# Build a Bent-Plywood Kayak

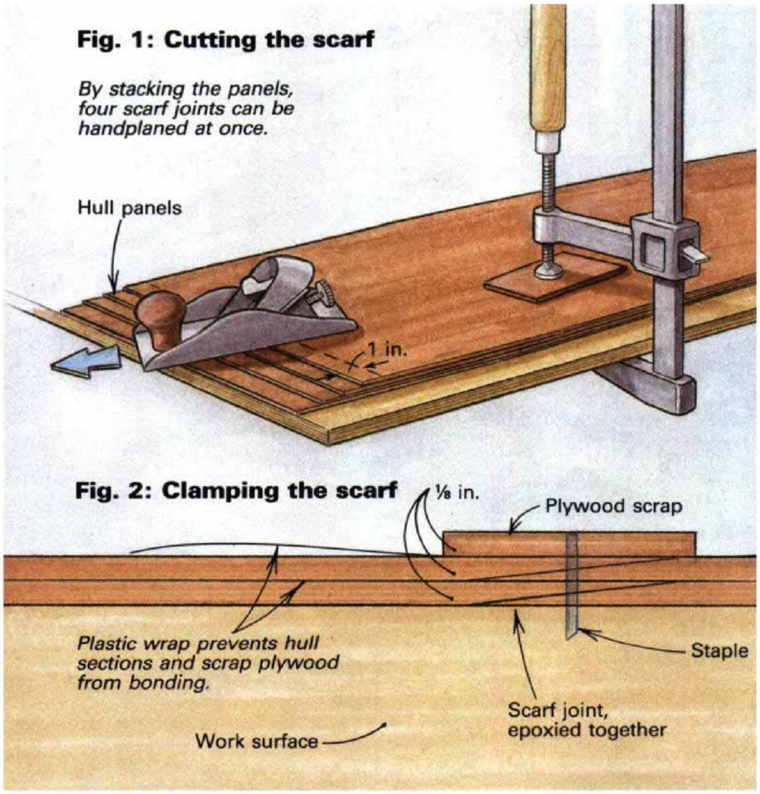
*Stitch-and-tape construction can put you on the water in less than a fortnight*

by Chris Kulczycki

Building a boat is something many woodworkers have thought about but often dismiss. It takes too much time, money and specialized skills to build a boat, right? Not necessarily. With the technique I describe, you'll be able to build the sleek, handsome kayak shown above for less than $200, in less than two weeks and with little more than a jigsaw, block plane, hand drill and a pair of pliers.

In the early 1960s, a technique known variously as compounded plywood, stressed plywood, developed plywood, and, most descriptively, tortured plywood was developed for building multi-hull sailboats. Soon thereafter, an Englishman named Dennis Davis developed several kayaks using this method; all of today's compounded-plywood kayak designs are based on Davis' early work.

Compounded-plywood construction consists of taking a two-dimensional sheet and forming it into a three-dimensional shape with compound curves by bending it in two planes simultaneously. On my boat, this is done by stitching together pieces of thin plywood to form halves of the hull. Wood screws, staples and copper wire ties are all used to hold pieces in place while epoxied joints cure. As the piece is stitched up along the keel line (see the glossary on p. 71 for




definitions of this and other boatbuilding terms), the plywood begins to rise off the work surface, forming a compound curve. A form or frames can be used to help develop the final shape or, as in this kayak, the plywood simply can be held in shape by the deck and deck beams. This type of hull, in which the skin is the primary stressed member, is called a monocoque structure. It results in a rigid, very light boat (about 25 lbs. for this model). This kayak is designed for use on ponds, lakes and slow-moving rivers and streams. As light as it is, it's quite fast on the water. It's also easy to transport, load and unload and can be stored by hanging it from the garage or shop rafters.

## Materials: Marine plywood and expoxy resin

Plywood can be bent nearly to its breaking point when building compounded-plywood boats, so it must be of very high quality. Plywood containing voids will not bend evenly and could very possibly crack at the void. The best marine plywoods are from European manufacturers, such as Bruynzeel, Lydney and Shelman; they are expensive—as much as $60 for a 3mm sheet—but their quality is remarkable and you only need two sheets for this kayak. I buy my plywood from Harbor Sails, 1401 Russell St., Baltimore, Md. 21230 (they ship throughout the country). Marine plywood is also available at many large commercial lumberyards.

The thickness of the plywood used is important in creating the desired hull shape. If it's too thin, it will not bend into a smooth curve; if it's too thick, it will break before reaching the intended shape. Generally, the thickest plywood that can be bent to shape produces the best results. I prefer okoumé (a type of mahogany) marine plywood because it's light, easy to work, bends smoothly and takes epoxy well. For this kayak, 3mm okoumé marine plywood is ideal, but, if you can't justify the expense, 3rnm okoumé bending panels (an exterior-grade panel) will work nearly as well. Bending panels are virtually indistinguishable from marine plywood and cost between a third and a half as much. The sheer clamps, deck beams and carlins are made from clear straight-grain spruce or fir.

Epoxy-resin adhesive makes the construction of this boat possible. It is used in several capacities here. Unthickened it's used to bond fiberglass tape (along the exterior seam of the hull) and as a strengthening and waterproofing agent in a process known as epoxy saturation. This process involves coating the hull with the epoxy resin, usually both inside and out, rendering the boat absolutely watertight. This prevents rot and delamination and adds strength to the hull by filling the grain that's opened from the plywood's being contorted into shape. The epoxy also soaks deep into porous woods—such as okoumé—leaving a tough, protective exterior skin and a smooth base for a varnish finish.

The expoxy resin is thickened with chopped cotton or silica fibers to slow the epoxy's flow and to increase its strength when used as an adhesive or a gap filler. I prefer the cotton fibers, so that's what I've used on this boat. You should be able to find epoxy and epoxy thickeners at marine-supply stores. About 2 quarts are needed for this boat.

## Making the hull panels

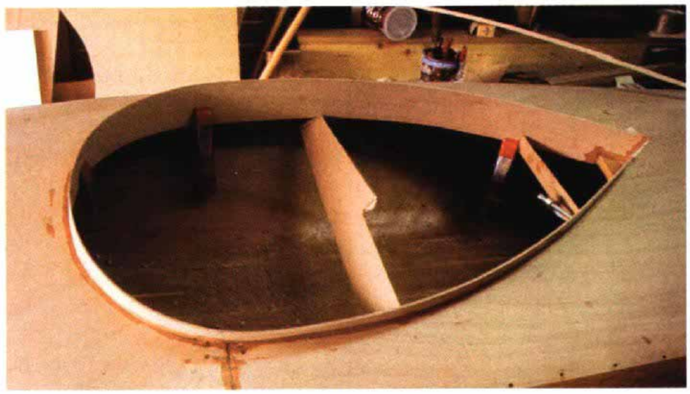
I cut the hull panels in pairs to ensure that they're identical, so the hull will be symmetrical. I lay out the panels on half of the plywood sheet; then, holding a wooden batten against brads driven at the measurement points (see the hull-panel layout on p. 71), I draw the curved lines. Next, I cut the sheet in half lengthwise, stack the halves and cut out the hull panels together. I always cut the panels a bit proud and trim to the layout lines with a block plane.

Bow and stern panels are joined with an 8:1 scarf to make the two full-length hull panels. With 3mm plywood—about ⅛ in. thick—the scarfs are 1 in. wide. I mark my scarf line on each panel and then stack all four panels with the midships' edge of each on the scarf line of the panel below (see figure 1). The scarves should be planed on the insides of the bow panels and on the outsides of the stern panels. The bottom panel is just flush with the edge of my work surface. I plane a ramp from the top line to the edge of the bottom panel. The individual plys will appear as bands as you plane. By keeping the bands parallel and of consistent width, you can cut a flat scarf surface that will result in a clean joint.

There are basically two ways of clamping the scarf joint: You can use pressure (weight or clamps), or you can tack it. I prefer to tack the joint. I position the two pieces I'm joining at the scarf as best I can; then I check their alignment by running a string line along the bottom edge of the panels. When the string just touches at the scarf, the tips of the bow and stern should be exactly 9 in. from the string line. Once the joint is lined up, I clamp the panels to the workbench, far enough back from the joint so that I can apply the epoxy. I smear epoxy (thickened with chopped cotton fibers) onto both sides of the joint and cover it with plastic wrap. Then I lay the second set of panels on the first and again cover the joint with plastic wrap and a strip of scrap plywood. I staple every couple of inches along the joint, right through the joints into the bench or a piece of scrapwood below (see figure 2). I then tap each staple with a hammer to ensure even clamping pressure. When the epoxy has cured, the scrap plywood can be pulled up along with most of the staples. I fill the tiny holes left by the staples with a mixture of epoxy and sawdust.

The last step before joining the two hull halves is to glue on the sheer clamps. The sheer clamps-full-length ¾-in. square strips of spruce or fir—are glued to the top inside edge of the hull to stiffen it and to provide a gluing surface for the deck. I lay the hull panels back to back (outside faces of the boat facing each other) and then position the sheer clamps in as fair a curve as possible. I glue and clamp both sheer clamps into place at once, trying to produce

***Once the epoxy that holds the sheer clamps to the hull** has set, small holes are drilled all along the keel line 4 in. apart and ¼ in. from the edge. Then the center portion of the two halves of the hull are sewn together with copper wire.*



***The coaming (above) is held in place with scraps of plywood** until the epoxy cures. Then thin strips of ash are bent around the top of the plywood to provide a lip on which to mount a spray skirt.*

***After the epoxy on the inside seam has dried,** the hull is flipped over. A single length of epoxy-soaked fiberglass tape strengthens and seals the center of the keel, and then the bow and stern sections can be stitched to complete the hull joint (below left).*

***Epoxy holds the carlins to the deck beams** and the deck beams to the sheer clamps (below right). Stainless-steel screws provide clamping pressure and can be left in or removed. Once the sheer clamps and carlins have been planed so their top surfaces match the radii of the deck beams, the deck can be scribed to the hull.*

mirror images from one side of the boat to the other. Any plywood that's extending above the sheer clamps can be trimmed off later.

## Joining the hull

The two hull panels are temporarily held together with short twists of copper wire and then joined permanently with epoxy-saturated fiberglass tape. Taped joints are strong, light and waterproof and, when carefully laid, the epoxy-saturated tape becomes quite clear, leaving a joint that's all but invisible.

I drill ¹⁄₁₆-in.-dia. holes every 4 in., ¼ in. from the edge of the hull's center seam and stitch the panels together for 42 in. on each side of the scarf (see the photo above). The wire should be twisted on the outside of the hull and flattened against the seam inside. As the hull is stitched, I raise and support the bow and stern to keep the hull close to flat across the boat (athwartships). In boatbuilding, more than other crafts, fair curves are essential, both aesthetically and for reasons of fluid dynamics. Any bumps or hollows created on the flat will be greatly magnified when the boat is rolled up.

I begin taping the panels by spreading a bead of thickened epoxy so that it just covers the wires inside the boat. I lay a 90 in. length of 3-in.-wide fiberglass tape over the joint and wet the tape with unthickened epoxy resin. This process is repeated twice more, each length of tape a few inches shorter than the previous one, to avoid creating stress points. I work the epoxy into the tape with a disposable brush to eliminate any air bubbles or dry spots.

Once the epoxy inside the hull has cured, the boat can be (carefully) flipped over. I cut off the wire ties flush with the outside of the boat, sand off any epoxy that has dripped through the joint and apply a single layer of tape and epoxy to the center 7½ ft. of the hull. To keep the tape clear, only unthickened epoxy should be used on the outside of the hull (see the photo at left above).

I begin stitching the bow and stern sections of the boat together; when the sheer clamps touch, I cut bevels on each with a handsaw and then plane the bevels, so they'll meet neatly. A bead of thickened epoxy and two layers of tape complete the joint on the inside of the bow and stern sections of the hull. This new tape overlaps the tape applied earlier by a few inches; the new tape should be soaked as before with unthickened epoxy and brushed out to eliminate any bubbles or dry spots. Running a single layer of tape the full length of the outside hull and epoxying it finishes joining the hull.

## Fitting the deck

Two deck beams hold the hull at the proper width (or beam), add rigidity around the cockpit and hold the deck at the proper arch. I laminated my deck beams from three strips of 1-in. by ¼-in. spruce using a simple arc-shaped laminating jig and a few C-clamps. The radius of the aft-deck beam is 25 in., and the forward-deck beam's radius is 18 in. The tighter radius creates a higher arc, which provides more knee room.

To install the deck beams, I use either a pipe clamp or string to hold the hull at 26½ in. (outside dimension at the scarf). I bevel the ends of the deck beams, so they'll fit neatly at 16 in. from the scarf, fore and aft. I then epoxy the deck beams to the sheer clamps, using 1½-in.-long #8 stainless-steel screws to hold the deck beams in place until the epoxy cures. The screws may be left in or removed, as desired.

The two carlins (see the drawing) provide a gluing surface for the deck and the cockpit coaming, and they stiffen the cockpit area. I glue and screw the carlins to the deck beams so that the carlins' sides are vertical, and then I plane their tops and the tops of the sheer clamps to match the radius of the deck beams, as shown in the bottom right photo on p. 69.

I transfer the shape of the deck to the second sheet of plywood by holding it on top of the hull and tracing the hull's shape onto it. The deck is cut about an inch oversized and then trimmed later after fastening. Notice that the two deck sections meet at the widest part of the cockpit, not at the hull's scarf.

I coat the underside of the deck and the inside of the hull with unthickened epoxy just before installing the deck. I use thickened epoxy to glue the deck to the carlins, deck beams and sheer clamps. To avoid the hassle of having to clamp the whole arrangement, I tack ¾-in. bronze ring-shank nails every 3 in. along the sheer clamp. The bronze nails also provide a nice traditional touch. I lay out and cut the cockpit opening next and then reinforce the butt joint between the two deck halves with fiberglass tape epoxied to the underside.

## The coaming, seat and trim

The coaming helps to keep the paddler dry by preventing water from sloshing into the cockpit. Its lip can also hold a spray skirt, a welcome feature in rough water. The coaming is formed with a 3¼-in. band of plywood glued to the carlins, deck beams and deck (see the top photo on p. 69). In addition to epoxying between the coaming and the deck beams and carlins, I also add a fillet, or bead, of thickened epoxy under the deck to strengthen the coaming-to-deck joint. I glue two thin strips of ash or another easily bent wood to the top of the coaming to form the lip. (See the drawing on the facing page for coaming details.)

The plywood seat rests on two cleats, so any bilge water can wash under it. The seat and cleats are both saturated with unthickened epoxy before they're installed. I glue the cleats to the hull and the seat to the cleats. Adjustable foot braces are available at kayak shops, and I've used them, but a simple wooden block glued in place will suffice. Positioning of the foot brace will vary according to the height of the paddler. I trim the boat with a ¾-in. by ¼-in. ash rub rail to protect the gunwale and to hide the deck-to-hull joint. I epoxy it on and tack it with ¾-in. brass escutcheon pins.

## Finishing with varnish or paint

I saturate the outside of the hull with epoxy, applying it with a foam roller—it's difficult to get a smooth epoxy finish with a brush. If you take your time and use a foam roller, sanding should take less than an hour. Unfinished epoxy is not a sufficient finish, though, in spite of its being waterproof. Left unprotected, it will react to ultraviolet (UV) light, turning milky and unattractive; therefore, it must be covered with varnish or paint. Marine varnish contains UV filters, is long lasting and is fairly abrasion-resistant. I varnish the inside of the boat as far as I can reach into it. I stick with established marine brands such as Z-Spar, Woolsey, Interlux and Epifanes. Z-Spar's Captain's Varnish is particularly easy to apply over epoxy.

If the kayak is going to see many rocky beaches, though, painting the bottom with marine enamel might be a better idea. Enamel's greater degree of resistance to abrasion will reduce maintenance substantially. Whether you paint or varnish, it's necessary to wash the boat with soap and water before proceeding because the epoxy releases a soap-like film as it cures that will prevent varnish or paint from drying. After the varnish or paint has dried, I screw nylon-webbing grab handles to both ends of the deck, grab the kayak and head for the nearest body of water. □

*Chris Kulczycki is a boatbuilder and freelance writer living in Arlington, Va. Plans and kits far this and other compounded-plywood kayaks are available from the author's company, Chesapeake Light Craft, 34 S. Pershing Drive, Arlington, Va. 22204. For Dennis Davis' plans, contact him at 9 Great Burrow Rise, Nortbam, Bideford, Devon EX39 1TB, England.*

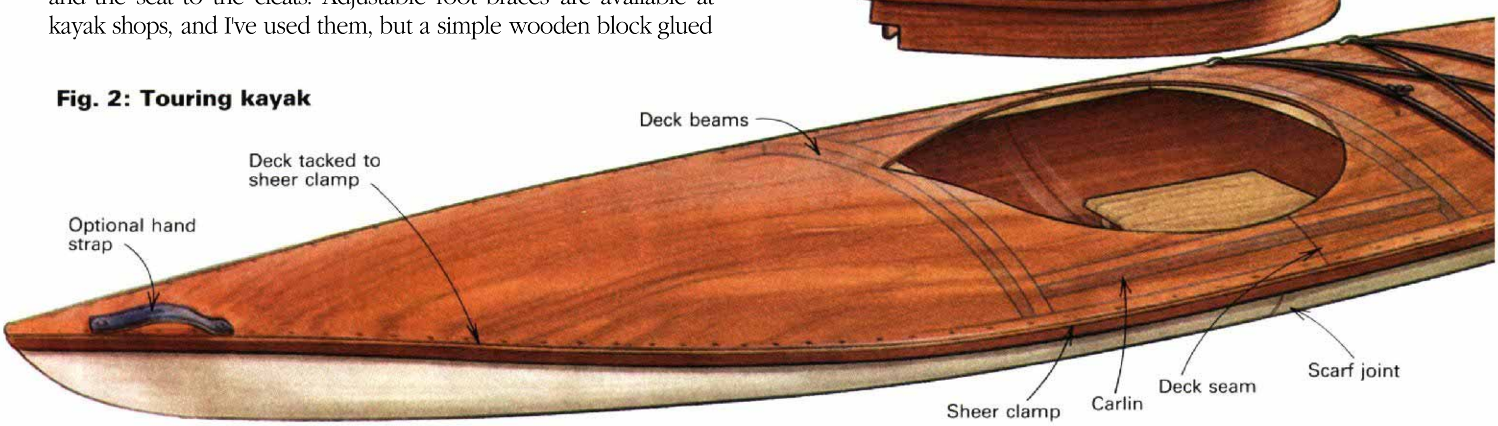
## Further reading

*The Gougeon Brothers on Boat Construction* by the Gougeon Brothers, Gougeon Bros., Inc., PO Box 908, Bay City, MI 48707.

*Sea Kayaking: A Manual for Long-Distance Touring* by John Dowd, University of Washington Press; 1988.

*Sea Kayaker* (a quarterly magazine), 6327 Seaview Ave. N.W., Seattle, WA 98107.


Fig. 2: Touring kayak






Photos: author; drawings: Bob La Pointe

**Glossary**

Beam - The vessel's width.

Bilge - The lowest portion of the inside of the hull.

Bow - Extreme forward end of the boat.

Carlin - A beam running fore and aft that supports the deck.

Coaming - A raised lip around the cockpit designed to deflect water.

Deck - A rigid covering that prevents water from entering the boat.

Deck beam - A structural member running across a boat's width to support the deck.

Fair - Smooth, lacking bumps or hollows.

Gunwale - The upper edge of the boat's sides.

Hull - Outer shell of a boat.

Keel line - The lowest continuous longitudinal centerline of a boat.

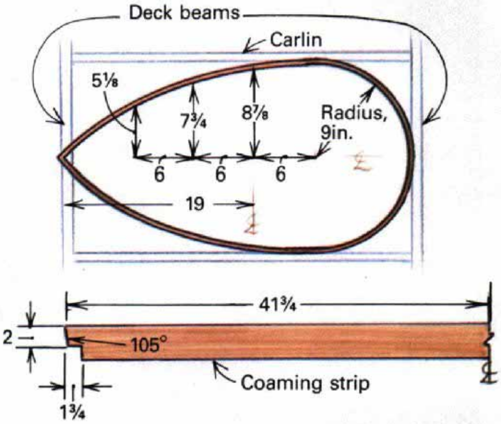
Midships - The central portion of a vessel.

Rub rail - A strip of wood near the hull-to-deck joint designed to protect the hull.

Sheer clamp - A wooden member to which the hull and deck are fastened.

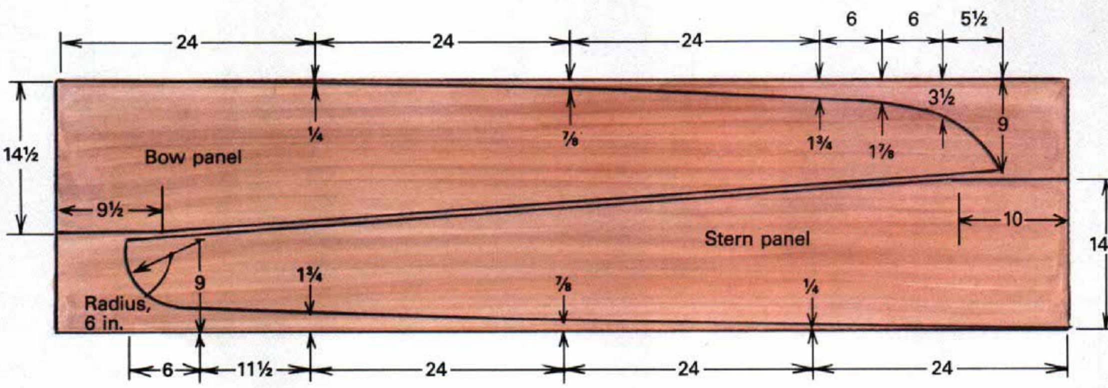
Stern - Extreme back or aft end of the boat.

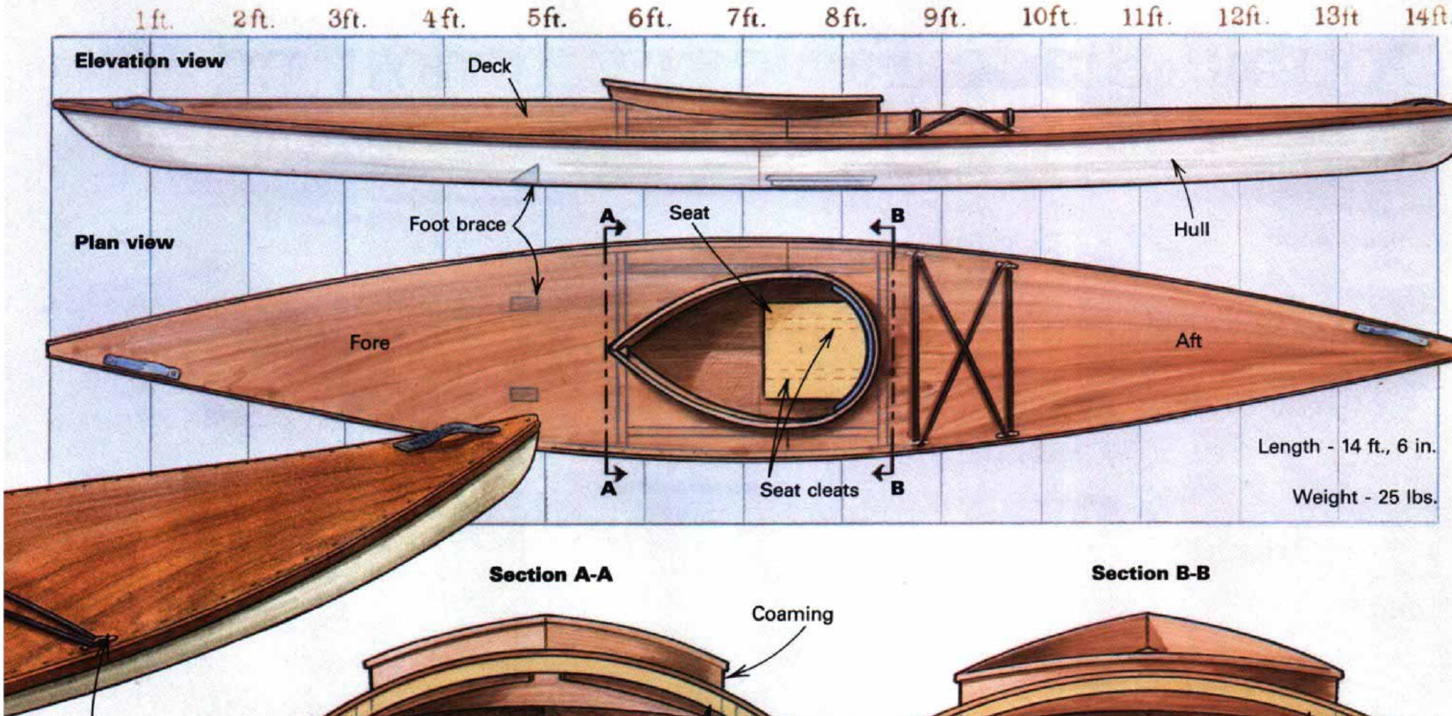
**Coaming detail**




**Hull panel layout**

*Rip one sheet of plywood in half and layout bow and stern panels on one half. Stack the two half sheets when cutting out the panels.*




*Optional hold-down rig consists of padeyes and bungee cords.*

*Use only marine epoxy adhesive.*

*Flotation bags should be used.*