

Galilee Boat Model



Dick Webber

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Dick Webber, 2009

I was fortunate to visit Galilee in 1995 and 1996 and see the recovered and preserved remains of a boat, found to be 2,000 years old, located on the northwest shore of the Sea of Galilee near the Kibbutz Ginosar.

The investigation and restoration of this ancient boat was conducted by Dr. Shelley Wachsmann¹, the Meadows Professor of Biblical Archaeology in the Nautical Archaeology Program at Texas A&M University.

My goal was to build a “scratch-built” model as the boat might have been when originally built, following the descriptions in Dr. Wachsmann’s book, *The Sea of Galilee Boat*², published by the Texas A&M University Press in 2009. This is an historically significant boat, especially for those of Christian and Jewish faith (see ⁴Flavius Josephus and the ⁵*New Testament*). It is the type believed to have been in common use on the Sea of Galilee between 100 BC and 70 AD. Professors Steffy³ and Wachsmann believe the hull form is representative of the many (hundreds) fishing⁹ boats in use during this era on the Sea of Galilee.

Following the boat’s restoration, Dr. J. Richard Steffy,³ also of the Nautical Archaeology Program at Texas A&M University, drew detailed specifications of the boat. Converting Dr. Steffy’s dimensions, a 1:10 scale model has the following approximate measurements:

	<u>Metric</u>	<u>U.S.</u>
Length:	77.70 cm	30.6 inches
Width:	22.90 cm	9 inches
Height:	12.50 cm	4.92 inches
Planks:	.35 cm	.1365 inches thick, with an average width of .468 inches
Keel:	.94 cm	.37 inches wide, narrowing to .312 at bow and stern
	1.14 cm	.4485 inches high, narrowing to .312 at forward tip
Frames:	.59 cm	.234 average inches wide
	.69 cm	.273 average inches tall

A dial caliper was used to measure the parts (the finished parts are nominal dimensions, since wood isn’t easily cut to the thousands of an inch). I deviated from the original construction method by building the frames in one piece instead of half-frames, and attached the frames to the keel first, then attached the planks (strakes) instead of planks first, as the original was built. I added 8 frames to the 9 shown on Dr. Steffy’s drawing (see page 14), for a total of seventeen.

This article is intended to provide help for others to build a similar model, and to use personally as a model when describing New Testament scriptures relating to Sea of Galilee events and stories. Included are the scaled drawings of Dr. Steffy.³ In 1990 Texas A&M graduate student, William H. Charlton, Jr., was commissioned to build a 1:10 scale model to Dr. Steffy’s specifications. Charlton’s article was published by the *Seaways’ Ships in Scale*⁷³ magazine in its January/February, 1993 publication. The model is in the Kibbutz Ginosar Museum at the northwest side of the Sea of Galilee.

A pantograph was used to convert the drawings in Dr. Wachsmann's¹ book to the full scale size for the model (see page 14). With a stock of white oak for the keel and frames, and Eastern Red cedar for the planks, away we go.

Making the keel:

The keel is the first step. Resaw 4/4 white oak to a slightly thicker width than needed, and use a thickness planer to bring it to .37 inches. The shape of the keel is traced on the wood and bandsawed to a height a little more than .4485, then I used a four inch sanding wheel on the drill press to smooth and sand to the correct height.

From the same .37 inch oak stock the stem and sternposts were cut so that the grain ran vertically, and were attached by a scarfed glue joint. Through that joint I drilled a hole using a #26 drill and inserted a cane skewer⁸ that was .145 inches in diameter (similar to the method of treenails used in the original). The original boat probably used a mortise and tenon or hooked scarf joint to fasten to the keel.



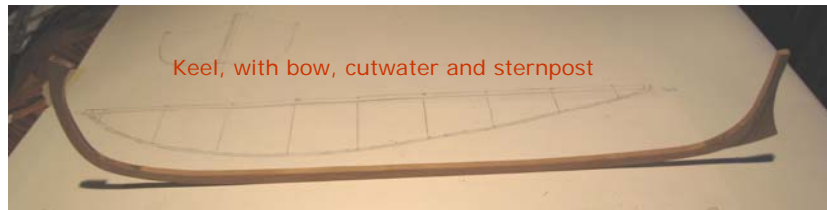
Skewer inserted



Drill #26 hole in keel scarf

Cut and fasten the cutwater prow to the bow stem. In the original boat it is thought the cutwater was attached with a tenon on the end of the keel. I elected to use the skewer method.

After gluing the cutwater to the bow stem post, I drilled two holes through the bow stem into the cutwater and pinned with skewers.



Keel, with bow, cutwater and sternpost

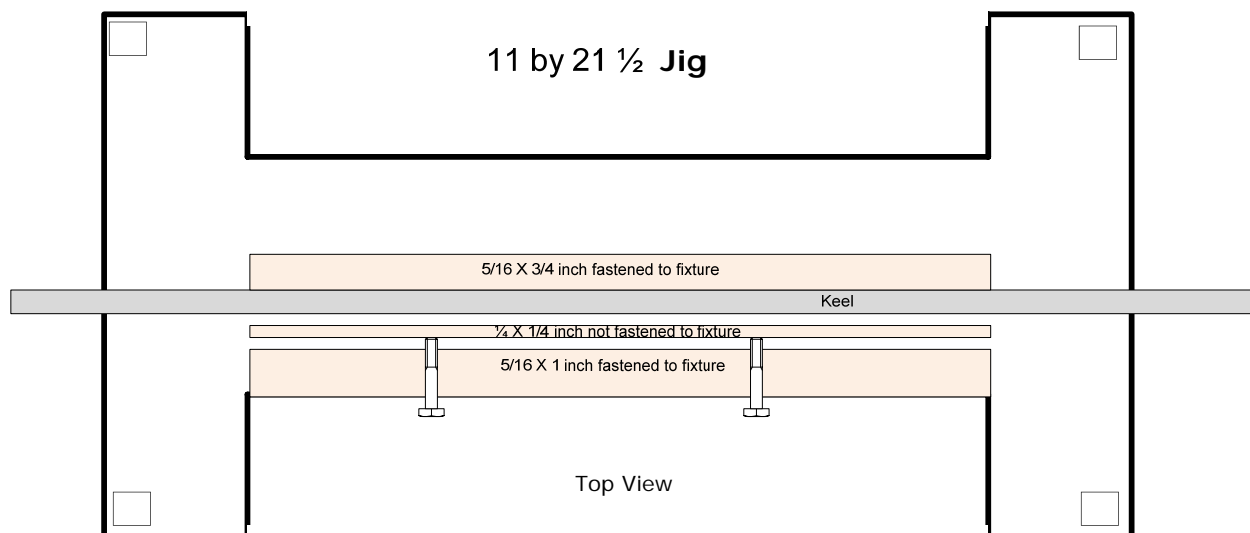
Frame shapes and material:

The material for the frames was resawn from white oak and planed to a thickness of .234 inches. The patterns for the frames were copied from Dr. Wachsmann's¹ book by placing the frame plan in a copier and enlarging to a width of 8 3/4 inches (9 inches minus 1/8 X 2). Each frame was drawn on paper, traced on the .236 thick oak, and the outside shape bandsawed. Do not bandsaw the interior of the frame at this time. Save the paper patterns in case frames must be remade or repaired.

To attach the frames to the keel a jig was constructed of 3/4 inch MDF (see page 5). A 5/16 inch thick wood strip was screwed to it lengthwise in the center of the base, and a 3/4 inch strip was screwed to the base. A pair of bolts were inserted to press another piece against the keel, in its upright position. The middle of the base was bandsawed to a narrower width to give better access to the hull when finishing.

Construction Jig:

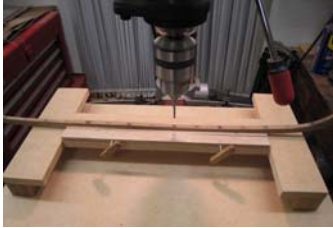
A jig is helpful to securely hold the boat when working on both planks (hull upside down) and frames (hull right side up). Cut a 3/4 inch piece of MDF board 21 1/2 inches long and 11 inches wide. 3 inches of each end was left 11 inches wide and the narrow the waist to 5 inches. To this a 5/16 inch high by 1 inch wide strip was glued and screwed lengthwise to the board, even with the inside edge of the waist. Into this piece insert two 2 #8, 32 tpi bolts, 1 inch long horizontally about 8 inches apart. An easy way to do this is to use a #29 drill and thread with an 8-32 tap so that the wood is threaded. Another piece of hardwood 5/16 inch by 1/4 inch was cut but not fastened to the board. Wooden handles can be made to fasten to bolt heads for easy adjustment against the keel. Another piece 5/16 inches thick and 3/4 inches wide was glued and screwed to the MDF board lengthwise. This third piece is located in such a way that as the bolts are tightened, the unsecured piece is pressed against the keel of the boat to hold it securely. With the keel fastened to the board it is in position to fasten the frames to the keel.



Frames Construction:

Enlarge the frames drawing on page 14 to the scale of the model. This should make the boat 9 inches wide at its widest, including plank thicknesses. Make a pattern of each frame, being careful to match the height, width and shape. Trace the pattern on the .234 inch thick oak stock, and cut the outside shape of each frame. I cut the frames with the grain horizontal, and that was a mistake. Cut the frames so the grain runs vertical for the sides of the frames. In addition to the 9 frames shown on the drawing, I added additional frames between each one shown, for a total of 17. Draw the vertical centerline of each frame. Scribe a line slightly more than .234 inches in from the outside of each frame, which will be the cut line to remove the unused center, but don't make the cut yet. When you stack the frames in order you will see the compressed shape of the hull.





Keel held in jig to drill holes for frames

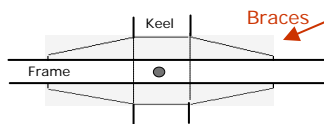
A #26 drill was used to drill holes on the centerline of the keel at the location of each frame, and in each frame to dowel to the keel. Drill the center of the bottom of each frame to a depth slightly more than the width the finished frame will be.

Each frame is placed in the drill press vice bottom-side up. The frames are .234 inches wide and the drill bit is .1285 in diameter, so the frames on either side of the drilled hole need to be braced. Extend the braces to fit over the cross grain portion of each frame. Glue braces on only one side of the frame at this time, so there will be a flat surface when band-sawing the interior.

A machinist's centering drill more accurately locates each hole. It is important that the top of the frame be perfectly level and the centerline vertical in the drill press vice so the hole will be vertical to the axis of the keel.

Temporarily fasten each frame to the keel with cane skewers to check the horizontal and vertical alignment of the frames. Make any final adjustments needed to the frames.

Shape the outside edges of each frame to conform the vertical sides to the linear shape of the hull. The contour below the bilge line can be different than at the vertical edges.



When satisfied the frames are aligned, bandsaw each frame to a width of .234 inches. Glue braces on the other side of

each frame as shown to strengthen the cross grain. These braces can be as thin as 1/32 inch thick.

When all frames are cut, drilled and shaped, fasten each to the keel with skewers in their proper location, and glue.



With the frames in place, the stem and sternposts were strengthened with oak braces between the two end frames and the stem and sternposts. Cut to the contour of each, extending from the bottom of the end frames up to the bottom of the future caprails (gunnels). The sternpost brace was shaped to the horizontal contour to better fasten planks. Variable speed rotary tools (like Foredom and Dremel) or a belt sander are helpful for shaping.



Construction jig holding keel and uncut frames



Mark the .234 inch width to cut frames



Cut frames doweled in place to keel

Fastening planks (strakes) to the frames:

After the frames are attached to the keel, to prevent the frames from becoming distorted during planking, I used masking tape to fasten the portion cut from the interior of each frame back in place. To hold the frames in alignment during planking, cut a 1/8 inch thick piece of plexiglass (plywood will work) in the shape of the top of the boat (top view) and use heavy duty double-sided wood turner's sticky tape along the top edge of the frame to adhere the plexiglass to the top of the frames. Be sure each frame is centered.

With the plexiglass attached, place the keel and frames upside down on the jig, with the bow and stern ends overhanging the length of the jig. The four feet 1 1/2 inches tall elevate the board to keep the overhanging bow and stern from touching the work table on which the jig rests.

Plane 36 inch long cedar planking material to .1365 inches thick. Cut in strips approximately 1/2 inches wide, but only cut pairs for each side of the keel as they are installed. Some planks will need to be less than 1/2 inches wide around the curve of the bilges.

After steaming and bending to the shape of the keel and frames, attach the first two planks (garboards) on either side of the keel. Bend each pair of subsequent planks to fit against the previous plank and to the frames. Where needed, bevel the edge of each plank to form a solid edge-to-edge joint with the previous plank.

After each plank has been clamped and dried, glue⁷ the edge next to the previous plank and to each frame. Take special care to follow the curve at the sternposts when shaping the ends of the planks.



Stern view of garboards

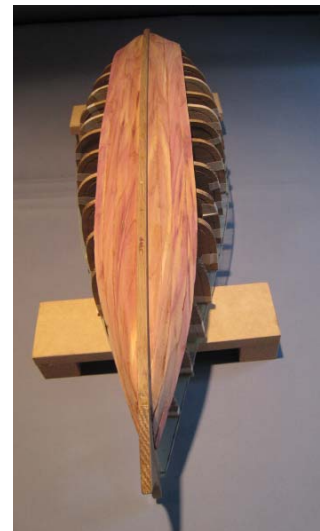


Bow view of garboards

Clamp planks in place and dry overnight before gluing.

To fit the first two planks on either side of the keel, the planks are beveled on the outside ends so there is contact with the frames for the whole width of the plank.

There are different views about how planks should be installed. See Model boat builders' discussion website, www.drydockmodels.com.



First ten planks in place



Finding suitable clamps⁶ for bending and gluing planks to frames can be a problem. Useful clamps for the purpose are six inch quick bar clamps (far right), two and four inch C clamps (below), and two and six inch spring clamps (left). The small C clamps are especially helpful to force the plank edges in alignment. The quick bar clamps work well to pull the planks together. The spring clamps can help hold the stern and stem plank ends.

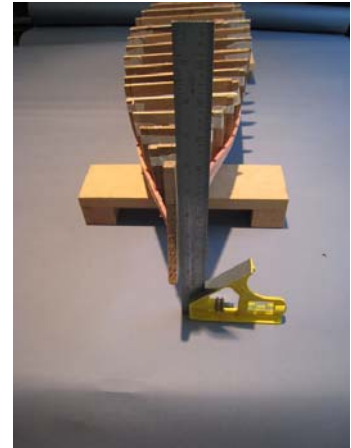


One plank at a time is trimmed, steamed and glued. It takes about one day for each plank, as drying time is needed after each plank is steamed and clamped in place, before it is glued. Moisture content should be 15% or less before gluing.

Measure the circumference from the keel to the top of the frames at the stern, bow and amidship. The distance at the stern and bow is less than the distance amidship. To compensate, thin the width of the planks toward the stern and bow. Monitor the distances as planks are added in order to make adjustments. As the planks get closer to the gunnels, it looks better that they be as uniform in size as possible from stem to stern. Use wood scraps between the clamps and the material to prevent clamp marks and staining.

Note: the ancient strakes were hewn from solid timbers to curvature instead of bending.

As planking continues, check the stern and stemposts to be sure they are vertically in line. This can be done by attaching a square (can be fastened to the work table), against the end posts (photo at right). The stress of bending planks can warp the keel. If out of line, clamp the squares to each endpost as later planks are glued in place. Adding planks port, then starboard, with endposts held in clamps, tends to balance the stresses by the time you reach the gunnels. The final plank should be level with the frame tops.

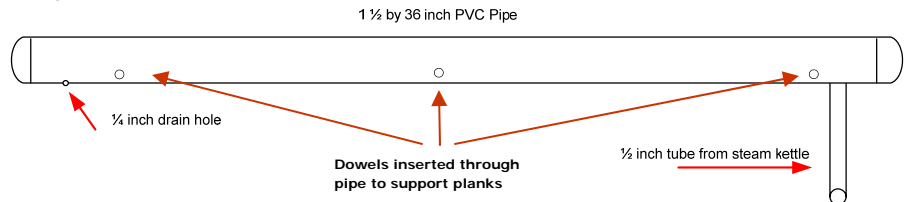


Check for keel warp

Steam planks:

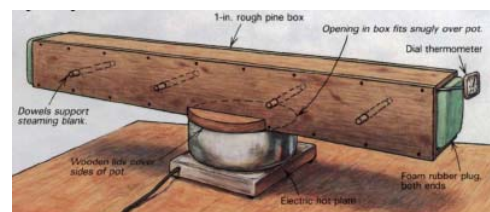
An easy to make and inexpensive steam box can be made from a 1 1/2 inch PVC pipe 36 inches long. Cement a cap to one end. The removable cap in the other end is used to insert pieces to be steamed. Cement a 1/2 inch plastic tube (or a size tube to fit your teapot spout) into a hole in the bottom of the pipe to insert steam. Drill a 1/4 inch hole in the bottom at the opposite end to exhaust water and steam. A 48 ounce teapot with a spout and an electric hotplate produce the steam. The steam from the pouring spout should be directed into the steam tube with as little leakage as possible. Seal any leaks. Drill holes and insert rods across the tube to hold planks. 30 to 45 minutes of steaming should be sufficient. A wood steam box may be superior, but is a little more expensive and work to make.

At right and below: a steam box made of a 1 1/2 by 36 inch PVC pipe and tubing. Trestle stand knocks down for easy storage.



Trestle stand holding steam tube

At left, teapot on hotplate produces the steam for bending using a PVC pipe for the steam box. At right is a wood steam box over a teapot and hotplate.



Caprails (gunnels/gunwales):

When all planks are complete, cut cedar or oak caprails to install on the tops of the frames and the planks. Lay the hull upside down and trace around the outside of the hull. This pattern can be used to cut caprails from the oak stock used for the frames, or from the cedar planking material. Cut the rails wide enough to cover from inboard the top of the frames to about 1/8 inch outside the planks. Allow enough length so the ends of rails fit partially around the stem and sternposts.

Where the port and starboard caprails meet at the stern and stem, cut a v-shaped piece approximately 1 inch long that joins the two sides of the rails. Cut a concave curve on the inside edge, and glue in place.



Inside rails:

Glue rails to the frames on the inside of the hull the length of the hull, approximately 1 1/4 inch below the gunnels. Cut these from the oak frame or cedar plank material and cut approximately 1/4 inch wide. Glue the thwart to which the mast is secured on top of these rails. Cut a half-circle in the aft edge of the thwart the diameter of the mast. Insert the mast into the mast step on the keel. Make a half-round bracket to clamp the mast to the thwart. Locate the thwart to rake the mast approximately one degree toward the stern.

Photo at right shows hull with mast step, caprails, decks, rails and removable ceilings (floorboards).



Sail, Rigging, Decks and Ceiling:

The excavation of the boat did not reveal the sizes or types of mast, sail and rigging. Professors Steffy and Wachsmann relied on their knowledge of other ancient boats of the period to conclude it was a brailed rig sail, square or rectangular in shape. Evidence of a single mast step was found slightly forward of amidship, fastened to the keel. The boat accommodated four oarsmen and a helmsman who used quarter rudders for steering. They believe there were decks at the bow and stern that together covered about 40% of the length of the boat. No mention is made of the elevation of the decks. Ceilings of planks served as footboards, lying on top of the frames.

Each model builder can determine these details. I tried to follow the photos of the model made by William Charlton in 1990, who worked at the direction of Professors Steffy and Wachsmann. Following are my estimates for these details.

Mast and yardarm: A mast was turned 24 1/2 inches high, with a diameter of .575 inches at the foot, tapered to .525 inches at the top. 1/2 inch below the top of the mast I cut a 1/8 inch wide by 5/8 inch tall through mortise, and a pulley 1/2 inch in diameter to fit inside the mortise. The pulley turns on a brad for a shaft. This receives the halyard to raise and lower the yard. A cleat at the foot of the mast ties off the halyard.

I turned the center portion of the yard .45 inches in diameter, tapered toward the ends, and 18 inches wide.



Pulley in Mast

Rigging: Dr. Wachsmann writes: "The single square sail was carried from a mast, which was stepped into the small mast step - little more than a chock. The mast was supported longitudinally by fore and aft stays and perhaps also by shrouds. The yard was raised and lowered by means of one or two halyards and was controlled by a pair or braces attached to the extremities of the yards. The crew spread and took in the sail by working the brails. These lines¹¹ were attached to the foot of the sail and then rose vertically, perhaps through wooden rings sewn to the fore side of the sail."

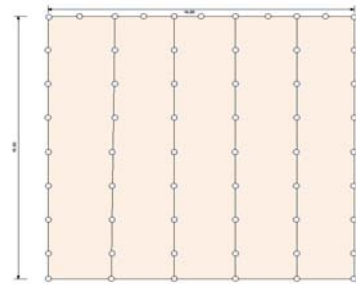
There are many choices for rigging lines. I chose EB Everbilt twisted Mason line⁸, of mixed fibers of nylon, polyester & polypropylene #18 (.05 inches).

Rigging the sail with the yard and brailles is mostly guesswork, as details are not found about how this might have been accomplished.

Sail: A loose-footed sail—a brailled rig. Some estimate modern sail widths of twice that of the hull. I scaled this down to 16 inches of width, and a height of 15 1/2 inches.



The sail was made from one piece of fabric, with flat felled seams to simulate five vertical panels. Small (5.6mm) closed rings were sewn every 2 inches down the outside edges and the flat seams for six braille lines. Through these thread the braille lines, and tie each line to the foot of the sail.



Sail Plan

Additional rings were sewn at the top to lash to the yard. Lines are attached to the yard-arms and to the outside edges of the foot of the sail. Make four posts to fasten to the carrails near the stern to secure the braille and yardarm lines.

Some possible methods to operate the brailles:



1. Allow the braille lines to pass over the top of the yard.

2. Make rollers fastened to the yard, one for each braille. Run the braille lines over the rollers and

down to posts near the stern (I chose this method).



Decks: The aft deck would have been the largest, as it held the heavy nets used for fishing. I made the aft deck 8 inches long and the forward deck 7 1/2 inches long. Decks were made of cedar strips (using the plank material). Glue supporting strips inside the length of the boat to frames on port and starboard sides at an elevation 1 1/4 inch below the gunnels. Glue cross-braces between these supporting strips to support the decking.

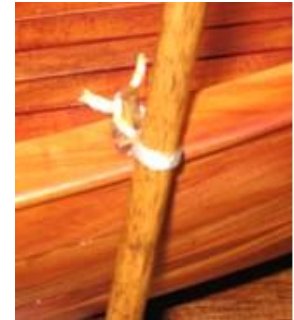


Removable Ceilings

Ceilings:

Glue cedar planks to oak or cedar cross-strips (like the decking), shaped to lie loosely and flat over the frames. These can be made in sections on either side of the mast.

Oars: Four oars, two on each side. Oars and rudder were turned on a lathe to be 10 inches long and .35 inches in diameter, and the blades shaped by carving and sanding. Oars are lashed to thole pins on the gunnels. See *Oars*: Shaw & Tenney¹⁶.

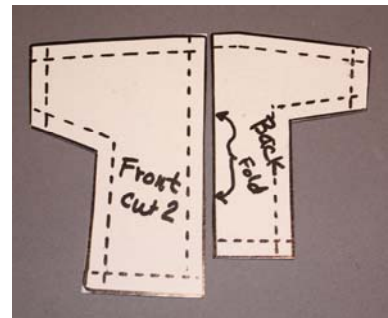


Thole Pins

Steering: Quarter rudders on each side of the boat were used to steer. Constructed like the oars, with handles approximately .4 inches



Figures: The average man between the Hellenistic and Byzantine period was estimated to be 5' 5" tall¹⁰. A simple tunic was the customary garment. Wood figures 14 cm. high for the men that match the scale of the boat were found at Hobby Lobby stores⁸ and at



www.MadisonArtShop.com¹².

The figures were painted, and the fuzz from a dog's toy was cut and glued, then painted for the hair of each figure.

Tunics for the figures were made of greige colored linen/cotton¹⁵. Tunics of the period would have been made of either linen or wool (from sheep or camels).

Instructions to make tunics:

Cut out the pattern to cut fabric. Serge the front edge of 2 front pieces, and press under the edge. Sew down with decorative stitch, and sew front to back at shoulder. Iron the seam open and then to the back. Top stitch with decorative stitch. Turn under the sleeve edge and stitch with decorative stitch right sides together. Sew side seam from sleeves opening to bottom of hem. Iron seam open. Turn out the hem bottom edge. Make sash.

Display Stand:

I chose to make a cradle-like oval base of mahogany, 20 inches long and 10 inches wide, and routed an ogee edge. Two vertical supports 6 inches wide, 1 1/2 inch tall, and 9 inches apart are shaped to the contour of the hull and keel, and mortised into the base. Felt strips were glued over the top of the supports.



Finishing:

When all planks are in place, trim any uneven edges. Using the flat side of a sharp chisel, trim exposed edges in the direction of the rising grain. Initial sanding can be done with 80 grit, finishing with about 180 to 220 grit.

If there are gaps between planks, they can be filled with slivers of cedar trimmed to glue in the gaps. Very small gaps can be filled by inserting glue and filling with sawdust, or by using color-matched filler, such as Elmer's Carpenters Wood Filler. Color-matched filler can be made by mixing filler with sawdust from the planking material (test on scrap before applying to the hull). Apply one coat of finish before making repairs.

Tung oil is my choice for the finish. It permeates (polymerizes) the wood and dries to a permanent and water-resistant finish that acquires a fine patina with time. The first two coats can be brushed on and dried overnight. After a light sanding, subsequent coats can be applied and wiped with a soft rag before becoming tacky. Allow each coat to dry overnight. Three to four coats provide a durable finish. Add more coats if desired. This finish is a good choice for all exterior and interior parts.

Apply finish to the interior of the hull before installing the two decks. Most of the area under the decks will be unseen, but the finish is good protection.

When finishing the outside of the hull is complete, you may want to insert nails to simulate the iron nails used to fasten planks to frames in the original boat. 3/8 inch long by .026 inch diameter brass nails are available from Micro-Mark¹¹. Stick them in a sheet of polyurethane foam and spray-paint the heads black, then use a push hammer¹¹ to insert nails where planks join frames. Nail heads can be chemically darkened with gun blue. If you have trouble inserting the nails, drill holes with a mini drill bit¹⁴ size #72 (.025 inch). If wanting a uniform look, space nails the same distance apart.

Bibliography:

- ¹Dr. Shelley Wachsmann, Meadows Professor of Biblical Archaeology, Nautical Archaeology Program, Texas A&M University.
- ²*The Sea of Galilee Boat*, Dr. Shelley Wachsmann, Texas A&M University Press, 2009
- ³Scale drawings and details by Dr. J. Richard Steffy, 1924-2007, Nautical Archaeology Program, Texas A&M University.
- ⁴Flavius Josephus, *Wars of the Jews* (c. 94), *The Life of Flavius Josephus*
- ⁵*New Testament*, Biblical references in the Gospels to events on the Sea of Galilee. There are fifty references in the *NT* about activities regarding the Sea of Galilee.
- ¹⁰Page 317, *The Sea of Galilee Boat*²

Sources:

- ⁶Woodcraft, Sears, Lowes, Home Depot and other hardware stores.
- ⁷Glue choices are many. Titebond II or III are versatile and work well. If you might place the model in water, use Titebond III.
- ⁸Hobby Lobby Stores. Cane skewer-type dowels come in all sizes. Measure before buying.
- ⁹Galillean Fishing Economy and the Jesus Tradition, by K. C. Hanson, <http://www.kchanson.com/articles/fishing.html>
- ¹⁰Page 317, *The Sea of Galilee Boat*².
- ¹¹Micro-Mark The Small Tool Specialists — Push Hammer for nails and Brass nails 3/8 inches long by .026 inches in diameter.
- ¹²Madison Art Shop www.MadisonArtShop.com
- ¹³*Seaways' Ships in Scale* (Seaways Publishing, Inc., PO Box 525, Niwot, CO 80544-0525), mailto: orders@seaways.com
- ¹⁴Sloans Wood Shop, Lebanon, Tennessee. www.sloanswoodshop.com. 888-615-9663 for #72 .025 drill bits. If needed, they also have a pin chuck for mini bits.
- ¹⁵Jewelry Supply.com at www.jewelrystore.com

Additional reading:

- ⁹Galillean Fishing Economy and the Jesus Tradition, by K. C. Hanson, <http://www.kchanson.com/articles/fishing.html>
- Fishing at the Time of Jesus, by Dr. Elizabeth McNamer, mcnamere@rocky.edu
<http://www.americancatholic.org/Newsletters/SFS/an0704.asp>
- ¹⁵Making a simple tunic—<http://www.riverbendcombat.com/tunic.html>
- ¹⁶Oars: Shaw & Tenney, <http://www.shawandtenney.com/wooden-rowing-oars.htm>
- ¹⁷Steering Oars: The Case for the Steering Oar by Gary Dierking
http://www.proafile.com/view/weblog/comments/the_case_for_the_steering_oar/
- Ancient Harbors of the Sea of Galilee, by Gordon Franz,
<http://ldolphin.org/ancientharbors.html>
- Model boat builders' discussion website, www.drydockmodels.com

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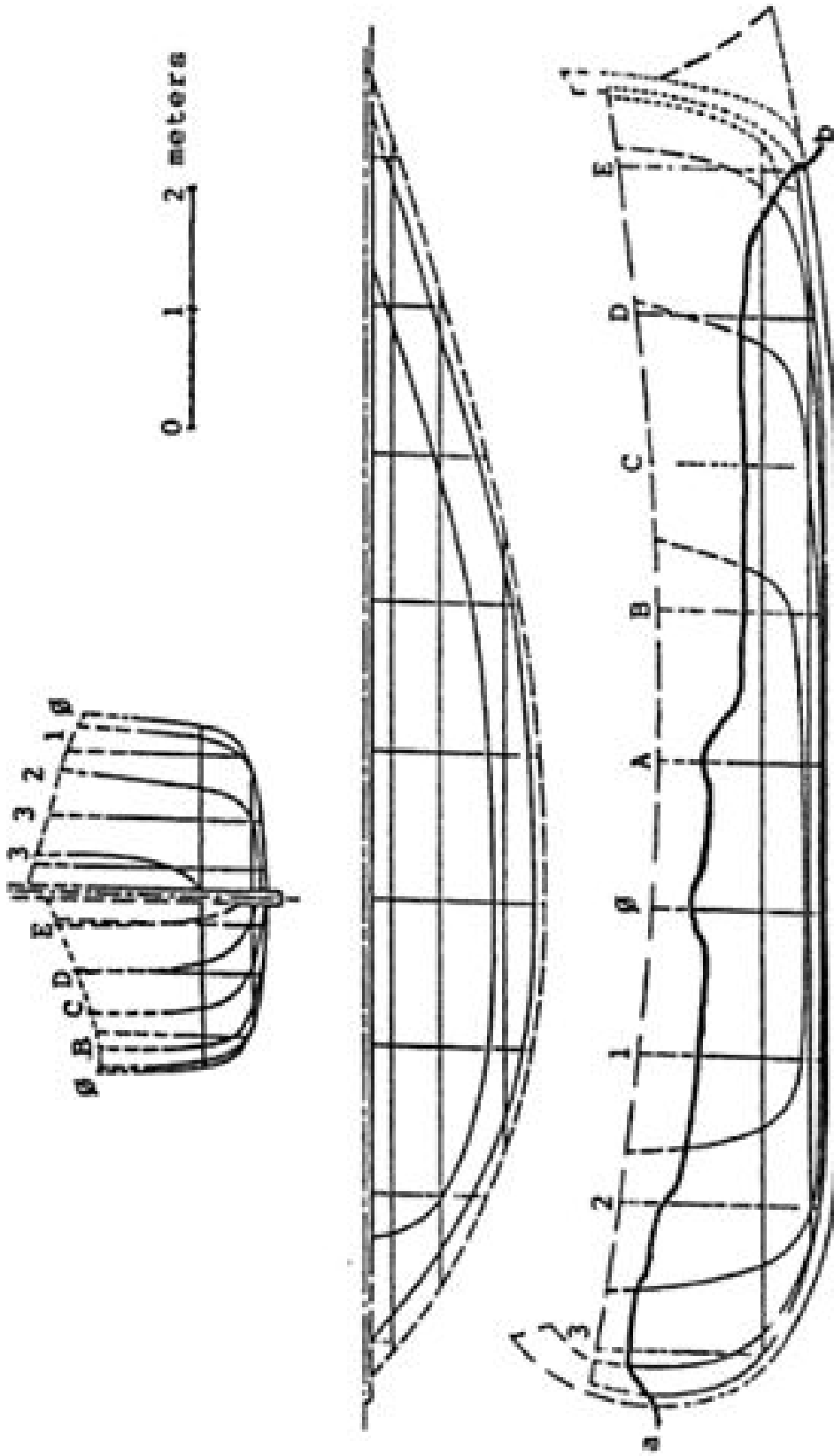


Figure 7 The Kinneret Boat. Total length: 8m (26 feet), maximum breadth: 2.5m (8 feet), depth: 1.25m (4 feet). The party recovered is under line a-b.

Acknowledgement: *Notes on the construction of the Kinneret boat*

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