

Heavy Weather Sailing - Making a Series Drogue

by David Lynn

Nothing seems to generate a more lively discussion among offshore sailors than the question “What is the best tactic for heavy weather at sea?” Is it heaving-to, lying a-hull, running before the storm, deploying a sea anchor, laying warps or setting a drogue? Likewise, a survey of the existing literature yields a number of differing opinions. The Pardeys advise heaving to with the help of a sea anchor deployed from the bow. Robin Knox-Johnson handled storms in the southern oceans by streaming a 600 foot warp from the stern. Bernard Moitessier and Vito Dumas found warps unsatisfactory, preferring to run before the storm. Many experienced seamen feel that lying a-hull and letting the boat look after itself is the best tactic. As evidence, they point out the many stories of abandoned vessels found safe and sound with the hatches open after the storm passed. Perhaps there is no one answer for all conditions and all boat designs, but some tactics are better than others.

Our experience with gales and storms has all been in the southern oceans. Our strategy in the past has been to run before the wind, reducing sail, until the weather increased to force 8 or so, and then heave-to for the duration. This strategy has served us well, but the gales and storms we weathered did not include breaking waves.

A boat can survive huge waves unless they are breaking. The inherent force and extremely steep face of even a relatively small breaking wave, however, will capsize and possibly roll a sailboat if it is caught beam-on. Researchers have found that the size of a wave required to capsize a sailboat depends in part on the boat design and ranges from 30% to 60% of the boat length. This means that some 40 foot sailboats will capsize if a 12 foot breaking wave is encountered beam-on, and virtually all 40 foot sailboats will capsize if a 24 foot breaking wave is encountered beam-on.

Likewise, a breaking wave taken on the bow or stern will cause the boat to slalom down the face of the wave until it reaches the bottom of the trough. If the wave is big enough, the boat will either broach and capsize, or worse, pitch-pole. Fortunately, most storms do not produce breaking waves.

So how do the various tactics fare in a storm with breaking waves? Let’s look at the options.

- Heaving-to. This is a good tactic to employ up to moderately severe conditions. This is not a comfortable or safe tactic for winds and seas beyond about Force 8 or 9, or when the waves are breaking. In addition, some fin keeled boats cannot heave-to.
- Lying a-hull. This was the most popular tactic in the 1979 Fastnet storm, and is traditionally the next step when heaving-to is no longer feasible. When the waves are breaking, however, the boat is quite susceptible to capsize and rolling, with a high likelihood of injury to the crew and loss of rigging and mast.
- Running before the storm. With a fresh, skilled crew and a maneuverable boat, running is a reasonable tactic, even with breaking seas. It is important to keep the boat at an optimum angle to the waves. Too much angle and you risk broaching. Too little angle and you risk pitch-poling. It is a less viable tactic in a typical shorthanded cruising boat as the crew becomes fatigued.
- Warps. Deploying warps from the stern when running before a storm has as many deterrents as proponents. Some sailors, such as Robin Knox-Johnson have reported good success with warps, and many others have had unsatisfactory results. The usefulness of a warp may vary with the length of the warp as well as with the height and period of the waves.
- Sea anchors. Deployed from the bow, a sea anchor or parachute keeps the bow into the wind.

The Pardeys use this technique to keep their boat hove-to in severe conditions. Critics say that sailboats, especially high windage vessels tend to yaw as the boat passes into the trough of the wave. If a wave hits it when it is off the wind, it is susceptible to high stresses on the rode, damage to the rudder and possible knockdowns.

- Drogues. Deployed from the stern, a drogue slows the forward speed of the boat and keeps the stern pointed to the wind. Its drawbacks are that it is difficult to recover, and the boat is susceptible to being pooped.

What is clear is that there does not appear to be a universally acceptable solution for all vessels and all conditions. Sailors who survive storms with no breaking waves often conclude that the tactics they employ such as heaving-to, lying a-hull or running with the storm are adequate to prevent capsizing. After our research and experience, we concluded that a drogue trailed from the stern seems the best tactic for severe conditions with breaking waves. The conclusions drawn from a multi-year study by Donald Jordon in cooperation with the US Coast Guard¹ convinced us that a drogue was the right approach. The study incorporated computer simulations, model testing and actual testing on full size boats and concluded that a suitable drogue deployed from the stern of the boat was the best method to avoid being capsized in breaking waves. An independent study by the prestigious Wolfson Unit of the University of Southampton had similar findings.

Once the conclusion was reached that the drogue was the best tactic, the study attempted to determine which drogue design was the best. In their estimation, a line with a series of small cones attached had several advantages over a single large cone or parachute type drogue.

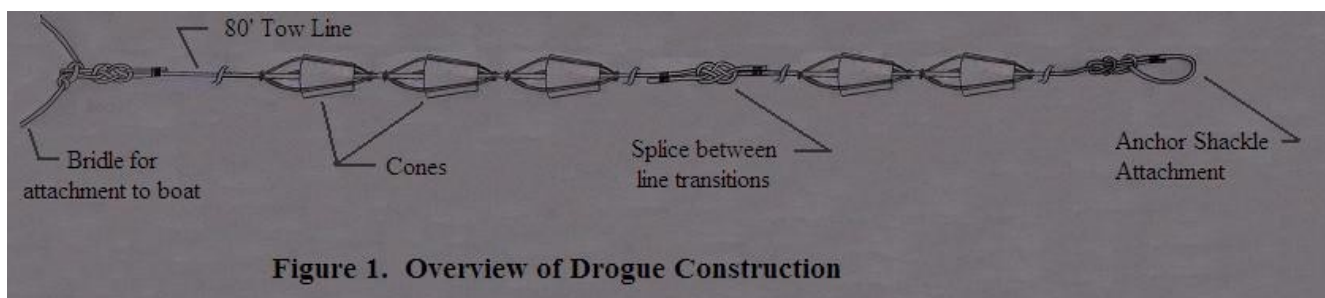
- The series drogue is simple and safe to deploy under difficult storm conditions. Assuming the boat is either running or lying a-hull under bare poles, the drogue can be payed out over the stern, building up load gradually.
- It is unlikely to foul or entangle it enough to make it ineffective.
- The series drogue rides below the waves and is not affected by a following sea. There are known cases where a parachute or large cone has been pulled out of the water and even catapulted ahead of the boat.
- The series drogue can be weighted whereas the parachute or single large cone cannot. When the boat is in the trough of a large wave, the towline tends to go slack. With the series drogue, the weight sinks, pulling the towline backwards and taking some of the unwanted slack out of towline.
- The load and stress on any one cone is small, making each less susceptible to fatigue-related failure. Since the number of cones is large, the failure of one or even several cones has little effect on the performance of the drogue.
- When a breaking wave strikes, the drogue must catch the boat quickly to prevent a broach. The series drogue, since some of the cones are near the boat where towline stretch is low, will build up load faster than a conventional cone or chute at the end of the towline. Similarly, if the breaking wave strikes at an angle to the towline rather than directly astern, the series drogue will build up load much faster than other types.
- It can be modified for any size boat by increasing the number of cones as well as the line length and size.

As with all drogues, however, the two biggest drawbacks are that it will not be easy to retrieve until the storm has abated, and if the breaking seas are large, you can expect to be pooped. Larger center cockpit boats would be less susceptible to being pooped. Assuming you have reasonably sized cockpit

drains, there is little to be done topsides. It is usually best to batten down everything in the cockpit, latch all hatches and washboards, and go below and get whatever rest you can.

Once we made the decision that we wanted a series drogue, we explored our options. It is possible to purchase a complete series drogue from at least two sources. You can also purchase a kit from Sailrite and save considerable money by doing the labor yourself. All the design information is available, so another option is to make your own. Since we were in South America at the time, making it difficult and expensive to obtain parts, we decided to make our own.

The Jordon/USCG study describes the design and construction details of a series drogue and since it was tax-funded, the information is available to the public. Figure 1 gives an overview of the construction. The cones are the same size for any boat – larger boats simply add more line length and increase the number of cones. As the number of cones increases, the initial line size must also increase to handle the added load. As you get closer to the end, the line size can be reduced since the load is less with fewer cones downstream.



The bridle performs two functions. It splits the load and feeds it to two strong points on the transom, and it provides a turning moment to keep the boat stern to the waves. Each leg of the bridle should be 2.5 times the transom width, plus an allowance for the splice and for attachment to the boat.

The following Table provides the design details for loads, line size and number of cones for different size boats. When using the table, use the gross tonnage for your vessel and then add 10%. For example, our Liberty 458 has a gross tonnage of 18 tons, so we use 40,000 lbs as our displacement for designing the drogue.

The total load on the boat is shown in the second column. The third column in the table shows the load on the attachment points on each side of the transom. The line lengths shown include the line required for the towing line (80 feet), but not the towing bridle. The lengths also include 5 feet at each end for splicing. A double braid line should be used rather than a three strand, which has a tendency to unlay as it is towed. The line sizes specified in the table are based on average strengths for double braid nylon line from several manufacturers. Check the breaking strength of the line you purchase. As can be seen, larger, heavy displacement boats require more cones and subsequently a related increase in labor.

Monohull Displacement (lbs)	Load (lbs)	Load at Attachment Points (lbs)	Line Length Required (ft)	Line Size (inches)	No. of Cones	Anchor Weight (lbs)
10,000	8,000	5,600	250	5/8	100	15
15,000	12,000	8,400	260	3/4	110	15
20,000	14,000	9,800	150/150	3/4,5/8	120	15
25,000	17,000	11,900	155/155	1,5/8	130	25
30,000	20,000	14,000	165/165	1,5/8	140	25
35,000	23,000	16,100	170/170	1,5/8	150	25
40,000	25,000	17,500	125/125/125	1,3/4,5/8	160	30
45,000	28,000	19,600	130/130/130	1-1/8, 3/4,5/8	170	40
50,000	30,000	21,000	135/135/135	1-1/8, 3/4,5/8	180	50

The number of cones and the amount of work required for our series drogue seemed daunting at first, but it proceeded quickly once we got into the project. We set goals for ourselves to complete a given milestone each evening, e.g. draw and cut out 25 cones or cut 100 strips of nylon tape.

To make our cones, we used an old mainsail, which was much heavier than necessary. The emphasis is on the word ‘old’ in the last sentence. This sail was retired about 4 years ago. Before we spent a lot of man-hours making all those cones, we wanted to be sure the sailcloth had not deteriorated and lost too much of its strength. To test the material, we made up a dozen cones, attached them to a line and, during a recent passage, dragged them for 24 hours. Our speed varied between 4 and 6 knots. The cones held up fine, but we did learn a few things about the construction and stitching, which are discussed later.

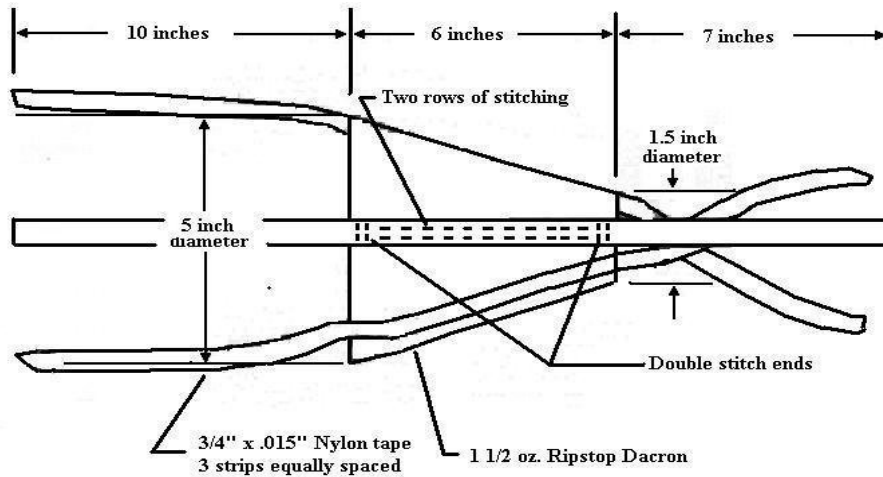
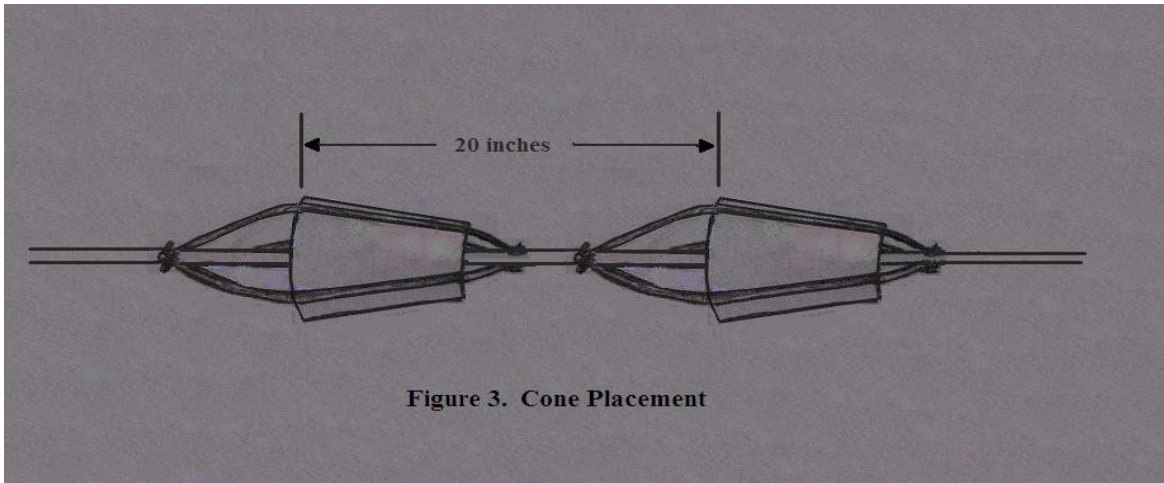


Figure 2. Drogue Cone Size

Figure 2 shows the recommended size and Figure 3 shows the placement of the cones. A 1-1/2 ounce ripstop nylon material is recommended for boats with a displacement of under 30,000 lbs. Larger boats should use a heavier material. We made a pattern (Figure 4) out of cardboard to mark the outline of each cone for cutting. We also used the pattern to mark each cone to aid in aligning the nylon tape for

sewing. We first tried cutting each cone using a hot knife, but found this to be too slow. We switched to a pair of electric scissors and then used a butane lighter to seal the edges.



The next step was to cut and mark each length of nylon tape. We placed pieces of masking tape on a flat surface to serve as a template for measuring, cutting and marking each strip of nylon. These strips were then sewn to the cones. One thing we discovered with our test run was that it is important to double stitch the tape at each end (Figure 2). Each piece of cone material was then folded in half and double stitched together. The last step was to turn each cone right side out so that the seam was on the inside. It probably doesn't matter, but we sewed each cone so that the tape was on the outside of the finished cone.

We next began attaching each cone to the line. The first step is to mark the line at 20 inch intervals, leaving 5 feet or so at each end for splicing. Thread all the cones for each line segment onto the line. The end of each strip of tape from each cone (six per cone) is pulled through the line and tied with an overhand knot (Figure 5) using either the single or double pass method.

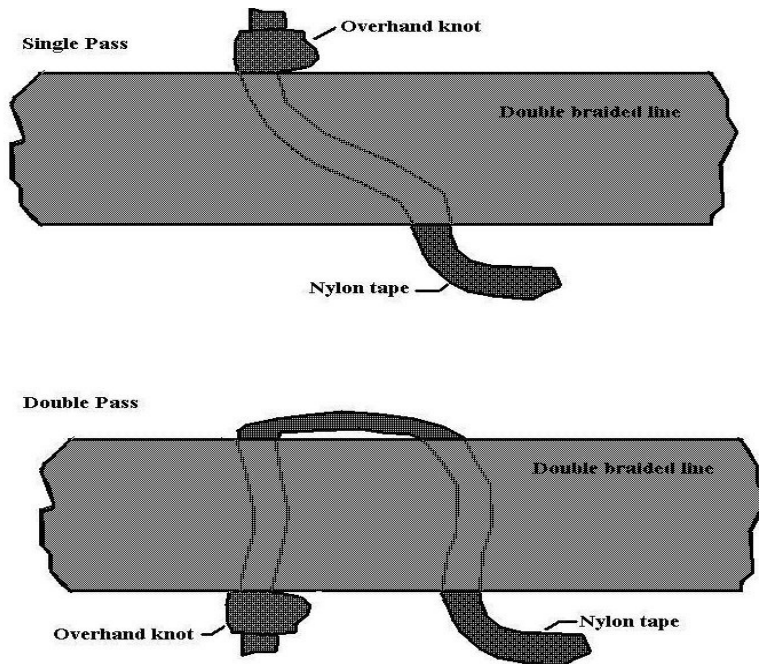


Figure 5. Attaching cones to line

We already had a splicing wand⁵ that worked well for this process, but you can make a tool using seizing wire bent into a loop and taped to a wooden handle (Figure 6).

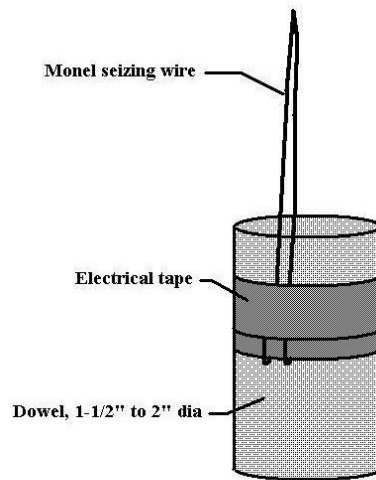


Figure 6. Tool for attaching cones to line

The next issue is the attachment of the line segments, towing line, bridle and anchor. A proper splice is stronger than any knot. The line we bought was manufactured in South America and we found it was almost impossible to splice eyes into it, unlike the line we were used to that was made in the U.S. Therefore, instead of splicing eyes into each end, we whipped each end and used a carrick bend to attach each segment together. The ends of the knot must be seized to ensure the integrity of this knot.

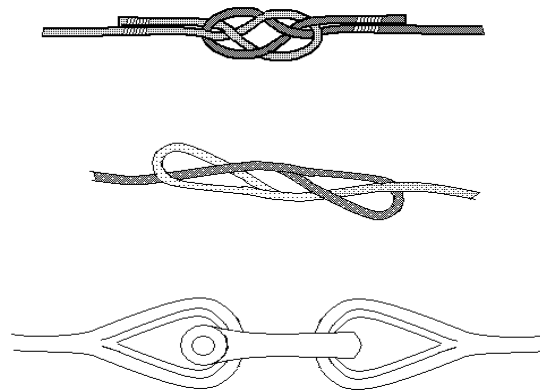


Figure 7: A carrick bend knot was used to attach each segment together.

Figure 7 shows this knot as well as the method to be used if you have eyes spliced into the ends of each line segment. You may wish to splice thimbles into the ends of the lines and attach them together with heavy duty shackles. If so, make sure you check the working loads of the shackles to make sure they will withstand the loads, and use heavy metal thimbles.

We used a span loop in the middle of the towing bridle and attached the towing line to it with a standing bowline at the end of the line. An extra half hitch was added to the bowline. Even a bowline may jam if it is towed through the water, and the extra half hitch lessens this tendency. Figure 8 shows these knots as well as the attachment method using eye splices. For the weight at the end of the line, we used a 20 foot length of 3/8" chain. We attached it with a shackle to a standing bowline at the end of the line with an extra half hitch as before.

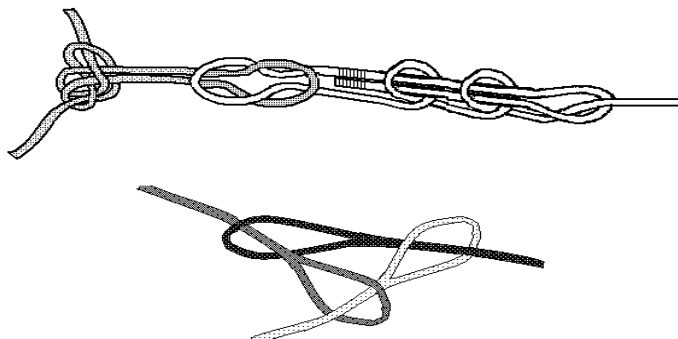


Figure 8: Use a span loop in the middle of the towing bridle and attach the towline to it with a standing bowline at the end of the line.

An important aspect of the overall system is the attachment points. These must, of course, be strong enough to withstand the load. The bridle splits the total load between the two corners of the transom, making the load at each attachment point no more than 70% of the total load. Most cleats and sheet winches are not designed to withstand stresses of this magnitude. The ideal alternative is to use an approach similar to your chain plates by bolting stainless straps to each corner of the transom (Figure 9). These should be through bolted and utilize backing plates. Use heavy shackles to attach each tow line.

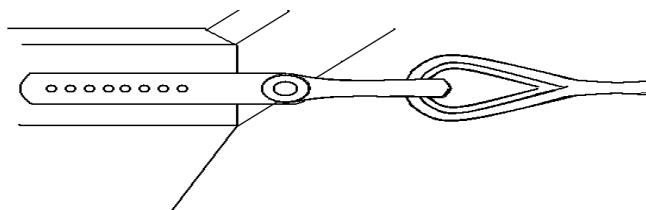


Figure 9 – Attachment method

The following table lists conservative size strap and shackles for several boat sizes. If cleats are used, make sure they are rated for the load and are bolted through the deck with substantial backing plates.

Load at attachment point (lbs)	Strap Size (Inches)	Bolts	Shackle Size
10,000	1/4 x 2.25 x 14	3/8 inch – 4 each	1/2 Inch
14,000	1/4 x 2.25 x 18	3/8 inch – 6 each	5/8 Inch
18,000	3/8 x 2.25 x 22	3/8 inch – 8 each	3/4 Inch
22,000	3/8 x 2.5 x 26	3/8 inch – 10 each	3/4 Inch

Chafe may be an issue as well. If the bridle is led through a chock, chafe may occur even with the use of chafing gear. You might use a short length of wire cable to attach to the nylon bridle, but only if you can route the cable without introducing a short radius or bend.

The last issue is the stowage of the drogue. You want to be able to get to the drogue easily and deploy it without tangling it. For a large boat, the total weight of the entire drogue system may be too much to handle in one large bag. You may want to keep the segments separate and only connect them together when you need to deploy it. This is a strong argument for using shackles. In any case, the lines need to be carefully stowed. We stow it the way we stow our spare rope anchor rode using figure-eight flakes. Instead of a round coil of line, we coil it in a figure-eight pattern and secure it with small line (Figure 10).

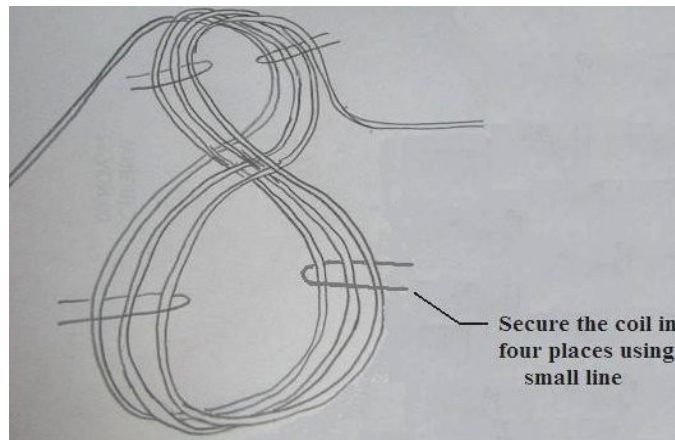
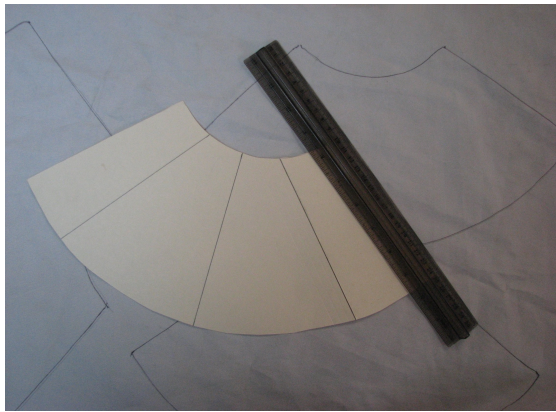


Figure 10 – Stowing the drogue

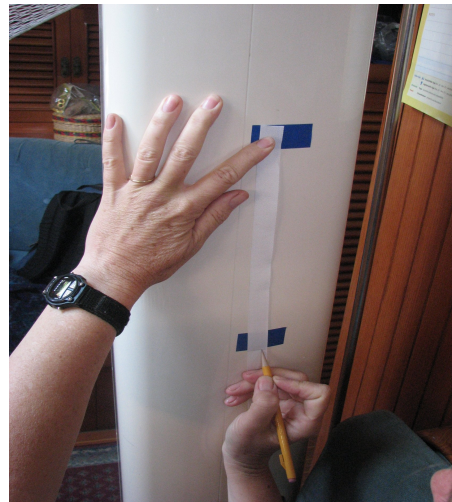
When we need to deploy the drogue, it is laid on deck and the small line is removed. We feed the ends of the bridle back through to our attachment points, secure them and then begin feeding out the rest of the drogue. Our boat speed needs to be slow enough that the drogue does not get out of control as it is deployed. Since we still heave-to until conditions worsen to the point that the drogue is of benefit, our boat speed is negligible. Once it is deployed, we drop the main or trysail and go below.

As mentioned before, as with any drogue system, the series drogue will be difficult to retrieve during the storm. We wait until conditions improve sufficiently to winch it in using the cockpit winch. The cones, if handled carefully, will pass through the winch without damage. It might also be possible to lead it forward and retrieve it using the anchor windlass in heavier conditions.

Though we have deployed and retrieved the drogue without difficulty on a trial run in 20 knots of wind, we have not had to use it in real storm conditions. We are hoping that we never have to use it for real, but having it available as a heavy weather alternative goes a long way towards our peace of mind.



Drogue pattern traced on sailcloth.



The mast and blue masking tape made a handy measuring tool for the tapes.



Sewing the tapes on the flat cones.



One of the 180 finished cones for this project.



Project complete...ready to be stowed and hope we don't have to use it.

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Jordan, D.J., "Investigation of The Use of Drogues To Improve The Safety of Sailing Yachts", U.S. Coast Guard Report No.

CG-D-20-87, May 1987, Available from:

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