

# Mare Liberum: On Paper Boat Construction

via: [www.thefreeseas.org](http://www.thefreeseas.org) (& [fb.me/thefreeseas](https://fb.me/thefreeseas))

“On July 4, 1874, journalist, author and adventurer Nathaniel H. Bishop [1837 - 1902] left Quebec, Dominion of Canada, with a single assistant, in a wooden canoe eighteen feet in length, bound for the Gulf of Mexico. It was his intention to follow the natural and artificial connecting watercourses of the continent in the most direct line southward to the gulf coast of Florida, making portages as seldom as possible, to show how few were the interruptions to a continuous water-way for vessels of light draught, from the chilly, foggy, and rocky regions of the Gulf of St. Lawrence in the north, to the semi-tropical waters of the great Southern Sea, the waves of which beat upon the sandy shores of the southernmost United States. Having proceeded about four hundred miles upon his voyage, the author reached Troy, on the Hudson River, New York state, where for several years Elisha Waters & Sons had been perfecting the construction of paper boats...” ~ from the 1878 edition of ~ Nathaniel Bishop, *Voyage of the Paper Canoe, A GEOGRAPHICAL JOURNEY OF 2500 MILES FROM QUEBEC TO THE GULF OF MEXICO, DURING THE YEARS 1874-5 (1878).*

“Elisha Waters was an amateur oarsman of no mean ability. He also was interested in amateur photography, and invented an improved shutter appliance and other camera devices. He was an aerial balloonist for the pleasure he derived from it, and had made ascensions with some of the best aeronauts in the country... Mr. Waters was the inventor of the paper dome, paper oil can, paper life preserver, etc. – and was, perhaps, more familiar with methods of working paper than any other man in the country.” ~ Gretchen Myers, *Paper Rowing Shell Building in the United States, 1867-1900* (1981). Waters's company also manufactured inks; little glass bottles marked with the Waters name and logo still show up at junk shops in Troy and surrounding towns. In 1901, a fire destroyed the boat and dome factory. Elisha and his son George both died within a few years. Waters held patents on his paper forms and this fact along with advancements in cedar planking technologies around the same time meant the effective end of the paper boat racing shell's 40 year history.

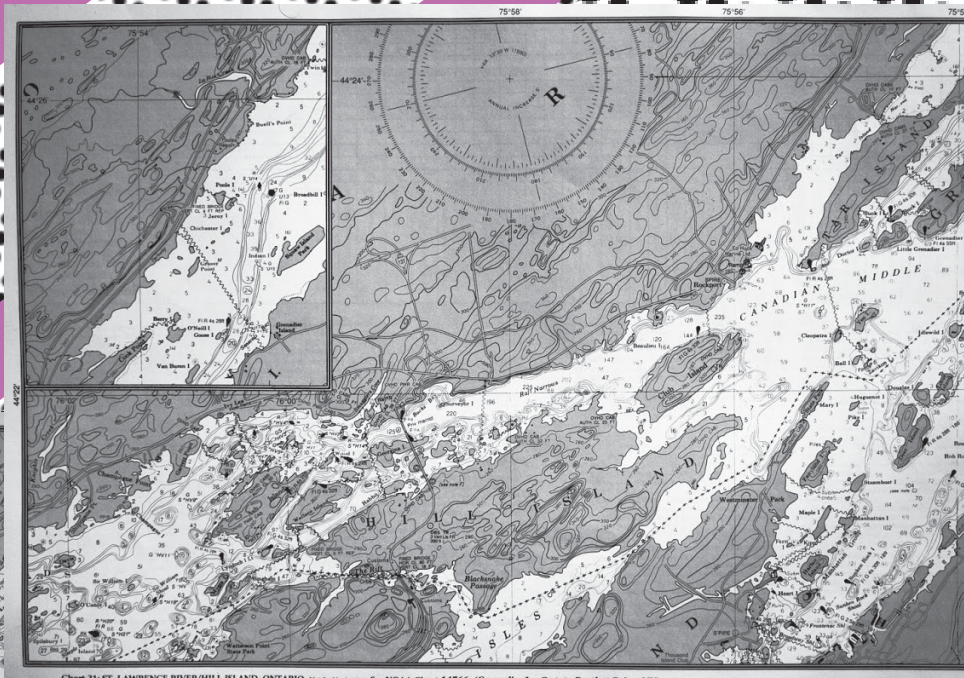
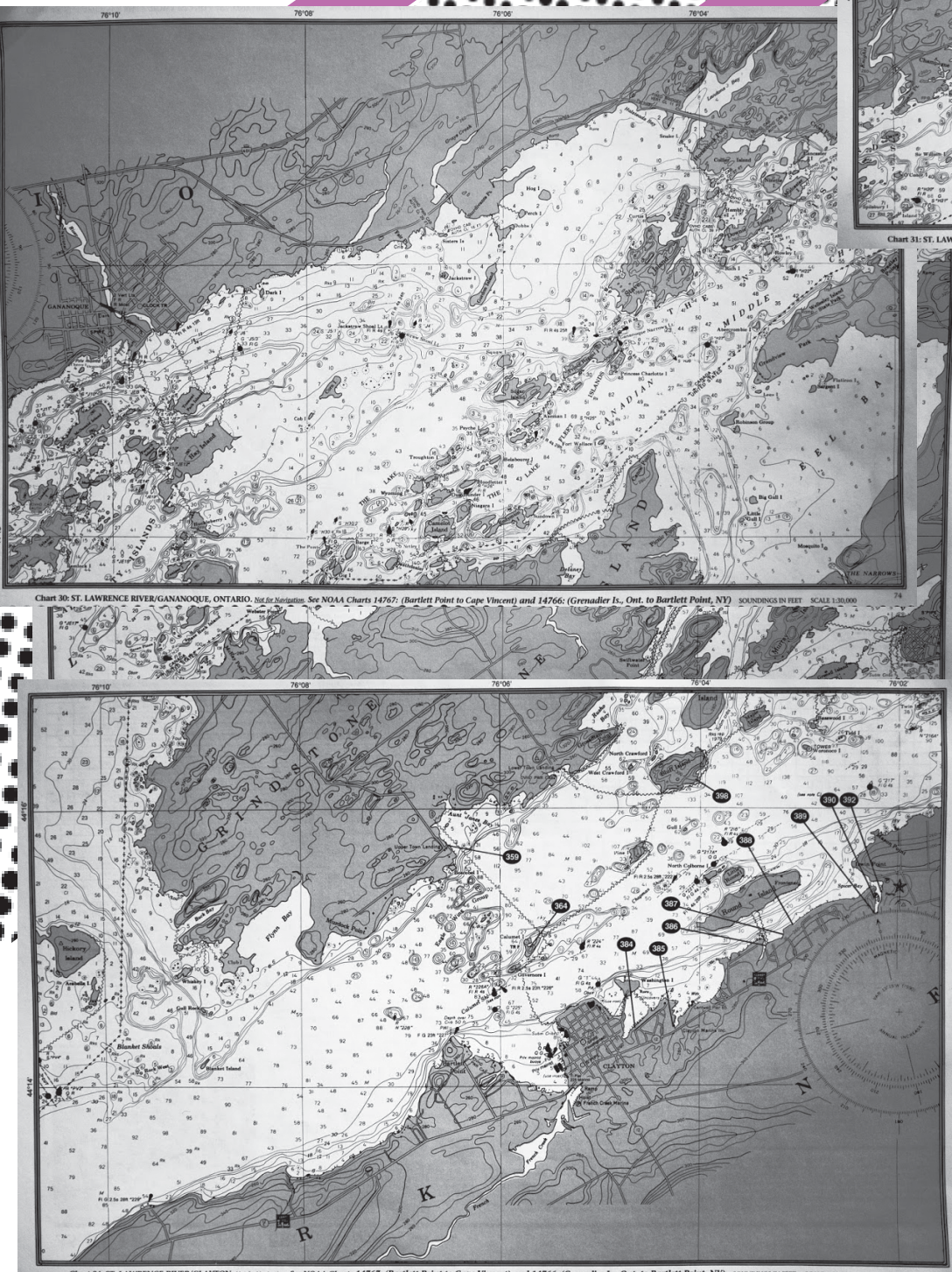


**PAPER BOATS**  
Have been rowed by the winners of NINETY RACES since their introduction in 1863. Early in April, we shall publish an *Illustrated Catalogue for 1874*, which, in addition to containing fine Woodcuts of our Boats and our latest improved models, will give a *complete list of the Boat, Rowing, and Sporting Clubs in the United States and Canada*, besides much other information of value to Oarsmen. Parties intending to purchase Boats the coming season should have a copy. For Descriptive Circulars and Price-lists of Boats, Oars, and Fittings, address  
**WATERS, BALCH, & CO.,**  
303 River Street, Troy, N.Y.

The Free Seas / Mare Liberum is a freemorph publishing, boatbuilding and waterfront art collective, based in the Gowanus, Brooklyn. Tracing its roots to centuries-old stories of urban water squatters and haphazard watercraft builders, Mare Liberum is a collaborative exploration of what it takes to make viable aquatic craft as an alternative to life on land, and as a technique of resistance toward a right to the waterfront city. The project draws from sources as diverse as ocean-crossing raft assemblages, improvised refugee boats built in Senegal and Cuba, and modern stitch-and-apply construction methods which make complex, classic boat designs approachable by novice builders. Mare Liberum has provided fleets of boats for artist projects domestically and in Europe and has exhibited work in galleries and museums including EFA Project Space, MASSMoCA and the Neuberger Museum. In 2011, the crew of Mare Liberum co-curated the exhibition *SeaWorthy* (with Flux Factory and EFA Project Space) which brought over 2 dozen artists to create new works and public programs around the waterways of New York City. For more information about the project, visit [www.thefreeseas.org](http://www.thefreeseas.org).

## Paper Bill of Materials

A boat to copy • Packing tape - one roll • PAM cooking spray • Titebond III wood glue - 2 gallons • Kraft paper - two 500 sq. ft. rolls • Wood shims - one pack • Marine epoxy - one gallon resin, 1/5 gallon hardener, optional waterproofing additive • Dimensional lumber - four 16 ft. 2x4's (or equivalent) • Wood Screws - one box of #6 2-1/2", one box of #8 3/4" (brass or stainless steel) • Thin scrap wood or masonite for making the jig • Cedar or Oak lumber - approx. thirty 1/4" x 1/2" strips, between 4' and 6' long for ribs and bang strips • An assortment of other scraps of wood for thwarts, breast hooks, rub rails, and floorboards.



shape of the desired model. The forms for these boats having been prepared, as already described for the racing-shells, and the frame being let into this form, so that the outer surface of the ribs, stem and stern pieces will conform with its outer surface, the paper skin is next laid upon it. The skin, manufactured from new, unbleached linen stock is carefully stretched in place, and when perfectly dry is from one-tenth to three-sixteenths of an inch thick. Removed from the model, it is water-proofed, the frame and fittings completed, and the boat varnished. In short, in this class of boats, the shape, style, and finish are precisely that of wooden ones, of corresponding dimensions and class, except that for the usual wooden sheathing is substituted the paper skin as described. . . .

My canoe of the English "Nautilus" type was completed by the middle of October; and on the cold, drizzly morning of the 21st of the same month I embarked in my little fifty-eight pound craft from the landing of the paper-boat manufactory on the river Hudson, two miles above Troy. Mr. George A. Waters put his own canoe into the water, and proposed to escort me a few miles down the river. If I had any misgivings as to the stability of my paper canoe upon entering her for the first time, they were quickly dispelled as I passed the stately Club-house of the Laureates, which contained nearly forty shells, all of paper. The dimensions of the Maria Theresa were: length, fourteen feet; beam, twenty-eight inches; depth, amidships, nine inches; height of bow from horizontal line, twenty-three inches; height of stern, twenty inches. The canoe was one-eighth of an inch in thickness, and weighed fifty-eight pounds. She was fitted with a pair of steel outriggers, which could be easily unshipped and stowed away. The oars were of spruce, seven feet eight inches long, and weighed three pounds and a quarter each. The double paddle, which was seven feet six inches in length, weighed two pounds and a half. The mast and sail - which are of no service on such a miniature vessel, and were soon discarded - weighed six pounds. When I took on board at Philadelphia the canvas deck-cover and the rubber strap which secured it in position, and the outfit, - the cushion, sponge, provision-basket, and a fifteen-pound case of charts, - I found that, with my own weight included (one hundred and thirty pounds), the boat and her cargo, all told, provisioned for a long cruise, fell considerably short of the weight of three Saratoga trunks containing a very modest wardrobe for a lady's four weeks' visit at a fashionable watering-place.

The rain ceased, the mists ascended, and the sunlight broke upon us as we swiftly descended upon the current of the Hudson to Albany. The city was reached in an hour and a half. Mr. Waters, pointing his canoe northward, wished me bon voyage, and returned to the scene of the triumphs of his patient labors, while I settled down to a steady row southward. At Albany, the capital of the state, which is said to be one hundred and fifty miles distant from New York city, there is a tidal rise and fall of one foot. A feeling of buoyancy and independence came over me as I glided on the current of this noble stream, with the consciousness that I now possessed the right boat for my enterprise. It had been a dream of my youth to become acquainted with the charms of this most romantic river of the American continent. Its sources are in the clouds of the Adirondacks, among the cold peaks of the northern wilderness; its ending may be said to be in the briny waters of the Atlantic, for its channel-way has been sounded outside of the sandy beaches of New York harbor in the bosom of the restless ocean. The highest types of civilized life are nurtured upon its banks. Noble edifices, which contain and preserve the works of genius and of mechanical art, rear their proud roofs from among these hills on the lofty sites of the picturesque Hudson. The wealth of the great city at its mouth, the metropolis of the young nation, has been lavished upon the soil of the river's borders to make it even more beautiful and more fruitful. What river in America, along the same length of coast-lines as from Troy to New York (one hundred and fifty-six miles), can rival in natural beauty and artificial applications of wealth the lovely Hudson? "The Hudson River," says its genial historian, Mr. Lossing, "from its birth among the mountains to its marriage with the ocean, measures a distance of full three hundred miles." ~ Nathaniel Bishop, *Voyage of the Paper Canoe*.

## Glossary and Practical Wisdom

-Do not approach a dock or another boat faster than you are willing to ram into it.  
-If you want to build a rowboat, it should be stronger than a canoe.  
-You could use paint to waterproof the paper, but with a clear finish you can see the paper get dark when it gets wet, and repair the problem. If it repairs, look for the spots. Cut around the area and remove the epoxy to expose the water to the air. Let the paper dry. Then coat it with epoxy again. **This Handy Repair Pack 101 (see QR code number XV on back)** is good to have around, even on the water.  
-Paper and water don't work well together. Gaps in your finish will soak the paper. Gaps between layers can trap water. Be diligent about identifying and destroying gaps in your paper hull.

-Don't stand up in a canoe  
**Keelson.** The keelson is a strip of wood on the bottom of the boat or on the inside of the hull. This usually runs down the middle of the boat and acts as an inside spine for the ribs. The keel is in the same location but on the outside of the hull.  
**Stem.** The stem of the boat is the front end, but it also refers to the wooden member that supports the shape for the front and back edge of the boat.  
**Strongback.** A strongback in boatbuilding is a structural jig that the boat is constructed on. Because boats are all curvy there are few flat reference edges, and a strongback can be used to measure from as well. In this case, the strongback physically preserves the locations of the edges of the original boat, since the new paper hull will not be strong enough to bend wood over to form the outer edges.

# Le Massicot \*

A Paper Skiff constructed at the ABM – July, 2012

(\* French for 'paper cutter')

# the PAPERei Canoe \*\*

A Paper Canoe built at Maker Faire, NYC – Sept., 2012

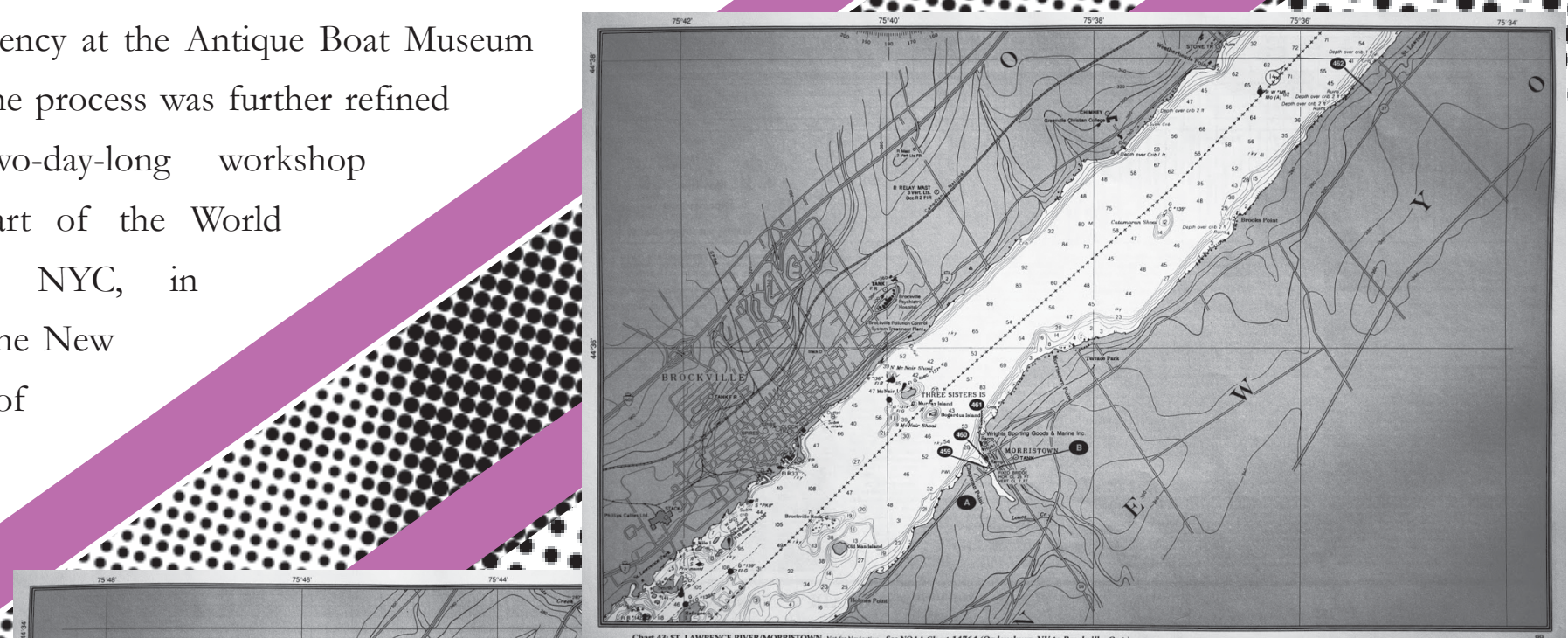
(\*\* a seaworthy paper copy of the cheapest canoe sold at REI)



In July of 2012, Mare Liberum, a collective of artist-boatbuilders from Brooklyn, New York, was invited to the Antique Boat Museum in Clayton, New York by curator Emmett Smith to construct a new craft inspired by the museum's collection. Reconnecting with the voyage of Nathaniel Bishop and the Troy, NY-built Waters & Sons paper canoes and inspired by the spirit of Homer Dodge, the collective decided to try to build a paper boat and to take that boat on a voyage. They selected a Peterborough Skiff which was being deaccessioned from the museum's collection to use as a mold for the paper shell, and set to work. Through a combination of historic research, consultation with ABM master boatbuilders, volunteers and staff, and testing of various materials, equipment and techniques, the collective managed to build, in two weeks time, a seaworthy Paper Skiff, on display here. Christened as "Le Massicot" (French for paper cutter) the Paper Skiff was subsequently rowed from Clayton, New York to Montreal, a distance of approximately 160 miles down the St. Lawrence River. The voyage took just over a week.

The plans contained on the back side of this broadsheet (the 7th edition of Mare Liberum's 5-year long boatbuilding instructional series) will guide the willing builder through an as yet experimental process of constructing a seaworthy craft out of little more than kraft paper, wood glue, a little bit of hardwood, and a sealer.

After our residency at the Antique Boat Museum this summer, the process was further refined during a two-day-long workshop featured as part of the World Maker Faire, NYC, in September at the New York Hall of Science.



"Inquiries regarding the history and durability of paper boats occasionally reach me through the medium of the post-office. After all the uses to which paper has been put during the last twenty years, the public is yet hardly convinced that the flimsy material, paper, can successfully take the place of wood in the construction of light pleasure-boats, canoes, and racing shells. Yet the idea has become an accomplished fact. The success of the victorious paper shells of the Cornell College navy, which were enlisted in the struggles of two seasons at Saratoga, against no mean antagonists, - the college crews of the United States, - surely proves that in strength, stiffness, speed, and fineness of model, the paper boat is without a rival.

The process of building the paper shell-boat is as follows: The dimensions of the boat having been determined upon, the first step is to construct a wooden model, or form, an exact facsimile of the desired boat, on which to mould the paper skin.

For this purpose the lines of the boat are carefully drawn out of the full size, and from the drawings thus made the model is prepared. It is built of layers of well-seasoned pine, securely fastened together to form one solid mass; which, after having been laid up of the general outline required, is carefully worked off, until its surface, which is made perfectly smooth, exactly conforms to the selected lines, and its beam, depth, and length are those of the given boat.

The model is now ready to be covered with paper. Two kinds are used: that made from the best Manila, and that prepared from pure unbleached linen stock; the sheets being the full length of the model, no matter what that may be. If Manila paper is used, the first sheet is dampened, laid smoothly on the model, and securely fastened in place by tacking it to certain rough strips attached to its upper face. Other sheets are now superposed on this and on each other, and suitably cemented together, the number depending upon the size of the boat and the stiffness required. If linen paper is used, but one sheet is employed, of such weight and dimensions that, when dry, it will give just the thickness of skin necessary. Should the surface of the model be concave in parts, as in the run of boats with square stems; for instance, the paper is made to conform to these surfaces by suitable convex moulds, which also hold the paper in place until, by drying, it has taken and will retain the desired form. The model, when perfectly dry, all wrinkles disappear, and it gradually assumes the desired shape. Finally, when all moisture has been evaporated, it is taken from the mould an exact facsimile of the model desired, exceedingly stiff, perfectly symmetrical, and seamless!

The paper is now subjected to the water-proof process, and the skin, with its keelson, inwales, and dead-woods attached, is then placed in the carpenter's hands, where the frame is completed in the usual manner, as described for wooden boats. The paper decks being put on, it is then ready for the brass, iron, and varnish work. As the skins of these boats (racing-shells) vary from one-sixteenth of an inch in the singles, to one-twelfth of an inch in the six-oared outriggers, the wooden frame becomes necessary to support and keep them in shape. In applying this invention to gigs, dingies, canoes, and skiffs, a somewhat different method is adopted. Since these boats are subjected to much hard service, and must be so constructed as to permit the occupant to move about in them as is usual in such craft, a light and strong frame of wood is prepared, composed of a suitable number of pairs of ribs, with stem and stern pieces cut from the natural crooks of hackmatack roots. These are firmly framed to two gunwales and a keelson, extending the length of the boat; the whole forming the skeleton

**Inwale and Outwale.** The general vicinity of the outside top edge of a boat is called a gunwale, and the inside wooden member of this area is called the Inwale. The outside wooden member of this area is called the Outwale. The ribs and hull are typically sandwiched between these two wooden members.

**Breast Hooks.** The beecher chunks of wood where the gunwales meet the stem and stern.

**Thwarts.** Wooden members spanning the boat laterally, sometimes all the way from inwale to outwale. They provide a lot of strength. Seats count as thwarts too.

**Rub Rails.** These are the bumpers along the bottom of the hull to protect it as you drag it ashore.

**Bang Strips.** These are the bumpers that are attached to the outside of the hull at the stem and stern to protect it from scratches when you run into things and drag it around.

**Hull.** The Hull is the outside surface of the boat. It keeps the water out, and the air in.

# Build the ML PAPERei Canoe

Follow these easy steps to your own paper canoe! Note: the roman numerals refer to the QR codes below.

## 1. Find a Boat \*



If you don't have access to an **eighty-year-old Lake Ontario Skiff (I)** from a **great antique boat museum (II)**, go to REI and buy a canoe. Don't worry, you will be able to return it for a full refund thanks to their **generous return policy (III)**. We used the **Saranac 146XT Canoe (IV)** for these step-by-step instructions.

## 2. Prepare the Boat

2a. Tape up crevices that would otherwise collect glue using packing tape. The packing tape won't stick to the paper when you're ready to pull it off.

2b. Spray the entire boat down with **non-stick cooking spray (V)**. This will make it easier to get the paper off once it dries. If your original boat is not made of plastic, wrap it in stretchy plastic wrap and tape the seams.

## 3. Prepare the Paper & Glue



3a. Mix up your Glue. **Titebond III (VI)** works best with one part glue to one part water. We used 2 gallons of Titebond III to make the 14' REI Canoe.

3b. Take out your two rolls of **kraft paper from Home Depot (VII)** – it works better than the stuff from Lowes. Cut the rolls into 3" wide strips using a chop saw.

## 4. Apply Paper & Glue



Dip paper strips in glue (we make a trough) and then lay them over the boat at approximately a 45° angle, and overlap them by half. You will need to build up 12 complete layers of paper (or about 1/8" thick). Because you're overlapping them by half, you only have to go over the boat 6 times. Alternate the bias of the paper with each layer.

## 14. Steam & Rib



14a. Find some recycled wood. Oak or cedar would be the best. If you're in NYC, check out **Build It Green (X)**. Cut this wood down for ribs – making them thin and small makes them easier to work with, and using a lot of them will make the boat stiff. 1/4" by 1/2" cross sections will do just fine. Lengths will vary depending on your boat.

14b. Build a steam box like **this one (XI)**. Steam the wood until it's soft, probably 40 minutes each. You can speed up this process by adding boards in every 5 minutes, and keep track of which one went in first.

14c. Steam the wood into the original boat. Hopefully you can remove any seats and parts that will get in your way. As soon as the wood comes out of the steam box pre bend it with just your hands into a rough curve. Then push it down into the boat as hard as you can and clamp each edge. **Here's an example of someone doing it right (XII)**. You will need at least 2 friends for this operation. It's tricky, but you'll get the hang of it. If the boards break make them steam longer. You can't over-steam them. The problem with steam bending is you need a million clamps. **Here are some cheap clamp alternatives (XIII)**.

## 15. Trim the Edges

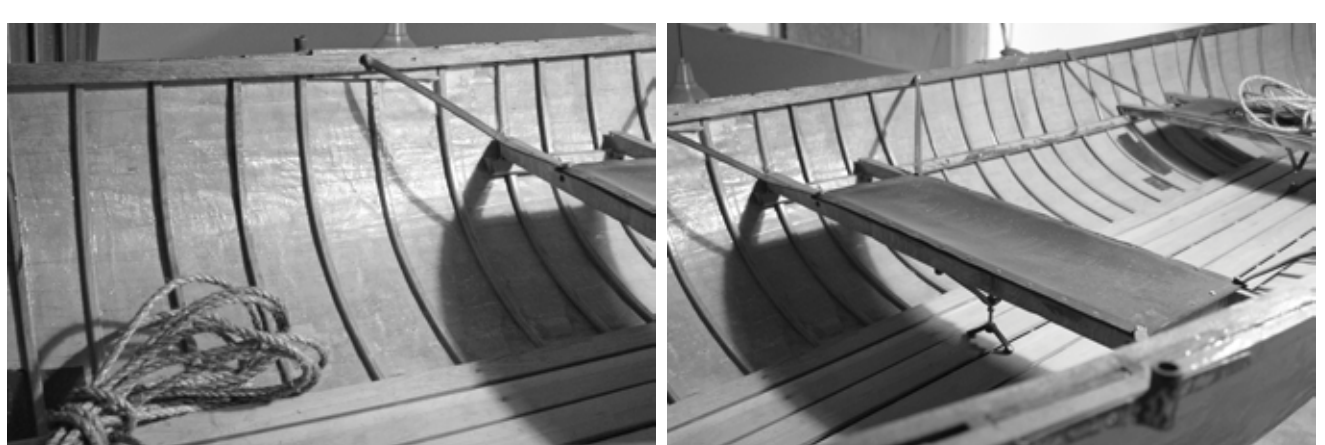


Trim the top edge of the paper hull to the inwale, and—before sealing this part with the marine epoxy—carefully cap it with a thin paper mache fold. This will help to keep water from seeping into the paper laminations.

## 16. Attach Shell & Gunwales

Set the paper boat onto the inwale (on the strongback) in an upright position. After the ribs have dried (24 hours) you can move them over into the paper boat, screwing them down to the keelsons and to the inwales, and gluing them to the paper with epoxy. With any luck it will all fit. Once the ribs are all in and the glue is dry, attach the outwales and trim the top edges of the ribs.

## 17. Rails & Seats



Rails run crosswise to the ribs and provide additional support, while serving as a mount for your seats. Add rails along the ribs as a place to screw in the seats. Fit seating to the rails and add thwart to stiffen the boat. You may want to add decks to the fore and aft topsides of the boat. Be creative.

## 5. Gaps are the Enemy

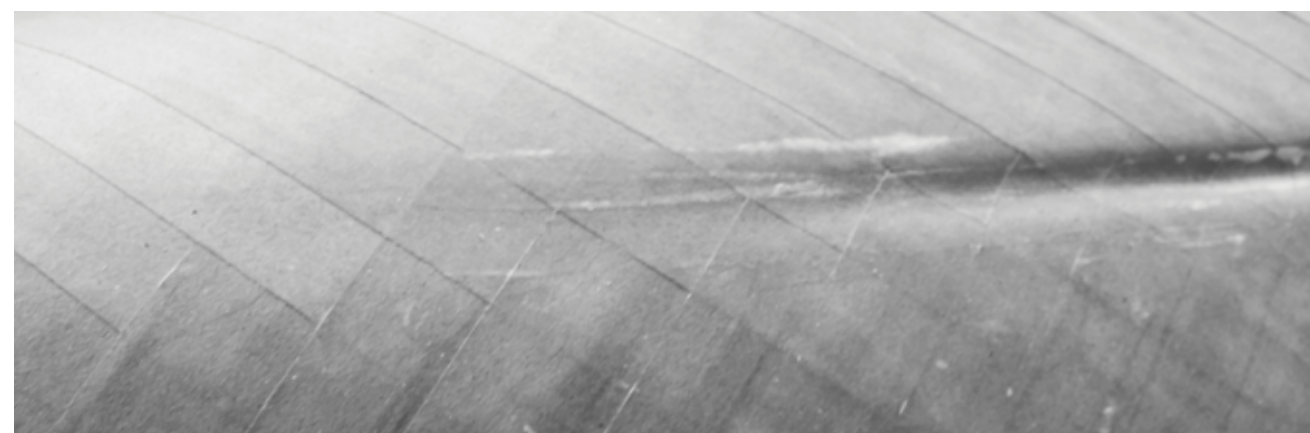
Trust us, you don't want them. Air in between the layers are weak spots that may also be susceptible to water. Make sure each strip of paper lays down tight and really, truly overlaps the previous one by half.

## 6. Paper the Stem & Stern



Lay paper over the stem and stern of the boat in small strips as shown. It's not easy to keep gaps from forming on the stem and the stern. Use smaller pieces and be super careful. Big strips won't work at all.

## 7. Herringbone



The last layer can be laid down in a nice herringbone pattern to trap all the ends.

## 8. Dry, De-Mold & Dry Again

Let the whole deal dry for 24 hrs. Once your shell is dry, using thin wooden shims and your hands work around the edge of the boat and slowly release the paper from the original boat. Set the paper form somewhere safe and let it dry overnight. It should be dry throughout before you begin the next steps.

## 9. Seal the Shell

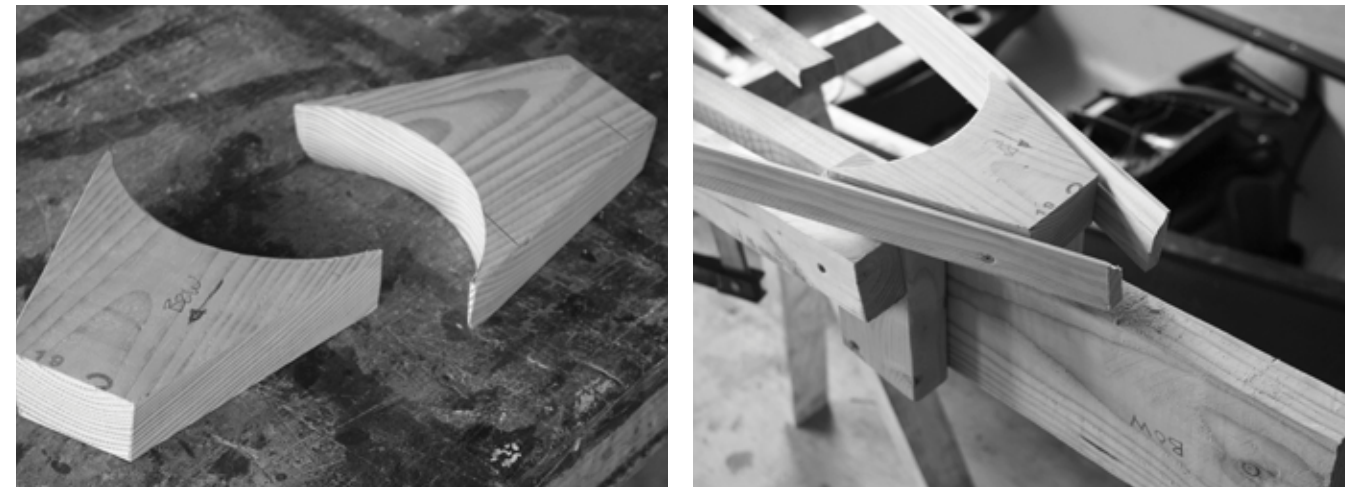
Brush on the first coat of marine epoxy to the inside of the boat. We used **West System 105 Resin (VIII)** with the **205 Slow Hardener (IX)**. This makes the process a little mellower, but it is still pretty gross and toxic. Please take the proper precautions.

## 10. Build the Strongback



Build the strongback to locate the position of the top edge, or "sheer," of the original boat. A beam or beams the length of the boat will support a ladder frame that lays against the top edge of the original. Blocks attached to this ladder frame will act as references for the inwales.

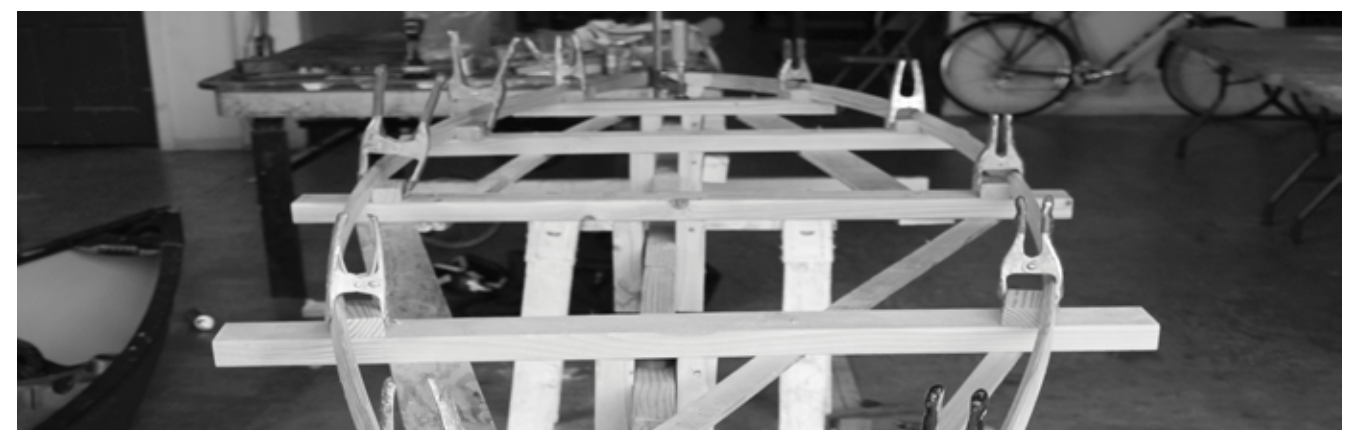
## 11. Breast Hooks



11a. Trace the outline of the bow and the stern onto the blocks of wood you will use for the breast hooks. Offset that line by the thicknesses of the inwale and the ribs (one inch in this case) and cut to that line. You will have to slightly taper the faces that mate to the ribs for a nice fit.

11b. Attach the breast hooks to the strongback at their corresponding locations at the bow and stern.

## 12. Inwales & Outwales

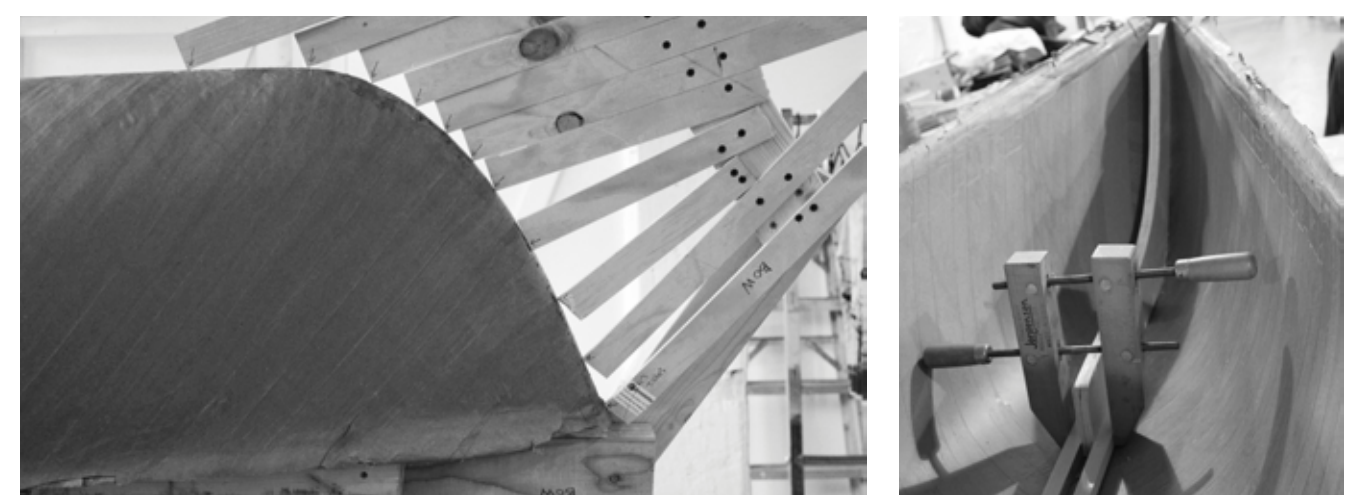


12a. Rip down really long boards to around 3/4" x 1" x the length of the boat for the inwales and the outwales or simply use 4 lengths of 16' pieces of trim moulding as we have here.

12b. Bend inwales over the strong back reference blocks to form the shape of the edge of the boat. Screw the inwale into the blocks that referenced the bow and stern. Now you can dry fit the paper boat to these inwales. Solid!



## 13. The Stem & the Stern



13a. Capture the curve of the stem and stern with a jig like the one pictured above. Now cut them out of plywood.

13b. Attach the stem and stern to each other by laying in two keelsons on either side of the stems, and screwing the keelsons into the stems from the side.

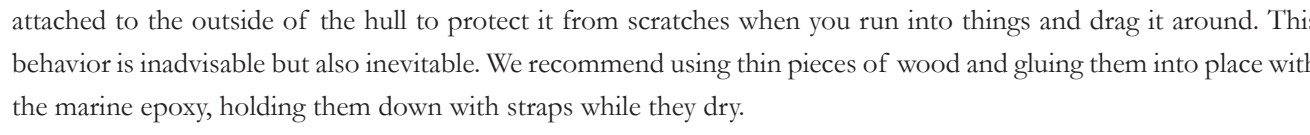
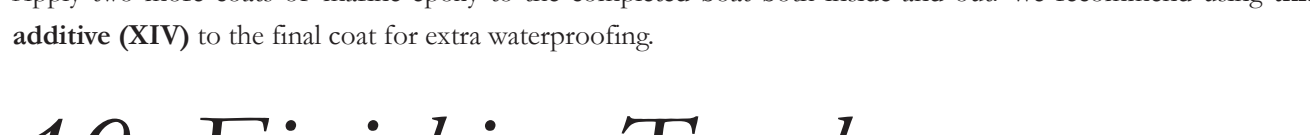
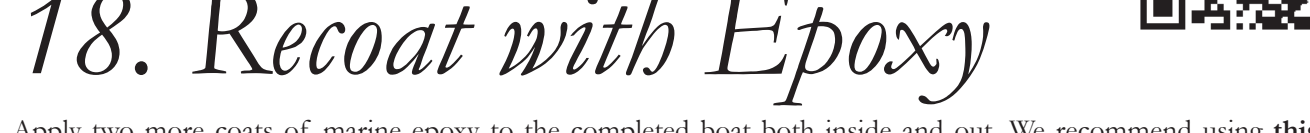
## 21. Return Canoe to REI, Get Out on the Water...



Then take your new paper boat out on the water! Bring a PFD and stay close to shore.



At left and below: the crew's trip up the St. Lawrence as represented by a series of QR codes. Footnotes to the text and illustrations for your boatbuilding journey.



\* It may be daft to start a boat-building guide with "find a boat," but even the Waters's original paper boats were always copied off of another form. The paper boat was invented when Elisha Waters's son George was making paper-mâché masks for a carnival. If you can't find a boat to copy (you live in the desert, you don't know any sailors) see our website ([www.thefreesas.org](http://www.thefreesas.org)) for plans for building many other kinds of boats where the first step is not "find a boat."