

Process for Building Double-Sawn Frames for the Chebacco Boat **Lion**

Section I

Full Frames - The frames in the middle section of the boat pass over and sit directly on the keel. I refer to them as full frames. Near the ends of the boat, where the dead wood rises, the two sides of the frame don't pass over the keel. Rather, they end by butting into the sides of the keel and deadwood. The two sides of the frame are usually joined by a strongback which passes over the deadwood. The process for building full frames is slightly different than for frames with strongbacks. It is the full frame process I'm describing now. In Section II, I will describe the steps for strongback frames where they are different.

1. Layout the plank side frame shape:

Mark half-breadths (HB) at the highest 2 waterlines (WLs) and WL 2. Mark off these half-breadths from the center line (C/L) on the platform out to both port and starboard (stbd). (Obtain half-breadths from the table of offsets if available, the story poles and the lofting floor. Use all three sources if available to ensure no mistake.) Lay the frame template on these half-breadth marks (either port or stbd side) and check all the grid lines, baseline height and C/L on the template for alignment with same on the platform. Adjust template position for best alignment with all the grid lines. In case of conflict, give preference to the baseline height, C/L and the highest HB. Once the template is positioned, put a finish nail near top and bottom of template to keep it in place (or clamp it if possible.) Trace the plank side contour from the template to the platform in pencil. Also transfer all bevel angles from the template to the platform. Flip the template over and repeat for the other half of the frame. Check the full-breadth dimension of the highest WL.

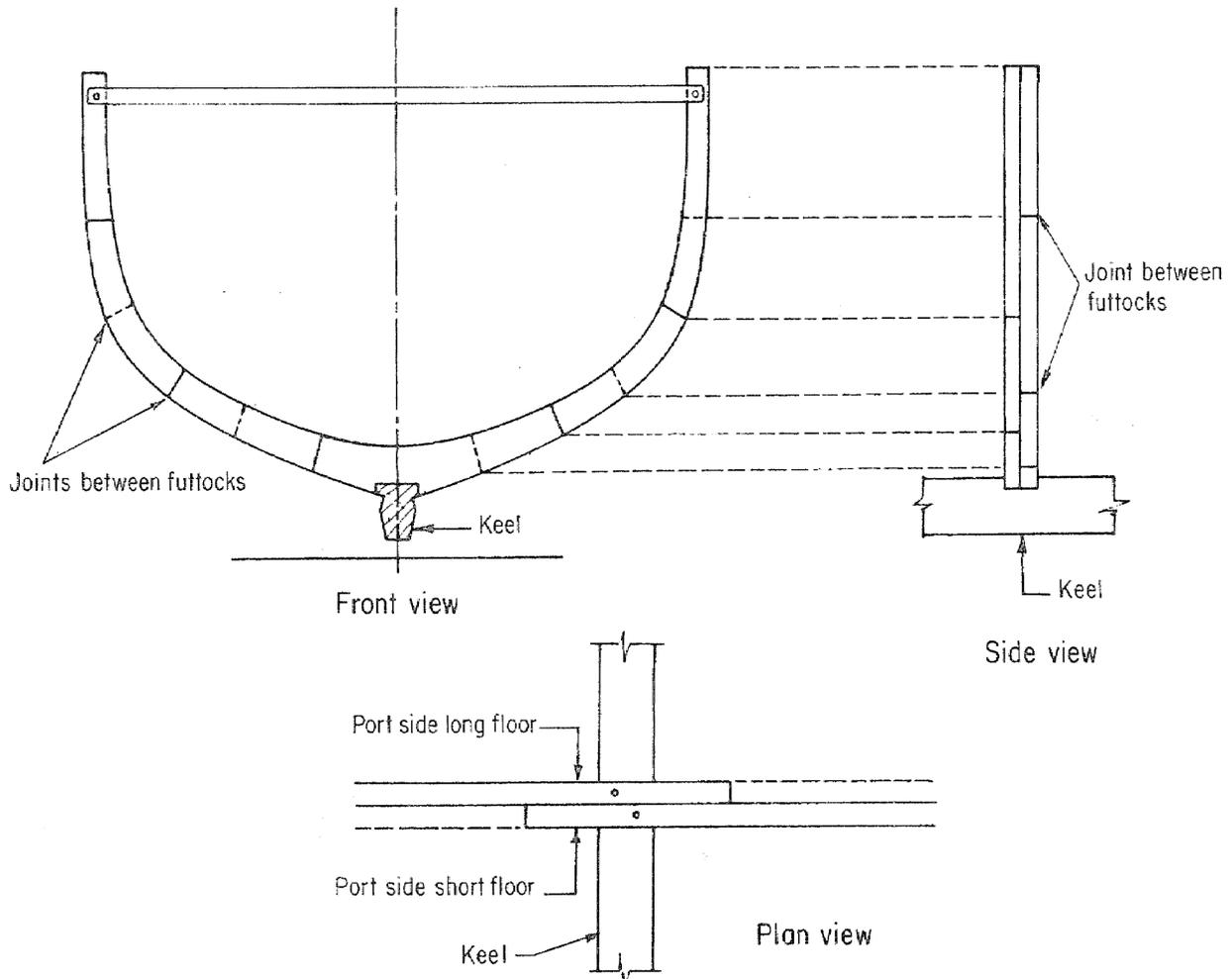
2. Layout the ceiling side frame shape:

Using the bevel table, determine how much extra width is required for each bevel angle. Add this amount to 4 1/8". Measure this total distance inboard of and normal to the plank side curve toward the ceiling side and make a mark. Repeat this at each bevel angle. Using the frame template as a french curve, connect these marks in a "fair" curve. Draw a straight line 6 1/4" above the "top of keel" line on the platform. Make this line about a foot long on either side of the CL. Starting about 3 1/2 feet from the C/L, fair the ceiling side curve in to the straight line 6 1/4" above the keel. Since the frame will be flat above the keel to accept the keelson, the bevel angle reduces to 0 degrees about 1 foot from the C/L. When fairing from the 4 1/8" width to the line 6 1/4" above the keel, keep the frame width about the same as surrounding frames by making measurements every foot or so and using a batten to connect the measurement marks. Repeat for the other half of the frame. (Note: The bevel table is calculated for 2", 2 1/4", 2 1/2", 2 3/4" and 3" thick futtochs. Use the correct column.)

3. Layout futtoch joint locations:

For most frames on Lion, there will be 12 futtochs total, ranging in length from 3 to 5 feet. Only the 4 smaller frames at the ends of the boat (2 aft, 2 forward) had fewer futtochs (varying from 10 to 6 futtochs as they diminished in size.) The two lowest futtochs which cross the keel are called floor timbers. They overlap where they cross the keel and are fastened together. The floor timbers will have a short arm and a long arm extending on either side of the keel. See the drawing below.) If the inner face floor timber short arm extends to port, the outer face short arm will extend to stbd. The short arm

should extend about 6" past the keel and the long arm about 3 feet. The more extension the better for either arm but, from experience, board widths available limit them to not much more than this. The rest of the futtochs start from the floor timber ends and extend up typically 3 – 4 feet in length (again limited by board widths available), with the joints alternating from inner face to outer face, so that each joint falls approximately in the center of the futtoch on the opposite face.



Drawing from "Fishing Boat Construction: 1 Building a Sawn Frame Fishing Boat" (FAO Fishing Technical Paper (96) Rev 1: 63 p.) John F. Fyson

Once the futtoch joints are located on the platform drawing, estimate the length and width of board needed for each futtoch. When estimating futtoch board size, allow an extra 1/2" in all directions to allow for sawing inaccuracies and blade kerf. Also make sure you are using the ceiling side curve which has been adjusted for bevel angle. (Note: At this point, you may find that joint locations must be adjusted to avoid needing boards which are bigger than you have on hand.)

4. Make futtoch patterns:

Port and stbd futtochs will be symmetrical, consisting of 6 pairs. One of each pair will be in a

different frame layer and on the opposite side of the frame from its twin. 5 patterns will be needed. Each pattern can be used for its mirror image and the pattern for the top futtochs can be used for both the long and short top futtochs. So this pattern can be used for 4 of the futtochs. Using 6 mil plastic sheet (vapor barrier material), cut a piece which will overlay each futtoch with a couple of inches to spare in all directions. Tape the plastic over the futtoch drawing on the platform. Use a block of wood 5/16" thick set outside the futtoch line and make a mark with sharpie on the plastic pattern. Repeat this every 4" or so around the perimeter of the futtoch drawing. Make sure you follow the ceiling side line adjusted for bevel angle. This will give a pattern of marks on the plastic which is about 3/8" larger than the futtoch drawing in all directions. Mark each pattern in sharpie with the frame number, futtoch number and an arrow indicating the top of the futtoch and frame.

5. Mark and cut rough futtoch boards:

For each pattern, make 2 identical rough futtochs. Select appropriately sized boards and tape the pattern to a board. Using an awl, push through each mark on the pattern hard enough to make visible holes in the futtoch board all around the pattern sides and ends. Remove the pattern and immediately mark the end cuts on the board with straight edge and sharpie. This will help avoid confusing the end marks with the side marks. Also mark the futtoch number and top direction on the board. Move the marked board to the platform and use the frame template to connect the awl marks in a "fair" curve for the plank and ceiling sides of the rough futtoch. It helps to place the board roughly over the correct position on the platform drawing since this will show you the portion of the frame template which might work best to "fair" the curve. Once the sides and ends are marked on the board, cut the futtoch to shape on the band saw with square edges. Leave the line! Trim the "fuzz" off the bottom edges left by the band saw blade with a block plane, spokeshave or paint scraper. If you don't, it will make life hard when placing, measuring and marking them later.

6. Assemble the rough cut futtochs:

The futtochs will be assembled directly over the platform drawing. The inner face will be set face down on 1 1/8" thick wood blocks with the plank side of the futtoch located 3/8" outboard of the plank side line on the platform drawing. (The 1 1/8" blocks allow room for clamping and for drilling and driving the trunnels.) Use a small engineer's square to locate the 3/8" offset from the drawing up to the futtoch.

Start with the bottom futtochs (floor timbers for full frames). The outer face futtochs will be offset inboard of the inner face futtochs by an amount determined by the bevel angle at any particular point. For example, if the bevel angle is 10 degrees, go into the bevel table to determine the extra width needed for a 10 degree bevel (just as for adjusting the ceiling side line earlier) and measure inboard from the plank side edge of the inner face futtoch and make a mark. Repeat this at each point where a bevel angle is given on the platform drawing. Then set the outer face futtoch on these marks above the inner face futtochs. You will find that the curve of the outer face futtoch does not exactly match the curve represented by the marks you made on the inner face futtoch. This is because the curve of the frame changes slightly as you move away from the station line. But it will be close enough that you can set the outer face futtoch pretty close to the marks. This is one reason for the excess 1/2" left on the rough sawn futtoch boards. Use the "table clamps" (2x4s bolted to the platform) and c-clamps to hold the futtochs in position as you locate, cut and fit the butt joints and as you drill for and drive the trunnels. Use the miter saw for cutting the butt joints. For the floor timbers only, locate two trunnel holes clear of the eventual keel bolt and drift bolt which will be driven vertically through the floor timbers later. Temporarily fasten the floor timbers to each other with two 3/4" threaded rods in the trunnel holes. These will later be replaced with trunnels during final assembly. Don't spread bedding

compound between the two floor timbers yet, as this joint will be disassembled for cutting the bevels. For the rest of the futtochs, locate three trunnels in each overlap and offset them toward alternate sides of the futtochs to avoid having adjacent trunnels lie in the same line of grain to lessen the chance of splitting. However, be mindful of the eventual bevel angle so that the trunnel doesn't come out the side of the bevel (i.e., don't locate the holes too close to the edge.) Try to fit 3 trunnels in each mating surface. Drill the trunnel holes with the futtochs "dry fit" (no bedding compound). Heat the bedding compound to about 150-200 degrees F. Use the 8-3-1-1 mix. After drilling and disassembling, spread the compound on both surfaces including in the butt joints. After reassembling the bedded joint, check to make sure the assembly is located properly over the drawing. Re-clamp and drive the trunnels. As you work up the frame fitting and fastening, continually check that the assembly is correctly positioned over the platform drawing. In spite of the best clamping efforts, the assembly will move around as you drive the trunnels. You can either work up one side at a time (port or stbd), or you can work up both sides together. It seemed to be faster going up both sides simultaneously. Cut the protruding trunnel tops off flush with the outer face as you work up the frame using the Japanese pull saw.

7. Attach the cross-pall and diagonal braces:

Make sure the frame assembly is centered over the platform drawing. Adjust as necessary and clamp securely to the platform. Cut a 2x6 to length for the cross-pall. Remember to cut it short enough to remain inside the bevels to be cut later – otherwise you'll have to shorten it after the bevels are cut. On the platform, locate the bottom of the cross-pall 2" above deck height. Transfer this cross-pall location from the platform up to the frame using a square. Fasten the cross-pall with one 3/8" carriage bolt and two 2" #14 wood screws. Mark the CL on the cross-pall, squaring up from the CL on the platform.

Get out two 2x4s of approximately the right length for the diagonal braces. They will be fastened under the cross-pall at the C/L using an 11x11" x 3/4" plywood gusset and about a dozen 2" #16 wood screws. Locate the lower ends on the frame to achieve the best bracing against change of frame shape. Simply for appearance, I kept the lower ends of several frames in line with each other by making a mark on the platform to locate the brace. Fasten with three 2" #14 wood screws in each lower end. Make the cuts on the lower ends at approximately the same angle as the bevel in that area and make sure they are short enough to be inside the bevel to be cut later on the frame (just as with the cross-pall). Mark the plank side with the two highest WLs and baseline heights. Also mark the CL on the floor timbers and the line 6 1/4" above the top of the keel (which is also 10 1/4" above the baseline.) This will be the eventual cut line for the flat area at the top of the floor timbers.) Mark this line on the outer face, squaring these locations up from the platform drawing. Double check the accuracy of the C/L mark on the cross-pall.

8. Wedge and trim trunnels and Mark the plank side frame shape on the inner face:

Turn the frame over so its inner face is up. Wedge all trunnels. Use white oak wedges with the grain running along the length of the wedge. Seven degree included angle wedges work best. Use the radial arm saw set at 3 1/2 degrees for this operation. Cut the trunnels off flush with the inner face. Smooth the inner face with a block plane and cabinet scraper.

Use the frame template to draw the plank side frame shape on the inner face. Locate the template using the HBs for the highest WLs at the top and the baseline height and the CL on the floor timbers to locate the bottom of the template. Locate the HBs from the C/L on the frame. To do this, place a straightedge on the C/L marks at the floor timbers and the cross-pall. Then mark the HBs for

the highest WLs using the appropriate story pole placed against the straightedge. After locating the template on the frame, there should be at least 5/16" excess wood outboard of the template. When you are satisfied with the template location, clamp it in place and draw in the frame plank side shape. Transfer all grid line locations and bevel angles from the template to the futtoch. Then flip the template and do the same process for the other half of the frame. After removing the template, double check the plank side drawing by measuring the full breadth between port and stbd lines at the highest WL. Mark all grid lines (including baseline) and bevel angles on the inside of the plank side line so that they will still be visible after the bevel is cut.

9. Disassemble the frame and cut the bevel angles:

Turn the frame over (outer face up). Mark around the ends of the cross-pall and lower ends of the diagonal braces to make it easier to locate them upon reassembly. Remove the cross-pall, diagonal braces and floor timber bolts. Clean up the outer face using a block plane and cabinet scraper. Preserve the marks locating the ends of the cross-pall and diagonal braces. Turn each half frame over (inner face up). Starting with the bevel angles already marked on plank side of the frame, locate and mark the in-between angles by interpolation (every ½ or 1 degree, depending on spacing). Place a piece of masking tape all along the inside of the plank side line and mark these bevel angles on the tape in numbers big enough to be easily read while the frame is being fed through the bandsaw. Cut the plank side bevel. Do the same for the other half frame. (Note: You will probably not be able to cut the bevel all the way to the end of the floor timber due to not having a line to cut to or due to loss of bearing surface on the saw table for the last 6 or so inches. The bevel in this area will have to be finished later by circular saw, plane, chisel or spokeshave.)

On the inner face, counter bore the cross-pall bolt holes deep enough to recess the carriage bolt head.

The ceiling side bevels will be cut with the outer face up (opposite of how the plank side bevels were cut.) With the inner face up, transfer the bevel angles across the inner face to the ceiling side (normal to the curve at each angle), and mark each angle on the ceiling side. Also, transfer all grid line marks from the inner face to the plank side. Now, turn the half frame over (outer face up) and bring the bevel angles just marked on the ceiling side up to the outer face. Also on the outer face, measure inboard 4 1/8" from the freshly cut plank side edge and make a mark. Repeat this every 4" or so along the length of the frame, stopping about 3 ½ feet from the C/L. Using the frame template, connect these marks in a "fair" curve, thus forming the upper part of the ceiling side shape on the outer face. (Note: The template will have to be maneuvered creatively here, since the radii of the ceiling side are generally smaller than on the radii on the template.) As with drawing the ceiling side shape on the platform earlier, this line will taper from 4 1/8" frame width into the straight line 6 1/4" above the top of the keel at the floor timbers. In order to be able to draw a continuous fair line across the top of the floor timbers, it will be necessary to temporarily join the two frame halves with tapered trunnels. There is no need to use the cross pall and diagonal braces at this point. Start this taper about 3 ½ to 4 feet from the CL and make the frame width about the same as surrounding frames by making measurements every 6 inches or so and connecting these with a batten to make a fair curve. Now mark the bevel angles on the ceiling side line just drawn. Just as was done prior to cutting the plank side bevels, mark the angles on masking tape. Cut the ceiling side bevels. Ditto for the other half of the frame.

10. Final assembly of the frame:

Reassemble the frame inner face down without the 1 1/8" spacer blocks. This time, instead of bolts, use dowels in the cross-pall and floor timber holes, slightly undersized so they slide in and out without a struggle. Line the frame up on the platform drawing to ensure conformance (check accuracy of CLs, deck and baseline heights and plank side shape.) Clamp the floor timbers as necessary to draw the joint tightly together. Slide the frame down so the floor timber joint area is off the platform. Drill for two additional trunnels in the floor timber joint, again being careful to avoid the area where the keel bolt and drift bolts will eventually be placed. Unscrew the fastenings in the bottom ends of the diagonal braces and cross-pall and remove the floor timber dowels. Swing the frame halves apart, pivoting on the cross-pall dowels. Apply heated bedding compound to all mating surfaces of the floor timbers and bring the frame halves back together. Like before, clamp as necessary to hold the joint tight. Drive the trunnels in the floor timbers. Cut the protruding tops of the trunnels flush with the outer face and smooth this area with block plane and scraper. Refasten the diagonal braces and replace the wood screws on the cross-pall. Finish the bevels on the lower ends of the floor timbers which could not be reached on the big band saw. Use the circular saw, saber saw, electric hand plane, spoke shave and block plane as appropriate. Cut off the bottoms of the trunnels protruding under the frame. Slide the frame so one end of the cross pall is off the platform. Replace the dowel in the cross-pall with the 3/8" carriage bolt, inserted from the bottom with the head in the inner face counter bore. Repeat for the other end of the cross pall.

Reposition the frame accurately over the platform drawing, using the C/Ls, deck and baseline heights and plank side contour as guides. Clamp in place and mark the top of the keel on the plank sides, the keel sides on the top and bottom of the floor timbers and all the grid lines on both the plank and ceiling sides (check previous marks for accuracy and change as necessary). Ensure the C/L is marked accurately on the floor timbers and cross-pall.

11. Marking of grid lines, C Ls and keel notch, cutting of keel notch and erecting frame on keel:

Turn the frame over (inner face up). Wedge and trim the trunnels in the floor timbers. Clean up the inner face of the floor timbers with the block plane and scraper. Using the marks previously made on the plank sides, draw the C/L and keel notch cut lines on the inner face. Also mark the grid lines on the inner face in sharpie by connecting the marks on the plank and ceiling sides with a straightedge. Cut the keel notch. Leave the lines. It will be helpful to use two roller stands to support the frame at the band saw. After sawing the notch, chisel out the waste and finish to the lines and square it with a chisel. Determine the location of the limber cuts by checking the angle and height of the rabbet. Cut the limbers with a handsaw. The location of the limber cut is governed by the need to provide a large enough water channel so that it won't easily be clogged with debris in the bilge (maybe 1 to 2 square inches.)

Hoist the frame, weigh it and record the weight. Test fit the keel notch with the frame in place on the keel – chisel as necessary to get a snug fit. Hoist the frame off the keel, add bedding compound and lower it back in place on the station line. Plumb and level it. Brace it to the forward or after frame and to the barn structure to hold it plumb and level. Clamp it at the keel. Eventually it will get a drift bolt vertically into the keel and a through-bolt to the bottom of the keel. Put on a coat of heated linseed oil/turpentine mixture (2 parts oil, 1 part turps).

FRAME UP!!

Section II

Strongback or Cant frames

Toward the ends of the boat, some frames don't have floor timbers (futtochs which cross over the keel) because the deadwood rises up from the keel. These frames are processed slightly different than the full frames described up to this point. Their ends butt into the side of the keel or deadwood. The port and stbd sides of the frame are usually joined together by a strongback which passes over the deadwood. I refer to these as strongback frames, even though a few of them don't have strongbacks, but are just joined to the side of the deadwood by trunnels and horizontal bolts through the frame ends and the deadwood. Howard Chapelle calls these Cant frames in his book Boatbuilding.

The first step for Strongback frames is to locate the position of the strongback. On Lion, the strongbacks are the same thickness as the futtochs and will join each frame side by notching it into the outer face futtochs. The vertical position is determined by the height of the deadwood at the outer face of the frame. The deadwood will be notched just enough to make a flat spot wide enough to accept the strongback's thickness. The height of this notch then determines the height of the bottom of the strongback. (In the forward end of the boat, a few strongbacks will sit on the keelson instead of the deadwood.) Pencil in the notch on the deadwood. Measure the height of the bottom of the notch above the baseline or the nearest WL. Transfer this height to the platform. This will be the location of the bottom of the strongback. Pencil in the strongback on the platform. Extend its length past where you think the frame will pass. I've made the strongbacks 6" high so far. From this point the process is similar to the full frame process. I will go through the same steps previously described for full frames, describing only how the process differs for strongback frames.

1. Layout the plank side frame shape:

Same as for full frames.

2. Layout the ceiling side frame shape:

Same as for full frames except that fairing the bottom foot or so of this curve is done differently. Recall that for the full frames, the bottom of the ceiling side was faired into a point 6" above the top of the keel. For strongback frames, the desired amount of mating surface between the frame end and the deadwood determines how high the ceiling side curve will come into the deadwood. There should be enough mating surface for adequate fastening. You want enough room for at least two trunnels and one through-bolt.. Once you have determined how much mating surface you need, mark that height on the platform and "fair" the last foot or so of the ceiling side into that height. This will be done on a frame-by frame basis. At station 2 (frame number 4), a beefier solution may be needed in order to take the sideways stresses from the foremast, which will be stepped in line with this frame.

2a. Adjust the ceiling side shape to provide for the extra width needed for the bevels:

Same as for full frames, except the bevel will continue all the way to the deadwood (For the full frames, the bevel tapered off to zero degrees across the keel.)

3. Layout futtoch joint locations:

Same as for full frames, except that there will always be one joint located in the outer face futtochs where the strongback joins the frame. This will be the lowest joint on the outer face.

4. Make the futtoch patterns: Same as for full frames.

5. Mark and cut the futtoch boards: Same as for full frames.

6. Assemble the rough cut futtochs:

Same as for full frames, except the joint where the strongback will eventually be located does not have to be a tight fit. Just make it close enough so that drawing the frame shape and cutting on the band saw along the frame shape line will not be difficult due to excess gap. Keep trunnels away from the area where the strongback will be located. Also, there's no need to waste bedding compound in this area.

7. Attach cross-spall and braces:

Same as for full frames, except make sure the lower ends of the diagonal braces are well clear of the strongback location. For now, a temporary 2x4 brace will be placed within the footprint of the future strongback to hold the port and stbd sides together. Fasten it with three or four 2" #14 wood screws in each end. Mark the CL on this temporary brace.

Also, in addition to marking the highest 2 Wls, mark the rest of the waterlines as well, since it is difficult to establish the C/L on strongback frames in the next step. While you're at it, mark the B/L and keel side. If the B/L is not possible, mark the keel top.

8. Wedge and trim trunnels and mark the plank side frame shape on the inner face:

Same as for full frames except: There are no floor timber bolts and trunnels to deal with; and The process for locating the frame template is different. Since the C/L is hard to establish at the bottom, use W/L heights, B/L height and keel side to locate the template.

9. Disassemble the frame and cut the bevel angles: Same as for full frames.

10. Reassemble for final marking of frame-to-deadwood joint:

Reassemble the frame inner face down without the spacer blocks. Reverse the cross-spall bolts so the head is recessed in the counterbore on the inner face. Using grid marks on the plank side, CLs and baseline/deck heights, accurately position frame on platform drawing. Correct any plank side grid marks as necessary and transfer all grid lines from the platform to the ceiling side. Mark the cut lines for the frame-to-deadwood joint. (Note: Check the actual deadwood width, check the sides of the deadwood for plumb and check for vertical alignment over the boat C/L as marked on the floor, using a plumb bob or level. You may have to adjust the joint cut line to address any variations in the deadwood from its nominal dimensions, vertical alignment and location with respect to the boat's C/L.) Recheck CL marks.

11. Disassemble and cut frame-to-deadwood joint:

Disassemble the frame and turn inner face up. Draw the frame-to-deadwood cut line on the inner face by joining the marks on the plank and ceiling sides with a straightedge. Cut the frame-to-deadwood joint on the bandsaw. Leave the line. Finish the joint to the cut lines and square it up with a block plane.

12. Cut notch in deadwood for strongback. Reassemble the frame. Cut notch in frame for strongback and fasten it:

Check the notch layout previously drawn on the deadwood for receiving the strongback. If the location is satisfactory, cut the notch in the deadwood using a backsaw and chisel. Remeasure the height of the bottom of the notch and check that measurement with the height of the strongback drawing on the platform. Correct the strongback drawing if necessary. Reassemble the frame inner face down with no spacer blocks. Position the frame accurately over the platform drawing, checking all grid lines, heights, CLs and the frame-to-deadwood joint. Securely clamp the frame. Mill the strongback to futtoch thickness, 6" in height and leave extra length to extend past the frame sides. Square up the position of the bottom of the strongback from the platform drawing to the outer face and draw the strongback bottom on the outer face, port and stbd. Make a cut inside this line with the circular saw set just deep enough to cut through the outer face futtoch. Place the strongback bottom on this cut line to mark the cut line for the top of the strongback on the outer face. Cut inside this line and remove the portion of the outer face futtoch just cut free. Fit the strongback into the notch with extra length extending beyond the frame plank sides. Mark the end cuts, including the required bevel. Take the strongback to the bandsaw and cut the end bevels, leaving about an eighth inch extra on each end. Before final fastening the strongback, check the frame-to-deadwood joint to make sure that it hasn't opened or closed while cutting the notch. Apply bedding compound to all mating surfaces and fasten the strongback with two 4" #18 wood screws in each end. Finish cutting the end bevels flush with the plank side using a chisel and spokeshave. Before unclamping the frame from the platform, mark the CL on the strongback. Mark the grid lines in sharpie by joining the marks on plank and ceiling sides with a

straightedge. Recheck the frame-to-deadwood joint.

13. Cut limbers, weigh and raise into position for test fit: Same as for full frames.

14. Bed, plumb, level, brace and coat with linseed oil/turpentine:

Same as for full frames except a trunnel will be added in each end of the strongback to supplement the wood screws after the frame is braced in position. A drift bolt will eventually be driven vertically down through the strongback into the deadwood. (Adding this drift bolt will be put off as long as possible, in case the frame leveling or plumbing has to be tweaked later.) Four trunnels (2 port, 2 starboard) will be driven near the bottom of the frame into the deadwood.

FRAME UP!