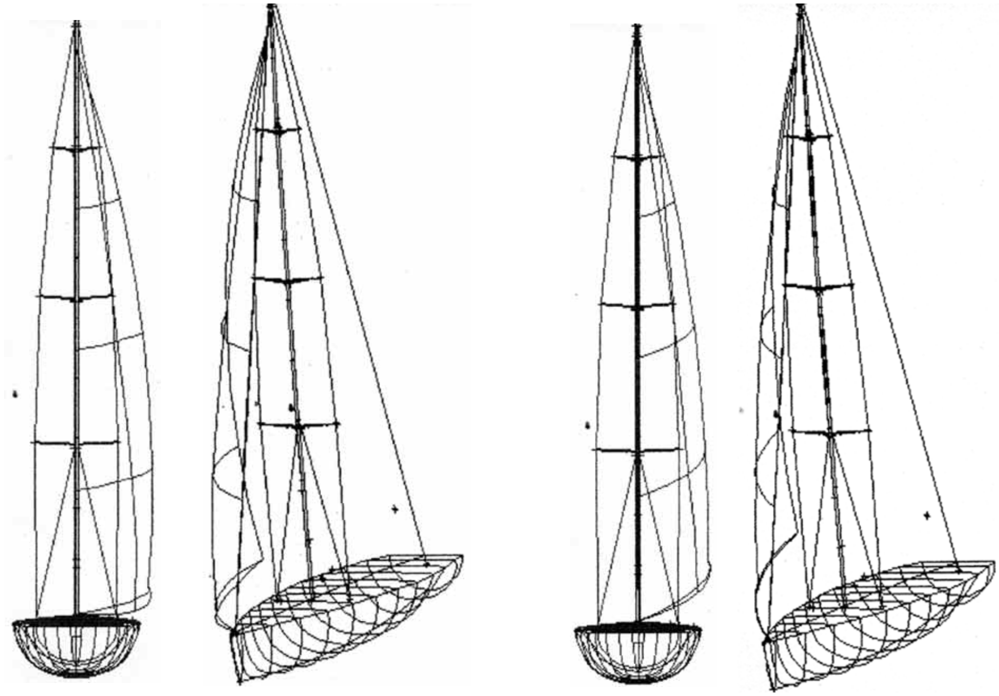




The following 14 wire-frame drawings are from the sail-design computer of Dan Neri, North Sails RI's chief sail designer. One set of drawings is for a conventional low-clewed genoa. (left). This sail has a 140-percent overlap and a 3.5-foot (1.07m) clew height above deck. The second set is for a 130-percent LP genoa with a 6.25-foot (1.92m) clew height. Both sails are proportioned for a 40-foot (12.3m) masthead sloop. In the first four sets, the sails are trimmed for beating in a 28-degree apparent-wind angle.

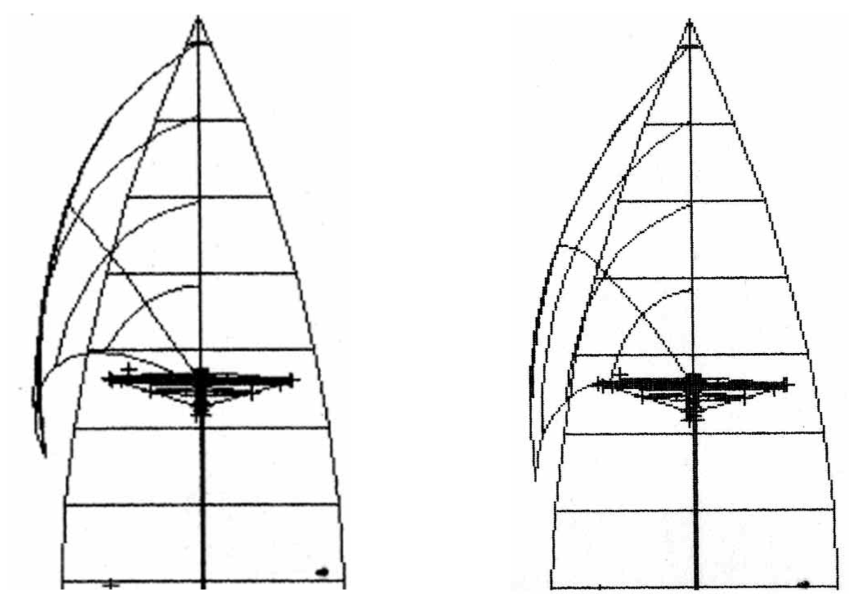
The separation between the foot of the sail and the deck allows pressure bleed under the foot. The more separation, the more bleed, and the slower the boat. The ideal situation is to have the forward third of the foot sealed directly to the deck. On the other hand, as we've stated before, the low-clew sail is harder to trim on a reach and tends to scoop water when a sea is running. (North Sails RI drawings)

TOC
Last Chapter
Next Chapter
Help!



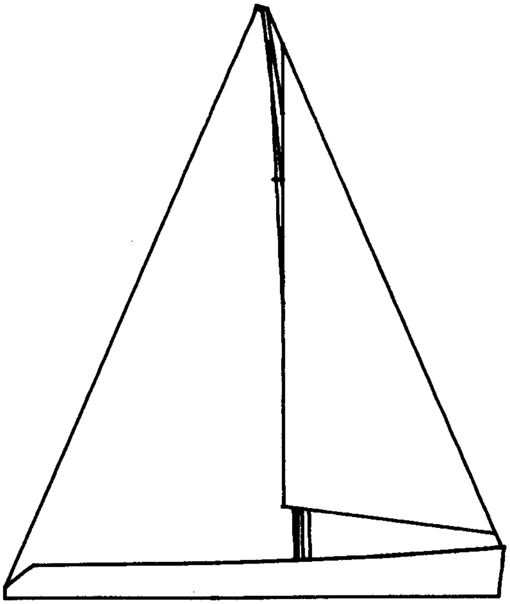
These drawings show the sails eased off to a 45-degree apparent-wind angle. Notice how the back end of the lower clewed, larger LP'd sail *hooks* back towards the boat (most noticeable in the lower left drawing). The farther off the wind you sail, the worse this problem will be. This slows the boat, creates lots of *weather helm*, and increases heel.

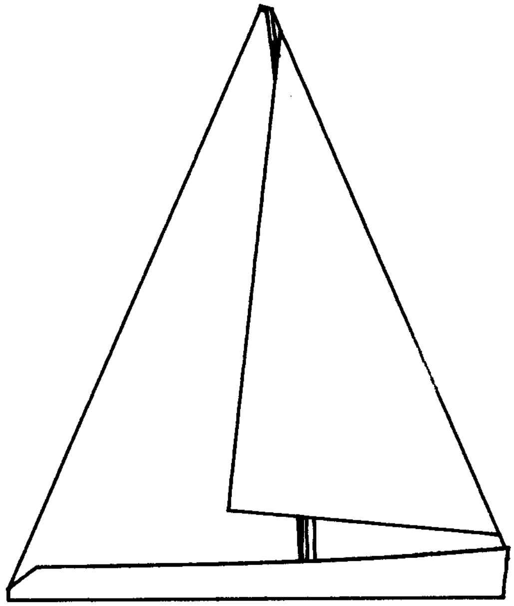
On the other hand, the higher clewed sail has a very smooth, straight exit. This is faster, reduces the weather helm, and cuts down on heel. Ideally, you would have two different sails for two different conditions — a low-cut genoa for upwind work and a slightly smaller, higher clewed reaching jib. In this case, the clew height of the jib is going to depend on what angle you want it optimized for. The further off the wind this design point, the higher the clew. The higher clew in this series of drawings is a compromise sail, designed to work upwind and close reaching. It would not be perfect for either, but it is a reasonable compromise. (North Sails RI)



TOC
Last Chapter
Next Chapter
Help!

TOC
Last Chapter
Next Chapter
Help!



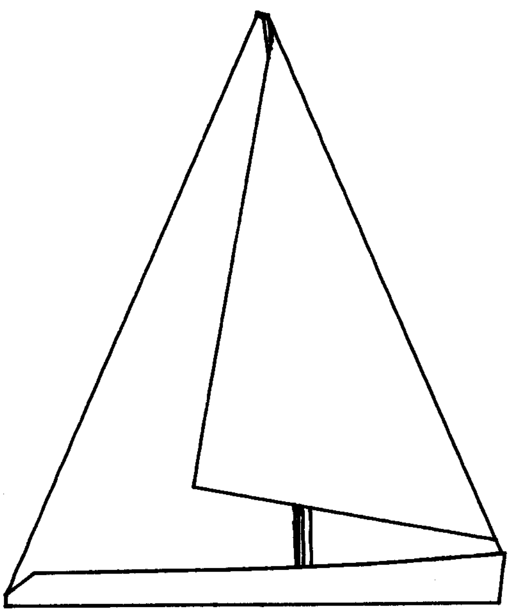


When the time comes to sit down with your sailmaker, you will need to give him an idea of how large you want your jib or jibs to be made, and what you want to do about clew height.

The upper-left drawing shows a nicely proportioned working jib. This type of sail would be used if you had a wide staying base for your shrouds and could not overlap the shroud efficiently (with the clew of the jib) when going to windward. The clew is moderately high, so that the sail will sheet well when reaching. Note how the tack is up quite a way from the deck. This allows space for the roller-furler drum and will avoid chafe problems between the pulpit and the foot of the sail when sailing off the wind.

The head of the sail is down from the masthead to allow for the roller-furling hardware, and to keep the angle of the head from getting too narrow. Excessively narrow head angles are hard to trim, and it's difficult to build them strong enough. The leech of a sail like this would be cut so that it just kissed the upper and lower spreaders, to provide maximum sail area ahead of the mast. This dimension— the distance between the headstay and the spreader — should be fitted on the boat with a partially built sail, to allow for the sheeting angles and sail curvature, and to develop the maximum amount of sail area.

The upper right jib is a 125-percent "lapper." It sheets outside the shrouds. The clew has been raised a bit more than on the working jib on the left. The tack is in the same position, so you'll clear the pulpit, but the head has been rasied just a hair.



A lapper is a good all-around sail — efficient to windward and still good when set on a pole while sailing wing-and-wing downwind. In light-air reaching conditions it may be underpowered, but in any sort of a breeze it generally has plenty of sail area for most boats.

The bottom-left drawing is for a jib top or reacher. The sail is 130 percent of the forward triangle. The clew has been rasied quite high, so that it sheets nicely when sailing free. The clew should also be designed so that it leads to the end of the main boom when broad-reaching. This usually requires a somewhat higher position (shown here) than what might otherwise be the case.

If you have a roller-furling working jib, and need something to fill in off the wind and when reaching in light airs, consider a sail like this. It's made from very light material, and is flown on its own luff rope or wire. It is hoisted on the spinnaker halyard and can be put away with a roller-furling drum at the base, or a spinnaker-type snuffer.

This relationship between staysail and yankee jib is about right. Overlap is minimized, and there is a nice slot between the sails. The high clew of the yankee makes it efficient to use when the sheet is eased. However, to windward there is a tremendous amount of loss at the tack and head due to pressure bleed-off, not to mention a high center of effort for the sail as a whole.

ADDING A CUTTER STAY

Before we start talking about heavy-weather canvas and staysails, we need to discuss where they are going to fly. This brings us to the subject of cutter stays.

The minute you consider heading offshore, you need to think about spar support and heavy-weather canvas. A very efficient way of increasing mast support while getting a wonderful place to fly heavy-weather headsails is to add a cutter stay.

Coupled with the cutter stay will be a pair of running backstays to counteract the cutter stay's forward pull. These extra shrouds will increase the fore-and-aft stiffness of the mast enormously, adding to safety factors, especially when the main is reefed. The ideal compromise position for support is at or just above the second spreaders on a double-spreader rig, or about two-thirds of the way up on a single-spreader rig. If you're going for a really large staysail, you may want to move up more, although there will be less support.

Your normal working headsail will tend to hang up on the staysail stay when you tack; the larger the headsail or the farther forward the staysail stay, the bigger the problem. A forestay release mechanism to facilitate removal of the forestay will make tacking easier. A Hyfield lever works well, or the base of the stay can be attached to a moveable car and a track. Another approach is to use a hydraulic cylinder.

Whichever way you go, remember that this stay is structural. If you're bolting a tack fitting to the deck, be sure to pick up a bulkhead inside with a knee brace or to run a strut from the hull to the base of the fitting to dissipate the load. Don't try to put the staysail-stay load straight into an unsupported span of deck.

TOC
Last Chapter
Next Chapter
Help!

Double head rigs can be very powerful, when they are trimmed correctly. However, getting the two sails in the correct relationship is difficult, and takes careful, constant attention by the crew. In this shot of *Intermezzo II* the two headsails are oversheeted (they are way too close together!) and so are interfering with one another.

TOC

Last Chapter

Next Chapter

Help!

Runners

Running backstays are required to counteract the forward load of the staysail. These are generally at a much wider angle than the staysail stay and can be one size smaller. Be sure that the backstay tangs on the mast are slightly above the cutter stay, and check to see that the backstay wire will be clear of the spreader when they are tightened.

The actual position aft of the deck fittings is a matter of some compromise; the farther aft they are, the less load on the rig. However, runners provide an excellent brake for the main boom during unexpected jibes and are good handholds. I like to see them so they just catch the end of the main boom. On the other hand, if they're clear of the main boom, both runners can be set when the mainsail is deeply reefed with both sail and boom clearing. Try to avoid locations that would put them in the middle of side boarding gates.

Runners should be cut short enough so that when pulled forward, their blocks clear the deck by 6 inches (152.4 mm). If there's a trunk cabin or pilothouse, check the runner block for interference as it runs forward. When the runners are aft and supporting the mast, you can use either a single rope pennant through a turning block, or put a block on the end of the stay and use a 2-to-1 purchase. This latter approach has the advantage of splitting the load into the deck. A retrieving line, to pull the runner forward when it's not in use, is run from the end of the runner to the mainmast chainplates and then aft to a jam cleat in the cockpit.

If you have a single set of primary winches, it will be necessary to add a second set of winches in the cockpit to handle the running backstay to windward and staysail to leeward.

Sheeting Angle

The most critical aspect of this whole equation is staysail sheeting angle, especially if you want to have an effective double-head rig. A double-head-rigged staysail will sheet quite close to the centerline, so you may have to lay down some new traveller track. The key is the difference between the angles of the jib and staysail. Ideally, the staysail should sheet 2 to 3 degrees closer than the jib under double-head rig usage. If your jib is sheeting at 12 degrees to the rail, try for a staysail sheet angle of 9 degrees. On the other hand, if you are going to sail with the staysail alone, then you may be able to use your jib-sheet tracks if you foot off a bit more.

Cutter Stay Chafe

Having just convinced you to add a cutter stay, now let me tell you about the downside. Every time you tack, your jib or genoa has to drag itself across the cutter stay. Not only does this slow the tacking process, it is also very hard on the sailcloth.

Each tack across the cutter stay shortens the life of that headsail, as the fibers are bent across the stay. The more heavily resonated the sail is, the bigger the problem.

If your headsail happens to be made of a laminated fabric (i.e., Mylar and Dacron, or Spectra and Mylar), the degradation will be even worse.

If you want your headsails to really last, be sure to remove the cutter stay whenever possible when tacking (or roll the jib up as your bow comes through the eye of the wind).

Sundeer is heading into a tropical squall in this photo. Because it was already blowing in the high 20s we ran off and doused the jib, leaving just staysail, main, and mizzen flying. Even though this is a heavy-weather staysail, the clew is quite low. On a vessel as powerful as *Sundeer*, with little tendency to scoop her bow wave aboard, you can get away with this. However, most heavy-weather staysails would lift the clew more off the deck.

STAYSAIL

The staysail can be a real workhorse. When the breeze starts to pipe up it provides an efficient means of changing down in sail area, and since it's aft of the bow a bit, it is less prone to scooping water. At the same time, when flown under a reaching jib, drifter, yankee, or even spinnaker, it can provide extra drive.

If your primary headsail is poled out to windward, the staysail can be flown sheeted to leeward. In this position it helps "slot" the mainsail by providing extra flow over the all-important leading edge.

We then have two very different requirements: first, a medium-to heavy-weather means of shortening down, and second, augmentation of light-air and downwind sail power. Ideally you would have two staysails — a heavy one for higher wind strengths with a high clew, and a light-wind sail with more shape that is a deck sweeper. However, this is probably not going to be practical due to space/budget restrictions, so you have to make a choice. In this case, optimize the sail for the upper wind ranges.

Double Headsail Sloops

With conventional sloop-rig proportions, the forward triangle is much smaller than on a true cutter. So when a cutter stay is added, the tack fitting will be a lot closer to the headstay tack than is the case on a cutter rig.

This makes it impractical to fly the staysail and jib together (unless the sails are used downwind in a wing-and-wing configuration).

Properly sized, a staysail can be used with a full main and still balance reasonably well. If your working headsail tops out at about 18 knots of true wind, a large staysail will begin to work effectively in the low to mid 20s. There is a gap where you'll be undercanvassed, but in that amount of breeze, there's plenty of boat speed for cruising anyway. Add a reef in the main, and you're up in the high 20s in windspeed. A second reef in the main gets you into the 30s without having changed a sail.

You then have the choice of using a reefing staysail or changing down to a small storm staysail.

TOC
Last Chapter
Next Chapter
Help!

TOC
Last Chapter
Next Chapter
Help!

The Erickson 41 *Windshadow* (left photo) with the Naranjo family aboard, was a frequent companion during our circumnavigation. Compare the height of the clew on their heavy staysail with that of *Sundeer* on the preceding page. This is a more-conventional height for a heavy-weather sail. The staysail is used here in light air in conjunction with their jib top. While not as effective as a low-clewed light-air staysail, it works better than nothing and avoids the space and expense of the specialized light-air sail.

Another double-head-rig configuration (right photo), this time on my Dad's original *Deerfoot*. This is the "classic" combination of high-clewed yankee and low-clewed staysail. The yankee just reaches the cap shrouds. This is an effective combination for the double-head rig but is much more difficult to trim for speed than a single larger sail would be.

Cutter Rig Staysail

Here the staysail will be smaller than with the double-headsail sloop rig. Sail construction will tend to be heavier and flatter than otherwise would be the case.

Staysail Shape

With fore-and-aft lower shroud support, the lower shrouds will interfere with the leech of the staysail. To get around this, the sailmaker does several things. First, the head of the sail is dropped down a couple of feet from the mast. This also provides some needed separation from mast turbulence. Second, the leech is hollowed out a bit. Remember, when measuring for a staysail, the sail will not be straight as measured, but curved a bit, drawing the leech of the sail forward. This means the sail can be somewhat larger than actual measurements dictate.

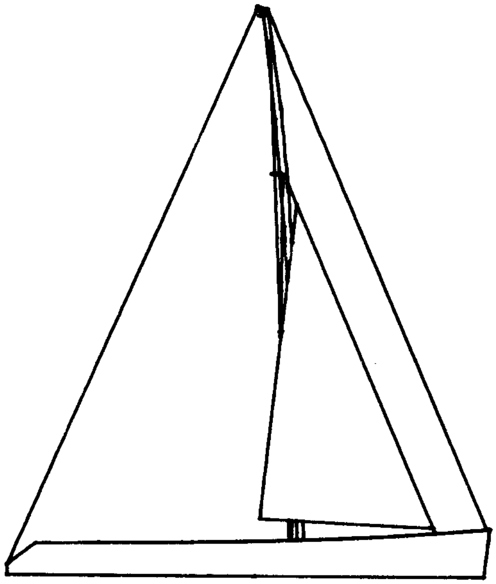
If you have single (aft) lower shrouds, the first obstruction the staysail will hit is the lower spreader. The leech will be hollowed to just clear this point and then the clew extended to just aft of the lower shroud, on the inboard side.

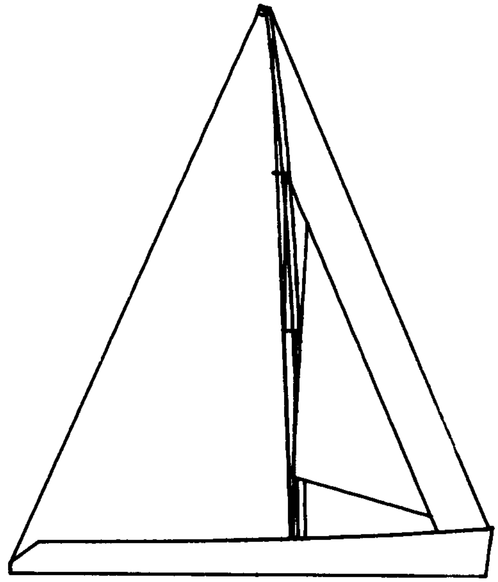
In the absence of sheet-lead restrictions, the clew of the staysail should be quite low, providing just enough deck clearance so the sail will be properly shaped when the lead is moved forward for downwind work. A staysail with this configuration will end up overlapping the mainmast by a hair.

It's not a bad idea to ask your sailmaker to install a few battens along the leech to reduce chatter.

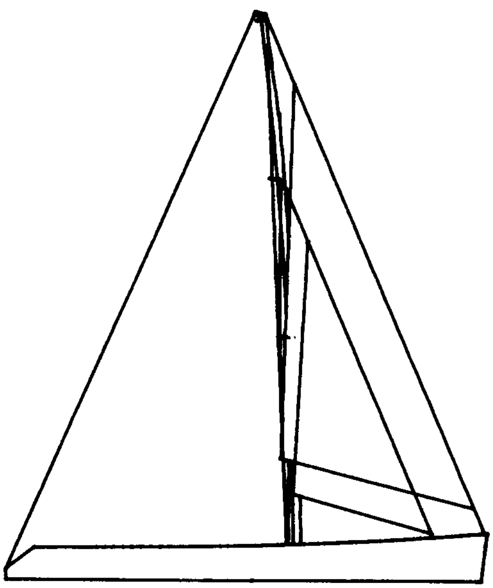
Boomed Headsails

Before leaving the topic of headsails we need to briefly discuss boomed jibs and (more commonly) boomed staysails. In theory they allow you to have a self-tacking headsail and eliminate the need for poles when sailing downwind.





There are two basic approaches to staysail design. The first (left illustration) maximizes staysail sail area. The foot of the sail is close to sweeping the deck, with just a hair of gap left open for water to pass under. The tack is as low as practical. The leech will just kiss the lower spreader, and the clew will come as far aft as leech hollow allows. This sail will be very effective under certain conditions when used with a working jib (especially one with a higher clew to minimize interference between the two sails).



The problem comes in heavy weather. On all but the largest of boats, this staysail will be easily damaged when reaching or beating in less-than-ideal conditions by seas that sweep across the deck.

For heavier weather, along with more robust construction, the tack and foot must be lifted off the deck so that there is plenty of room for water to pass underneath (as shown in the upper right).

The higher clew of this design will make it easier to trim, reducing the amount of movement required of the jib-sheet car as apparent wind shifts.

In heavy weather this becomes a critical factor, as an improperly sheeted sail will have either the leech or foot chattering. That chattering can quickly lead to severe damage. At the same time, the last thing you want to do is to go forward during a gale and move a jib lead forward or aft. So the higher clew is a must for a heavy-weather staysail. If you don't want to spend the money or space on two sails, stay with the heavier weather sail and accept the compromise in lighter conditions.

The bottom illustration shows the heavy staysail being flown under a small working jib. If your full-sized jib is damaged, this type of rig can be reasonably efficient. And, if heavy weather is expected, starting out this way makes it easier to shift down in sail area by rolling up (or dropping) the outer jib.

To some degree, a boom will perform both of these functions. However, there are numerous negatives associated with the concept. First and foremost is the fact that under many conditions of foredeck work, the boom will be unstable. In addition, if it decides to head in your direction, when you're on the foredeck there isn't much you can do, short of going over the side, to avoid it.

In this same vein, the booms have a habit of really messing up an otherwise easy-to-work-on foredeck when you're in port. They limit headsail shape and size and don't provide any means of vanging (i.e., eliminating twist in the head) when they are eased.

If you get the impression that I'm not in favor of jib or staysail booms, you're right.

TOC
Last Chapter
Next Chapter
Help!

TOC
Last Chapter
Next Chapter
Help!

An on-deck view (above) of a double-head rig. The staysail shown has the clew lifted for heavy weather. This also makes the sail easier to sheet when sailing free. (North Sails RI photo)

Here is the one time that a boomed staysail is an advantage (right photo). With the jib furled, sailing upwind with boomed staysail and mainsail, all you have to do to tack is put the helm alee. The staysail boom takes care of itself. Of course you have the clutter of the boom on the foredeck to contend with the rest of the time.

FULL-BATTEN HEADSAILS

Full-batten headsails make sense, too. Up forward, the battens' ability to eliminate luffing adds to longevity and sail-pocket control. Battens eliminate leech chatter and make the sail easier to hoist, drop, and feather.

If you have a sloop without an intermediate forestay, a full-batten working jib can eliminate the need for roller furling (if you sacrifice overlap, which is pretty inefficient anyway). The battens really come into their own on staysails and storm jibs.

When we designed the sail wardrobe for *Sundeer*, we decided to apply this full-batten logic in our foretriangle. Because we had a staysail stay, we were limited to a single full batten in the upper part of the jib (which would clear the staysail stay when tacking). This batten helps the shape of this very efficient, high-aspect sail tremendously. On reaches, where the tip would normally twist off in an uncontrolled fashion, we could maintain sail shape, which increases drive enormously.

We've also adopted full battens in our storm jibs. Over the years we've observed that damage to storm jibs almost always comes from luffing due to improper sheet leads or changes in wind direction. Using full-length battens reduces this problem.

The negative with full-batten headsails is in stowage. To be really convenient, they have to be left on deck and stowed on the stay. Since we have a large forepeak, this isn't a problem with the storm jibs. If stowage is a problem, I recommend dispensing with the full battens.

How the battens are laid out is important. With hank-on sails they can be parallel with the water, as long as the jib hank is placed just below the batten. If the hank is placed above the batten (or if two hanks are used), the batten(s) will bind on the way down the headstay.

A nice-looking full-batten main with a conventional roach. The gently rounded leading edge and straight leech make it both easy to trim and fast. (North Sails RI photo)

THE MAINSAIL

There are all sorts of debates about the best way to make a cruising mainsail. Some folks advocate doing away with battens entirely, and others (like us) say you should have not only battens, but also lots of extra roach. We'll discuss some of these issues below. For now, keep in mind that the enormous change in sailcloth, batten materials, and hardware that's taken place in the last few years has opened up all sorts of possibilities. Not all sailmakers or many cruisers have yet learned what's now possible.

Hollow-Leeches

There are some advocates of doing away with battens entirely, which leads to a hollow-leech mainsail. This cuts down on maintenance, but the sail is very difficult to shape and loses a tremendous amount of drive — far more than what's lost from the small amount of sail area that's cut off from the leech.

In addition, the higher induced drag associated with a hollow-leech main will cause the boat to heel more. Yes, you read that right; reducing leech sail area in this manner will actually increase your heel due to the much higher induced drag of the narrow tip on the main.

As a result, I feel a hollow-leech mainsail is a big performance and comfort mistake.

Loose-Footed Sails

It used to be that all mainsails were attached to the boom every few feet with slides or continuously with a boltrope. There were sound structural reasons for this inherent in the sail materials that were used. However, today, with high-strength sailcloth and a better understanding of how stresses are concentrated in the corners of a sail, it is structurally feasible to use a loose-footed main. This sail offers the cruising sailor a better range of sail adjustment — from flat to full — with the outhaul controls. The sail will also set better in its lower panels.

There are some other advantages as well. A loose-footed mainsail is a lot easier to get on and off the boom. Sail ties and reef lines are easier to attach as well.

Attachment to the Mast

The most efficient way to attach a mainsail to the mast is with a boltrope and luff groove on the aft side of the mast. This is the norm on all racing boats and probably increases mainsail drive upwind.

However, for shorthanded sailing this approach presents a series of handling problems. In a breeze it takes several sets of hands to raise the sail. When the sail is lowered, it drops out of the luff groove and will blow off to leeward unless the crew is quick on their feet. During reefing this obviously adds an extra dimension of difficulty.

The alternative is to attach the main with slides. The slides stay on their track permanently, so when raising or lowering you don't have to worry about the sail feeding into a groove or blowing away.

When you reef, the slides stack up at the bottom of the sail track, holding the sail in place. This means the reefing-tack cringle must be slightly higher than the reef clew to allow for the slides.

Types of slides are discussed more fully under sail construction.

TOC
Last Chapter
Next Chapter
Help!

TOC

Last Chapter

Next Chapter

Help!

FULL BATTENS

One thousand years ago the Chinese were sailing the world (while Europeans were cowering close to home) using full-battened sails. Thirty-five years ago we were racing small catamarans with full-batten sails. In both situations, the establishment deemed full-batten sails something of an oddity—and in the case of racing boats, battens were banned.

When we started cruising with *Intermezzo*, we had a full-batten mizzen built, but due to a lack of suitable hardware and batten material, we left the mainsail with its short battens.

When we built *Intermezzo II* we decided to use a full-length batten at the top of the sail. This had the advantage of preventing the top of the sail from hooking inside the cap shrouds during a jibe (with the resultant damage to the sail that almost always occurred) and giving us better sail shape at the top.

By the time we'd gotten around to designing *Sundeer* in 1986, the materials were available to cobble together proper full-batten sails on large cruising yachts. Today everyone is in the act, and there are dozens of choices on hardware and batten material, making the sailmaker's job much easier. And guess what? The establishment has even made full battens legal in IMS and PHRF racing, albeit at some penalty (which proves they are faster).

Why Full Battens?

The full-batten sail improves performance, eases handling, increases longevity, and reduces wear and tear. How? Well, to begin with, you and your sailmaker have better control over sail shape. The battens reduce the tendency for draft to migrate aft as the wind increases, and they keep the leech from closing as quickly as it might when the breeze pipes up.

Obviously this improves performance in windy conditions, but in light airs the full battens reduce sail slatting — even more of a performance benefit.

If you've never sailed with full battens and properly rigged lazyjacks, you can't imagine how easy it is to tame a mainsail. Even the 820-square-foot (76.2-square-meter), 175-pound (79.4kg) mainsail on *Sundeer* was easily handled by Linda and me.

When a puff comes through and you're temporarily overpowered, easing the sheet to ease heeling *is not* accompanied by a violent flogging of the sail. This means you can luff the main through more wind than before (and avoid reefing longer), with a lot less wear and tear on the sail.

And, when the time does come to reef, the sail will sit quietly while you winch the reef clew down to the boom.

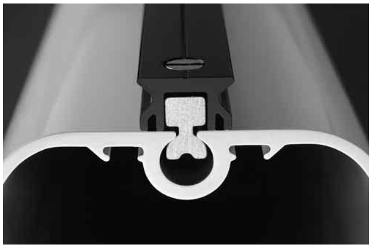
This aspect, combined with the fact that the roach load no longer causes a hard spot at the inboard end of the battens, adds significantly to the useful life of your sail.

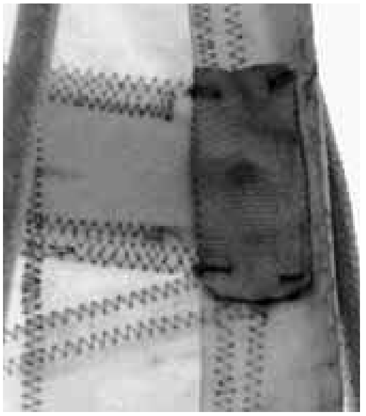
New Main or Retrofit?

One of the nicest features of full battens is that you can retrofit them to an existing mainsail to improve performance and longevity just as effectively as if you were buying a new sail. And if the present sail is getting towards the end of its useful life, full-length battens will add quite a bit of time to its serviceability.

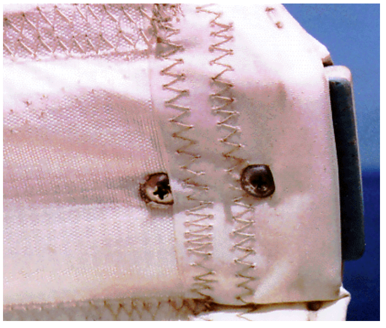
Of course, if your present main is shot, a new sail may make the best sense. In either case, the hardware and system details are the same.

Three views of Harken's latest offerings in the full-batten world. These ball-bearing cars run freely, easing the chore of getting the main up and down. However, they are heavy; the track adds significantly to spar weight; they open the gap between spar and sail), and they are expensive. If you can tolerate the weight aloft, and if the cost doesn't bother you, these systems do work.





Over thousands of sea miles the aft end of batten pockets will endure a lot of wear. These are bolted into place, with the bolts running through grommets in the sailcloth. This way the cloth is not chafed by the batten end. The bolts are covered with a piece of webbing to prevent them from catching on light sails or the backstay.



Batten Material

From a cruising standpoint, the batten stock's reliability is the first concern. The second question is weight-to-stiffness ratio. Obviously, you want the lightest batten aloft that will do the job and provide years of trouble-free service.

The first question, then, is just how stiff the batten needs to be. This is somewhat problematic and subject to a bit of testing. Happily, you can begin experimenting with very inexpensive batten stock. If your sailmaker has experience with full-batten sails, he can guide you to the best starting point. But you need to guide him on how you want the sail to behave.

As a general rule for offshore work, when in doubt, make it stiffer. Just supporting the leech area can be accomplished with light battens, but it takes stiffness to keep the sail quiet when it is feathered.

Next, there's a basic shape decision to be made. Rectangular shapes lend themselves to lightweight sandwich construction. A set of sandwich battens will weigh as little as 50 percent as much as a comparable set of solid-glass battens and will be stiffer to boot. But sandwich battens are significantly more expensive and more prone to breakage than solid glass.

Having used all sorts of sandwich-, solid-, and hollow-fiberglass battens, we've settled on round battens as the best compromise. All-fiberglass round shapes are stiffer for a given weight than solid-glass rectangular shapes.

If you're going to use round battens, the next decision is: Hollow or solid? Very stiff, light battens can be achieved by increasing diameter and decreasing wall thickness. For coastal work this makes sense. Offshore, however, as much as I hate the weight aloft, the heavier, solid round sections make the most sense. They are much more abuse-tolerant than the lighter hollow battens and can stand uncontrolled jibes better.

These fiberglass battens are "pulltruded." (Pulltruding is much like extruding plastics or aluminum, except in this case the pulltruder mixes unidirectional fiberglass threads or tows, as they are known, with resin.) There can be a substantial variation in resin type, glass-to-resin ratio, and the amount of filler used. The best battens are made with vinylester resin, about 65 percent glass-to-resin ratio, and very small amounts of filler. The vinylester resin allows the batten to flex more before it will break. Polyester resins are more common. Ask about glass-to-resin ratios as these can vary widely. Remember, the more glass-and-less resin, the better the batten.

Solid round battens are actually not that heavy. Here are some typical weights for Bainbridge/Aquabatten stock: 3/4-inch battens (19mm) are 0.356 pounds per foot (0.524 kg/meter); 7/16-inch battens (11mm) are a quarter of a pound per foot (0.367 kg/meter); 3/8-inch (9.6mm) battens are 0.09 pounds per foot (0.132kg/meter); and 5/16-inch (8mm) batten stock is just 0.06 pounds per foot (0.088kg/meter).

The use of full-batten sails on race boats has brought with it a supply of high-strength, lightweight epoxy battens, in filament-wound and laminated construction. These can be amazingly tough, yet light in weight. Before investing in a set of these, it is best to use cheap battens to find the right combination of stiffness for your needs. Once this is established, using the existing battens as a benchmark, order the high-tech units.

Then there's the low-tech approach. Jim Lidgard, a leading Kiwi sailmaker, frequently uses PVC pipe with fiberglass inserts in the forward sections to support his full-batten sails. This was the approach Jim and Cheryl Schmidt used on *Wakaroa*, and after 8,000 miles of sailing, Jim reports that he hasn't had any problems yet.

TOC

Last Chapter

Next Chapter

Help!

TOC

Last Chapter

Next Chapter

Help!

The photos above and below show a conventional full-batten sail with what I would call average draft built in. (North Sails RI photos)

The photos above and below are of a Sundeer 64 main with an aggressive roach profile. This sail is much flatter than you might expect, as the Sundeer hull shape is quite easily driven and requires less sail force to move it through the water. The flatter rig produces less drag and less heel. (North Sails RI photos)

Batten-End Chafe

It is critically important that the end of the batten that contacts sail cloth (usually the aft end) be smoothly rounded so chafe is minimized. This should be filed, sanded smooth, and finally wrapped with a bit of tape.

Broken Battens

What do you do when battens break? There are several considerations. First and foremost is the possibility of damage to the sail. If the batten is pulltruded, the odds are that it will not totally snap, but that the longitudinal glass fibers will hold the two sections together. In this case, you have time to act. If, on the other hand, there is a good chance of the batten breaking into sections and one of those jagged edges poking through the sail, you'll need to get the sail down and repair it.

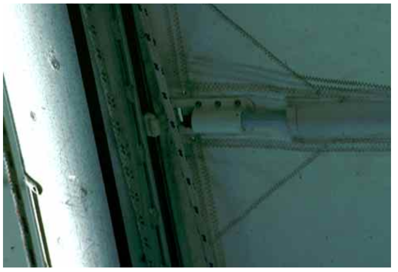
Assuming you do not have spare battens aboard, there are several means of making temporary repairs. One method is to splint the broken section of batten by using another batten section, piece of pipe, or chunk of timber. The splint can be attached with sail tape, duct tape, or even fiberglass filament packing tape.

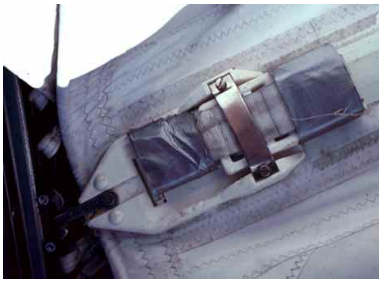
If you are using round battens, it is often possible to create a split from a larger diameter piece of pipe, into which the batten ends are slipped. Once again, tape can be used to keep the batten sections in place while they are re-inserted into the sail.

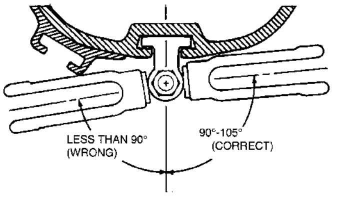
Shape Control

Ideally, the battens should be tapered in front to help the sail keep its pocket forward. Some battens can be purchased ground down in size toward their forward ends to optimize shape. Or, with laminated rectangular battens, the forward ends are thinner. Another approach is to slip a second piece of batten material alongside the aft half of the primary batten. If the two sections are taped together at close intervals you can get a nice airfoil shape without too much work. Full-batten sails, however, still respond to luff tension (like a soft sail) for draft position and volume.

Generally speaking, we've been able to make untapered battens work well by moving the sail pocket about 5 percent farther forward than would otherwise have been the case. The shape in the sailcloth then battles with the lack of shape in the batten, resulting in a very good-looking compromise.







There are all sorts of ways to deal with batten hardware, and the choices are greater than ever before.

One of the critical issues is how far aft of the mast the batten itself should start. This depends on the mast shape and the presence of a trysail track. If you have in-line spreaders (where they are at right angles to the centerline), the battens need to be able to bend slightly forward of perpendicular, as shown in the drawing at bottom. (Battslide drawing).

Ideally there will be some means of simple adjustment at the forward end. The two top photos on the left have crude approaches to adjustment, but they get the job done. More elegant are the two Battslide receptacles shown in the two lower left photos. These have bolts that are easily adjustable with a socket wrench while the sail is on the mast.

The length of the mast slide (upper right photo) is important for smooth operation. Longer is better. We typically have our sliders made 3 inches (75 mm) long.

TOC
Last Chapter
Next Chapter
Help!

TOC
Last Chapter
Next Chapter
Help!

Hardware

There's probably no area that's seen as much development in the last decade as that of front-end hardware. At the simplest, you can use a reinforced Dacron pocket with a conventional sail slide attached just *under* the batten pocket. Yes, there will be some chafe on the sail that the specialized hardware will eliminate, but this is a quick and easy way to go. Done properly, you can expect upwards of 3,000 miles before pocket-chafe maintenance is required. Just be sure to use a *single* slide placed underneath each batten. And, it's a good idea to make this a metal slide, too.

Several hardware suppliers have inexpensive molded-plastic batten receptacles that are bolted to the front of the sail and then webbed conventionally to a sail slide. These units provide a tightening screw to adjust batten tension. We've found that they do a pretty good job.

The next step up is one of Russ Foster's "Battslides." Russ has been making these aluminum jewels since the late eighties, and they come in a variety of shapes and sizes. The key ingredients are an aluminum slide that fits in or over your existing slide track, a miniature stainless-steel gooseneck fitting, and a batten receptacle. We tested some of Russ's first Battslides; in *Sundeer's* first 16,000 miles, we found them trouble-free. Since that time, we've specified his hardware on all of the boats we've done.

Russ has recently come out with a new unit for round battens, which incorporates a very clever adjustment mechanism. Batten tension can be changed in a matter of seconds with a socket wrench with the sail furled.

Getting the Sail Up and Down

Full battens have gotten a bad reputation in some cruising circles as being hard to raise and lower. This is due almost entirely to how the sail is attached to the mast.

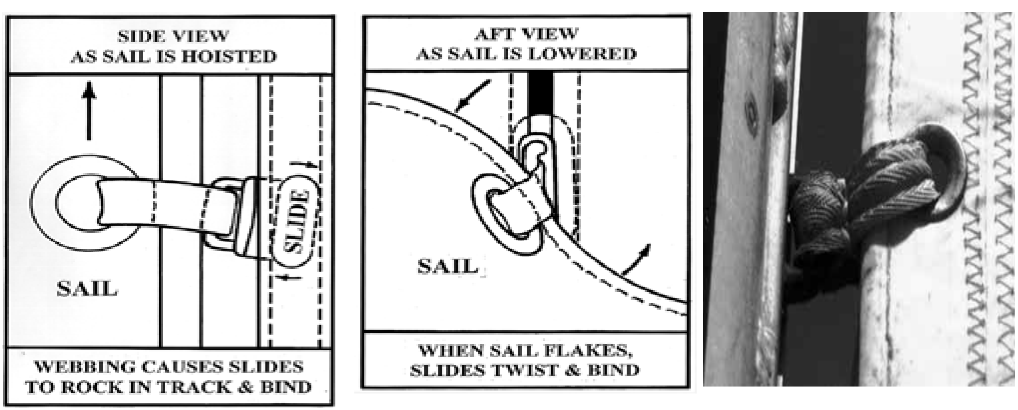
First, the slides that attach batten hardware, as well as the intermediate luff-attachment points, need to be longer than the norm. If they are of conventional length, the slides tend to twist or wrack in the sail track and bind on their corners as a result.

If you have a full-batten sail you can pull a slide out and looking at the wear. If it is even all the way around, the slide is not binding. If the wear is tapered or trapezoidal in shape, the slide is cocking and binding.

We usually specify our attachment hardware to be 2 inches (50.8 mm) long, rather than the normal 1 1/4 inch (31.8 mm).

Intermediate Attachment Points

Of even more importance are the intermediate attachment points. When a "normal" sail is attached with slides there is a minimal distance between slide and sail bolt rope. The slide webbing forces the slide to run up and down the mast in line with the bolt rope. But when you go to full battens, the batten-end hardware moves the bolt rope (or luff) of the sail aft of the spar about 2 inches (50.8 mm). If the intermediate slide is attached with a single piece of webbing, the slide can drag behind the sail (in up or down mode). As it drags, it cocks or angles itself against the sail track and creates all sorts of friction. There are two ways around this. The first is to use an upper



These two drawings show the problems that occur with conventionally webbed-on intermediate slides. When there are problems with a full-batten sail going up or coming down, 90 percent of the time it because the intermediate slides catch.The photo gives an indication of how this happens. (Battslide illustrations)

Here's an alternate intermediate attachment point. Webbing slides up and down helps keep them in alignment when the sail is going up or down.

(Above) Battslide has developed this simple solution to the intermediate slide problem. We tested the early models on *Beowulf*, and they worked like a dream.

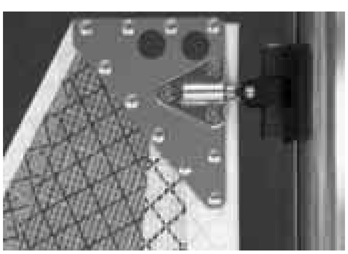
The photo below shows how this hardware works as the sail is being raised or lowered.

and lower webbing for each intermediate slide, spread at 45-degree angles to the slide (i.e., a 90-degree angle between the webbings). This tends to force the slide to track parallel to the bolt rope.

The other approach is to use some of Russ Foster's new attachment hardware made to cure this problem.

Headboard Connection

Headboards suffer from the same problems as other attachment hardware. Because the headboard is several inches removed from the sail track, the slides attached to it can rock in the track, causing lots of friction. Attachment slides need to be prevented from racking. This can be done with stainless-steel straps, bent into a deep U-shape and bolted to the headboard, or with proprietary hardware from one of the manufacturers mentioned above. But you must be sure the slides are forced to travel up and down the mast parallel to the sail.



The photo above shows a similar concept for the headboard. This is probably okay for up to 40-foot (13m) yachts, but above this size it would be preferable to have top and bottom headboard attachments to better distribute loads when reefed.

The relationship between distance aft of the mast of the batten hardware and trysail track is clearly shown in this photo (right). (North Sails RI photo)

Just to show you there's nothing really new, we adapted this Harken hardware to a full-batten system back in the early '80s for a Deerfoot 58 we built in Denmark (left).

TOC
Last Chapter
Next Chapter
Help!

Roller-Bearing Cars

The Harken brothers have adapted several of their dinghy travelers to the Battslides, marrying the advantages of Russ's rugged gear to their easy-running cars. While the use of their track adds somewhat to weight aloft, it does make the sail easier to get up and down. Other hardware manufacturers like Antal and Frederickson have followed suit, so there's no lack of choices.

There are several drawbacks which have to be weighed against the advantages of this gear. First is cost. You can easily add several thousand dollars to a mainsail (with this hardware) for a 40-footer (12.2m). Next, as mentioned above, is weight. Tracks weigh in at a little over 1/2 pound (0.23kg) per foot. That doesn't sound like much, but it is a huge knock on your center of gravity and stability (especially in a capsize mode). Third, the cars are quite long, and they add substantially to the stacking height of the sail, making halyard attachment and covering more difficult.

While we realize we are in the minority today, we have not found it necessary to use external track and roller-bearing cars on our own boats.

Batten Layout

Batten count varies with boat and sail size. The more battens you have, the better the shape control and the less flogging in the sail.

On the other hand, more battens mean additional cost and weight aloft, and tend to make the main stack up a little higher on the mast when it is furled. Still, the handling benefits are so great that we've found it best to work as many battens as possible into the layout.

On a 40-foot (12.2m) luff I'd want to see at least five battens — six would be even better. On *Sundeer's* 60-foot (18.3m) luff we had eight battens, and on *Beowulf*, with about the same luff length and a lot more roach and stability, we stayed with eight.

Laying out the battens on the sailplan involves a number of trade-offs. John Conser of Windward Sails in Costa Mesa, California, has been making full-batten mains for over 20 years. John points out that "ideally, each batten would be attached perpendicular to the leech. This increases batten support of the roach." John goes on to add that "if battens are placed at too much of an angle to the mast, the sail will be difficult to raise and lower."

In practice he finds that keeping the battens close to square with the luff up to the highest two or three works well. He also keeps the bottom battens parallel with the boom and reefs. The last few battens usually end up at about half of the ideal angle to the leech.

Batten spacing can be even on a conventional sail. But as your sail tends towards more aggressive roach, the top battens will progressively be spaced closer together.

Reef points work best when placed just under the battens.

Partial Approach

An alternative to a full layout of battens streaming across the mainsail is to have the top two or three battens made full length, with a couple of mid-length battens below. This gives you the advantage of controlling head shape and giving the leech good support, but it limits the increase in stacking height, weight aloft, and hardware costs of the full job.

If you take this approach, the lower battens should be between 40 percent and 50 percent of the luff-to-leech dimension.

Lazyjacks

Perhaps the hardest part of this full-batten system is finding the right lazyjack layout. We've been through 14 alterations so far, and I think we've finally got the formula down pat.

Here's the problem. Ideally, you want the lazyjacks to provide lots of support for the sail when it's dropped. That's easy enough. But, at the same time, you want to be able to hoist the sail without slacking the lazyjacks off (or the sail drops to the deck). What happens in most cases is that the leech of the sail hooks under the lazyjacks until the sail has been raised part way, so you end up taking the lazyjacks forward to hoist. A lazyjack system that reduces leech hooking is what you're looking for.

In our case, it wasn't until we dropped the attachment point of the lazyjacks on the mast to the lower spreaders (or about a third of the mast height), that the system started to work really well. This keeps the angle to the boom flat and provides good support for the furled sail, so by the time you've hoisted past the second batten the leech is through both lazyjacks and you're free to hoist away without worrying about a tangle.

The next question hinges on the actual lazyjack rigging. First, keep in mind that you want the system to remain tight as the weight of the sail comes onto the boom. We have found that 3/32-

TOC
Last Chapter
Next Chapter
Help!

inch (2.4mm) plastic-coated stainless wire works well as a pennant from the mast to 4 or 5 feet (1.2 m or 1.5 m) above the boom. To the end of this wire pennant is attached a small bullet block. We use 5/16-inch (7.9mm) Dacron rope for the next stage. This attaches at the end of one side of the boom; about 80 percent of the way aft works best for normal sails. If you have an aggressive roach take it right to the point of the clew. From this dead-end point the line runs forward over the block hanging down from the mast. It then passes under the boom, through a small plastic fairlead, and back up to the hanging block on the other side. From this block it goes back aft to the end of the boom, through another small bullet block, and back forward down the boom. The line then ends in a small jam cleat. This way you have a single line adjustment for *both* sides. When the sail is furled, gasketed, and ready for the sail cover, we ease the lazyjacks so they don't interfere with the sail cover, which is applied in normal fashion.

It took us 14 versions on *Sundeer* before we finally got a lazyjack system we liked.The key, shown here, is to get the battens sticking beyond the lazyjacks as quickly as possible so you don't have to keep them in line (as Linda is doing here).

If the system is worked out correctly for your boat, you or a crewmember will have to keep the leech between the lazyjacks for the first few feet of hoisting. Once the leech sticks out beyond the lazy jack pennant, you can hoist away without fear of fouling.

We've found the combination of *strong* lazyjacks and full battens makes it unnecessary to use cringles to keep the sail neat when reefing. In turn, this reduces the chance of damage to the sail should a reef line suddenly break and put the sail load on the cringles (which almost always leads to a trip to the sailmaker!).

Shroud Chafe

One area of chafe you do have to watch is with standing rigging and spreaders. Since the battens don't give as easily as the soft cloth, you need to make extra chafe protection efforts where they rub. We have found that the very best chafe protection is made from thin sheets of UHMW (ultra-high molecular weight) plastic. It has incredible abrasion resistance yet is easy to sew. Be sure to add this chafe protection wherever a batten can chafe against the shrouds and spreaders, in both fully hoisted and reefed positions. This is most easily accomplished by sewing on long, narrow strips to the battens.

Sailmaking Considerations

For a sailmaker experienced in full-batten sails, they are easier to design than sails with short battens. He doesn't have to deal with the batten "poke" problem so common in the old-style sails, and shaping of the back end of the sail is much easier to control. Of course, there are some extra steps in construction.

Batten Pockets

The forward end of the full-batten mainsail will be taken care of with the hardware we've already discussed. At the aft (leech) end you will need a very robust, chafe-resistant pocket. This is usually constructed with several layers of sailcloth or webbing with one additional layer of chafe-resistant material like vinyl or UHMW.

On larger yachts, Polyester Maxi webbing or Spectra webbing is frequently used at the aft end of batten pockets.

TOC
Last Chapter
Next Chapter
Help!

TOC

Last Chapter

Next Chapter

Help!

Telltales

Before setting sail with your new full-batten main, there are a couple of additional things to consider. The first is telltales. Since your full-batten sail won't luff easily, telltales on the sail are necessary to give an early indication of stalling or pinching. To make the telltales easier to read, have small windows sewn into the sail at each telltale, and include a full set of leech telltales, too.

When the windward telltale blows forward or the leech telltale blows to windward, you're pinching. Footing off or trimming the sail should get the telltales streaming aft nicely.

If the leeward telltales are blowing forward or the leech telltales are sucked to leeward, the sail is stalled. Ease the sheet or head up to get these flowing.

The same applies to headsails. A couple of windows just back from the luff of the jib, about one third and two thirds of the way up the sail, will help the trimming job enormously.

The Leech Wire

Then there's the leech line. With full battens, especially if you have added a little more roach, the leech line can be an extremely efficient mechanism for adding camber to the sail in light air or when sailing off the wind. Since you'll be using this adjustment more than before, and since it will take more force to compress the battens, run the leech line from the end of the boom forward toward the gooseneck where it will be easier to handle. A small tackle on the end may help, too. It's a good idea to use a light piece of 7x19 stainless wire instead of rope; it will handle the chafe at the batten ends better and won't stretch.

Sail Planform

I've saved the best part for last: Design of the sail roach. Aerodynamicists and sail designers know that the optimum planform (shape of the sail when viewed from the side) has an elliptically shaped tip, with the foot of the sail firmly attached to the deck or endplate. Obviously there are some practical limitations that prevent achieving this ideal. You have to be able to walk under the boom, so it isn't practical to seal it to the deck. In a conventional context, the leech has to clear the backstay (well, not really, but we'll talk more about this next). There is only so much load the sailcloth can support. Finally, of course, the battens must be able to hold out any sailcloth you put outside the basic triangular shape.

Using a lot of stiff battens means that you can support anything that will fit, so you want the sailmaker to design the largest roach with which you are comfortable.

MAXIMUM ROACH

So far we've been talking about mains (and mizzens) that reside within the triangular confines of the mast, boom, and standing backstay. Now onto the next phase.

Would you like to make a quantum leap in your cruising performance? Does the idea of sailing faster with less heel sound appealing? Does your conservative (by today's standards) cruising rig leave you wallowing in the wake of your more highly powered neighbors? If the answer to any of the above is yes, read on.

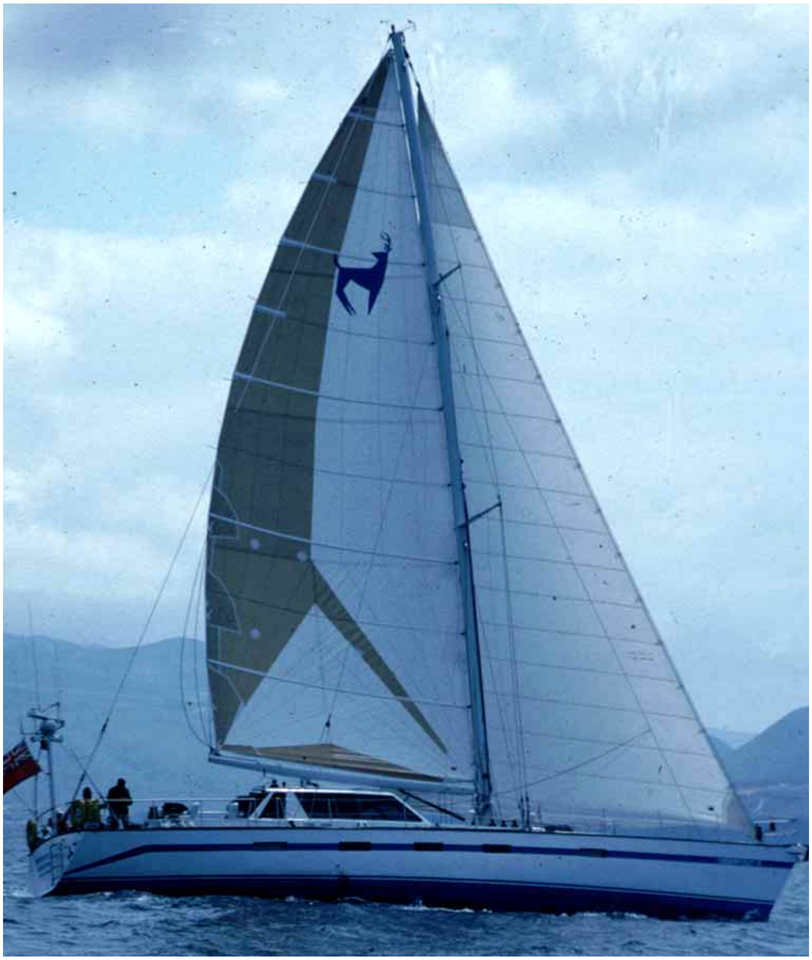
First, a little theory. Sailing to upwind, sail area generates lift and drag. To improve performance the objective is to reduce drag as much as possible while increasing lift. In most cases, within a fixed set of rig parameters, there's little you can do toward this end.

Of the various forms of drag you deal with, *induced* drag is the most harmful. Reducing induced drag allows you to sail in a more upright fashion, closer to the wind, and faster, too. (The less efficient your hull and keel are to windward, the more important this becomes.)

Short of replacing your entire rig with a taller, more efficient spar section and putting on a new deeper-draft keel, there's been little you can do — until now.

On the other side of the equation, boat speed (in light-to-medium airs) is pretty much a function of sail area. More area equals more drive, and as long as you're not overcome with drag (in the form of heeling), more sail area is better.

In the last ten years, as the full-batten sail has come of age, I've seen dramatic proof that reducing drag and increasing area really helps cruising boats to perform. In six cases I've been directly involved with, hollow-leech mainsails have been replaced with full-batten conventionally roached sails. The 10-percent increase in sail area has been, as expected, beneficial.



The overlap on this main past the backstay is 28 inches (711 mm).That looks and sounds like a lot, but today we are much more aggressive with the roach.

But more surprising have been the other results: significantly less heel while going faster, with *reduced weather helm*.

Counterintuitive as the preceding statement may seem, there is sound basis in theory.

When I asked John Letcher, a highly experienced aero/hydrodynamicist about our observed results, he wasn't at all surprised. "Induced drag is inversely proportional to span (luff length) squared, divided by sail area. The closer you can get to an elliptical tip shape, the better off you're going to be." And of course, what we'd observed with the added roach area was an effective step toward an elliptical tip shape.

I asked John just how much better the drag might be. "The difference between a sail built to IOR maximum dimensions and a hollow-leech sail could be as much as 40 percent," he told me.

This is even more important on a cruising boat, with its relatively inefficient (compared to a racing boat) hull and fins.

Peter Schwenn at Design Systems added that "the extra area, up high, works better because the wind is stronger aloft. And even though the center of effort in the sail is higher and there's more area, the reduction in induced drag could result in less heel."

More Is Better

If a small amount of roach is good, is a lot better? The answer is a definite yes. The closer you get to an elliptical tip shape with more sail area up high the better off you'll be. The open-class dinghies and catamarans have known for years that this is fast, and now the BOC and America's Cup yachts are going this route for the same reasons.

The problem with most cruising rigs, however, is that the permanent backstay that is needed to support the mast gets in the way of an optimized sail shape.

The Mistake

With the above facts in mind I sat down with John Conser to design a new mainsail for my dad's 74-foot (22.6m) cutter. Sailplan in hand, I told John we wanted as much roach as possible. The two of us reckoned we could sneak 3 or 4 inches (76.2 mm or 101.6 mm) past the backstay with

TOC
Last Chapter
Next Chapter
Help!

TOC
Last Chapter
Next Chapter
Help!

Here are a couple of excellent before-and-after shots from *Sundeer.* The original main and mizzen were quite conventional in roach, having IOR maximum mid-girths. After the success with my Dad's main we decided to push the design envelope farther and went with an even more aggressive overlap on *Sundeer.* For the mizzen we took a different approach. The permanent backstay was removed and we swept the spreaders aft at 19 degrees. This allowed us to remove the permanent backstay so the mizzen could have a really nice tip shape.

Note the difference in clew heights on the jib. The original, lower height was a full half-a-knot faster to windward and close reaching. But Linda was uncomfortable, as we were unable to see boats to leeward, so we had the clew raised.

the leech of the sail. That would increase the total sail area of the sailplan (main plus forward triangle) almost 8 percent, compared to the existing, normal roach; and given my Dad's very conservative mast height, he could use everything we could bend on.

Four weeks later you can imagine how we felt when the new mainsail was hoisted and instead of jutting just a few inches past the backstay we were looking at a 28-inch (688.8mm) overlap! A combination of dimensional error on my part and computer mistake on John's had led to this fateful moment.

The sail looked very sexy, and a quick calculation showed if a way could be found to use the sail (doubtful) we'd end up adding 12 percent to the *total* area of the rig! Horsepower we were after, but this was a bit extreme.

As we sailed out of the harbor in light airs everybody aboard could *feel* the increased power and speed. For most of the afternoon, each time we tacked and jibed, the main would be dropped a couple of feet on the halyard. Obviously this wasn't going to work other than for testing. As the time approached to head back, I asked my Dad to let us try a series of tacks and jibes without dropping the main. "Just for fun, let's see what happens."

You can imagine our surprise and then delight as the overlap paused and then cleared the backstay. John and I looked at each other, as the impact started to sink in. If we could work out the details we might just have a quantum leap in performance.

Upon returning to the dock we examined the leech of the sail. It had suffered a bit of chafe from the backstay where the battens rubbed. Other than this, everything looked fine.

The next day, in 10 to 12 knots of wind we went out again. Not only were we sailing 7 to 10 percent faster upwind compared to the old main, *but the boat was heeling several degrees less, and weather helm was reduced*.

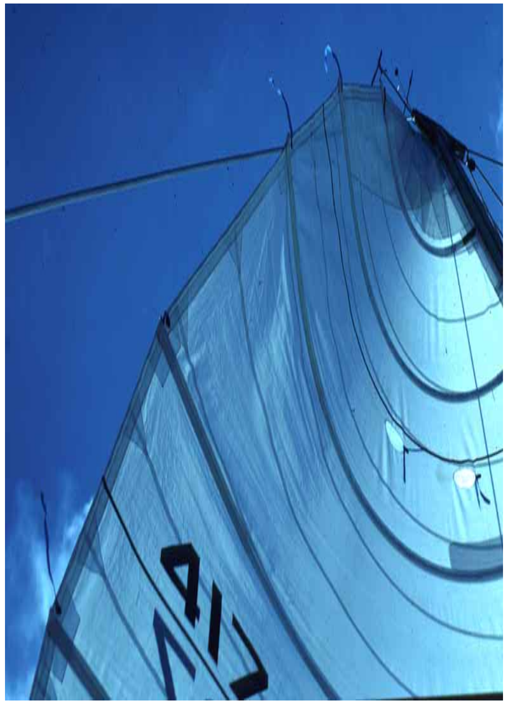
Since this point in 1990 John Conser and other sailmakers have retrofitted lots of overlapping mainsails. In every case, the boats have gone faster, stood straighter, and sailed with reduced weather helm.

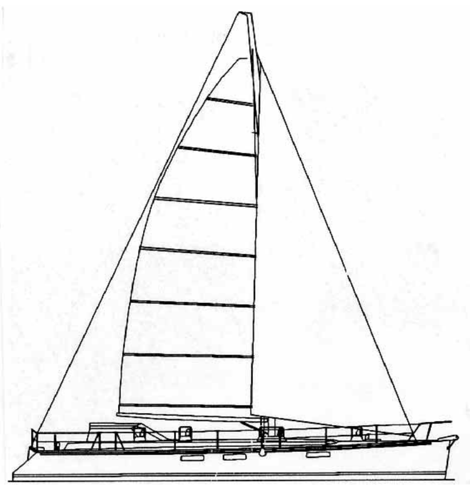
TOC

Last Chapter

Next Chapter

Help!





Two views (above) of the process of the leech clearing the backstay. It looks a lot worse than it is! However, it is necessary for the upper battens to compress substantially, which is why a batten with high modulus (like a vinylester pulltruded batten) works best.

In really light airs, (typically under 4 knots of apparent wind), it may be necessary to reef the main to get it to clear the backstay quickly. For this reason we typically specify the first reef be placed so that the sail is clear (left drawing). This also helps when motorsailing to windward, where the fully hoisted sail will be chafing against the back-stay half of the time.

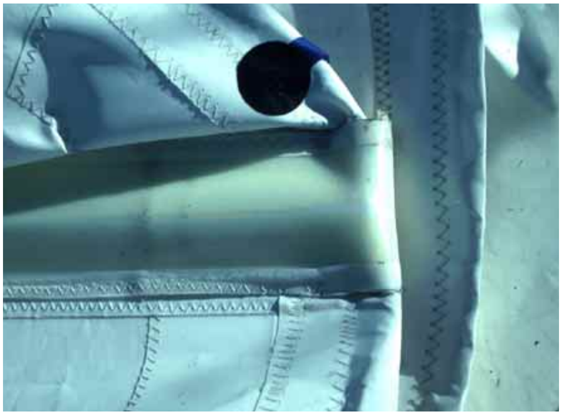
Design-wise, we now start from scratch and assume the mainsail will overlap the backstay. This allows us to make the jib smaller while increasing overall efficiency and boat speed with the larger main.

Advantages

Let's stop for a moment and consider the advantages of this maxi-roach approach. First, as we've already seen, sail area can be increased significantly while drag is reduced. Both boat speed and comfort benefit.

But this isn't just a light-air phenomenon. Consider what happens when it's time to reef. You put that first deep reef in, and sail area is about the same as it was with the old main, but the center of effort is lowered. This means better sail-carrying ability in a breeze with reduced heel. When you go to the second reef, that center of effort is really lowered!

The longer top battens make lazyjacks work better, too, a big plus when raising or lowering the sail.



One of the keys to getting the battens past the backstay is the use of UHMW chafe strips sewn onto the batten ends. Note how the UHMW is wrapped around the leech.

With more drive in your mainsail, the area of the headsail can be reduced if you're so inclined. A smaller headsail is easier to trim properly over a wide range of conditions and easier to carry into higher wind ranges without damaging the sail.

Backstay Chafe

To minimize chafe we've experimented with a number of different approaches. In the end, it is the simple methods that work best.

We found that a piece of PVC pipe, slipped over the end of the backstay and held in place with a hose clamp, takes care of chafe from the backstay, reducing friction when tacking and jibing at the same time (the PVC pipe is on only the upper portion of the backstay, where the roach overlaps).

To protect the sail, a 4-inch-wide (101.6mm) strip of 1/16-inch-thick (1.6mm) UHMW plastic is sewn over the batten pockets where they overlap the backstay.The UHMWPVC combination allows the sail to blow by the backstay in relatively light airs.

Batten Considerations

The upper battens are significantly longer than before, and as such, need to be stiffer than you might otherwise use. On the other hand, as the sail passes through the backstay the battens are deflected substantially, so you don't want them too stiff. The correct batten stiffness is a function of trial and error. In the end, you want them just stiff enough to support the roach when you're reefed down, and no more.

We've ended up using solid, round, pulltruded battens made from vinylester resin.

How Much Overlap?

When the time comes to design the roach of your new main, just how much overlap you use depends on a series of factors. First, a decision needs to be made about the wind velocity in which you want the sail to clear the backstay.

An alternative with aggressive roach is to use a short reef that drops the main just enough to get it to clear in light conditions. Or, if the boom has plenty of clearance over the cockpit, sometimes a deep cunningham adjustment, with the halyard eased a foot or two, will do the trick.

Only experience can yield the optimum results. However, there's something to be said for going as far as you think prudent. It's always possible to cut off roach but impossible to add it.

We've wrestled with this problem on a number of boats. On *Sundeer*'s mainsail, with a pretty flat backstay angle, we went to a 28-inch (711mm) overlap. When the first of the Sundeer 56s went into the water we went really aggressive, to 32-inch (812.8 mm) overlap on a much shorter hoist, and got away with it.

Tacking and Jibing

We've been cruising with these big-roach sails for some time now and have found a couple of tricks to tacking and jibing.

Upwind, if the main is really trimmed hard, it is necessary to ease the sheet a touch as we come through the eye of the wind. The lighter the airs, the more we ease the sheet.

Dan Neri, a sailmaker with whom we've worked on lots of aggressive mainsails suggests holding the boom up by the new weather rail (to leeward before tacking) until the top of the sail has cleared.

Jibing in anything over 5 knots of *apparent* wind goes smoothly. With winds lighter than this, it is necessary to make sure the boom is accelerated as it comes across, either by swinging the helm a little quicker than normal, by giving the sheet a good tug, or by pushing on the boom.

TOC
Last Chapter
Next Chapter
Help!

Just how far can you go? On the Sundeer 64s we typically specified sail shapes in which about 78 percent of the rectangle of the luff and foot were filled with sail. On *Beowulf* we pushed this to 82 percent. We now realize that we can go farther, adding more horsepower for little cost. The bigger roach twists off the leeward more efficiently and is easier to hoist, since the battens clear the lazy-jacks more quickly.

In very light airs, where the main won't clear quickly and maneuvering room is at a premium, we drop to our first deep reef. Then the sail blows through easily. (At this point we have the same sail area as with the old small-roach sails).

How Will Your Boat Benefit?

All boats will benefit from the extra efficiency and horsepower of high-roached sails. However, some rigs will be able to add more sail area than others.

The more distance between the end of your boom and the backstay, the more area you'll be able to add. With a lot of older cruising designs this can be very significant.

If you're sailing on an older hull design with a deep canoe body and perhaps a longish keel, the reduction in induced drag will be significant.

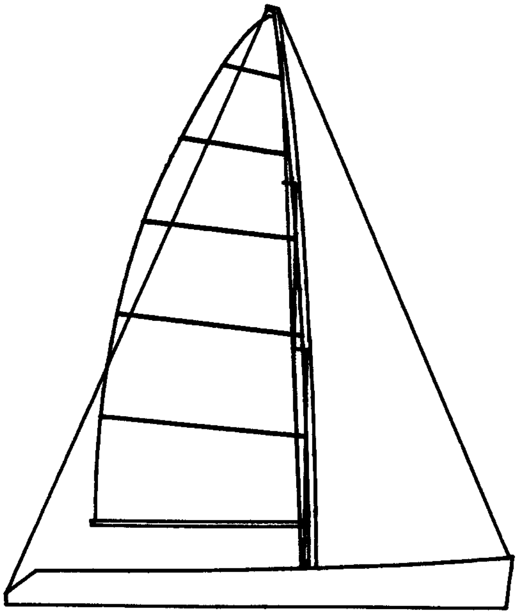
Weather Helm?

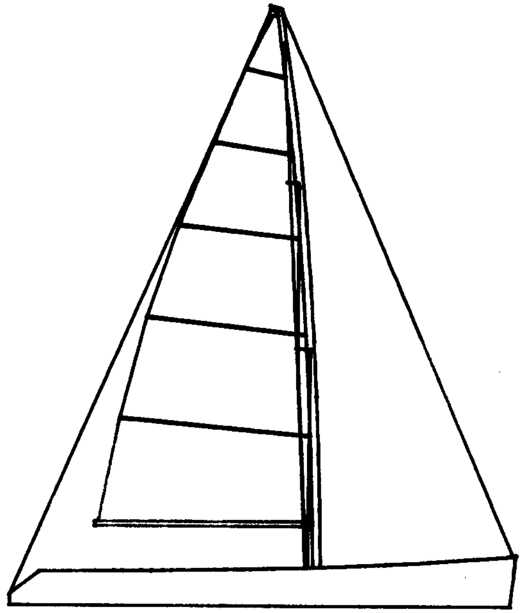
Even though you're adding area on the back of the sail, the improvement in induced drag eases weather helm. Our own experience is that weather helm is actually *reduced* with the use of these sails. Moving the point of maximum draft somewhat forward can also offset any concerns you have about helm.

Does It Make Sense for You?

There is absolutely nothing you can do to an older cruising boat that will increase performance as much as one of these sails, regardless of how much money you're prepared to spend.

What's the risk? Not much. When it's time to replace your mainsail, if you give this concept a try and find it doesn't fit your style of seamanship, the sailmaker can reduce roach with a minimum of effort. But once you feel the power that comes from one of these sails, the odds of your cutting it back are pretty slim.





TOC

Last Chapter

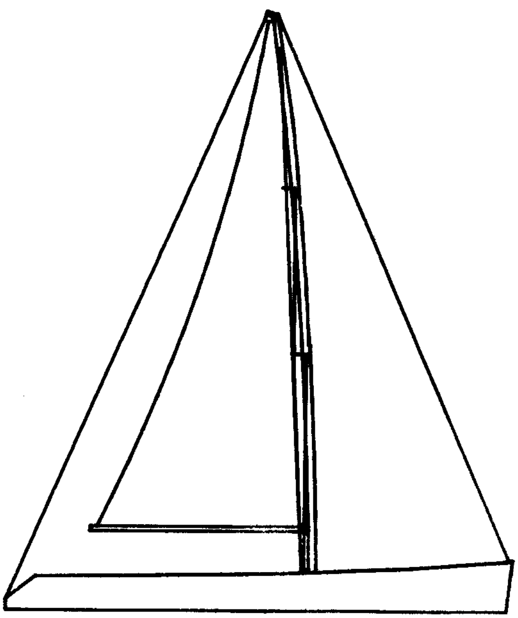
Next Chapter

Help!

A mainsail with maximum roach past the backstay generates a large increase in forward drive with a small increase in drag. This is due to the much higher effective aspect ratio (achieved with the eliptically shaped tip) as compared to a conventional sail.

The mainsail in the upper left drawing has 17 percent more sail area than the non-overlapping main in the drawing to the right. The induced drag of the left sail will be lower due to its more efficient tip shape. This means less weather helm and less heeling, even though there is more sail area up high and aft of the center of lift of your keel. While this may sound counterintuitive, we can tell you from a lot of real-world experience that things do indeed work this way.

There is only one thing you must watch: Sail shape. A sail of this nature will need to be a bit flatter than what you normally would use, since it doesn't require a lot of shape to develop full power. Also, the leech must be designed so that it opens to leeward, rather than hooking to windward under load.



In total contrast to the two upper sails, take a look at the sail below. This is what is commonly called a "cruising main." Theoretically, by eliminating the battens, you get a sail that lasts longer and requires less maintenance. This is indeed correct.

Unfortunately you also must hollow the leech to keep it from fluttering, since the battens have been removed. This makes the sail a lot smaller and less efficient.

This sail has just 77 percent of the sail area of the right-hand sail, and only 66 percent of the sail area of the larger design on the upper left. Add to this the very narrow top, which is exactly the opposite of what you want aerodynamically. That narrow tip will "bleed" pressure from the leeward to windward side, increasing induced drag, heel, and weather helm in the process.

If you were to make both the hollow-leeched main and the past-the-backstay main, and then try them out on the same boat, you would find less heel and less weather helm with the bigger sail.

The single most common cause of mainsail repairs is the clew reef line chafing or being released before the cringles have been untied. When this happens, the sail tears right through the cringles.

To avoid this problem we always tie the clew to the boom after the reef has been pulled down and then ease the reef slightly so that the load is taken by the tie (and the reef acts just as an outhaul).

TOC

Last Chapter

Next Chapter

Help!

MAINSAIL REEFING

On a cruising boat, when the time comes to reef, you want to take a big bite out of the sail. Sure, you may be just a bit underpowered at first, but then you won't have to go through the hassle of reefing again for a long time. I like to see the first two reefs take out as much area as three reefs on a racer. The reefs should be placed so the boom is lifted slightly to prevent it tripping in the sea when you're reaching and well-heeled. On our 50-footer (15.5m) we took our reefs in 6-foot (1.8m) bites, but with our 62- and 67-footers (18.9m and 20.4m) we went to 8-foot (2.4m) reefs. The outboard reef lifted both booms 2 feet (0.6 m) from their normal horizontal position.

Tripping Reefs

If your main boom tends to drag a bit when reaching in a breeze with the sail fully hoisted, a tripping reef will solve the problem. Basically, you should have an additional clew sewn into the leech, about 2 feet (0.6 m) above the boom. The tack remains at the same point.

Reef Cunninghams

Since you are probably going to have sail slides attaching the mainsail to the mast, you will find that the reef cunningham (luff downhaul) points have to be raised enough to allow for the stacked slides. Make sure your sailmaker remembers to do this.

Basically, count how many slides between the tack and each reef, multiply this by the slide height, and add this to the height of the eye being pressed into the sail.

Or, if you are using a reef hook on the inboard end of the main boom, the cunningham grommet will need to be let back a bit in the sail so that a forward pull is maintained on the foot of the sail.

Boom Height

One area for potential performance gain is in the boom height. If your boom doesn't overhang the cockpit, consider lowering it. You gain sail area down low where it doesn't affect stability, and dropping the weight of the boom has a positive impact on the vertical center of gravity. As a bonus, it's easier to furl a sail onto a low boom. Aboard *Intermezzo II* and *Sundeer* we ended up with a boom just 3 feet (0.9 m) off the deck at the forward end.

Of course, one does have to keep track of the boom trajectory when jibing or when there is risk of a jibe.

SPINNAKERS

It wasn't until our 13th day out from Mexico toward the Marquesas Islands that we rediscovered the spinnaker aboard *Intermezzo*. The doldrums were very much in evidence, and the steady southeast trades that Mr. Maury's pilot charts had forecast showed little promise of making an appearance. We were hot and uncomfortable as *Intermezzo* rolled her way slowly downhill.

Bored with reading, I decided to drag out our spinnaker, just for the afternoon. A short time later, having rigged the necessary paraphernalia, I was amazed to find us clipping along at 6 to 7 knots, steadied down, with a refreshing bit of air finding its way into the cockpit and down below; the fact that it was apparent wind didn't make it any less cooling. Five days later, in the lee of Nuka Hiva, we pulled down the chute.

During our subsequent journies across the Pacific, Indian, and Atlantic oceans, we flew the spinnaker on 33 of a total of 118 days at sea on long passages.

Aboard *Sundeer* and *Beowulf* we've found the same sort of numbers. When sailing off the wind, the spinnaker is in use over half the time.

The major reason we carry the chute in light airs is comfort. The additional speed it lends to the boat steadies motion tremendously. The apparent-wind angle moves forward and increases airflow over the boat.

This photo was taken of *Intermezzo* as we left Christmas Island in the Indian Ocean. It was about the only time Jim Schmidt, on the 70-foot (21.5m) *WinSon*, was ever ahead of us. The spinnaker is a classic CCA design, quite full by today's flatter standards. The fullness made it easier to fly on a run (it was more stable). But it wasn't much good for reaching.

Most surprising is that we've found the spinnaker to be less work than twin jibs. Sailing at the beginning of our Pacific crossing with twin jibs was reasonably fast but rolly, and the sails required a lot of tending. We've yet to find those steady trades that allow you to go for weeks without touching a sheet. We were always taking the leeward jib off the pole as the wind went forward, and then putting it back on as the wind went aft. The windward jib sometimes had to be doused altogether as the wind went forward. With a spinnaker there is only one pole to deal with, and the sail can be carried much closer to the wind than the weather jib of a twin rig.

And what of those black squalls bearing down out of the night to tear the heart out of our stout vessel? I've always assumed the worst that can happen under normal circumstances in the trades is a moderate knockdown. Has it happened to us? Several times. A most memorable knockdown came just before making our landfall on the Marquesas. One squall, stronger than the rest, caught us unaware. At the time we were carrying our big mizzen staysail as well as the chute. With 30 knots of wind on the beam it wasn't long before the spinnaker was in the water. Once the mizzen staysail sheet was let go, however, and the autopilot turned off, we were able to head back downwind. Fifteen minutes later, as the squall passed, we were back on our way, shaken but no worse for the experience.

There are some areas and conditions in which prudent seamanship dictates against carrying a spinnaker. One example is crossing the southwestern end of the Indian Ocean. Here, if anything above deck is lighter than bulletproof, one of the severe southwesterly gales that quickly comes out of clear air will be sure to take the sail — and possibly everything the sail is attached to as well. But in the trades, spinnakers are the thing.

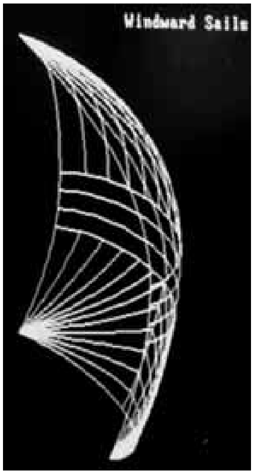
TOC
Last Chapter
Next Chapter
Help!

TOC

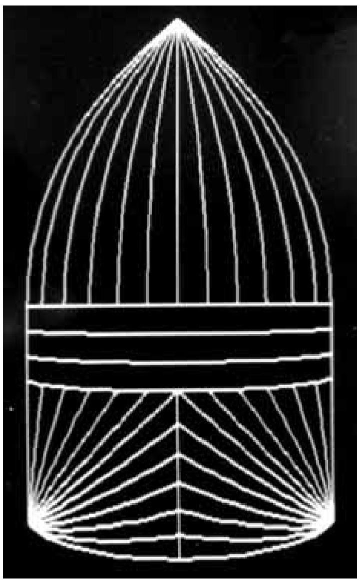
Last Chapter

Next Chapter

Help!



John Conser's computer developed these views of a new reaching chute for *Deerfoot II.* Eventually built from 2.2-ounce nylon, with the pole pulled down low the sail could be used as a balloon jib (with the pocket forward and leech nice and open), while with the pole lifted to a normal position the sail did well through a very broad reach.



Design

Your spinnaker can be designed to be stable and easy to fly. *Intermezzo*'s spinnaker was nothing special by the standards of her racing days. It was a plain 1.5-ounce nylon crosscut of maximum size for her rating. But being a crosscut and having a narrower head angle than today's spinnakers, it was simple to handle. The full shape meant it wouldn't carry well on a reach, but it was a dream in light stuff downhill, and that's where we wanted it to behave.

On our more recent spinnakers we've gone to using two plies of cloth along the edges. This doubles up on strength in the areas most subjected to damage. The negative with heavy edges (whether from doubling plies or using heavy tapes) is in damage control. When you blow out a spinnaker built this way, instead of just a simple tear and two sections of sail to sew back together (spinnakers usually blow out right across the head panels about a third of the way down from the luff) the damage will extend down the tapes or double panels. It will take two or three times as much work to repair.

The new "radial T" shapes, where all panels radiate from the three corners and meet in the center, are the strongest form on panel layout. It adds a bit to cost, but it's worth it from a longevity standpoint. These shapes also fly very well when reaching and are reasonably stable farther off the wind. You'll want to discuss the head angle and width of the sail as it goes up. Most racing sails have very wide head angles and try to maintain maximum width halfway up the luff, as is allowed in the racing rules. However, for cruising, a little narrower head angle and a width at midpoint of maybe 90 percent of the foot makes more sense.

Two views of *Sundeer*'s triradial spinnaker built by John Conser for *Sundeer.* Compare the shape of this sail to the photo of *Intermezzo on the previous page*. The sail on *Sundeer* is much flatter. We could sail as close as 50-degrees apparent with the pole forward as shown here and on the next page.

We normally keep our spinnakers down to a head angle of about 85 or 90 degrees (a racing sail might have a head angle of 110 degrees).

Sailcloth

The main consideration for a cruising spinnaker is longevity. You have to look at the chute not as it is normally used, on a calm afternoon's sail, but in the context of what may happen — a sudden squall, perhaps at night.

The sail should be strong enough so it can take some mistakes on the part of the crew and come through without tearing. This includes broaching, rounding up, and filling with a bang on a repeated basis!

To this end it makes sense to go a little heavier than would normally be the case. As with working canvas, a slight increase in weight aloft will pay huge dividends under adverse circumstances.

Finally, discuss with your sailmaker the tear resistance of the various fabrics. Race-boat fabrics are very stretch-resistant for shape control. This makes them brittle. Once they start to tear, the rip spreads very quickly. Softer sail cloth gives a bit more and is much better at resisting the spread of localized damage.

Guys and Sheets

In order to reduce chafe it's best if sheets and guys are made a size or two larger than normal. The guy, which takes the most load, should be at least 30 percent stronger than the sheet.

It's a good idea to splice a shackle onto the end of the guy, and then use a round plastic "donut" to prevent the shackle from pulling into the end of the spinnaker pole. A bowline will get the job done as well, but when the time comes to remove the guy the knot will be really crunched by the pole end, making it difficult if not impossible to untie.

As a safety precaution we never knot the bitter ends of the halyards, sheets, or guys. The guy is run through the pole so that the clew of the spinnaker is free to run in the event of a knockdown. If someone goes overboard, it's easy to get the sail off the boat.

Spinnaker Socks

A lot of cruisers today use a spinnaker sock to aid in sailhandling. If properly engineered, it can be of help with larger sails. However, the socks take some debugging and getting used to. Where they are most valuable is in the trades when the wind is on and off with squalls thrown in. Without a sock, you're obligated to get rid of the entire sail when the wind drops too far or when the engine is started. However, with a spinnaker sock the sail

Mike Gluck picked up a used 12-meter spinnaker for his Deerfoot 2-62 *Moonshadow*. This sail is a pure running shape and would not be suitable for any sort of reaching. It is so large that a steady breeze and sea state are required to get it to fly comfortably. If the breeze is too light or sea state a bit lumpy, a less aggressive and smaller sail would be faster and easier to fly. In this photo they are trying to beam reach with the sail. Note how full it looks compared to *Sundeer's* spinnakers. In any sort of breeze this would cause problems with helm control and heeling.

Sailmakers talk about spinnakers in terms of head angle. This is about as wide a head angle (below) as you are ever going to see!

A Deerfoot 63 beam reaching with a North Tri-Radial. This is a nice all-around shape. You can broad reach or run with it and sail on a close reach in light airs.

The head of an ATN spinnaker sock with block and control line hidden under the control-line cover.

This elliptically shaped fiberglass bell is one of the ATN secrets. It goes up and down with very little friction compared to a stainless rod. Note how the control lines are captured inside the cover.

can be collapsed and left aloft in its sock until conditions improve again. When left aloft, care must be taken to keep it from chafing on the spar as the boat rocks back and forth.

On the other side of the equation, the sock adds some weight to the sail and tends to distort the head, making it more difficult to fly in light airs.

The best "conventional" sock we've used is provided by ATN in Fort Lauderdale, Florida. They've developed a snuffer with an elliptically shaped fiberglass ring at the bottom. This shape matches the natural folding characteristics of the spinnaker and prevents the sock from twisting. An interesting feature is the way the up/down control lines are covered. These are run inside a pathway of cloth sewn onto the basic sock, getting rid of the tangles that sometimes result with other systems. This extra pathway is cut from a different color of material and provides a distinctive band to watch so twists can be eliminated. Finally, they provide a swivel and stainless steel pennant at the head of the sail so it can fly somewhat free, allowing space *on top* of the sail for the snuffer to accumulate.

They work like a charm. In fact, in moderate airs we've been able to snuff the spinnaker after just easing the sheet, even when reaching (as opposed to collapsing the sail in the lee of the mainsail).

The ATN snuffers are so efficient, however, that you must be careful with them when the breeze is up. The spinnaker can generate tremendous forces trying to squeeze the fiberglass bell towards the head. We've learned the hard way on *Sundeer* to only use the sock when the spinnaker is collapsed in the lee of the main if there is more than 15 knots of apparent wind (on a smaller boat, of course, one could increase this wind range).

With an asymmetrical chute the snuffer will tend to hang up on the clew-patch reinforcements. As a result, snuffers for these sails are typically specified the same length as the leech (rather than the luff). The result is a messy bottom part of the sail that you are left to deal with. We prefer to bring the snuffer fairly close to the tack fitting so that we have the option of snuffing the sail all the way down. If conditions are light, or if we expect to use the sail again after a short period of time, we don't pull the sock past the clew.

If the sail is stowed with the sock all the way down, with the spinnaker at about 85 percent hoist, we stop and manually run the bottom of the sock up past the clew patch so it does not hang up when we want to unfurl the sail.

TOC
Last Chapter
Next Chapter
Help!

TOC

Last Chapter

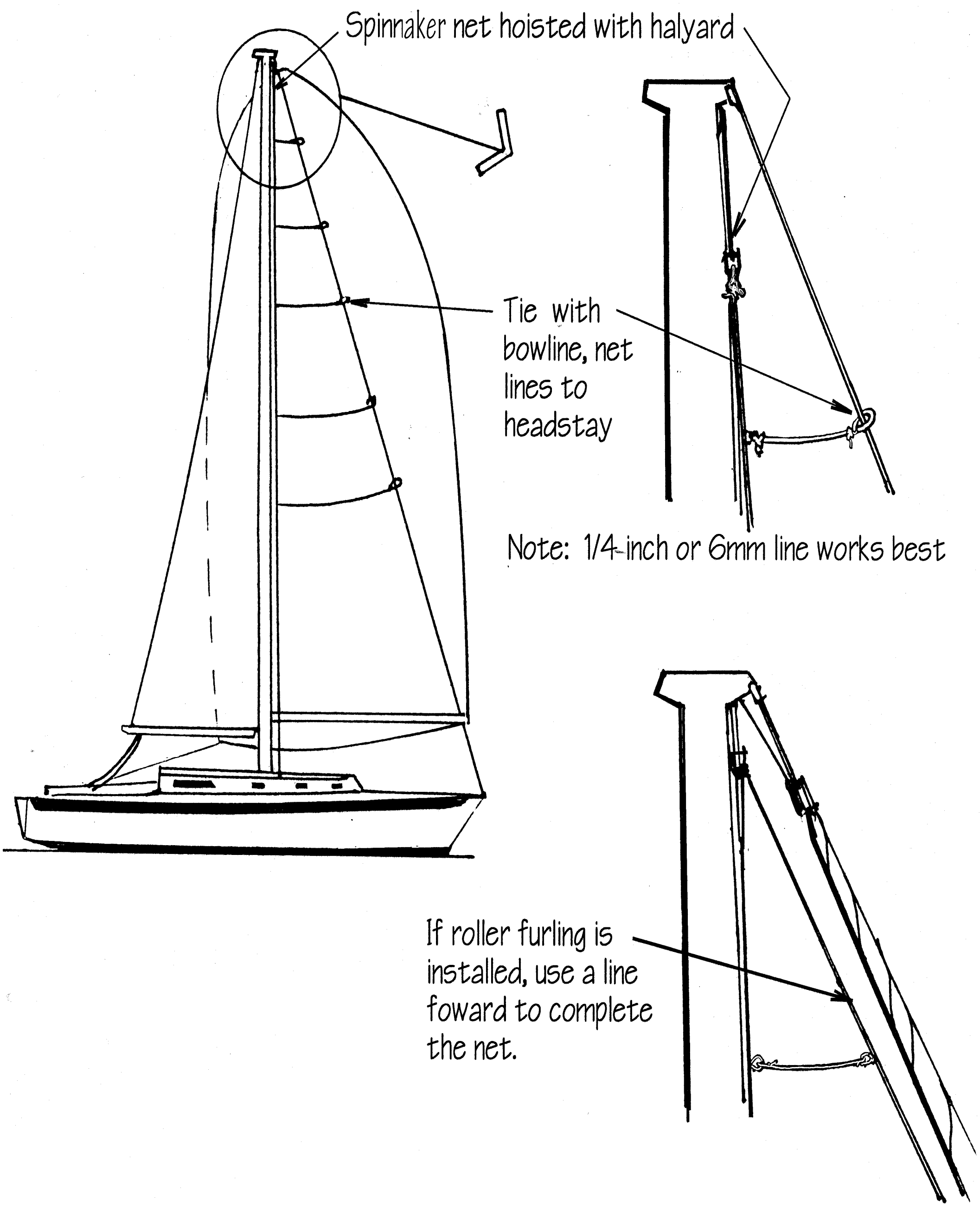
Next Chapter

Help!

Nets

We carry a spinnaker net any time we're running, or if the winds are light and shifty. It prevents accidental wrapping of the chute around the headstay.

It's made from light line, usually 1/4-inch (6.35mm), and is hoisted on the jib halyard. The horizontal lines are tied with bowlines around the headstay (snaps would catch and tear the chute) and are attached in turn to a vertical line from the jib halyard to the deck. The bottom end is tied off to the base of the mast. The horizontal lines come back about halfway to the mast.



If you plan to carry a spinnaker when cruising short-handed, a net, to prevent headstay wraps, is a very good investment. Otherwise, over time, the odds are the chute will wrap around the headstay. This frequently leads to a damaged or destroyed sail.

TOC

Last Chapter

Next Chapter

Help!

A very early asymmetrical spinnaker on the original *Deerfoot*. This sail was so flat that today it would be called a reacher. For sailing at beam- to broad-reaching angles it worked fine, but for running angles it would just collapse unless poled out to windward like a jib.

ASYMMETRIC SPINNAKERS

Now we get to the interesting side of the spinnaker equation. Under competitive pressure from the “sport-boat” market with enormous bowsprits, asymmetricspinnaker design has come a long way.

Both BOC and Whitbread racers have proven these sails to be faster off the wind as well as reaching.

The asymmetrical shape allows the sailmaker to put a true airfoil into the sail’s cross-section, reducing drag and increasing lift. The asymmetrical spinnaker becomes not only faster, but has less of a tendency to overpower the boat into a broach.

The longer luff of the asymmetric provides a better aerodynamic shape as well, while the high clew makes for better sheeting angles when reaching.

Asymmetric shapes are commonly associated with bowsprits or poleless situations. However, they also work with spinnaker poles. If we were buying a spinnaker today and planning to use a pole with it, we’d go with an asymmetrical before a conventional sail.

Runner or Reacher

Race boats will have an inventory of shapes developed for a variety of wind angles and strengths. For cruising we’ve got two considerations — running and reaching. A reaching sail can be used for running but will neither be as stable to fly nor project as far to windward (if used in a poleless situation).

A true reaching asymmetrical can be carried as close as 40 degrees apparent. But a sail cut this flat will need lots of attention on helm and sheet.

A true running asymmetrical will fly as deep as 155 to 160 degrees, but not any closer than about 90 degrees apparent.

Since we usually carry only a single spinnaker, we prefer a compromise. We go with a moderate reacher, cut so that we are limited to about 50 to 55 degrees apparent-wind angle. This is a touch fuller than the true close reaching sail and so much less fussy to fly. On *Beowulf* we’ve found that in a moderate breeze when we’re sailing at deep angles, we can carry it to about 155 degrees true and it will stay filled.

Tack Placement

Ideally, the tack would be attached to a bowsprit, hopefully one that could be articulated to windward. However, in all but the most modern boats this is not going to be the case.

The next logical tack point is the end of the bow roller. Generally speaking, if the bow roller is strong enough to take the down load of the anchor chain (at full breaking strength of the chain), it will easily handle the tack loads of the asymmetrical chute.

Running Layout

We've already mentioned flying the asymmetrical like a conventional spinnaker, with tack to weather. But there is another interesting way to go: To use the sail wing-and-wing, with the main to leeward, tack positioned as far forward as possible, and clew sheeted through the end of the spinnaker pole to windward. For running square this can be a very efficient way to use the sail.

An alternative is to fly the jib on the pole to weather and sheet the spinnaker through the end of the mainboom. In doing this you'll want to "scandalize" the main; i.e., put a reef in it so that the spinnaker to leeward gets some clean air at the head (the jib will cross-feed from the weather side, too).

A modern cruising chute on a Valiant 42. Compare how much fuller this sail is than the one on the preceding page. It can be used down to angles as deep as 140 to 150 degrees. Beyond this it will become very difficult to fly unless poled out. (Port Townsend Sails photo)

Luff-Control Hanks

When we were designing the sail wardrobe for *Intermezzo II*, the size of her rig (moving up to a 62-footer [18.9m] from a 50-footer [15.3m]was initially intimidating!) had me looking for answers to keep the light, free-flying spinnaker under control.

What I was concerned about was our ability to get the sail down and under control when caught by a squall.

Harry Ellens, our South African sailmaker for *Intermezzo II*, put three reinforced grommet points along the luff of the asymmetric spinnaker he had made for us. To these I attached, via long pennant lines (made from 3/16-inch/4.8mm nylon) some jib hanks. The hanks were attached to the headstay. This allowed us to do was to keep the sail under control while it was being lowered.

A nice-looking asymmetrical on the Sundeer 64 *Artemis*. John Conser cut this sail more for broad-reaching and running than close-reaching, although it could be flown as close as 55 degrees apparent. For really deep running, however, the sail would fly much better if tacked off a spinnaker pole.

TOC
Last Chapter
Next Chapter
Help!

TOC

Last Chapter

Next Chapter

Help!

Three views of a modern asymmetrical running chute on a J boat. This sail is designed to project its luff to windward. Because the tack is so far forward (on the bowsprit end), and therefore away from the mainsail, you can run very deep with this design. However, they require constant attention on helm and sheet. (North Sails RI photos)

If we were caught in a squall, we could run off before the wind, sheet in the leech against the mainsail, and then drop the chute in the vacuum behind the main.

The system worked reasonably well. However, it made jibing a pain. So once we got used to working with the bigger boat and getting the spinnaker down when conditions were difficult, we stopped using the hanks. Still, if your asymmetrical has you intimidated, this approach may make sense.

Asymmetrical Construction

If your sail is to be used as a reacher, then the sailcloth weight is going to have to go up, and some thought must be given to using a harder, more stretch-resistant fabric, as stretch on a reaching sail quickly develops into drag.

Panel layout is invariable radial for strength and stretch resistance.

One of the tricks that North Sails RI used on the asymmetricals they made for *Beowulf* was to put a shock-absorbing bungee at the tack of the sail. This helped to absorb some of the load when the sail collapsed and then suddenly filled.

TOC

Last Chapter

Next Chapter

Help!

These two photos of the Sundeer 64 *Marine Flower* show a mizzen asymmetrical chute that offers a reasonable compromise between size, shape, and ease of flying. Notice how the sheet leads to the end of the mizzen boom. John Conser designed the sail so that as the apparent wind moves aft and the mizzen is eased, the lead on the spinnaker adjusts almost automatically.

MIZZEN HEADSAILS

How you treat mizzen headsails depends greatly on the rig proportions of your vessel and how you intend to use the boat. For most ketches and yawls these sails are a waste of time and effort. *Intermezzo* came to us with a variety of mizzen spinnakers and reachers. But they were so difficult to fly and created so much trouble for the helm, that we rarely used them (unless we were trying to show off for a photographer).

On the other hand, modern ketches, where the mizzen is of substantial size and where hull balance reduces steering chores to where a mizzen jib or spinnaker can be used with a pilot, can get tremendous benefit from a mizzen headsail or two.

On *Sundeer* we found that we'd drop our main spinnaker in squally or marginal conditions but carry on with the mizzen chute until 35 knots of true wind when broad-reaching or running. The mizzen jib was effective when beam-reaching. It also worked surprisingly well when sailing at very deep angles if we pulled the tack to the weather rail and aft. It acted like a leading-edge flap over the mizzen keeping flow attached and making a significant increase in boatspeed.

The mizzen spinnaker is typically asymmetrical in this day and age and cut fairly flat. However, if it is made really flat it will be difficult to fly so there's a delicate compromise here.

MINIMUM SAIL INVENTORY

Now that we've reviewed the *potential* inventory, it's time to make some hard choices. The first considerations are budget and cruising requirements. Assuming that the sail inventory must be adequate for offshore work, here is what I would choose on a tight budget.

To begin with, the mainsail must be in reasonable condition. If the cloth is in good physical shape but maybe a little stretched, a recut or addition of full battens can do wonders for longevity and drive at modest price. Even restitching can be done at modest cost. In fact, most stitching problems will be on the perimeter of the sail and can be taken care of with a home-style sewing machine.

The main will need several *deep* reefs, especially if there isn't a trysail aboard.

Next, a good working jib will be required. I would choose a sail that can be used when the wind is in the high 20s and the main is deeply reefed. This is probably about 90 percent of foretriangle area on most boats. In lighter conditions a heavy staysail, which will double as a storm jib, can be flown underneath the jib.

TOC

Last Chapter

Next Chapter

Help!

These three sails — main, working jib, and staysail — will cover a majority of all needs (although you'll be underpowered in lighter airs). The key is that they stay together structurally, as there are no backups in the inventory.

The problem with this inventory is that it leaves you woefully underpowered in really light airs. With an engine and enough fuel capacity, this may be acceptable. However, if you are headed offshore on long passages, chances are that you will not be able to power much of the way. Therefore, you are dependent upon your sail inventory to get you there, even if the conditions are extremely light.

With this in mind, adding a little more to your budget would get you a wire-luff reacher to be flown from the spinnaker halyard. This fills a large gap in light airs and can be used to leeward with the working jib flown on the pole when running. Space requirements for the reacher are nominal.

The next level up would be in the foretriangle. Here, go to a 110 to 120 percent genoa as a standard sail and reduce the working jib to about 70 percent for heavier airs and backup. The staysail is still in there doing double duty.

Consider a storm jib to back up the staysail in heavy airs, and then a trysail. Depending on your cruising philosophy and plans, these might come aboard before the spinnaker.

As you allocate budget and make your selections, bear in mind that at some point, one or more of your sails may be damaged and unusable until you get to land and have a chance to repair them. What do you do in this case?

If your working jib is torn, a staysail and storm jib can be flown together as a double-head rig, with staysail inside and jib on the headstay. Not a lot of power in light airs, but it will keep you moving, and in moderate conditions you will be surprised at how quick such a rig can be.

If the largest jib is out of commission and you are running, the next size down flown to windward with a spinnaker pole, while the staysail is used to leeward, will get you there.

Used Sails

An excellent way of stretching the budget is to buy used sails. Cast-offs from race boats are frequently available for less than 20 percent of the cost of new sails, while still in excellent condition. Over the years we've purchased a variety of used sails this way, ranging from genoas to spinnakers. While the dimensions and shapes have not always been optimized, the prices certainly have been!

SAIL CONSTRUCTION

Asking a group of sailmakers what's the best way to build a good cruising sail is like asking sailors what's the ultimate hull shape. No two answers are going to be the same. Subjects such as cloth weight and construction, seam widths, types of stitching, and even thread color are subject to debate. Then, throw in a variety of ways in which the sail will be used and, for the new cruiser, it's a confusing brew to say the least.

Sail design and construction usually receive a lot less consideration by cruisers than other subjects like the right dinghy, electronics, or fridge system. Yet it's the sails that do most of the work of moving you from one anchorage to the next. The construction and cut of sails affect not only boat speed, but also comfort. A sail that retains its designed shape through a wide range of winds will be less apt to heel you over in a strong breeze.

Budget is, of course, a limiting factor. But when you look at sail cost, to budget accurately you must divide initial cost by years of *useful* service. In many cases a sail that costs more initially will be less expensive to own in the long run. To a racer, a sail that is structurally sound, but has lost a slight edge in speed has little value, yet it still may have many miles of cruising left. This is especially true as you get farther off the wind where loads are less and shape is not as critical as with beating and close-reaching. Still, there aren't many cruisers who consciously want to go slow or who think it's fun to heel over an extra 3 or 4 degrees on a long passage because a sail has stretched out of shape. All of us, cruisers and racers alike, want the strongest, longest lasting, and least expensive sails we can get.

When you walk into a loft to discuss a new sail, the sailmaker will ask some basic questions. Boat size and type are, of course, standard. Then you have cruising grounds. If you're primarily a weekend sailor and Long Island Sound is your body of water, lighter weight construction will do fine. On the other hand, if you're a Buzzard's Bay afficionado or sail San Francisco Bay, obviously there's going to be some heavier fabric and reinforcement in your future. Finally, there's going to be discussion about the wind range of the sail in question.

TOC

Last Chapter

Next Chapter

Help!

When you start to look at heading offshore, other factors come into play. First, reliability is crucial. There aren't many lofts halfway to the Marquesas islands. Second, odds are you'll be sailing shorthanded and will want to avoid sail changes as much as possible. This means your sails have to be built for *a wider wind range*. Third, you're going to be putting more miles on in a single trans-oceanic passage than the average weekend sailor will in a decade of cruising.

What all this adds up to is the fact that there are no pat answers to the ultimate sail equation. You and your sailmaker have to make some basic decisions about use and budget. Then you can start to look at the details that go into making a long-lived sail.

Loads

To understand the correct mix in sailmaking you must first give some thought to the loads involved. Static loading is a function of sail shape (high-aspect-ratio sails are more heavily loaded than lower-aspect sails), sail size, boat stability (the stiffer a boat is, the more load it will put on a given sized sail), and how tightly sheeted the sail is. A working jib that begins to deform at 22 knots of apparent wind when strapped in tight will be happy at 28 knots apparent eased off on a reach, and even happier on a broad reach in 32 knots of wind.

Loads work in three directions: along the leech; fore and aft across the sail; and diagonally from the head, clew, and tack towards the center of loading.

With most sails, by far the greatest loads are along the leech. The luff of the sail is the next most heavily loaded area, while the mid-sections are just about coasting. The higher the aspect ratio (in headsail or main), the higher the leech loads compared to the rest of the sail.

The loads end up concentrated in the corners of the sail. The highest are in the head of the sail. Clew loads are typically about 20 percent less than the head and extend into the body of the sail at an angle of 20 to 40 degrees inside of the leech (depending on sail shape, camber, etc.).

I categorize the second type of loading as working loads, or those which come from luffing, chafe, and attachment to the spars. Working loads will rapidly break down a sail and prematurely shorten its life if not dealt with correctly. Batten pockets, leech stitching, reef reinforcements, and clew patches are all subject to failure before the actual sailcloth fails.

This is usually a function of flutter and chafe along the leech, rather than an indicator of the actual sail load.

Sailcloth

The cloth for a cruising sail should be chosen for stability, handling, and longevity. I am sorry to report, however, that these are mutually exclusive features. Compromise is inevitable. And sailcloth weaves, laminates, and orientation are changing so fast that whatever you think is hot today will be obsolete tomorrow. Still, there are some basics that most of the professionals seem to agree upon.

Without getting into a lot of sailcloth details, you should understand that woven cloth has threads typically running in two directions. Those that run the short way are called the fill; fill threads are straight. The threads that run the long way are called the warp; these run over and under the fill threads. The way the threads are packed, the weight and shape of the thread, and how the cloth is finished after weaving are what determine the structural properties.

Threads that run parallel to the sail loads resist stress most efficiently. Diagonal, or what is known as bias loading, is resisted only by the tight packing of the threads and/or post finishing that may roll on filler into the fabric, or heat it to shrink the threads tighter or both.

The harder a finish is — i.e., the more rigid (whether the result of finishing or weaving) — the more resistant to stretch it will be. On the other side of the coin, a hard finish sail has less tear resistance than softer finishes. Softer fabrics that are stretchier are usually stronger, meaning in an ultimate sense they will last longer. However, due to increased stretch under load and the resultant loss in sail shape, you may stop using the softer sail long before its structural life is over.

Lighter sailcloths can be made very efficient at carrying loads in the long (warp) direction. But the fact that the warp threads have to run over and under the fill means that above 6 ounces in cloth weight, the fill-oriented fabrics are more efficient, since the warp threads allow the heavier weaves to move too much under load.

Woven-Cloth Stability

Modern woven cloths get their stability (resistance to stretch) from several sources. Initially there is the actual weave of the cloth. This, however, will not be enough to maintain shape, unless the cloth is very heavy for the application.

TOC

Last Chapter

Next Chapter

Help!

To enhance stability, the cloth is calendered (run through roller under pressure and heat), which tends to fuse the threads together. The fabric may also be impregnated with a larger or smaller dose of resin in the process, lending even more stability.

There are some problems with heavily finished sailcloth. To begin with, it becomes very stiff and is hard to work with on the boat. This means it is more difficult to furl and cover when used in a mainsail (this is not a big factor in jibs).

The stiffer the fabric, the more important it is to flake the sail on the boom, as opposed to rolling it in a traditional harbor furl.

Highly finished fabrics also tear more easily than softer materials. This is because the threads are held in line by the finishing, so they tear one at a time, instead of bending together and resisting a tearing load.

Finally, as highly finished sailcloth ages, the surface finish begins to break down. You are then left with a weave that may not be able to maintain sail shape under load.

What's the answer for long-lived cruising sails? Increase the thread size and count in the fabric and reduce finishing. This ends up with a sail that is heavier and somewhat more costly, but it will be much easier to handle and hold its shape longer.

Laminated Fabrics

In a cruising context, laminated fabrics are typically made up of three or four different materials, each chosen and then assembled for a specific set of properties. The fabric is typically named after the load-carrying thread material. This is usually a woven material, with threads on a 0 / 90-degree axis (sometimes with a 45-degree-bias thread line thrown in to help with diagonal loading). The heaviest yarns run in the warp direction (long way) and carry the heavy loads from the corners of the sail (hence a radial panel layout).

Smaller yarns run the short way across the fabric and resist stretch parallel with wind flow.

A film, typically Mylar, is then used, onto which these load-bearing threads are glued.

Finally, a tightly woven scrim of Dacron, polyester, or sometimes Spectra is glued over both sides of the inner plies. These outer layers offer chafe and UV protection and in some cases carry a bit of load.

Performance-wise, these outside layers do not bring much to the table. They add longevity and weight but are not really load-carrying. This is why they are rarely seen on racing boats. But for a cruising yacht, they are essential.

The nature of the laminated fabrics is such that they do not like being stuffed in sailbags, and they abhor remaining wet for long periods of time. They should be stored dry and carefully folded. Long-term exposure to moisture can break down the laminations.

The storage issues are somewhat mitigated when they are used for roller-furling sails.

Radial Panel Construction

Ideally, to build the strongest, lightest, and longest lived sail you will orient as many threads as possible parallel to the loads. Where loads are such that the lighter warp-oriented fabrics can be used, this leads to radial-cut sails, with fabric panels splayed out from head, tack, and clew. Radiating the panels allows the sailmaker to optimize thread loading.

Some sailmakers will build headsails with panels radiating just from the clew, since a headsail that is attached to a luff groove has the most loads concentrated from the clew toward the luff.

Cross-Cut Construction

As cloth weight jumps above 6 ounces and the fabrics become more efficient in the fill (short) direction, you get into the familiar cross-cut sail shapes. You can also find very nice cross-cut shapes in lighter cloths as well.

Is a cross-cut better than a radial? That's very much a question of whom you talk with. Some sailmakers insist one is clearly the best. A great many others say that the question is more complex, a function of cloth more than shape, and that "fad" has a lot to do with it as well. My own feelings on the subject are mixed. With today's sailcloth you can get a very good sail in either panel orientation. Computer-driven design and cutting mean there is only a slight cost premium for a radial sail. On the other hand, cross-cut sails seem to be more easily reshaped for a final season or two of use. Since this is all very dependent on sailcloth technology, you can be sure the equation will change.

TOC

Last Chapter

Next Chapter

Help!

Seamless Construction

North Sails RI with their Genesis designs and North Sails with their 3DL approach have pioneered the use of seamless, molded sails in the racing world. There are a lot of debates about these sails in the racing fraternity, and they may or may not at this time offer us cruisers some advantages. However, the technology is fascinating and bears a look.

The sails are machine-built. First a membrane of Mylar is assembled in the shape of the sail. The reinforcing, in the form of Kevlar or Spectra tapes or yarns, is then glued down. This has the advantage of keeping all the load-bearing yarns oriented exactly along the stress lines.

Because the yarns are pulled off a spool rather than being woven, a greater selection of sizes and finishes are available with which to engineer the sail.

In a racing context, the sum of all of this is a lighter sail for a given strength, which (theoretically) has a longer sailing life.

Sail weights can be reduced by as much as 40 percent compared to conventional construction. However, the technique is too new to have been tried on cruising boats, so we'll have to wait to see if there's a long-term advantage for us.

Radial construction has been made efficient by modern sailcloth and computer-aided design for panel layout and cutting. (North Sails RI photo)

The Ideal Cruising Sail

The issue of cross-cut or radial ends up as a contest between shape-holding versus aesthetics.

If the radial sail is built from woven (non-laminated) fabric, it will eventually break down along the bias axis of the fabric (at 45 degrees to the thread lines). The fabric will stretch between the seams. The seams, however, which are essentially two-plied, will resist stretch and over time begin to stand out from the surface of the sail.

The overall shape of the sail remains pretty much the same as when new. But the surface looks lumpy or corrugated to some degree.

The cross cut also stretches over time. But the results are the opposite. The sail becomes deeper in draft, and the point of maximum draft slides aft with stretch. With the seams being at right angles to the maximum loads, they have more load on them than with a radial sail and so stretch more evenly with the rest of the fabric.

The result is a sail that is more even-looking, but one with an inferior shape.

In terms of boat speed, heel, and comfort, the lumpier radial sail shape, with the correct camber ratios, is going to work better.

Of course, radial sails are more expensive than cross-cut, but the gap is narrowing as sailmakers learn more about building these sails and as their computer programs get smarter and easier to use.

All of our boats until *Beowulf* had cross-cut sails. The materials to build large radial-cut sails did not exist until recently. However, when the time came to do *Beowulf*'s inventory, after thorough analysis of what was available and lots of discussion with Dan Neri we went with radial-cut Spectra for main, mizzen, and working jib. Given our very high loads we felt cross-cut Dacron would stretch too much when the breeze was up.

TOC

Last Chapter

Next Chapter

Help!

Cloth Weight Versus Longevity

In most engineering calculations, you'll find that as loading is reduced on a given structure, its useful life is increased at an accelerating rate. A structure giving you 2,000 hours of use when operated at 80 percent of its ultimate strength may last three times as long as 70 percent of yield. The same holds true to some degree with sailcloth. Assuming comparable structural characteristics, a heavier cloth will outlast a lighter cloth. However, trying to pin down cloth manufacturers or sailmakers on this subject is tough. It seems nobody has any definitive data.

My own experience indicates that going up one weight above the norm in cloth makes good financial sense for offshore work. However, you must be sure that the heavier cloth has good stretch characteristics. If it's too flexible it will last well but will stretch out of shape, creating a baggy sail in a breeze. In the Caribbean charter business mainsails that might normally be built from 6-ounce material are usually done from 9- or 10-ounce fabrics to allow for sun damage and mishandling.

Two-Ply and Tapered Cloth Weights

If your leech loads are really high, but the mid-forward part of the sail is lightly loaded, does it make sense to use the same weight cloth throughout? No. With a cross-cut design, the cloth must remain the same from leech to luff. Sailmakers use a second ply of fabric along the leech. As long as the stretch characteristics of the fabrics are correctly matched, these two plies will share the load. It provides a bulletproof back end to your sail (where most of the work is done), while keeping the front of the sail lighter, easier to handle, and adequately strong.

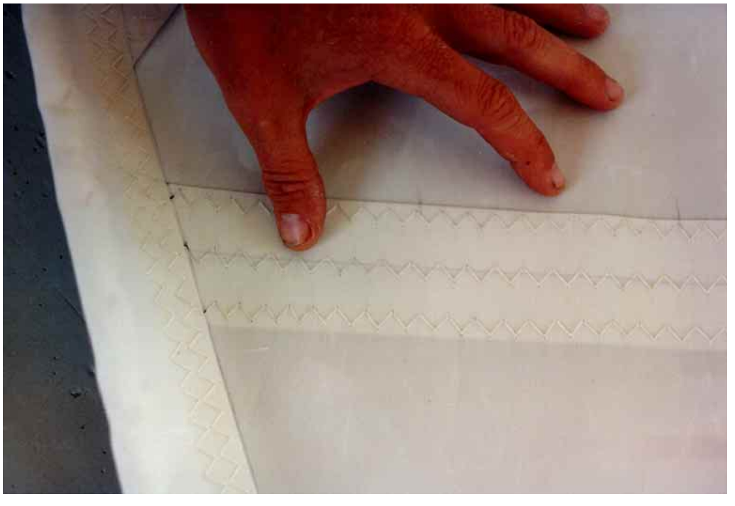
When you go to a radial cut, the sailmaker has the option of fine-tuning the panel weights, but there is a practical limit brought into play by the varying stretch characteristics of different weights of cloth.

Stitching

The most critical aspect of sail construction is stitching. It is the stitching, after all, that holds all the pieces together. If not done correctly, a seam will start to work and pull; then at some unsuspected moment the entire seam will tear, leaving you with a large pile of rags to take back to the sail loft.

Let's take a minute to look at how a sewing machine works. There are two thread sources: the needle (on top) and the bobbin (below). The needle carries the thread through the sail layers. As it penetrates the bottom layer, the bobbin hooks its piece of thread into the needle's thread line. If the tension of the needle and bobbin are correctly set, the resulting lock between the two threads will take place in the middle of the two pieces of cloth.

Getting the thread tension set right is very much a function of "feel" by the sewing-machine operator. It varies with thread weight, sailcloth weight, how many layers are being sewn at once, and how fast the cloth is fed through the sewing machine. Many sailmakers will have one machine set up for basic seaming and a second just for finishing the reinforced areas of the sail. Larger lofts will often have eight or ten different machines set up to deal with the myriad of sailclothes now being used. It's not unusual to find some areas on every sail where the stitch tension is a little off. The key is to make sure these areas have been restitched correctly.



Wide seams with three rows of stitching will add substantially to the life of your working sails. The wide seams spread out the load and the extra row of stitches allows more chafe to take place before a failure occurs.

Structurally, it's the hole with the bobbin/needle interlock that does all the work. The more interlocks, the stronger the stitching. Steve Reed, a sail-design engineer with North Sails, says they look for 25 "connections" per inch of seam for the body of the sail increasing to 38 connections in the corners.

The sailmaker adjusts the stitch count by changing the pitch control on the sewing machine. The tighter the pitch, the more stitches you get per inch.

There are two basic types of stitching in use today. The first is the zig-zag stitch with which we are all familiar. The second approach is called a three-step zig-zag. This takes a bit more room but doesn't tend to bunch sailcloth as much and is therefore favored with light sails made from nylon or mylar and lighter weight Dacron materials. Because the three-step zig-zag stitch puts more thread connections into the sail, it is an all-around stronger system.

Two rows of stitching are the minimum required. Heavier sails, as well as those built for long-term usage, sometimes have three rows of conventional zig-zag stitching. This is a full 50 percent stronger than two sets. This way if any single row gives out, you still have a fully functional sail. We like to have all our working sails sewn with three rows of stitching. With the three-step zig-zag, two rows are somewhat stronger than three of conventional stitching.

Most sailmakers use a high-quality thread manufactured by Hemingway and Bartlett called "Dabond." Weight varies with sailcloth needs. Light spinnakers use 33 to 46, heavier spinnakers 46 to 69, small working sails use 69 for seams and 72 for finishing, while a 50-footer might have 90 for joining and 138 for finishing. There's also some consideration to be given to thread color. Darker colors stand up the best to ultraviolet radiation and show chafe better. Dark thread also makes it easier to check sail shape in crosscut seams.

The final issue in stitching is needle size. Structurally, you want the smallest hole possible. However, small needles have a problem disipating heat buildup (because of their reduced surface area). If there's too much heat at the needle/sail interface, it will tend to melt thread and sailcloth. So the needle needs to be big enough to get the job done, but not too big. Again, the issue is one of experience and feel.

Seams

There are two types of sail seams. If they run perpendicularly to the loads, as in a cross-cut sail, they cannot be built too strongly. And if the sail is damaged at some point, the odds are the problem will start with a bad seam.

On the other hand if the sail is of radial construction, where the seams are aligned with the loads, they have very light stress on them.

Sails of this nature resist damage better. If they start to have a problem, it does not have to be dealt with as quickly as with a load-bearing seam.

Initially, seam width is a function of sailcloth weight and the type of stitching to be done. As sail weights increase, so do the seam widths. A sail with three rows of stitching, or one that uses a three-step zig-zag, is going to take wider seams. Seams will run from a 1/2 inch (12.7 mm) in width on a spinnaker to 1.5 inches (38.1 mm) or more on heavier sails.

It makes sense to discuss the concept of an extra-wide seam to allow for re-stitching later on in life if you expect to really put a lot of miles on your sails. Adding an extra half inch to the seam will hardly affect weight aloft or cost, but by allowing for an inexpensive restitching in later life it could add years to a sail's useful life.

Hard Spots

It is in the corners of a sail where all the loads are finally concentrated. As a result, multiple layers of cloth are splayed out along the edges and towards the center. In order to avoid a hard spot (which would be prone to failure), the various layers of reinforcing cloths are tapered. The actual weight of the fabric used and the final quantity of layers will depend on the loads of the sail, its use, and the base sail-fabric weights. If you start with a heavier fabric, the corner patches can be somewhat lighter.

Here are some average patch dimensions for the sail corners (the percentages are multiplied by the luff, leech, or foot dimension to get the length of the patch): For local sailing the clew should be 2 percent, the head 5 percent, and the tack 8 percent. For offshore work the clew should be 5 percent, the head 18 percent, and the tack 8 percent.

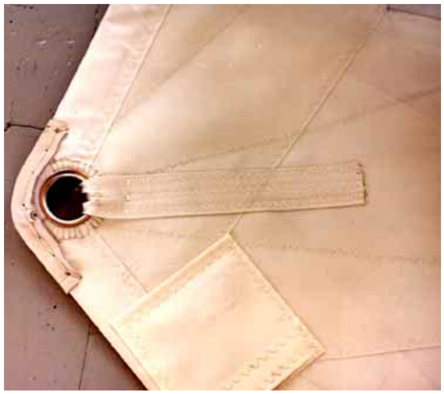
I like to have the final two layers of the clew reach at least *past* the first reef clew.

TOC
Last Chapter
Next Chapter
Help!

There are several ways of terminating the corner reinforcements. In the old days, a ring was carefully sewn into the cloth, and then the load was spread out with seizing to a constellation of smaller rings. Today you'll find most sails have a compression ring that is forced into the corner reinforcements with a hydraulic press. There's a diversity of opinion about the need for webbing in addition to the ring. Over the years we've always had webbing sewn in as a precaution, although we've yet to have a ring fail. Still, it's a comfort to have it there, and the cost/weight trade-offs are nominal.

You'll frequently find a stainless D-ring webbed into the corner instead of the pressed ring. The approach used is generally a function of the way in which the sail is to be attached to your spars. Stainless D-rings do fail occasionally. However, if you keep an eye on deformation you'll have plenty of advance notice of trouble.

When we worked on the design of our sails for *Beowulf* with Dan Neri, he suggested we look at a soft clew on the working jib. Instead of a pressed ring, Dan built the sail with a series of webbings sewn into the corner. We then tied the jibsheets through this webbing. This approach has the advantage of eliminating a bit of risk to the foredeck crew as well as the paint job on the mast.

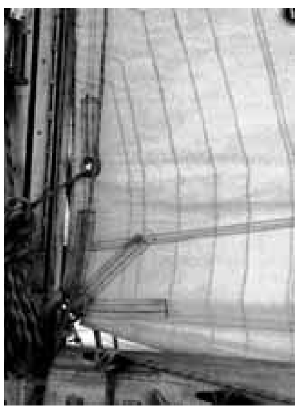


This is a traditionally sewn clew ring. Not many sailmakers today even know what one of these looks like! This one was made at Port Townsend Sails.

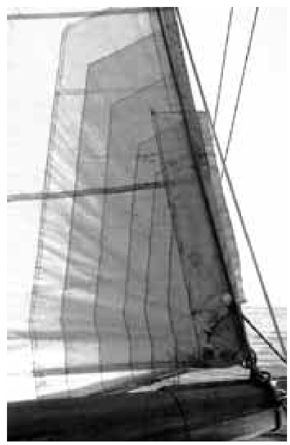
Reef Reinforcements

Even though your reefed sail is smaller, the loads on the corners are actually *higher.* (With a lower center of effort in the sail plan the sail actually works harder to heel the boat then when fully hoisted.) Even so, most sailmakers use reinforcements that are *smaller* than noted above. This is based on the concept that the sail is only reefed for short periods of time. And, if that's the way the sail *is* used, it is a valid approach. But, if you're headed offshore it makes sense to have the reef clews made as strong as or stronger than the normal clew.

You need to discuss with your sailmaker the type of reef reinforcement to be used. Triangular patches are the most common and easiest to apply. These work fine; the only drawback is they tend to make the sail stiff, which can be a headache when furling and covering the sail. The other approach is to use lots of narrow bands or strips of cloth radiating in a fan pattern. This is just as strong but far more flexible. You may encounter some puckering between the strips, but this will not affect the sail's aerodynamics to any measurable degree.



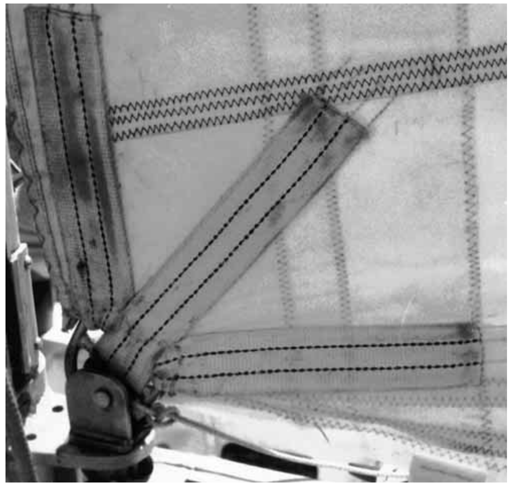
The tack and cunnigham on *Sundeer's* mainsail are heavily reinforced. Note the many layers of Dacron plus webbing.



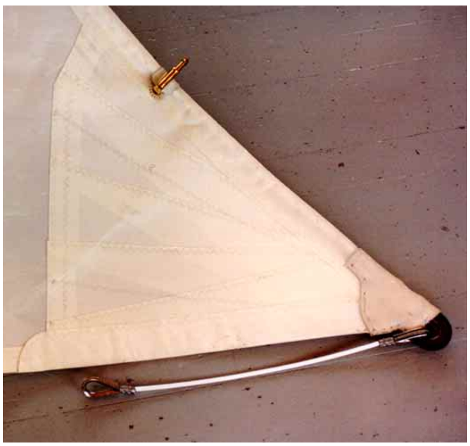
The clew on *Sundeer's* main and mizzen were even more heavily reinforced. The rectangular sailcloth patch is actually a cover for the leech cord.

Another consideration are the reef cringles, used to tie up the belly of the sail after the clew has been pulled to the boom. Years ago, when fabrics were weaker, these were used to spread the load along the boom. Today they are used just for housekeeping. But if the clew reef pennant fails, the load is suddenly transferred to the cringles causing the main to tear (one of the most common repairs in a sail loft). To avoid this, make sure that the cringle reinforcements are *stronger* than the tie lines. The tie line should fail before the sail tears. (Keep an eye on that reefing pennant!)

TOC
Last Chapter
Next Chapter
Help!



A significant amount of load occurs at the tack. Using a D-ring with webbing reinforcements is one way to efficiently deal with the loads.



The photos abovet show a traditional approach to head and tack construction. Note the heavy thimble, sewn-on hank, and leather chafe and sun guard.

A sewn reef clew with webbing pressed between grommet and ring. The ring protects the webbing from chafe by the reef line. The leather protection on the leach is a nice detail.

Batten Pockets

Battens get a bad rap among some cruisers. Yes, they are a source of frustration and have been known to damage sails. And yes, many experienced cruisers use hollow-leech, battenless mainsails. However, if you give up the fight prematurely, you're condemned to an extremely inefficient sail shape and loss of sail area.

Until recently, sailmakers used battens that were extremely short due to racing-rule limitations. Rule-makers and sailmakers have now seen the light, so we are getting longer battens and much longer-lasting sails. For maximum roach support with minimum hassle, the batten should be four to five times the roach dimension. If you have 12inches (304.8 mm) of roach midway down the leech, the batten itself should be 48 inches to 60 inches (1,219 mm to 1,524 mm) long.

My preference for the top batten is to make it full length. This helps prevent the leech from hooking under the cap shroud when jibing and gives the sailmaker a lot of help in shaping the sail.

The next issue is how the batten pocket is constructed. Assuming your battens have nicely smoothed ends and edges, chafe will not be significant. If the pockets have four layers of cloth at each end (in addition to the basic sailcloth), that should take care of your internal chafe problems. Battens need to be under tension. Some sailmakers put shock cord into one end of the pocket. Others use a tight-fitting pocket, which puts a little compression directly onto the batten.

TOC
Last Chapter
Next Chapter
Help!

A D-ring webbed onto a reef clew (above right) with a combination of Kevlar (it's a Kevlar sail) and Spectra webbing.

Compare this pressed ring (upper left) with the more traditional sewn ring (bottom left facing page). The pressed ring has a series of serrated teeth that bite into the sailcloth. If there's enough reinforcement, and if the ring is of sufficient size, these work quite well. The small jam cleat is for the leech line when the sail is reefed.

The biggest problem with battens is keeping them from flying out of the back end of the sail when you're reefing (and the sail is flogging). Most sailmakers use "trap" pockets (which insert from the back end), but we have not had a great deal of offshore success with this approach. So we've always made it a point to *sew* the pockets shut after inserting our battens. Another approach that seems to be popular in New Zealand is to use a trap pocket which inserts from the *front* end. In either case, front end or sewn shut, if the battens stay put you'll find the extra performance well worth the trouble.

Leech Construction

The most highly loaded part of any sail, and the area most prone to chafe (a deadly combination), is the leech. As a result, extra precaution must be taken to guard against chafe and provide more-than-adequate reinforcements.

For inshore work on smaller boats, the leech area is folded over to provide an extra two layers of reinforcing. However, the stitching with this approach is subject to chafe from the leech line, and if it starts to go the sail will quickly sustain severe damage. A better approach which most sailmakers use for larger and/or offshore sails is to fit a separate tape as a leech reinforcement. This is then double stitched into place.

Finally, to protect the seam areas and provide extra reinforcement, a triangular piece of cloth can be worked in at each seam between tape and the body of the sail. These patches are especially important on headsails.

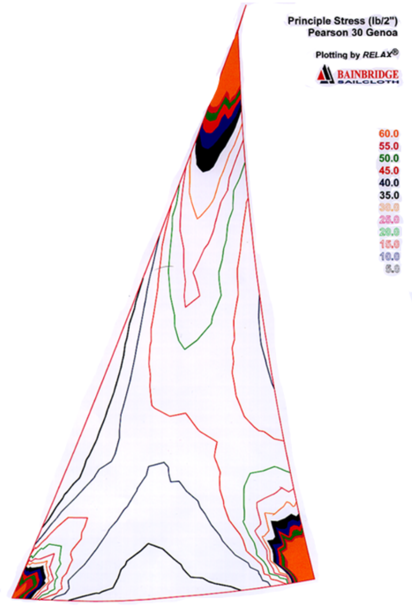
The RELAXed Approach

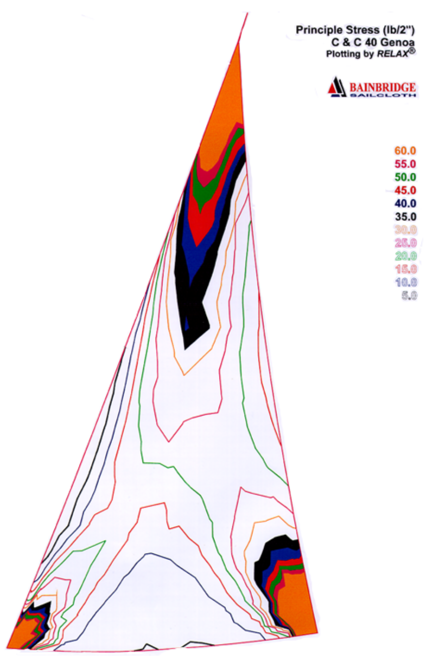
One of the recent offshoots of the America's Cup programs is the RELAX stress mapping software which is able to predict sail loads. Greg Jarvis at Bainbridge/Aquabatten, one of the major sailcloth suppliers, was kind enough to run off some sample stress maps for us to demonstrate how sail loads change with size and shape.

The following series of drawings are all from Greg's computer.

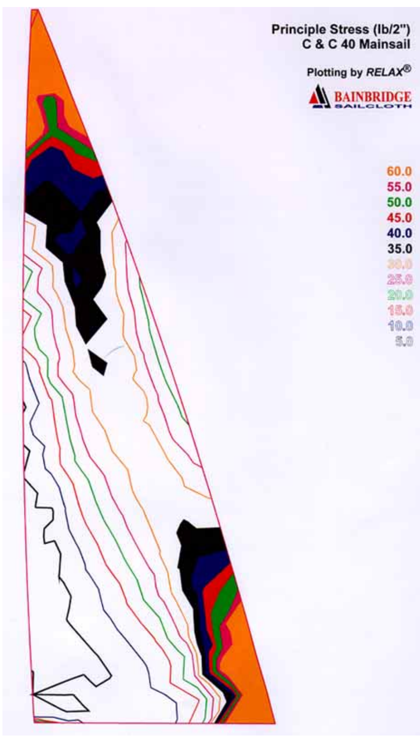
This first set of drawings shows the loads encountered with a Pearson 30 when sails are loaded to the maximum. The colors represent the load in pounds per 2-inch strip (a typical method for sailmakers).

Note how light the loads are in the middle of the sails and how they concentrate towards the three corners.





This set of drawings is for a C & C 40. This is a much larger and more powerful vessel than the Pearson 30, and the stress levels are higher accordingly. The high aspect-ratio of the mainsail also increases loading on the clew, head, and intervening leech.



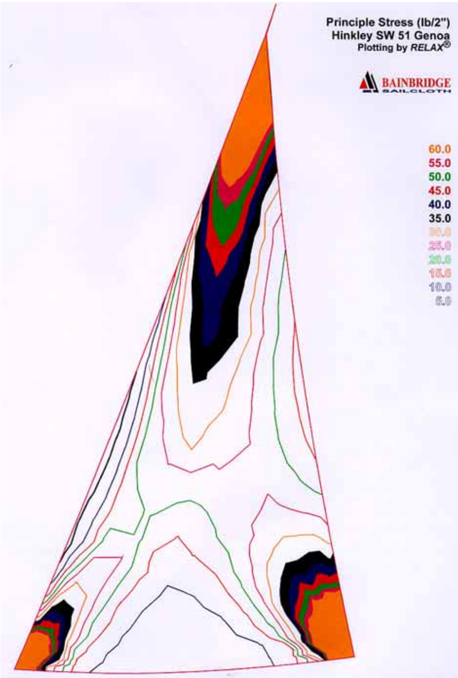
TOC
Last Chapter
Next Chapter
Help!

TOC

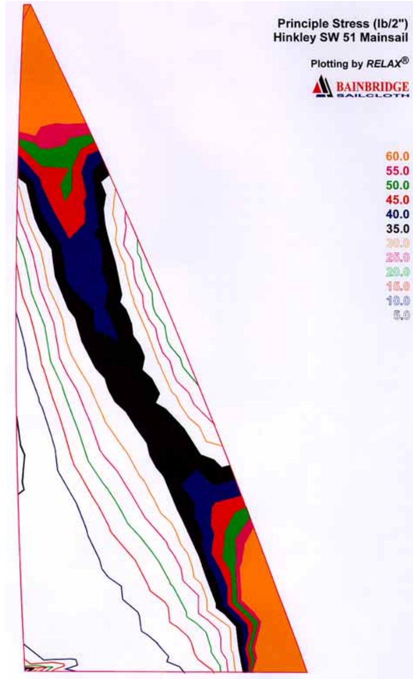
Last Chapter

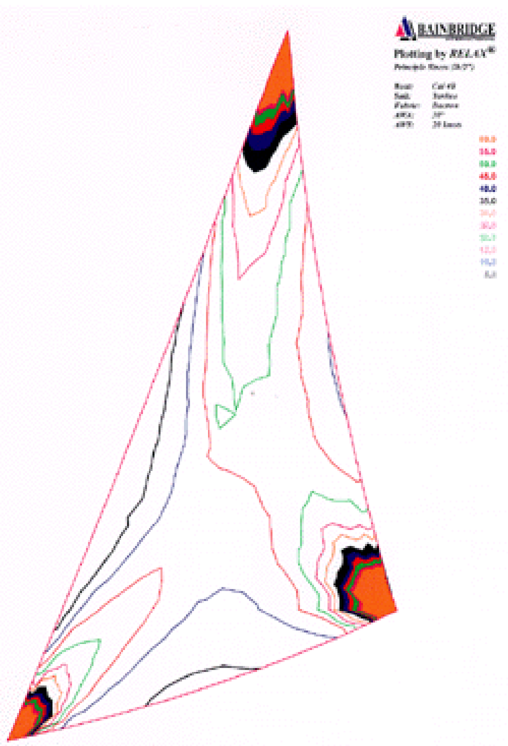
Next Chapter

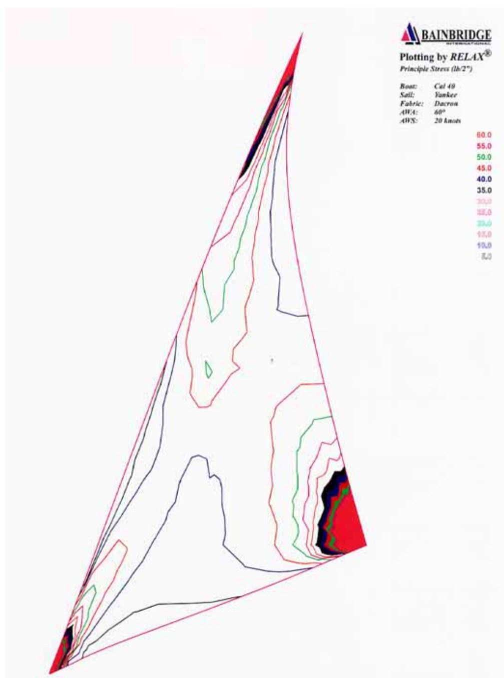
Help!



This set of stress maps is for a Hinckley Sou'wester 51. Even though the main is of lower aspect-ratio, the pure size of the sail coupled with increased righting moments of the larger vessel, has increased stress by a factor of almost three compared to the previous drawings.



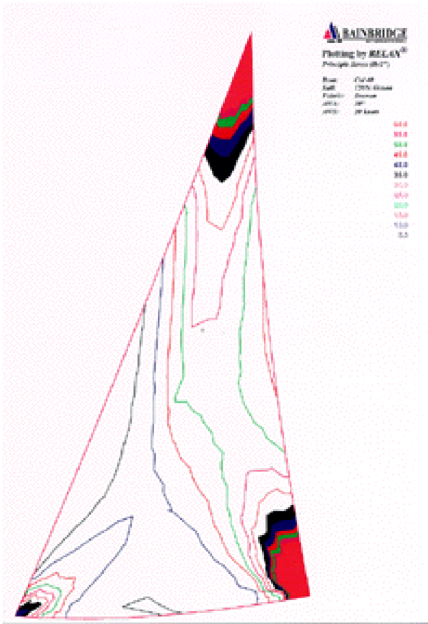




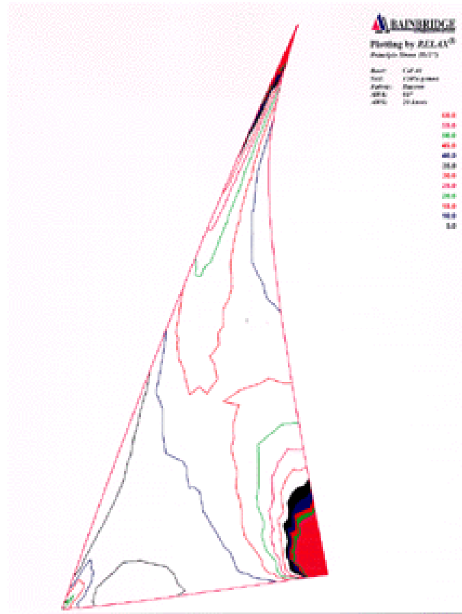
The following stress maps were made for a Cal-40 in a variety of conditions.

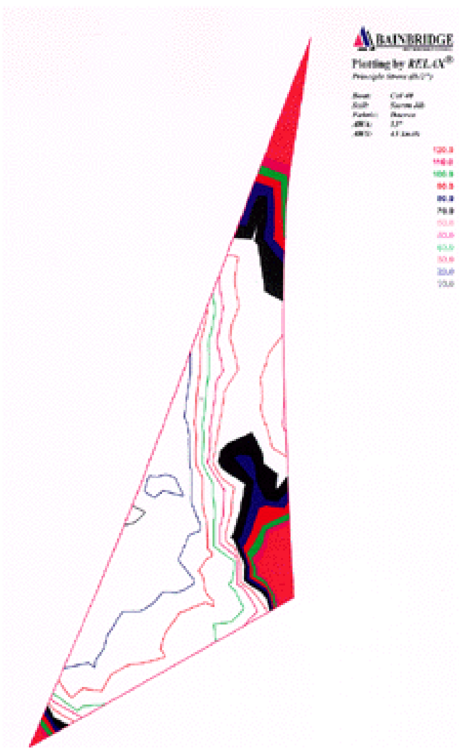
The first drawing (left) is for a yankee jib in 20 knots of breeze trimmed for beating (30 degrees apparent).

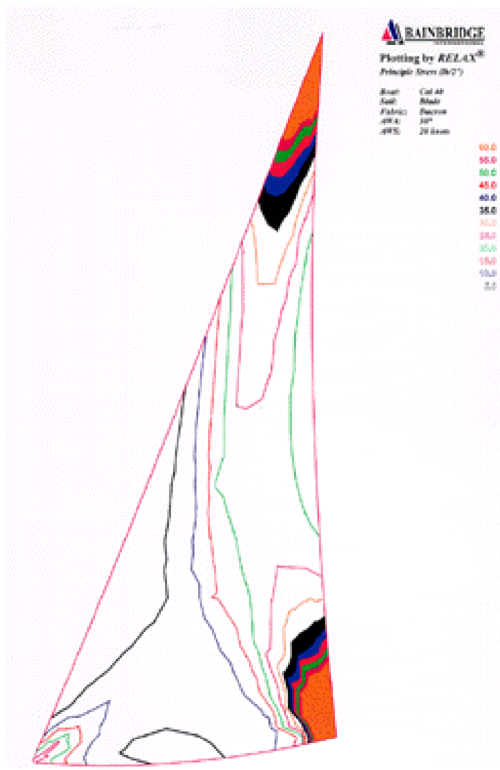
The drawing at right is for the same sail, but eased off to a reach (60 degrees apparent). Note how much lower the loads are once you begin to reach off than when beating.



Here we have a 120-percent genoa under the same two sets of conditions as above. Note how the loads are higher when beating with this sail (because of its lower clew and higher-aspect-ratio).







Finally, we have a Cal-40 blade jib, still being flown in 20 knots of breeze on a beat. This non-overlapping sail is quite a bit smaller than the lapper. However, the higher aspect-ratio puts a good deal of load on the head and foot.

Here's a storm jib flying at 55 degrees apparent-wind angle in 45 knots of true wind. Even though this sail is less than one-third the size of the other sails, the loads are much higher.

When you are thinking about sizing deck gear, halyards, and sheets, it should be with these types of loads in mind.

TOC
Last Chapter
Next Chapter
Help!

TOC

Last Chapter

Next Chapter

Help!

A traditional piston hank sewn on rather than pressed on. This takes a lot more labor, but if you ever need to change a hank it is a blessing compared to the pressed-on hanks normally used today. Note the chafing gear between hank and luff and the grommet reinforced by stitching.

The Winchard hank (above) looks neat but has several problems. First, because it is stainless there is no give against the headstay. This means it runs the risk of chafing through the headstay over time. Second, the spring clips tend to open at inopportune times.

Bolt Ropes

In the olden days of sailmaking with stretchier fabrics, a great deal of the sailmaker's art revolved around the bolt rope and how it was attached, as this was the primary sail-shape control device. Today, with seam shaping for aerodynamic control, the bolt rope becomes somewhat of an anachronism (unless you have a luff groove and require the bolt rope for attachment to the spar).

As far as sail shape or structure goes, a piece of sail tape will do nicely. Where a bolt rope does help is with slide or hank attachment. The grommets that are pressed into the sail, to which slides and hanks attach can bear against the bolt rope, help to distribute their load more efficiently.

Jib Hanks

We've already mentioned hanks in connection with storm jibs and staysails. Now let's take a closer look at these critical pieces of gear.

There are several choices in materials, but the only one that makes sense for long-term use is bronze. Yes, bronze hanks will wear, especially at the head and tack, but this takes place over thousands of miles. The alternative, stainless, won't wear, but it will chew up your headstay. That's by far the less desirable of the two situations!

Today, almost all sailmakers use a pressed-on hank instead of the more traditional webbed or seized hank. Yes, these are a lot quicker to install, but they can be a pain when you have to replace a hank.

What you need to look at is the cost differential between using the press-on hanks and the seized hanks. Then see if it's worth the extra money for sewn hanks. For serious offshore work, in many cases the sewn hanks are a better buy.

Several factors will bear on how your hanks perform. At the head of the sail, the halyard lead needs to be fair. If it is not, there will be lots of extra chafe on the top hank. When you use a sail that is short on the luff, be sure there are extra hanks at the head. The sheet will exert a substantial downward pull on the leech that will wear out a single top hank in short order. At the tack, be sure that the tack fitting is in line with the rest of the sail to prevent uneven loading on the bottom hank.

You also need to watch the bottom hank for jamming on the swage fitting at the bottom of the headstay. If it drops over the stay when the sail is lowered, chances are it will catch on the way back up, bending and eventually snapping the body of the hank.

Finally we need to discuss the spacing of headsail hanks. This is very much a function of wind range and vessel stability. As the load on the sail goes up, sail hanks need to get larger and more closely spaced. Otherwise, excessive halyard tension will be required to keep the luff from scalloping.

Every sailmaker has his own suggestions. In discussing this issue, bear in mind that the load between the hanks is a function of the square of the distance. If you have a jib with a 48-foot (14.6m) luff and hanks spaced at 3 feet (0.9 m) on center (16 hanks), and then drop the hank spacing to 2 1/2 feet (0.8 m) on center (a total of 19 hanks — just three more), the load drops by a third.

Mainsail Slides

The same basic logic that applies to jib hanks applies to mainsail slides. You can substantially reduce loading by adding just a few slides to the total. Your choice of slide material is varied, including bronze slides, stainless slides, plastic in various forms, and plastic-coated metal.

How do you decide? The first issue is strength. A slide normally doesn't take much load until you find yourself in light airs with a leftover sea. Then the sail will be flogging back and forth, trying to shake the rig down and itself loose. The violence of the motion and the load on the sail attachments are difficult to imagine under these conditions.

If there's a weak point, the shaking will find it. If one slide breaks, the load is quadrupled on the neighbors. (Remember: This is a distance-squared effect.) The next thing you know, those neighbors are gone, and before long the entire mainsail is hanging by just the head and the tack. So, you want slides that are stronger than normal.

Another consideration is friction. Metal slides are simply a lot harder to get up and down than plastic. But plastic in many cases is too weak. That leaves you with plastic-coated metal, a good bet in most cases.

The odds are that your sail will have plastic slides. Check them carefully for cracks and wear. Look at the lashings. Stay ahead of the wear and tear, and carry lots of spares!

Traditionally battened sails (short battens) have their slides webbed on quite close to the bolt rope.This prevents them from cocking and jamming as the sail is raised or lowered.

It is not unusual for lower slides to bind on their way up the spar. Using shock cord for attachment reduces this problem. (North Sails RI photo)

TOC

Last Chapter

Next Chapter

Help!

Two approaches to headboard attachment. The headboard at left will eventually chafe the slide webbing where it turns around the aluminum headboard plate. The more this sail is used when reefed, the quicker the chafe will be.

The detail to the right will work okay when the sail is fully hoisted. But when reefed, the leech will pull the head aft and down, putting tremendous loads on the slide just below the headboard. This will fail in rapid fashion, followed by the next one, etc. It would be better to have a slide right at the stainless ring.

Headboard Attachment

Headboard loads on the mast track are minimal when the sail is fully hoisted, as the halyard takes most of the load. But when you reef, the leech load pulls aft on the head and the halyard can't effectively resist the force due to the angles involved. At this point your headboard slides are really working hard. These need to be metal and should probably be seized on with stranded wire or Spectra webbing rather than woven Dacron tape.

Tack Reefs

In theory, your reefing hardware or cunningham (downhaul) should be positioned so there is no load on the sail-slide hardware. If this is not the case, there will be substantial pull on the slides toward the clew (out along the boom). No ordinary slide or attachment will withstand this loading for long. You may want to beef up the slide attachment at this point, in case someone makes a mistake. However, don't plan on using this long-term, as it is quite hard on the sail, hardware, and mast sail track.

Chafe

The ultimate enemy of any sail is chafe. The more miles you sail off the wind, the more care you're going to have to take. It's primarily stitching that is the most easily damaged.

There are two approaches to reducing chafe problems. The first is to apply a plastic sealant to the stitched areas. This provides an abrasion-resistant cover and forms a glue bond at each penetration. That bond will help the stitch hold in the event that chafe takes its toll elsewhere.

The other way to go is to apply an additional layer of sailcloth over the seams in areas subject to chafe (where the sail bears on spreaders, shrouds, the pulpit, etc.)

Sticky-back insignia tape is easy to apply (self-adhesive) and relatively inexpensive. If the area covered is subject to a lot of abrasion, a heavier piece of Dacron *under* the sticky-back will decrease the time between chafing-gear changes.

TOC

Last Chapter

Next Chapter

Help!

Costs

Surprisingly, the initial costs of building a bulletproof cruising sail are not that much higher than what you'll pay for local construction. To jump a level in cloth weight, add larger corner reinforcements, allow for wider seams, and beef up stitching; this will add less than 20 percent according to John Conser. Bill Menninger of North Sails and Jim Italiano of UK Sails agree. Fifteen to 20 percent is all the extra that's required. Is it worth the money? If you want your sails to last, it is.

Spreader chafe is always a problem. To minimize the problem, the trailing edges and tips of the spreaders should be polished smooth and rewrapped in chafing gear. This can be as simple as some rags and duct tape, or as elegant as leather boots. You will then want large chafe patches sewn onto the sail in a position for full hoist and for when reefed.

Roller-Furling Headsails

There are several considerations that will help make a roller-furling sail set better. The first is raising the clew of the jib somewhat. Olaf Harken, who with his brother makes one of the better roller furlers, suggests bringing the clew up about 5 degrees more than normal. A higher clew works even better, but then you start to lose efficiency.

The sail must be built with enough beef throughout to stand the upper end of the wind range in which it's intended to fly. Various sailmakers and/or equipment manufacturers say that a sail can

We've been looking for photos of roller-furled headsails for years, and this is the extent of what we've been able to dig up. You can see how drafty the sail is in the roller furled condition. This is exactly the opposite of what you want when the wind is blowing. The shape is okay for sailing off the wind, but for upwind work it would be better to change down to a smaller headsail. This problem can be mitigated to some extent by adding padding to the luff of the jib (It should be noted that the sail in these photos was quite old when these were taken and fuller than you might otherwise want the sail even before roller reefing.) (Mark Reuther/ Profurl photos)

TOC

Last Chapter

Next Chapter

Help!

be furled about 50 percent and still be effective. My own experience suggests something more like 30 percent at the outside. Of course, this is a function of what one considers an efficient sail shape. The apparent-wind angle has a lot to do with what is feasible. On the wind, shape is critical. But as the wind goes aft of the beam, a flat sail with draft well forward isn't as important.

There is a critical relationship between the halyard-sheave location and the location of the head of the sail. There needs to be about a 15-degree angle between the two to minimize the risk of wrapping the halyard around the roller furler as the sail is rolled up. With Pro-Furl units this is not so critical, as they have a built-in wrap-stop device. Remember, this also applies to smaller jibs that are shorter on the luff. The typical sailmaker's solution to this is to extend the luff tape up the foil so that the top of the tape is in the fully hoisted position relative to the mast-halyard sheave.

All roller-furling headsails lose shape and draft control when they are rolled down in size. And *no roller-reefed sail is ever going to look as good as a smaller sail cut for the higher wind conditions.* Of the six sailmakers I talked with when researching this section of the book, only one claimed that his roller-furling sails were as good reefed as a smaller sail. Charlie Ulmer, guru of the UK Sails loft, told me that he figures you lose about 10 degrees in pointing angle with a deeply roller-reefed sail.

Once again it's necessary to look at the conditions you'll sail in. For weekending and coastal work, a single roller-furling jib that can occasionally be reefed is probably sensible.

When the time comes to change a headsail that doesn't have hanks to attach it to the headstay, there are several things that can be done to increase the chances of success. (Or should I say, mitigate the chances of disaster?) To begin with, always keep the tack firmly attached to the foredeck. Tie it off before the sail is lowered. Consider doing what the early 12-Meter sailors did when luff grooves were first developed: They installed a series of grommets along the headsail luff, then wove a light line through the grommets to stack and control the headsail as it was dropped, venetian-blind style. Having the foredeck lifelines laced helps a lot.

Another approach favored by some sailmakers is to add a closed-cell, flexible-foam (or stiff-Dacron) ellipse to the luff area. Once again, area is removed from the center of the sail as it is rolled.

I discussed these issues with a local sailmaker, Tony Morelli of Morelli Sails in Ventura, California. Tony says the main problem in roller-reefed sails comes from the bulk of the head and tack reinforcement. All the layers and the heavy pressed rings used now make a big knot to wind up around. With more bulk at the top and bottom, the diameter of the roll is larger than in the middle. This leaves increasingly more fabric in the center of the sail, causing all that unwanted draft.

To get around this problem, Tony reduces the amount of corner reinforcements and uses a smaller-than-normal tack and head ring. To distribute the load, he then sews in long straps of webbing through the smaller rings and out into the body of the sail. The result is a much tighter roll all along the luff (although it is still not perfect).

Sails that are going to be roller reefed need heavy reinforcement points at each head and tack point. The load on the sail is in direct proportion to the area and to the square of the wind velocity. So even though the area is smaller when reefed, the total forces are much greater. There are two approaches. One is specific reinforcement points. This gets the additional layers of fabric where they are needed but adds bulk to the top and bottom of the sail, making the bellying problem in the middle worse. The other is adding an extra layer all the way along the leech and foot, but then the sail isn't as strong when the point loads occur at top and bottom.

A major consideration with roller reefing is sheet lead. As the sail is rolled, the genoa lead must be moved forward to compensate. When deeply reefed, most sails will lead forward of the main mast, and many yachts don't have lead positions that far forward. So check the leads before heavy weather catches you.

Another issue with roller-furling is ultraviolet degradation. UV-stabilized Dacrons are available, which some sailmakers apply as cover and reinforcement to the leeches. In climates that have a low UV incidence, and where the sail is used during the summer only, this approach can work. But for sunnier areas, and where the sail is left up year round, you are faced with the weight and shape problems of sewing on a proper acrylic-awning fabric.

TOC

Last Chapter

Next Chapter

Help!

STORM CANVAS

A critical element in dealing with severe wind and sea conditions is the storm-canvas inventory. If there's a variety of sails to set, you'll have more flexibility in dealing with the conditions encountered. Beating off a lee shore requires a different sail configuration than running off before breaking seas. The key is flexibility. You'll want to be able to adjust boatspeed to the wind and sea conditions found.

When you talk with experienced offshore sailors, you find that their storm canvas rarely sees action. In all our miles of sailing we have never been down to our very smallest sails, yet I would never go offshore without them, nor would many other experienced sailors, as the following story illustrates.

Tasman Gale

The port watch of *Samantha* looks uneasily over the stern quarter across the Tasman Sea. For the past two hours the lowering sky has signaled the arrival of a frontal system. The skipper rolls out of the sack at the deck crew's call. He taps the barometer, grunts, and then rubs his eyes. "All right, mates," he calls, "looks like we're in for a bloody northeaster."

The crew methodically begins preparations. *Samantha*, enroute from Fiji to New Zealand, was stripped down for "battle stations" even before she poked her nose into the trade winds three days ago. Heavy gear was stowed below. The dink, outboard, and sailboard were all stuffed into the forepeak and lazaret, and the dorades were removed and capped as the 42-foot (12.8m) sloop moved south into cooler air.

Although *Samantha* is moving easily now with #2 genoa and full main in the Force 4 southwester, the crew realizes that once the wind shift that accompanies the front hits, there will be little time to change sails.

The storm jib is hanked on to the intermediate forestay. The storm trysail is removed from its bag at the base of the mast and flaked out on deck. First the headboard is checked, and then each sail slide is examined for wear, each lashing for chafe. Two lashings need repair but rather than resew them now, the crew uses light parachute cord over the sewn lashings as a temporary fix.

Next the crew run the seams, the leech, and the corners. They pay particular attention to where the panels overlap along the leech, because these spots are the most vulnerable. Once their inspection is complete, they double-gasket the trysail, lead the sheets to the rail, and turn their attention to checking the storm jib already hanked on to the inner forestay.

The first drops of cool rain begin to fall. To the west, flashes of lightning play among the clouds. The wind drops, and the sails slat. *Samantha* rolls drunkenly in the confused cross-swell. A bit of breeze from the northwest fills in and then gives way to a southwest puff. The breeze backs, comes in from the northeast at 10 knots, and then dies again. Suddenly the rain begins in earnest. The crew scrambles to drop the genoa. The rain beats down, ever harder; they strip off the large headsail and dump it into the forward cabin, replace the storm cover over the hatch, and hoist the storm jib. The 40-square-foot (3.7-square-meter) sail looks like a diaper in the foretriangle.

The 35-knot wind arrives with a crack of thunder. Within 15 minutes it is blowing a steady Force 10 — 50 knots and more. The crew struggles to get the main down and gasketed. Double lashings are applied, and the boom is dropped onto the coachroof and then secured.

The storm trysail is next. Although the tiny sail is only 20 feet (6.1 m) on the hoist and 10 feet (3 m) on the foot, it takes the crew 20 minutes to set. The job would have been easier had it been done in advance, but then *Samantha* would have been shorn of adequate sail in the confused seaway before the front hit.

Samantha and her crew are now rolling along at hull speed with less than 15 percent of the normal sailplan set. Since the center of effort is low, she heels little. The rig is easy to handle and adjust, and the crew is comfortable, if a bit exhausted. If the front doesn't worsen, they can carry this rig through the night. By morning the storm line will have passed and the breeze lightened.

Storm-Sail Inventory

Having a sufficient inventory of properly prepared storm sails is essential. We like to carry more than just a trysail and a single storm jib. Two or even three jib sizes are better, not only because storms themselves vary, but also because conditions vary so during any one storm, requiring different amounts of canvas to adjust boat speed and angle as the wind and seas mature or drop off. *Storm-sail inventory is no place to compromise.*

TOC

Last Chapter

Next Chapter

Help!

Aboard our first *Intermezzo* we carried a 100-square-foot (9.3-square-meter) storm staysail constructed of 11-ounce Dacron and a 60-square-foot hurricane jib built from 7 1/2-ounce material. Rather than carry a storm trysail, we put a third, trysail-size deep reef into the Dacron main and heavily reinforced the head. I now feel this decision was a mistake. It meant that in ultimate conditions we would be calling on a sail we used every day. If the sail had failed, the result could have been disastrous.

Because *Intermezzo II* was a cutter, we could rely on both a heavy staysail and two sizes of storm jibs. With the cutter configuration we felt safe without a trysail, since the rig was designed to sail with only a staysail while going upwind in a heavy blow. A sloop rig, on the other hand, would need a trysail to balance the storm jib, particularly if you needed to claw off a lee shore.

Both *Sundeer* and *Beowulf* carried heavy staysails and one small storm jib. We felt that the ketch rig gave us added versatility in heavy weather and so limited the amount of storm canvas we needed to carry.

Finally, the staying system of the boat's spars must be considered. The rigging plan or the way the mast is tuned may make it difficult for the spar to stay straight when the mainsail loads are not applied at the masthead. Deeply reefing a main or setting a trysail puts aft and side bending loads into the middle panels where support is sometimes lacking. If you have not had occasion to find out how your spar reacts with storm canvas, find a rigger or sparmaker to advise you.

Storm Jibs

If you're going to be sailing offshore, the intermediate headstay (cutter stay) referred to in the previous section is an absolute necessity. Not only does this provide extra support for the main mast, but it's a convenient place to hank on storm canvas.

The storm jib is typically about 30 percent of the foretriangle area (this is not to be confused with what some modern raceboats call a storm jib but what is really a #4). It can be flown on the cutter stay or used on the headstay in conjunction with the staysail as a powerful heavy-weather double-head rig.

This form of double-head rig can also be useful when your #3 or #4 jib has been damaged and storm sails by themselves are too small to use, while the smaller genoas are too large. If heavy weather is expected, starting out with this double-head rig makes it much easier to shorten down, since you have to lower only one of the two headsails.

Where the foot of the staysail will typically be low to the deck, the storm jib has a very high foot.

We've always carried a hurricane jib. This sail is just 15 percent of the foretriangle area and is designed to be used when running off before a major storm.

Storm jib and trysail size is always the subject of some debate. The rig shown here on a Sundeer 56 sailplan has a normal-size storm jib and a somewhat undersize trysail. This rig will move a vessel of this design type quite easily, even in moderate conditions.

Sheet Leads

Storm jibs require special thought when being set. You will want to sail with sheet leads just a little more forward than usual to minimize the chances of leech flutter damaging the sail. Be sure the lead blocks are extremely strong. Even though the sails are small, the forces on the sheet can be higher than on the largest genoas.

Tack Pennants

Having a permanent, extra-long tack pennant is a good idea, too. In really large seas this will help avoid the sail being blanketed in wave troughs and will keep breaking seas out of the foot when beating. At other times you'll want the tack right down on deck to keep the center of effort low. Try setting sails with and without pennants, and note sheeting positions in your log for future reference. Remember that the natural lead position moves aft as you raise the sail. Check for chafe points on the sheets. If using inboard leads, what happens when you ease off on a reach? Will the sheet rub against the shrouds?

TOC

Last Chapter

Next Chapter

Help!

Downwind Considerations

Another consideration is running square. The storm jib will crash back and forth across the foredeck as it alternately fills and is blanketed in the lee of the trysail (or reefed main). The spinnaker pole will prove unwieldy to handle in storm seas, especially if you're shorthanded. But if you make your reaching strut a little longer than normal, it can fill in as a storm-jib whisker pole. (Be sure to tie off the sheet end of the pole so the sheet can't come loose.)

Storm-Headsail Construction

The highest loading of storm headsails comes not from wind pressure, but from improper leads (resulting in leech or foot chatter), being filled with water, or luffing.

Most storm sails that fail do so not in the body of the sail, but where panels are sewn together, or where the sail is attached to the headstay.

As a result, the edges of the sail should be extra heavily reinforced. This is especially true of the leech.

The luff and the hanks that attach the sail to the headstay also need careful attention. Extra layers of cloth, heavier sized hanks, and doubled or tripled hanks at head and foot are prerequisites.

Mast Safety

What's done behind the mast is complicated by rig engineering. When the mainsail is deeply reefed or a trysail is set with the head positioned in the middle of the spar, the leech loading on the sail tends to invert the mainmast into an "S" shape — a prescription for structural disaster. Making sure the head of the sail is even or just above a spreader point to eliminate mid-panel sideways deflection is a must. It's also important to have some form of cutterstay or babystay pulling forward at or just below the headboard.

Most of the IOR rigs sail with such low safety margins that for all practical purposes it's impossible to use a trysail or deeply reefed mainsail.

You may want to consider reinforcing the sail track where each reef occurs, especially on larger yachts. If your track is attached with pop rivets or sheet-metal screws, adding fasteners to tighten the spacing or welding the track down will improve strength.

The Trysail

If you're serious about heavy-weather sailing, put an external trysail track alongside the main track and run it right down to the deck. This allows the trysail to be permanently attached to the track, bagged and ready to go whenever you head offshore. Trysail track and slides should be heavier, if possible, than those used on the mainsail. If the mainsail has a bolt rope on the luff and you don't want to add a full track, an additional section of track down to the deck and a switch where this connects to the bolt rope track can be added. In this case the trysail will need slug slides to fit into the bolt rope groove. These slug slides should be solid metal, rather than plastic and metal. This approach, however, is not nearly as satisfactory as a proper track with flat slides.

Trysail Geometry

Trysails are typically lower in aspect-ratio than mains, with the luff being about 50 percent of the hoist and the foot about 70 percent of the foot dimension of the main. They will be cut so the clew is high enough to clear the mainsail furled on the boom in its normal position (although it's better to drop the end of the boom and lash it to the deck to lower your center of gravity and reduce the chance of damage in the event of a severe knockdown or rollover). You normally use double sheets, led to port and starboard genoa tracks and then to a primary winch. Since the trysail will be set in conjunction with a storm jib, you'll use the secondary winches for the jib sheets.

If pinching up on the wind is required, you can crank in both the windward and leeward sheets and bring the clew closer to the centerline.

WORKING WITH A SAILMAKER

If you're going to be buying new sails, allow plenty of time to work with your sailmaker. Keep in mind that sails built in the off-season will cost 10 to 20 percent less than those built when the sailmaker is busy.

You will want to fully communicate all details about how you expect to use your sails, where you'll be heading, storage issues, and what you are after in terms of longevity. Here's a recap of some of the things you'll want to consider:

- Measurements of critical dimensions (to be confirmed on board by the sailmaker).
- Sailcloth limitations (are there any materials, like laminates, you don't want him to consider?)
- How important is the "feel" of the fabric? Do you want a soft, somewhat stretchy and relatively unresonated sail, or do you want a "harder" finish that is more difficult to handle, but better on maintaining sail shape?
- Longevity expected of the sail and your willingness to pay a little extra for a better-lasting sail.
- Storage considerations. Where will the sail or sails be stowed on a passage and when in port?
- Batten details for mainsail and headsails.
- What sort of corner-connection hardware do you want?
- How about placement of leech and foot cord cleats?
- Clew height of headsails.
- Foot clearance of headsails.
- Roller-furling headsail reef requirements (if any).
- Reef positions for mainsails.
- Draft-stripe needs and locations.
- Telltale windows and locations.

There are two basic approaches that a sailmaker will probably take while working with you. If you have a moderate-size marconi-rigged monohull, the odds are that his or other lofts with which he is affiliated has built a bunch of sails for your type of boat.

On this basis he will know what to recommend in terms of shape and construction. Be clear about what your objectives are. You want to be sure that the database from which he draws your sail design really applies to your needs.

The alternative is to design the sail from the beginning, based on your input and the sailmakers experience, but not rely on any given models. This is typically a more time-intensive and costly approach.

Performance-Oriented Design

As the sail design requirements move toward performance cruising, the data that the sailmaker needs becomes more detailed.

Along with basic dimensional data and preferences as stated previously, you should also supply:

- Scale view of the deck plan (to go with the sailplan).
- Scaled drawing for all rig elements and connections.
- Draft, righting moment, and displacement data.
- Velocity-prediction data.

Over the last couple of years we've worked quite a bit with Dan Neri to develope sails for a series of production yachts and our own latest *Beowulf*. Dan is one of the smartest sail designers I've ever worked with, so his approach to sail-design process is worth looking at. Given the data mentioned above, Dan creates on his computer a three-dimensional model of the hull, deck, and rig. Existing sail shapes, or "molds" as they're called in the business, are then loaded onto the computer model. These molds are then optimized to fit the rig and the required true-wind angles.

The next step is to run a stress analysis. Most sailmakers today use "RELAX" for stress mapping.

The stability data and VPP information are critical to this phase.

One of the outputs from the stress mapping is headstay sag. The sail molds are adjusted for this factor, and then faired for the desired shape.

With the shape defined, Dan then gets into the construction issues. The first step here is to layout panel orientation and select fabrics. This will be based on the load predictions from the stress-mapping program, along with experience and, of course, the client's input.

With the basic fabrics decided on the reinforcements for the three corners and reef points are designed. The last step is to prepare this for production, nesting various panels on sailcloth to get the right thread orientation and to minimize waste. The end result is a computer file that is used to drive a plotter/cutter that actually cuts out the sailcloth panels.

TOC

Last Chapter

Next Chapter

Help!

THE DITTY BAG

The question of what to carry in your ditty bag will revolve around the type of cruising you're planning. If you're sailing close to home or in "civilized" waters, a basic repair kit — enough to see you to the sailmaker — will fit the bill. On the other hand, long-distance passagemakers will want a full kit aboard, with everything necessary to repair any sail that may go, regardless of the extent of the damage.

Many of the better cruising areas don't have sailmakers available. Nevertheless, if your ditty bag is well-stocked, a local tailor, awning maker, or upholsterer will be able to help out. This is usually much less expensive than domestic repairs. The key is having the materials.

Most repairs consist of restitching and require little expert knowledge. For larger problems, such as a bad tear requiring replacement of a panel or a torn hard spot like a clew, it's best to have some guidance. Ask your local sailmaker to provide a few pointers when the supplies are purchased for your ditty bag.

One of the keys to staying out of the repair business is catching trouble before it spreads. That old adage about a stitch in time is nowhere more applicable than at sea.

Basic Needs

In a simple kit you should have a good palm, an assortment of hand needles (all needles should be stowed in a container of coffee grounds or be well Vaselined to keep them from rusting), several weights of thread, a little wax to ease the passage of the needle and the thread, and pliers to pull the needle through heavier pieces of cloth. A hand-stitching tool is also helpful when a long seam has to be worked over.

Sticky-Back Cloth

The hardest thing we've had to deal with in sail repair is keeping old and new cloth aligned while being worked. Sticky-back sailcloth solves this problem and makes repairs much easier than before. When the protective backing is peeled away, the adhesive is pressed onto the old cloth. On large tears it's invaluable, and for chafe patches it can be used temporarily without stitching. It's also useful for doing quick fixes on very light sails. We've successfully used sticky-back without stitching spinnakers, drifters, and light genoas with small three-corner tears during passages when sewing was too cumbersome.

It is easiest to use sticky-back cloth if it is in rolls, typically 4 to 6 inches (101.6 mm to 152.4 mm) wide.

The sail should be clean and dry. Acetone or MEK does a good job of cleaning and dries quickly. Do not allow these solvents to puddle on the sail, however, as they will eat the plastic. Do not use lacquer or paint thinner, as they do not evaporate fast enough and have a high possibility of degrading the fabric.

Double-Sided Tape

For assisting in the repair of heavier sails, use double-sided adhesive tape or adhesive transfer tape, to hold the two cloths together until sewing.

To make any of these adhesives work well it's imperative to have a dry, salt-free sail. Washing with *hot* fresh water seems to do the best job. (Note: This applies especially to sticky-back sailcloth.)

Cloth Inventory

The actual cloth inventory can run from a few scraps for a temporary fix to substantial yardage. When traveling to out-of-the-way spots we've found it worthwhile to invest in enough material to replace the largest panel in each different weight sail we have aboard. This way, regardless of the extent of damage, some means of repairing the sail can be found. Without adequate inventory it will be necessary to scavenge from an old sail or cover, meaning at some point the repair will have to be redone. Better to carry a good inventory of cloth and fix it right the first time.

Sail Reinforcements

Sailmakers use cloth tape in construction on the edges of the sails. Since most problems occur on the leech or foot, having several weights of tape along is a good idea. The tape doesn't necessarily have to be new. It's frequently possible to pick up used tapes that were removed from sails being repaired at the local loft.

Webbing can be used to temporarily reinforce a damaged clew, tack, or head. Light webbing is the preferred material for attaching mainsail slides that are prone to chafe.

For larger boats it makes sense to carry a bit of Spectra webbing, which has all unbelievable load-carrying ability.

Hardware

Seizing wire, spare hanks, mainsail slides, and battens should also be included. If plastic hanks or slides are used on long passages, you should take enough extras to completely refit one sail.

Tools

A set of grommet tools is useful for sails as well as for covers. Number 3 grommets will handle most sail loads temporarily when placed in a fan pattern and seized together with wire to spread the load in sail corners. Also carry the proper dies for cutting out the sailcloth, as well as punches to bend over the grommet flange. A block of hard wood will be required to back up the die and punches.

Sewing Machines

Many of the cruising yachts we meet carry sewing machines. Our little Sears portable has worked its way, albeit slowly, through five layers of 8-ounce mainsail. The power requirements are minimal and can be handled by a small inverter. The machine sees lots of other applications aboard as well. We don't think it's necessary to have a special sail-repair machine; no real advantages are apparent. If AC current isn't available, hand-crank accessories are easy to come by. If you're going to buy a machine for sail-repair work, try it out on various weights and thicknesses of sailcloth. Don't be afraid to try something as heavy as a genoa or mainsail clew. There will always be a learning curve associated with thread tension.

A large inventory of sewing-machine needles in various sizes should be taken. Our experience has been that needles are frequently bent in the heavier cloth. We carry 40 needles of each required size: #20 for the heaviest work, and #16 for lighter sails. Appropriate weights of thread are carried as well. Lubricate with 3-in-One oil and WD40 every three to four months keeps the sewing machine running smoothly.

Contact Cement

The last item for sail repair is unusual but extremely useful — contact cement. It's the best way to make heavy structural repairs in the corners of a sail, where hand work or machine capability may not be up to the task. As soon as a load is applied, the contact cement spreads out over a wide area, reducing the concentration of stress. When used carefully it will extend the life of sails, covers, or awnings. Several pints and glue spreaders should be aboard. With older cloth that is perhaps a bit rotten from the sun, it's often the only method that will prolong the life of the material. However, use this only as a last resort, as once this adhesive has been used you won't be able to sew through it.

Tape

This doesn't sound like a very significant subject, but, believe me, it is. Having the right type of tape aboard will have a significant impact in a number of areas.

Ah, the ubiquitous duct tape. It has kept more leaky hatches dry and preserved more mast boots than anyone can imagine. It has also prevented miles of chafe on spreader ends, not to mention pulpits and turnbuckles.

Duct tape comes in a variety of qualities. The better the quality, the longer lived. The cheap material begins to disintegrate after a few months, leaving dozens of tails flapping in the breeze. We've found that the Nashua brand seems to work the best.

A variety of companies now market a self-sealing tape for chafe guard. The tape actually sticks to itself, making a very tough, waterproof seal. Sometimes it makes sense to wrap a sharp object first with duct tape, then put self-amalgamating tape on top.

The 3M company makes this material in a variety of widths, up to 2 inches (50.8 mm), for use in the electrical industry. It's ideal for boats, too, and less expensive than the marine brands.

If you wrap all external wire connections and any internal ones that might become damp, you'll have far fewer problems with your electrics.

TOC
Last Chapter
Next Chapter
Help!