Modeled & Rendered in Rhinoceros by Michael Philbrick

Modeling a Sailboat

By Michael Philbrick

This tutorial details every step of building the boat model pictured above. Because this boat is a serious, professional project, it probably should not be the first tutorial you follow in learning Rhinoceros, and it does assume at least a basic familiarity with the Rhinoceros interface. Please allow at least two days to complete this tutorial. In addition to following all the steps, be sure to check out the optional pages - they describe other solutions to many of the issues raised in this tutorial, and even cover how the scene above was textured, lit, and rendered in Rhinoceros.

Open boat1.3dm and save it out as boat.3dm on your local hard drive in a new subdirectory called boat.

> **Optional:** To match your colors to the figures in this tutorial, call up Tools/Options... and click the Appearance tab. In the Colors section, click on the color swatch to the right of the words "Viewport background," and the Rhinoceros color picker window will open. Click on the Named Color labeled Dark Gray, and click OK.

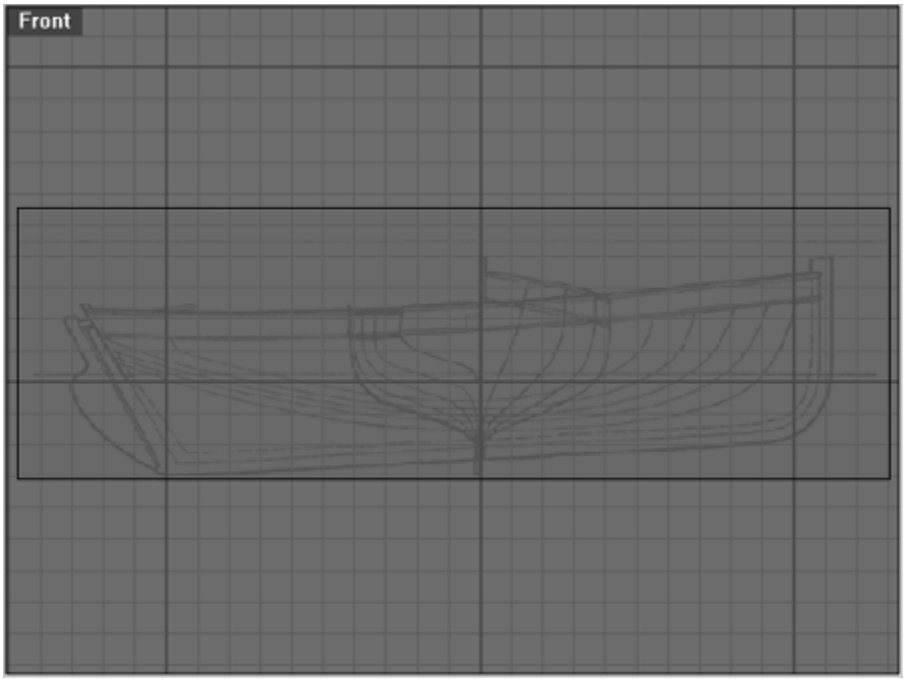
Still working under the Appearance tab, click on the "Major grid line" swatch. In the color picker window, enter a Hue of 0, Sat of 0, and Val of 80, and click OK. Repeat to set the "Minor grid line" to the same color. Click OK to exit Options.

Click in the front view, and choose View/Zoom/Extents.

To bring in an image to sketch over, go to View/Background bitmap/Place and when prompted, locate the file boat/Background/sections.tga on the CD-ROM.

Turn on the osnap 'End.' Working in the Front window, click once in the upper left corner of the rectangle, and then click again in the bottom right of the rectangle. This will align the imported image with the spline guide, so that the boat you build will be at the same scale and position as the sample files on the CD-ROM.

After the second mouse-click, a dim gray figure will load into the background, as shown below.

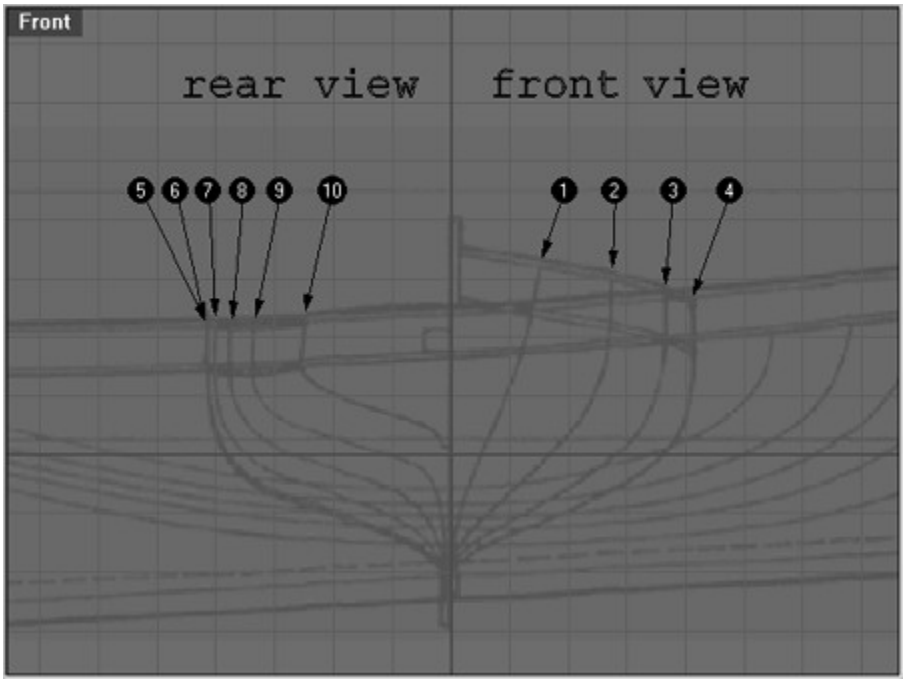


Maximize the front view and study the blueprint that you have imported. The views of a model shown in blueprints are often drawn differently than the views in Rhinoceros modeling windows. The scanned-in blueprint shown in the Front view actually depicts more than one view in the same model: it shows the boat from the side, with curves from the front and rear views superimposed near the center. This one blueprint image will provide many of the design specifications required to model the boat. Note that no blueprint is ever perfect, and that your own creativity as a modeler will come in to play at several points during this tutorial.

In the layer control window, turn on layer annotate1.

The numbers 1-10 point to the top end of each of an important set of curves. These 10 curves are the "sections curves" of the blueprint. The section curves are the main curves that will be used later to loft the hull.

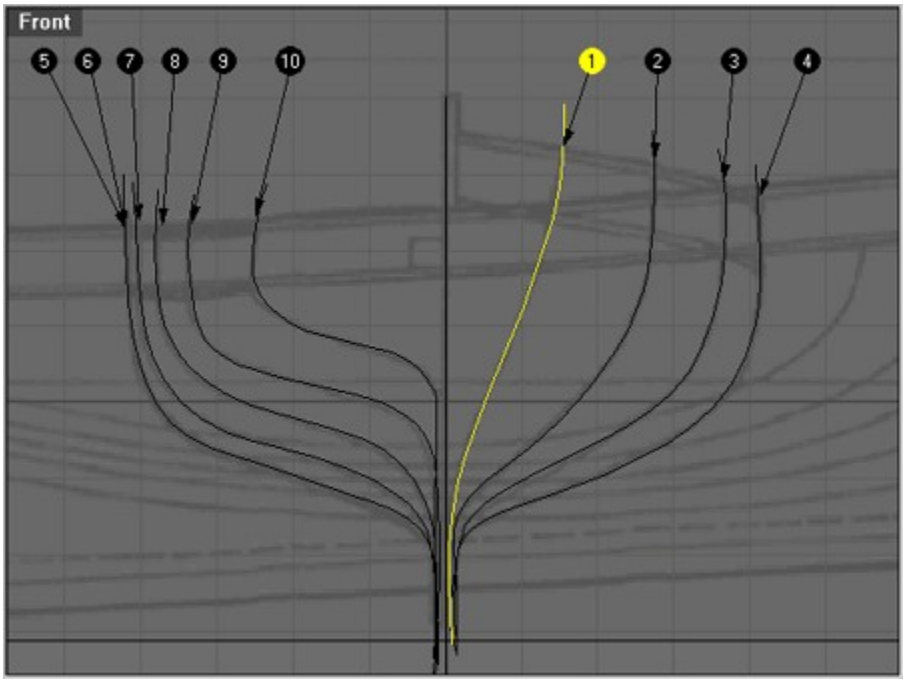
The section curves on the right (1-4) form the bow (the front end) and the sections on the left (5-10) form the rear of the boat.



Turn off the annotate1 layer. With end osnap off, trace over the lines 1-10 using **InterpCrv** (Curve/freeform/Interpolate Points). Note in the figure below that the curves being drawn can exceed the length of the section curves shown in the blueprint. These will be accurately trimmed off later.

Also note that lines 5 and 6 are similar in position, and may appear to be almost the same line. Carefully trace both of them.

In addition to the 10 numbered section curves, also draw a "centerline" straight down the middle, as shown below.



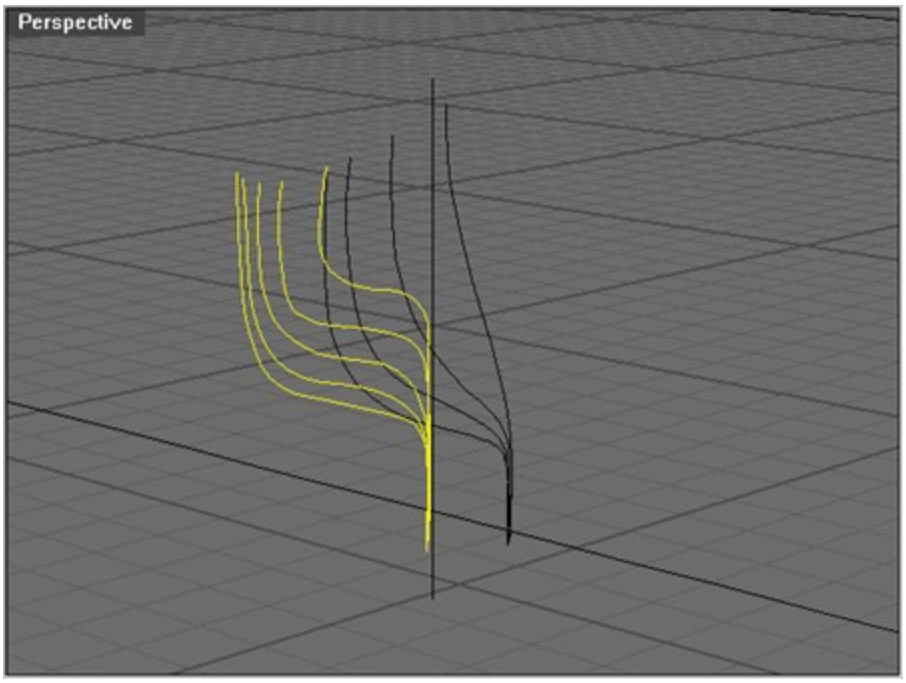
Save your file when done drawing all 11 curves.

NOTE: The following steps will rotate all the curves to the same side of the boat, in

order to distribute them down the length of the hull and prepare for a loft command that will surface the hull.

Select the 6 curves that form the rear of the boat, shown selected below. Turn on the 'end' osnap. With the perspective view active, hit **Rotate3d** (Transform/Rotate3d), select the top and bottom of the centerline, and enter **-90** degrees. In the front, view drag the curves to your left by **2** grid squares.

NOTE: This will prevent them from overlapping with the front curves, which you need to rotate them around. Select the other curves, which represent the front of the boat, and rotate them by (positive) 90 degrees. Result shown below.

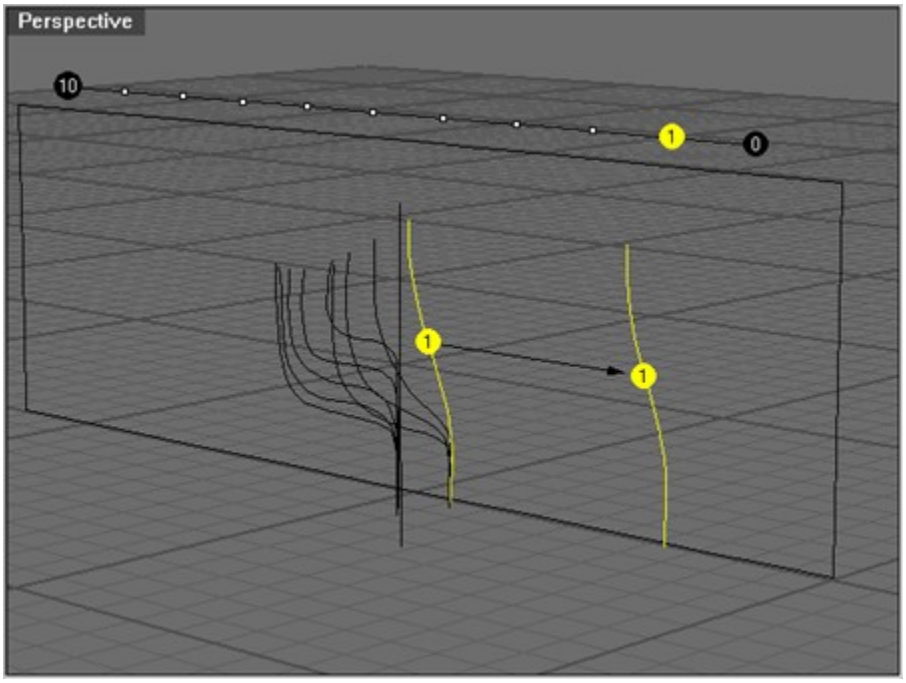


Save your file and continue with the curves you have (or open boat2.3dm)

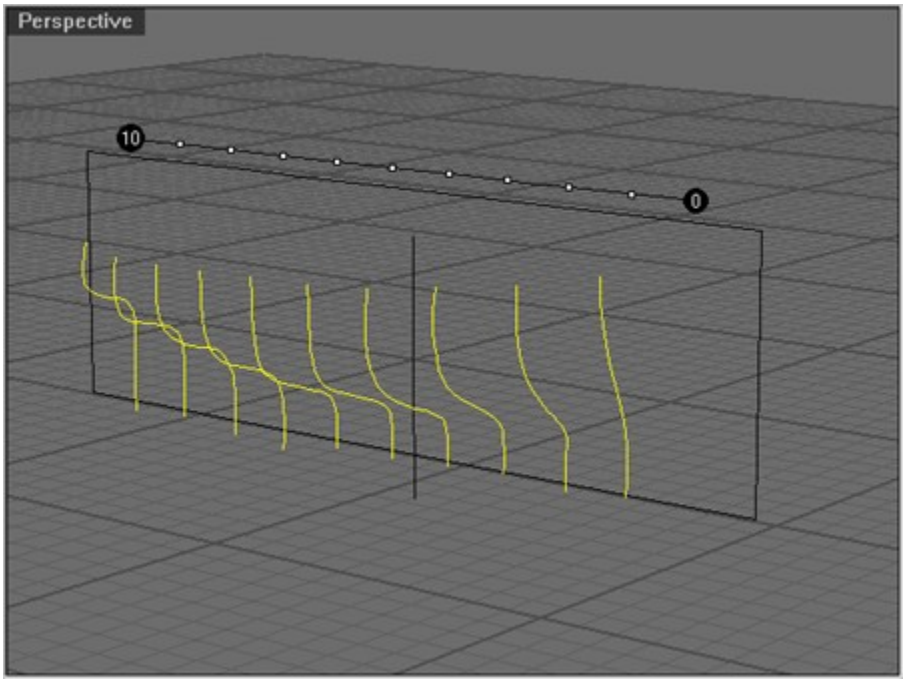
Maximize the front view and turn on layer 'divide'.

Draw a curve from 10 to 0, which is the approximate length of the hull. Select the curve and use the divide command curve/point/divide curve by/number of segments. Enter **10** when prompted for 'Number of segments'. This puts 9 points evenly spaced down the length of the hull.

In the perspective view, select the curve marked (1) below. Switch to the front view, hold down the Shift key (temporarily activating 'ortho' mode), and drag the curve horizontally to position it underneath the point labelled (1) below. NOTE: If you need to check your work at this point, turn on the layer named 'sample'.

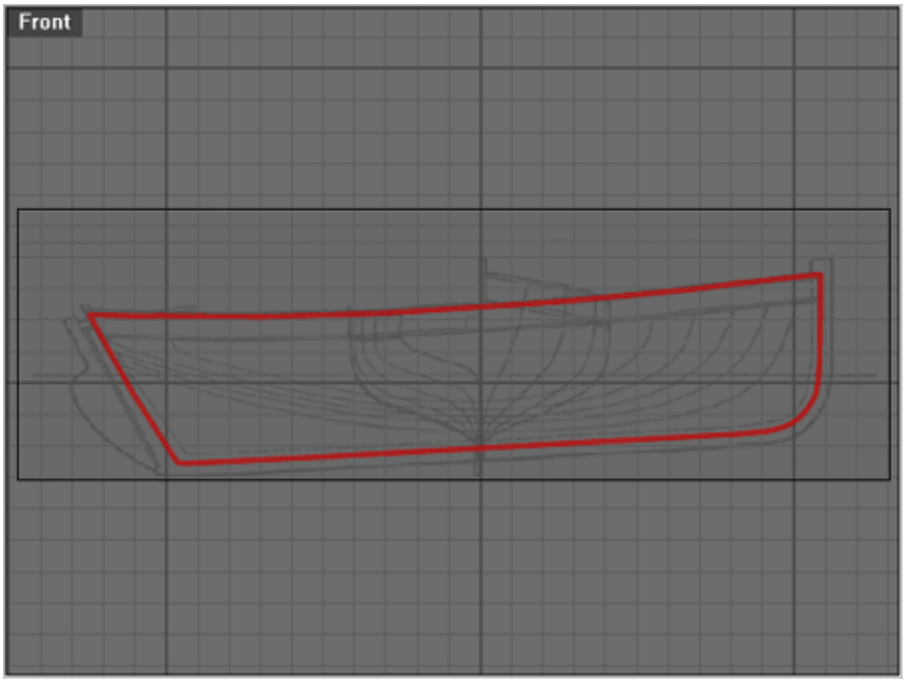


Continue distributing the remaining curves by moving each curve into alignment below its correspondingly numbered point, as shown below, and your results should resemble the image below..



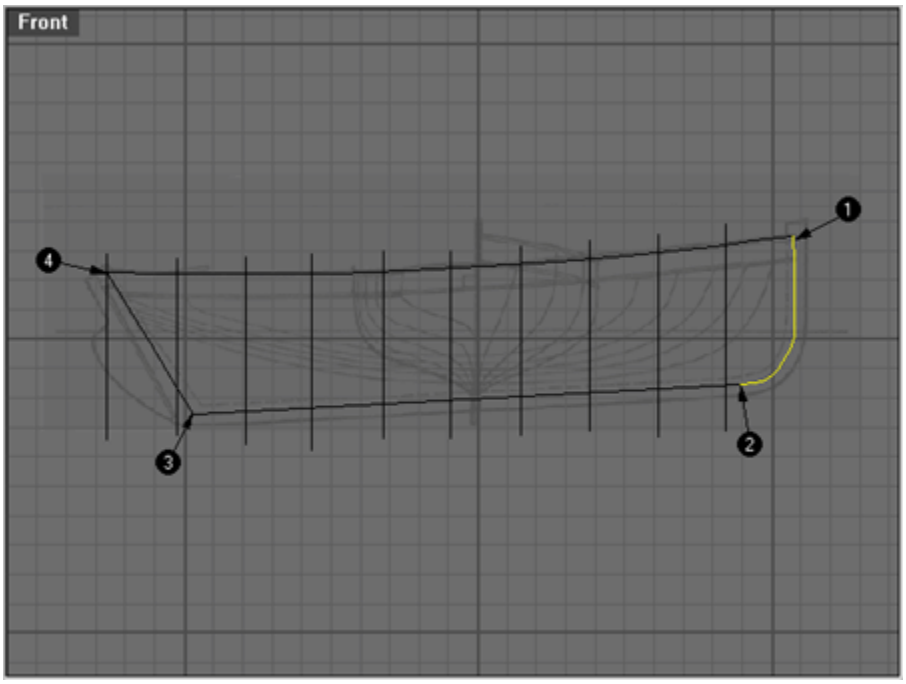
Don't forget that you have two lines close to, or on top of, each other at section 5 and 6. Delete 'sample' layer as well the annotate layers if you don't need them.

Save your file, and merge the b3.3dm file into your scene, or open boat3.3dm for a complete version.

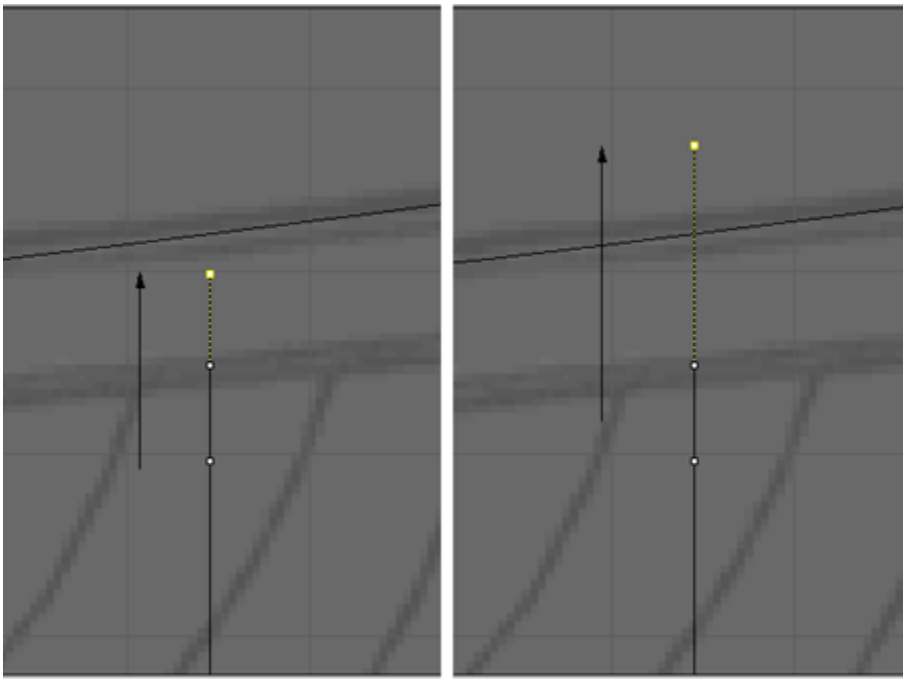


The red line in the image above indicates the object, line or curve that we are focusing on. With the front view maximized, and with end osnap on, draw a curve **InterpCrv** (Curve/freeform/interpolate points) from 1 to 2, tracing over the bow stem background line shown below.

Start another line from the end of the last line (2) and go to (3) and end the curve, repeat from 3 to 4 and 4 to back to 1. The image below shows the first curve drawn.

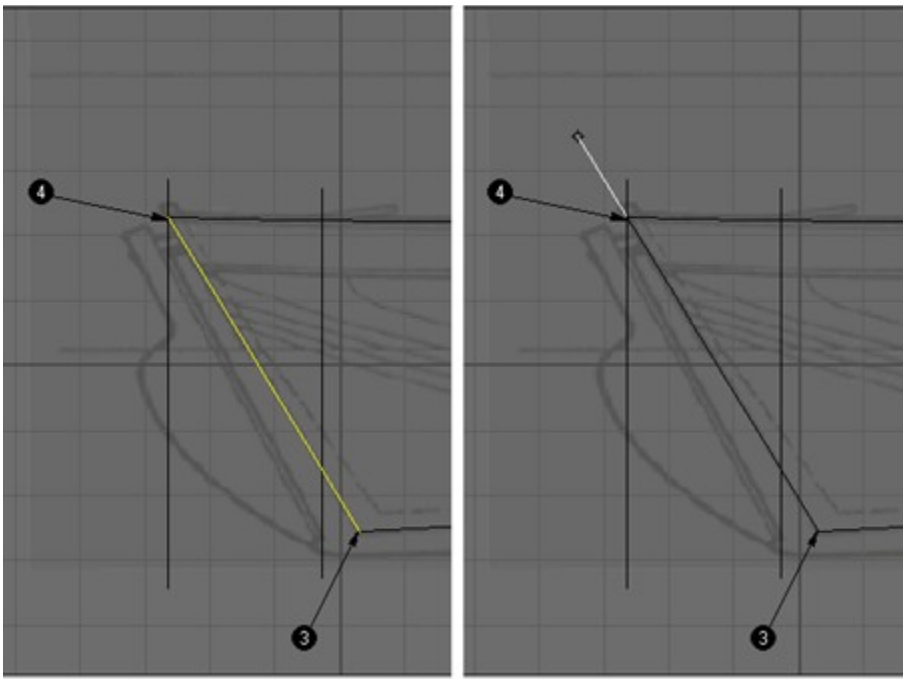


Use the top and bottom curves to trim off the tops and bottoms of the hull curves. The two curves to the left (9 and 10) do not need to be trimmed.
Note: If the section curves don't cross the outline curves, select the section curve and turn on the control points using **PtOn** (Edit/Point Editing/Control Points On). Now select the top CV and move it over the trim line, as shown below.



Delete the second to last curve (9). We don't need that curve, but we do need to make the last curve (10) angled to match the back end of the boat (transom or stern as it's called) which we will cover on the next page. Turn on the 'annotate curve numbers' layer to see the curve number if necessary.

Select the line (stern line that goes from 3 to 4) in the front view. Hit **Extend**, and when prompted 'Select Boundary Objects,' hit Enter (or spacebar.) When prompted to 'Select object to Extend,' select the curve and drag the end of the curve outwards, or enter **30** to numerically control the extension.



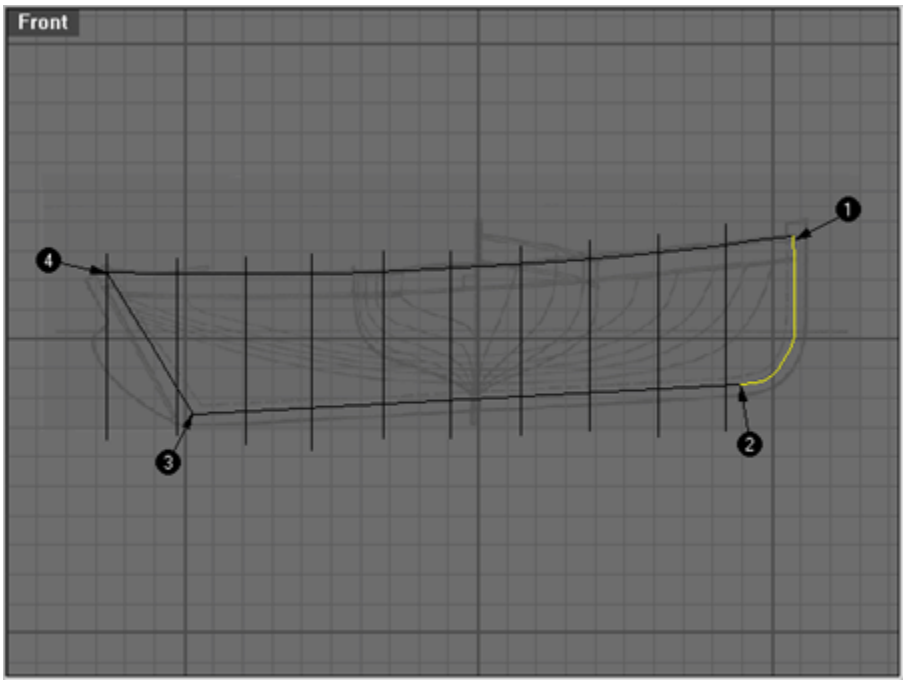
Hit **Extrude** (Surface/Extrude/Straight), and with the '**B**othSides' option activated, extrude the new plane wider than any of the curves in the right view.

Create a new layer, call it 'Transom,' and **ChangeLayer** the extrusion to that layer.

Go to the left view and select the curve and project **Proj** (Curve/from objects/Project) it onto the plane and hide the 'Transom' layer and save the file.

Save your file or open boat4.3dm

Select the bow curve (the curve highlighted below)

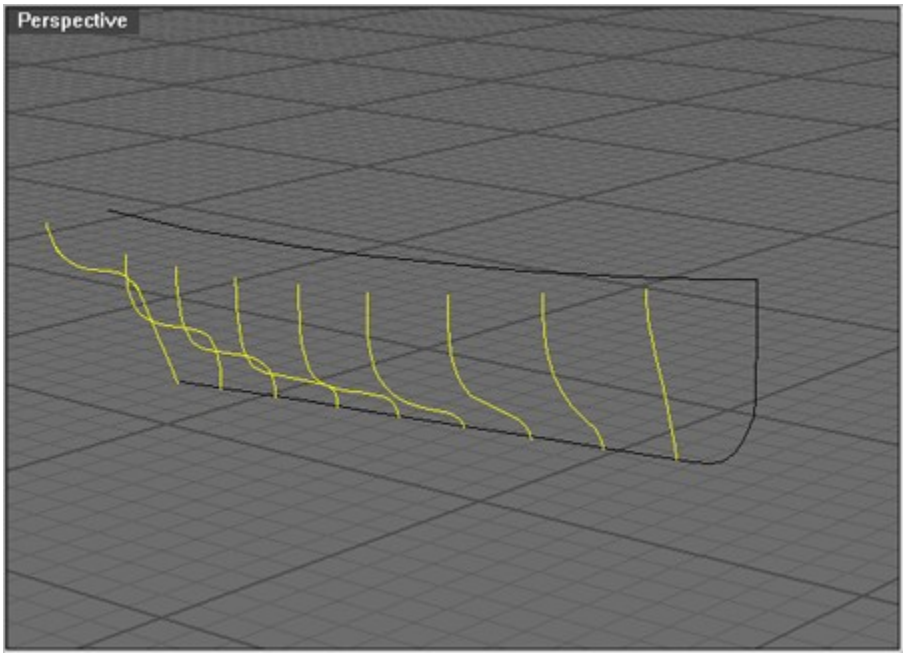


Rebuild (Curve/Edit_Tools/Rebuild) the bow curve with 12 points.

With the bow curve still selected, from the right view drag it to the left one snap (or **-2.5** units.)

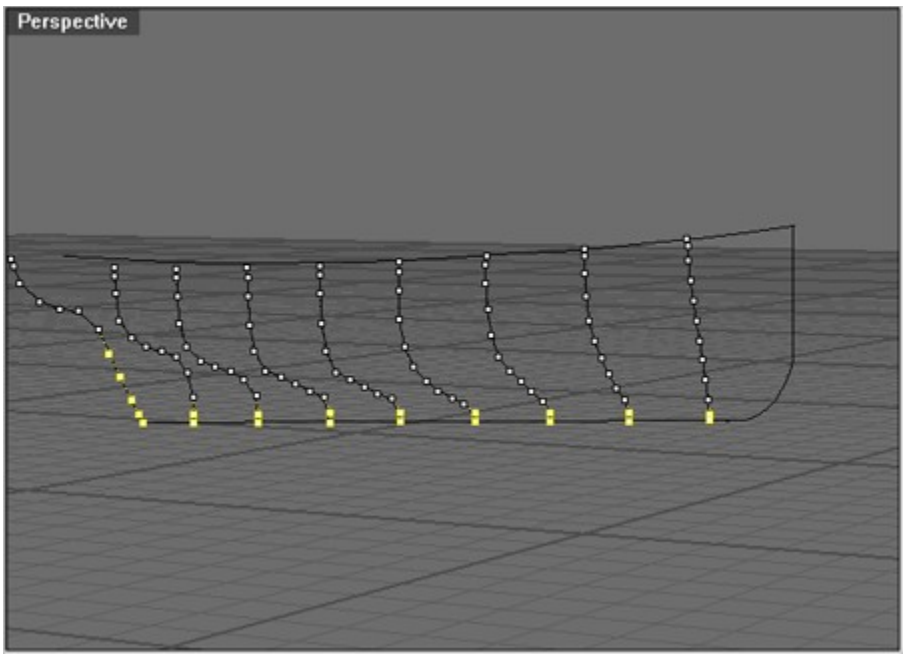
Overview: we need to keep the bottom and front edge of the hull **2.5** units away from the centerline to allow for the backbone of the boat to go down the center of the boat. This will be gone into in greater detail on Page 7.

From the right view, select the station curves and **Rebuild** them (using Curve/Edit_Tools/Rebuild) with 12 points. Select the station curves (1 through 10 below) and show CV's **PtsOn** (edit/point editing/Control Points On).

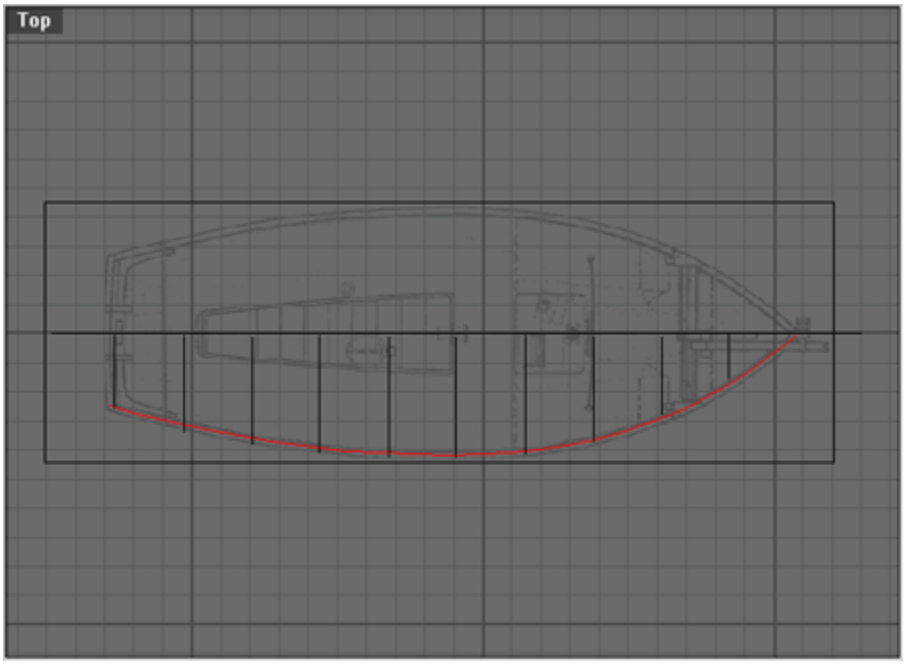


You now have the basic curves that you will need in order to shape the hull. However, they still need to be "tuned up" before they can be lofted to create a smooth hull surface.

Select the bottom two control points of each of the section curves shown below, and the bottom 5 of the transom curve, using **Lasso**. From the left view, turn on grid snap '**s**', and hit **SetPt** (with only Y checked off), then drag the points by **-2.5**.



Check out the top view and notice how the ends of the curves are not lining up with the middle of the background image rail (indicated by the red line below). To get a better visual reference turn the 'End' osnap on, and draw a **InterpCrv** connecting the top ends of the 'section' curves with a curve going the length of the boat.

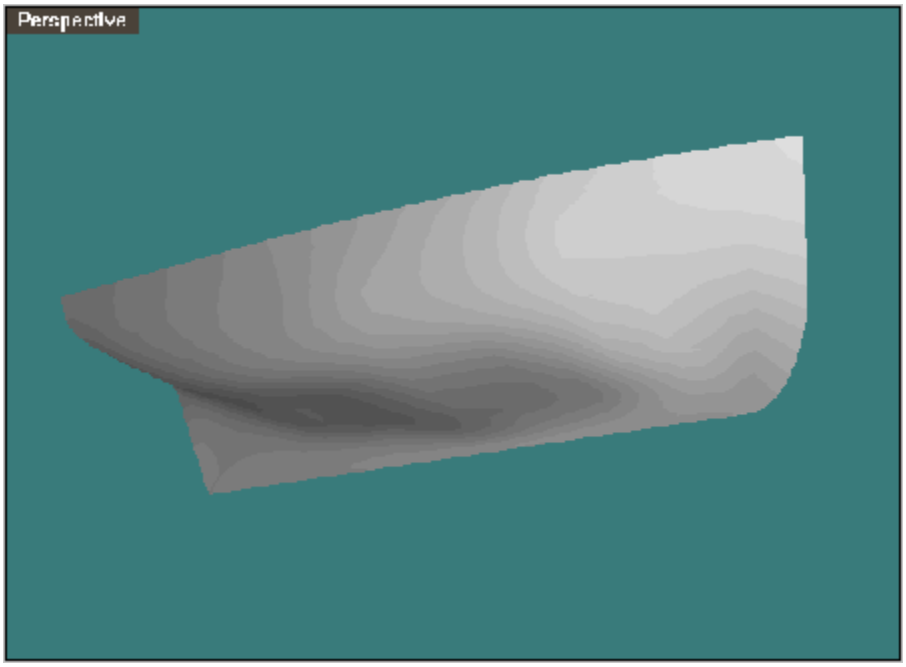


In the top view, select any curve that does not go all the way to the red line above, which marks a location in the middle of the rail. **Scale1D** the curves into place, being sure to snap the 'Origin point' to the end that is closest to the center line.

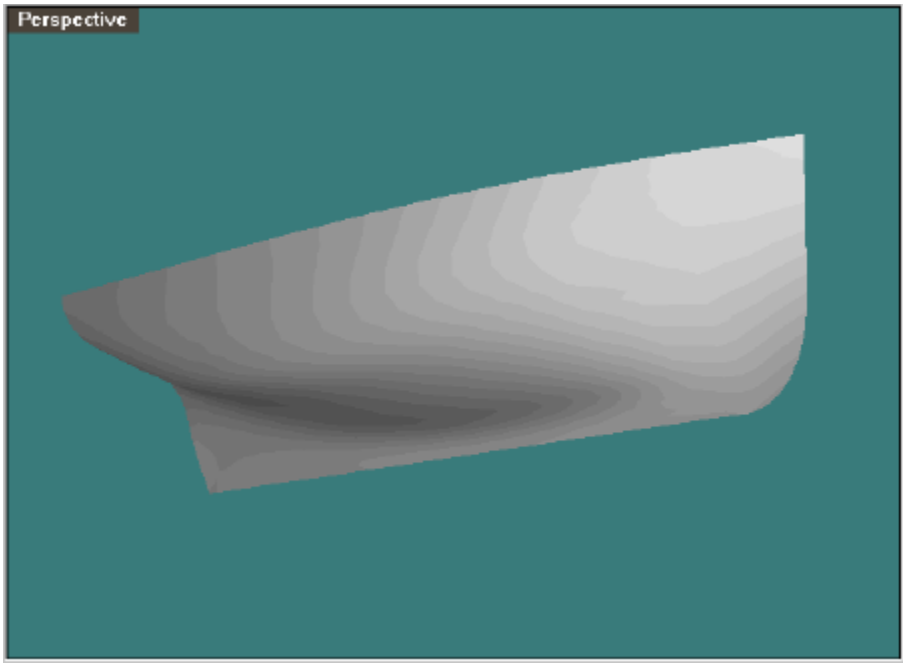
At this point you can continue with the tutorial or read the Optional Notes about 'visualizing the hull' surface and curves to check for errors.

> **NOTE:** Building the hull is the hardest part of building a boat or ship. You've been working since the beginning of this tutorial preparing for this Loft operation - now here's the big "payoff!"

Select all the section curves, including the bow, and hit **Loft.** Use a normal Loft, with 'Rebuild with 12 control points,' hit OK.

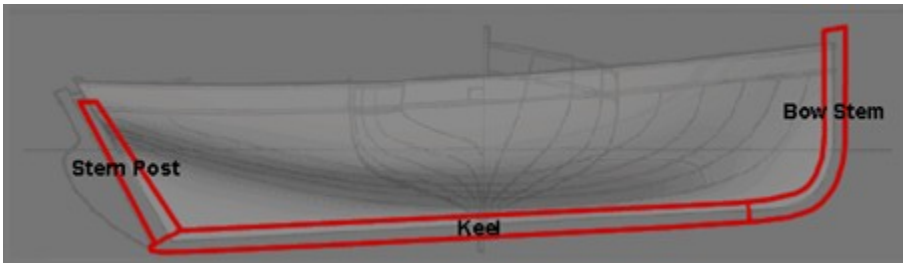


Well, check it out, to me it doesn't look too hot because there are shadows that indicate a uneven surface so let's give it the **RebuildSrf** treatment. Select the surface and hit **RebuildSrf** and make the settings 8 U and 8 V.



Congratulations - you've just completed the most difficult part of this tutorial. In the next section, we will finish the hull and add a deck and details.

Save your file and merge the b5.3dm file or open boat5.3dm

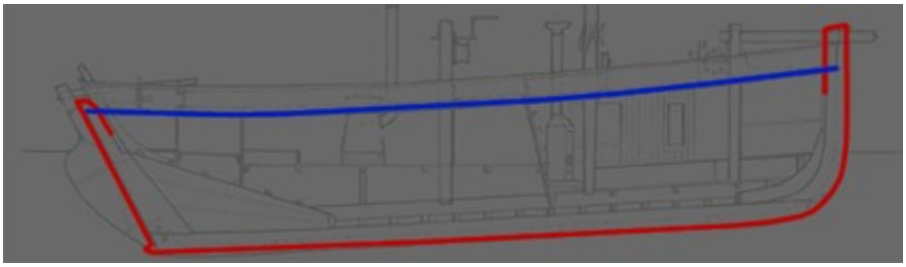


Together, the bow stem, the keel, and the stern post, shown above in red, form something like a "backbone" for the boat. The backbone area is a 5 unit wide center piece from the top view, and basically holds the boat sides and stern together. (Backbone is not technically a boat term, but it is a useful description. The timber used to make these three parts are also referred to as deadwood.)

Hit **SelCrv** and delete all of the curves, or make a layer and **ChangeLayer** the curves into the new layer. Finally, hide the hull surface.

Trace over the backbone (shown as a red line in the image below) referencing the arrows on the layer 'annotate3'. There is also a sample curve to use (or just to inspect for reference) on layer 'keel sample'.

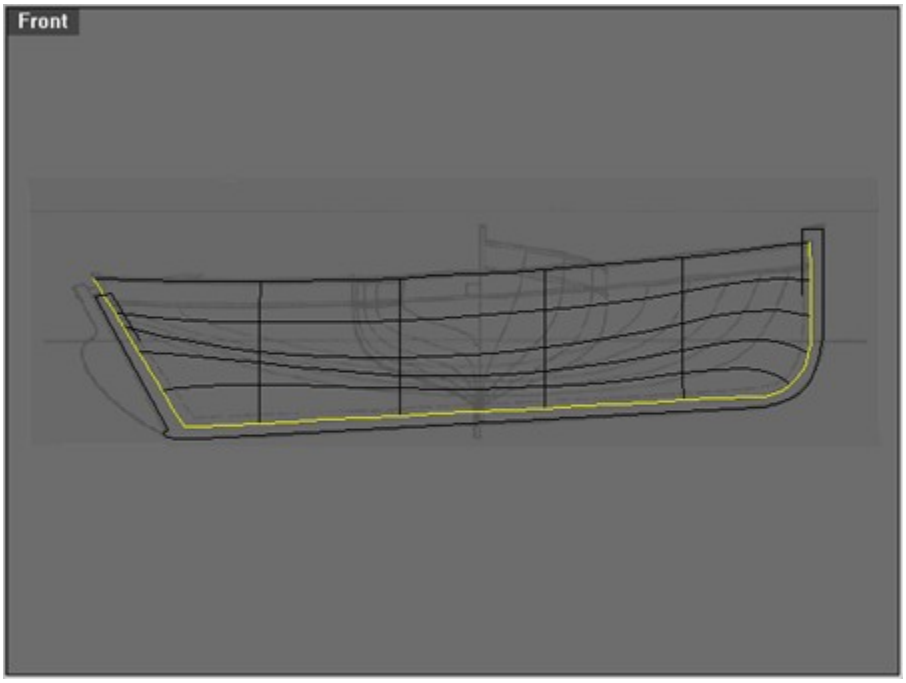
Use **InterpCrv** to trace over the background image curve indicated in blue below . This is just a temporary deck curve to be used for alignment in building the backbone.



Hit **Show** to show the hull.

On this page, the hull edges and deck will provide the curves needed to finish the "backbone."

Duplicate the edges **Dupedge** (Curve/From Objects/Duplicate Edge) of the hull, as shown below.

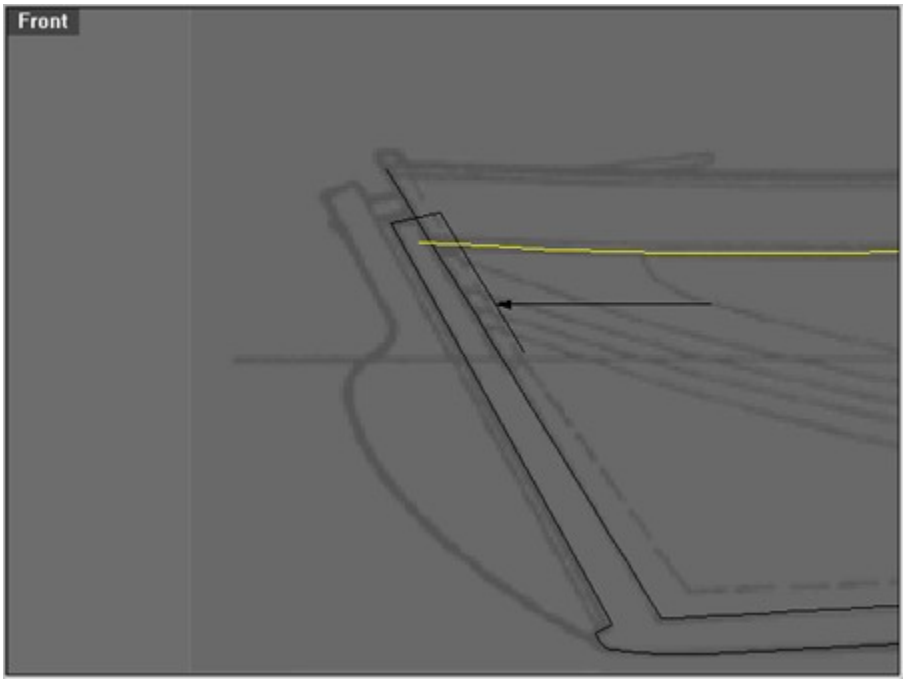


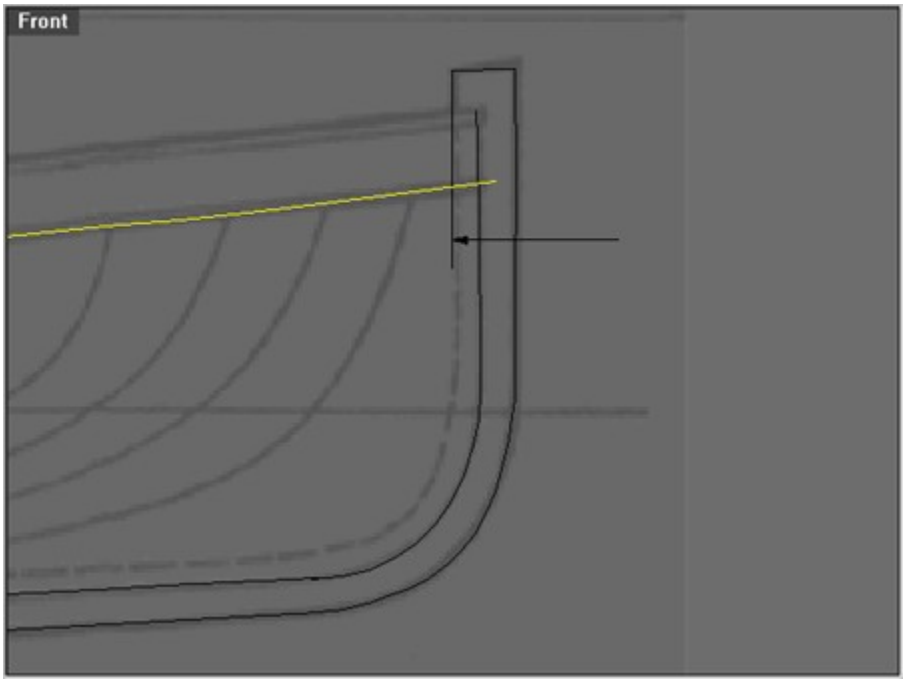
From the front view, project the dupedge curves to the construct plane **ProjCp** (Transform/Project to CPlane). This will put all the curves needed on the construction plane.

The following steps will show how to trim the curves:

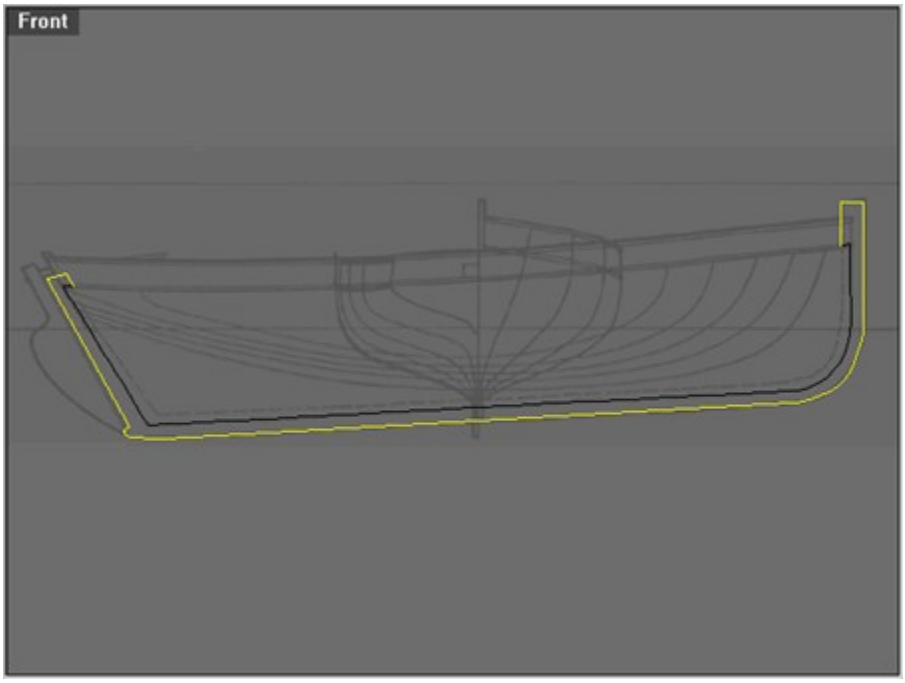
Select and **Hide** the hull using Edit/Visibility/Hide.

Hit **Trim**, select the deck curve as the cutting object, and trim off the pieces indicated by the arrows below.

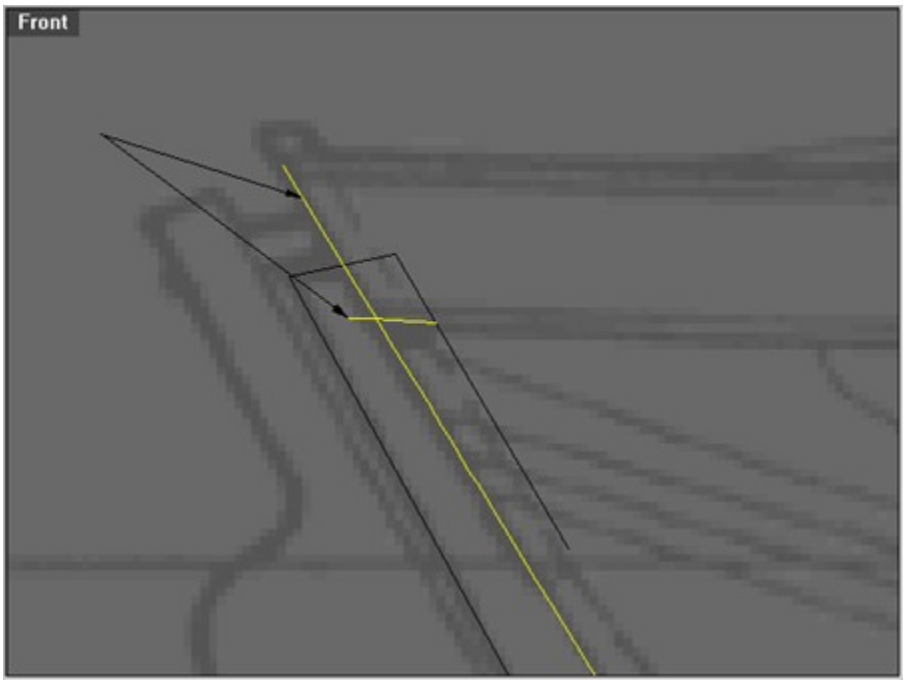


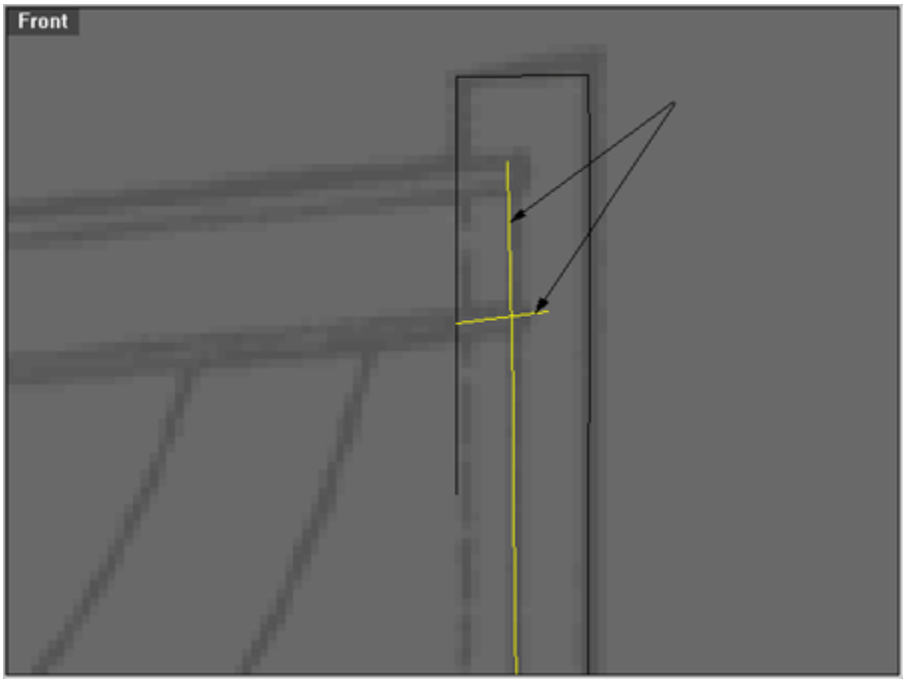


Hit **Trim** again, select the outside backbone curve shown highlighted below, and select the center part of the deck curve for when prompted for the curve to trim. The figures below shows that two "tails" are left at each end of the deck curve.

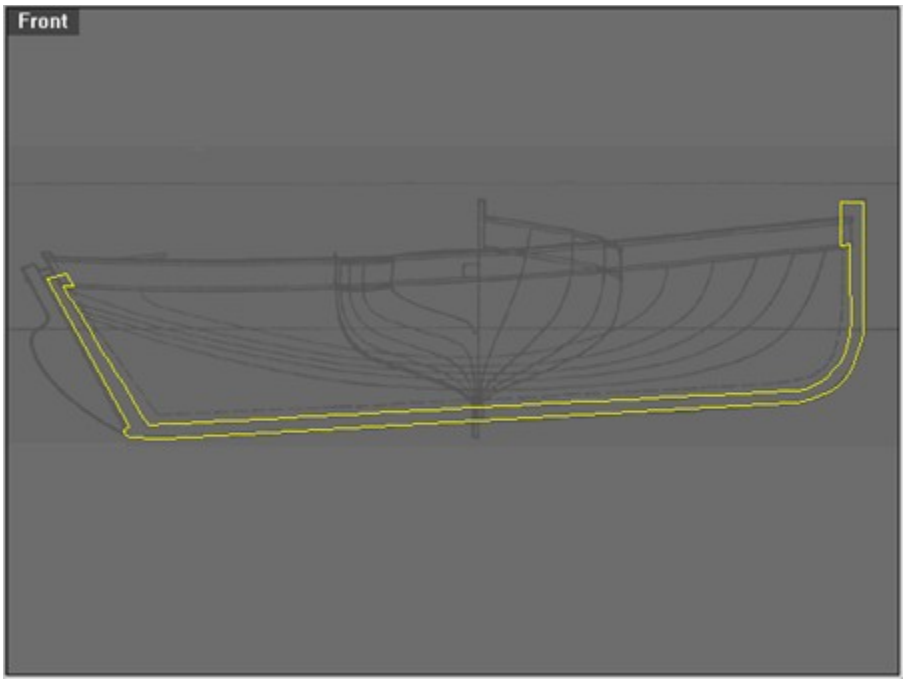


Hit **Trim** again. This time, select the two curves shown below as the cutting objects, and then trim off the ends indicated by the arrows.





You should now have the curves highlighted below:



In the front view, select the new curves, and hit Join. Select the joined curve and hit Extrude '**C**ap=Yes' type 'c' to select the cap option, 'b' to activate the '**B**othSides' option, and finally enter **2.5** as the '**D**istance'.

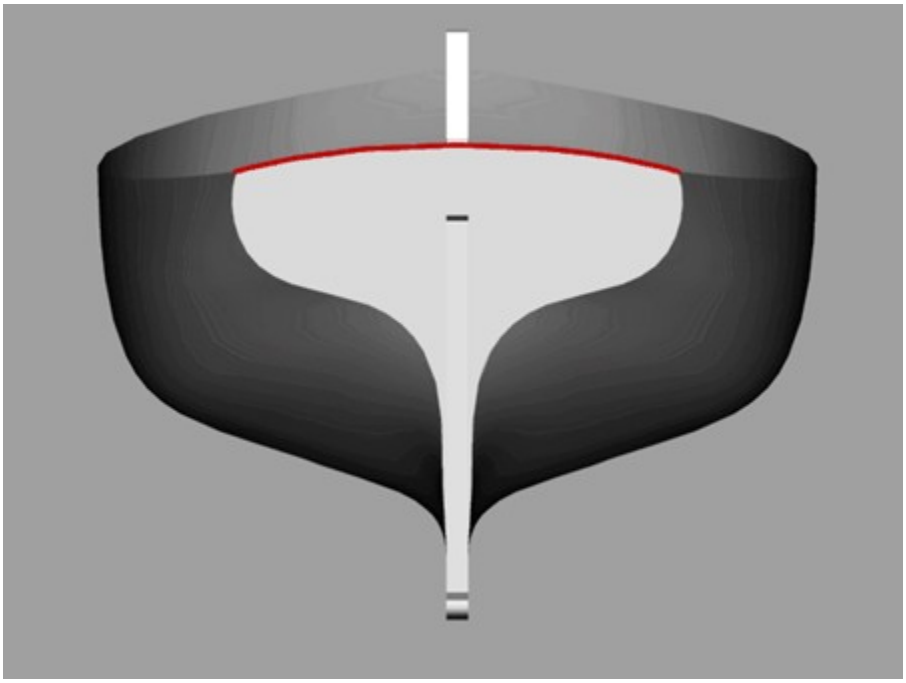
> **Note:** If you don't see a cap option, it means that the original rudder curves you made did not snap to each other's ends to form a enclosed area. Check the curve corners to see if they meet exactly end to end.

That completes the backbone of the boat.

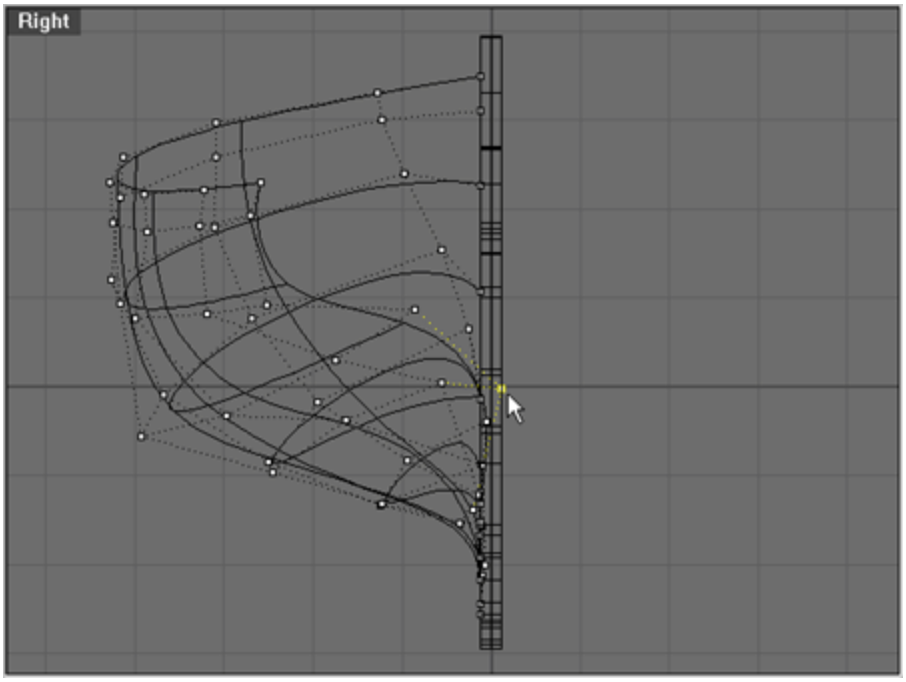
Save your file, and merge the b6.3dm file or open boat6.3dm

The 'transom' is the rear panel of the boat, shown in white below. The red line below indicates an

important curve that forms the top of the transom, running from one side of the hull to the other.

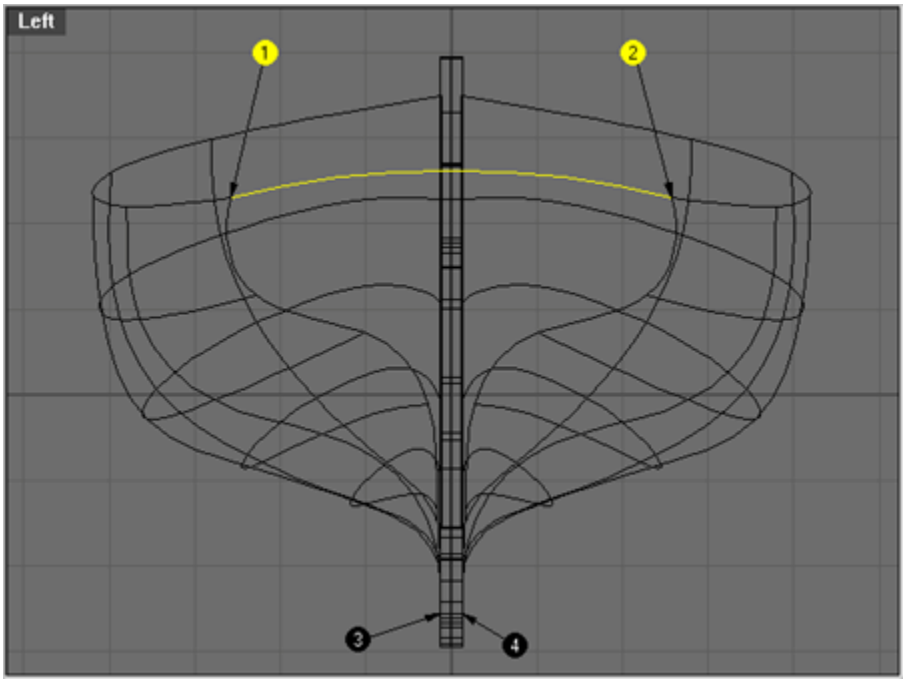


In the right view, select the point shown below and drag it about **5** units to the left. The hull is now prepared for a mirror operation.



From the right view, select the hull, hit **Mirror**, and enter '0'. Hold down the Shift key (to temporarily activate **Ortho**), move your cursor straight upwards, and click to define the end point of the axis of reflection. The mirrored result is shown below.

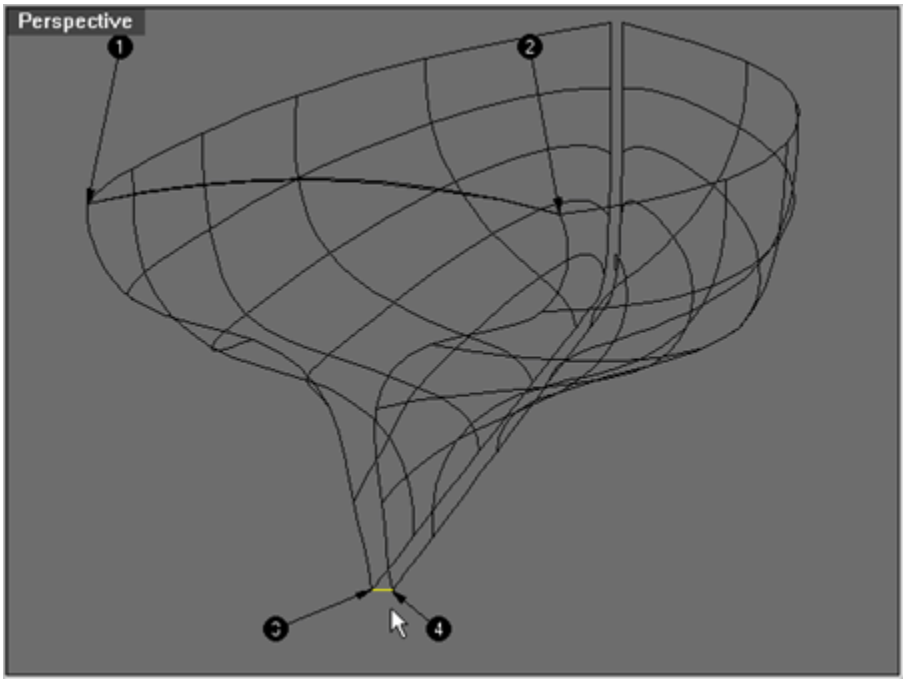
Turn on the layer annotate4, turn on the 'End' osnap, and turn on 'Planar'. Use the **InterpCrv** command to draw a 3 point curve between the points labelled (1) and (2) below. Position the middle point on the center axis, slightly above the height of the end points.



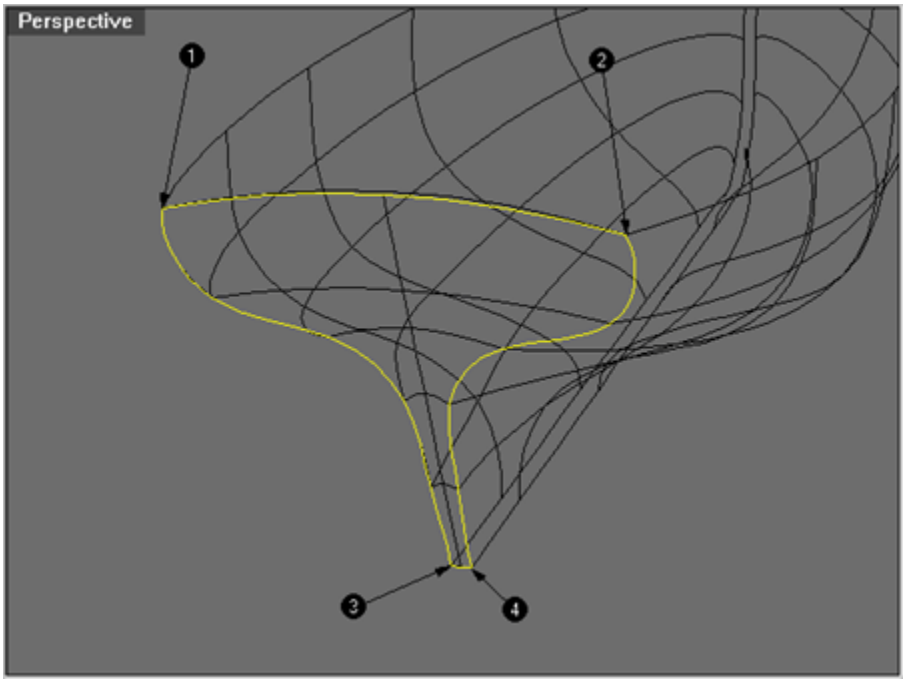
Turn on the transom layer. From the right view, **Project** (Curves/From Objects/Project) the curve you just drew onto the plane from the transom layer. Hide the transom layer.

Select the source curve from the previous projection and **ChangeLayer** it to the transom layer.

Hide the Keel, and draw a curve between the points labelled (3) and (4) below, to connect the the bottom of the hull sections.

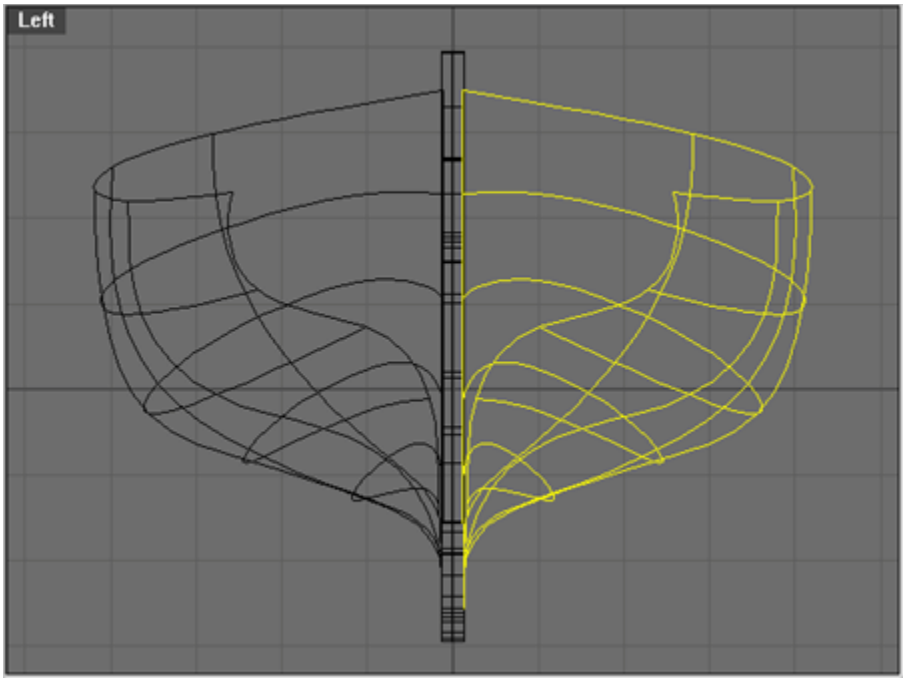


Hit **EdgeSrf** (Surface/Edge Curves), and select the four curves that make the transom as shown below.

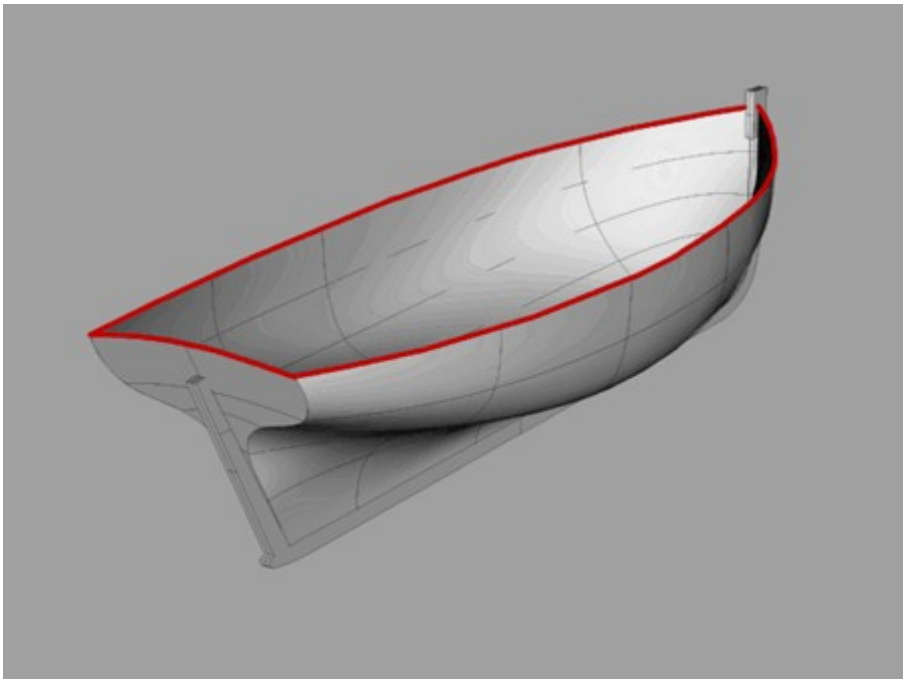


The hull is now complete.

Optional: There are other approaches possible to building a hull. For example, you could continue to smooth the hull by using **SrfMerge** (Surface/Edit Tools/Merge) between the sides and the transom. Click here if you want to see some other interesting approaches to modeling hulls.



The red line in figure below indicates the surface edges of the hull. The steps on this page will show how to create an elliptical rail following this outline.

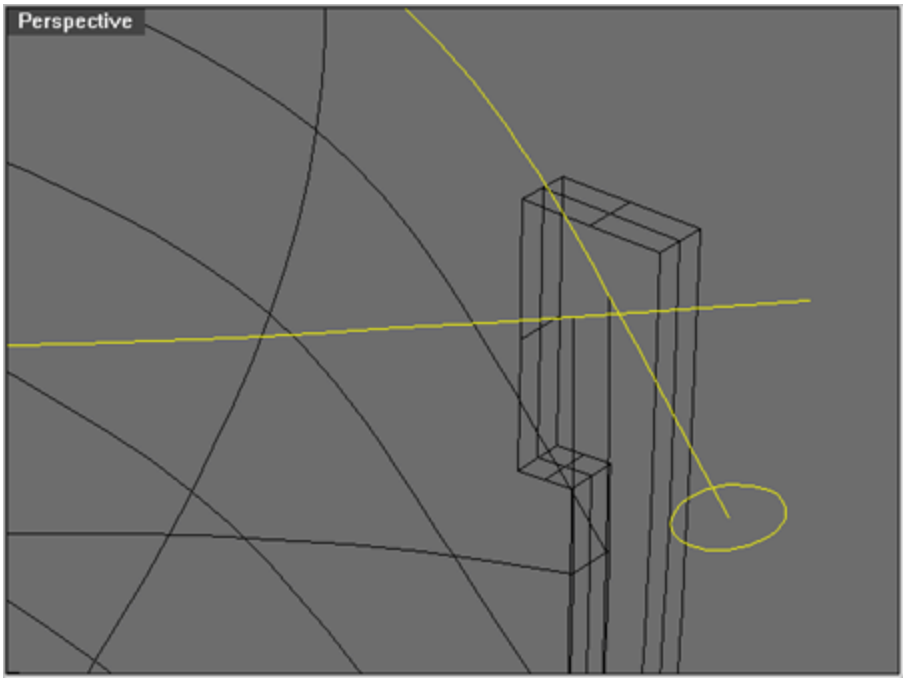


DupEdge (Curve/From Objects/Duplicate Edge) the top of the hull sides. There is already a curve at the top of the transom, so select and **Join** the three curves.

Maximize the perspective view.

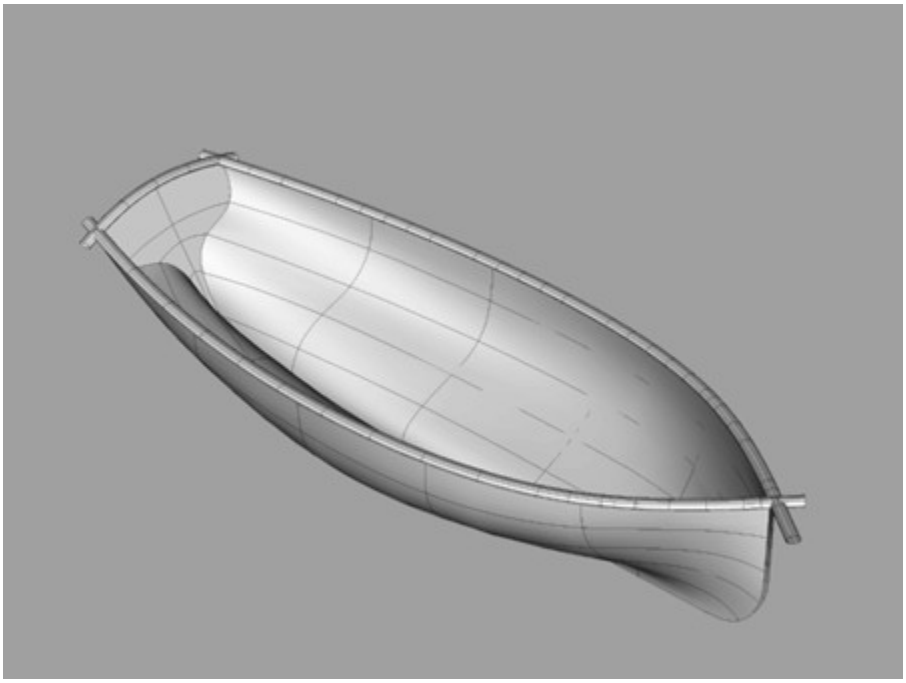
The two rail curves need to extend far enough to be trimmed back using the bow stem as the cutting object. Use the **Extend** (Curve/Extend/Extend Curve) command on the rail curve at the bow. At the 'select boundary edges' prompt, hit Enter. At the 'Select object to extend' prompt, select the rail curve and pull a line out off the end of the rail curve.

Put an **Ellipse** (Curve/Ellipse) near the end of the rail, use the '**A**roundCurve' option (A) and hit Enter. Drag the width, or numerically specify the width by typing **4**, and then enter **2.5** as the height of the rail.



Select the edge curves, and the curve that is at the top of the transom, and hit **Join**.

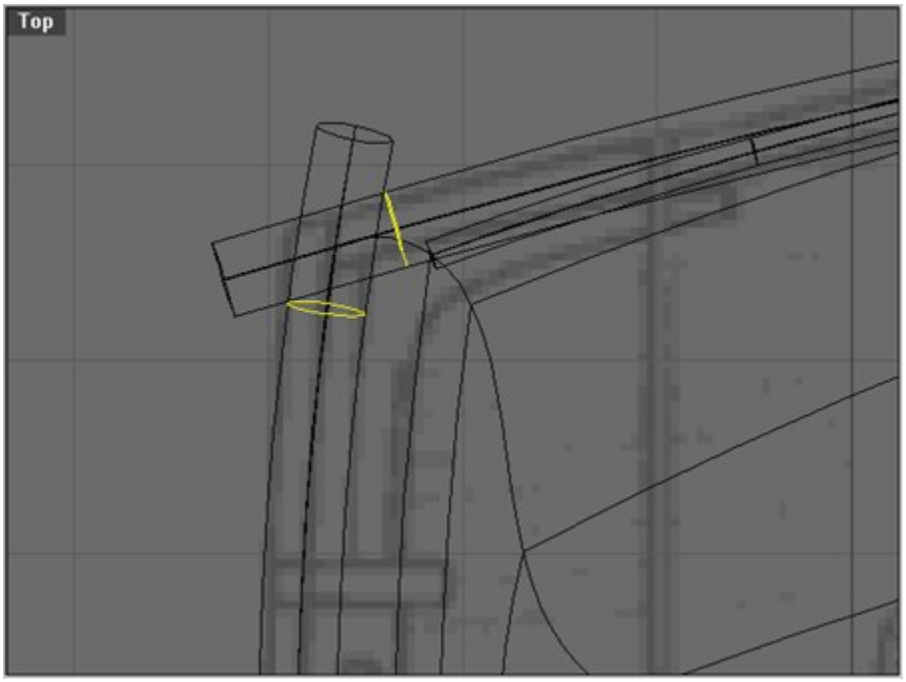
Hit **Sweep1** (Surface/Sweep 1 Rail) and select the rail as the path and the ellipse as the cross section curve. Use the 'Roadlike-top,' and 'Refit within .01' options. Notice that the rails extend beyond the top edges of the hull.



Select the two long rails and hit **RebuildSrf**. Give the rebuilt surface 10 U point and 4 V points.

Select the shorter transom rail and **RebuildSrf** it with 3 U and 4 V.

Go to the top view and zoom in on one of the stern corners.Select the stern rail and hit **ExtractIsoparm** '**D**irection=V' and extract an isoparm from the stern rail where it meets the side rail. Extract an isoparm from the side rail the same way as shown below.



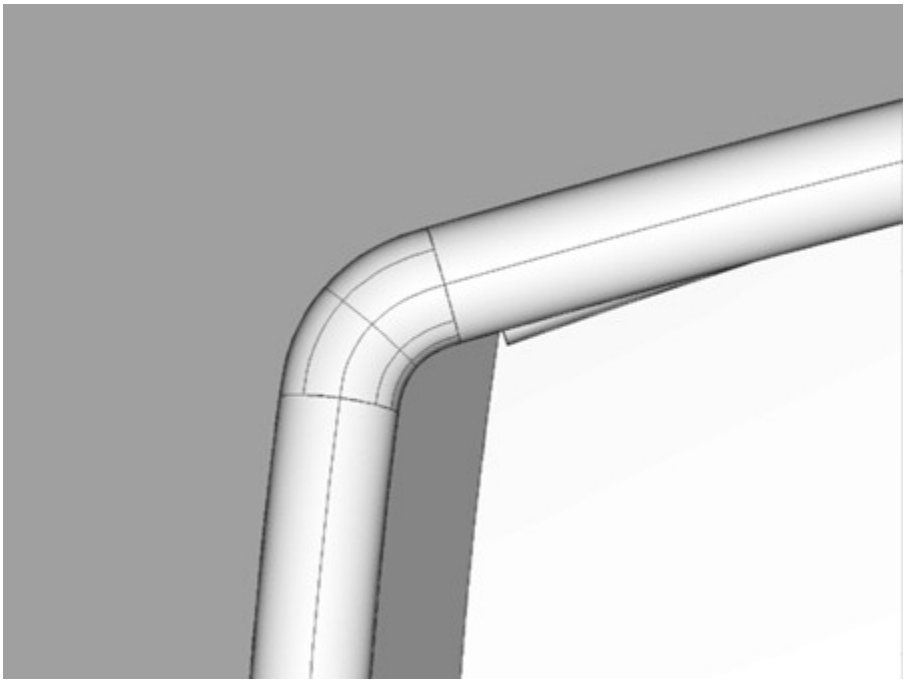
Split off the ends of the rails with the extracted isoparm and **Emerge** (Analyze/Edge_Tools/Merge Edge) the edges.

Check out Options/Units and make the 'Absolute tolerance' **0.1**.

> **NOTE:** The Absolute tolerance is an important adjustment that can influence the quality and the efficiency of your models. If you set the absolute tolerance to a higher number, such as 0.5, then the higher number would actually produce a lesser degree of accuracy, and the edges might not be perfectly fitted together. Conversely, if you were to make the tolerance too exacting, for example by using a setting of 0.01, it could create an unnecessarily dense surface. As a general rule of thumb, you will often find it most efficient to use a higher number for the absolute tolerance when building fillets, and use a lower number when creating blends.

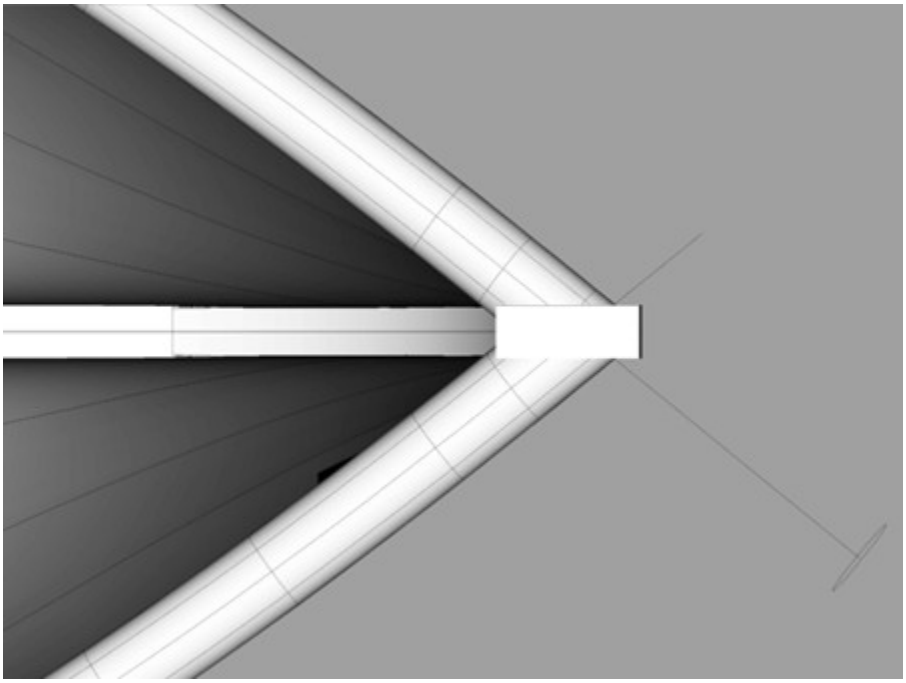
Delete the small ends of the rail and also delete the curves that were used for splitting.

Blend between the two rails: be sure to flip one the directions by entering **F**, and clicking on one of the points.



Hit **Show**, zoom in on the bow, and use the **Split** command. When prompted to 'Select objects to split,' pick one of the two rails. When prompted for the cutting object, select the keel.

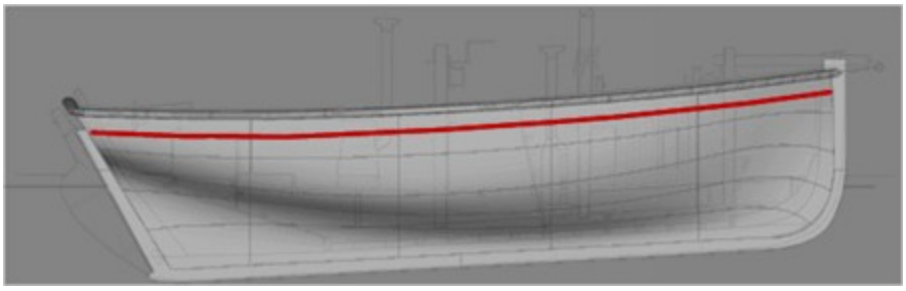
Repeat on the other rail.



The rails are now complete. Be sure to save your work before continuing.

Save your file and merge the b7.3dm file or open boat7.3dm

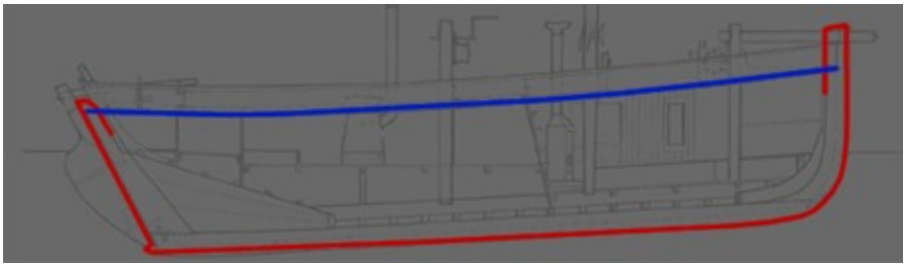
The red line below shows the edge of the deck, which is where the **rub rails** go. Rub rails are lower exterior rails that serve as a sort of side bumper for boats.



Turn on the 'picture frames' layer and replace the sections.jpg with the side.jpg using **PlaceBackgroundBitmap** (View/Background Bitmap/Place) and then turn off the layer.

Turn on layer 'annotate5' and trace over the #1 curve in the background image and trim it off at the hull ends.

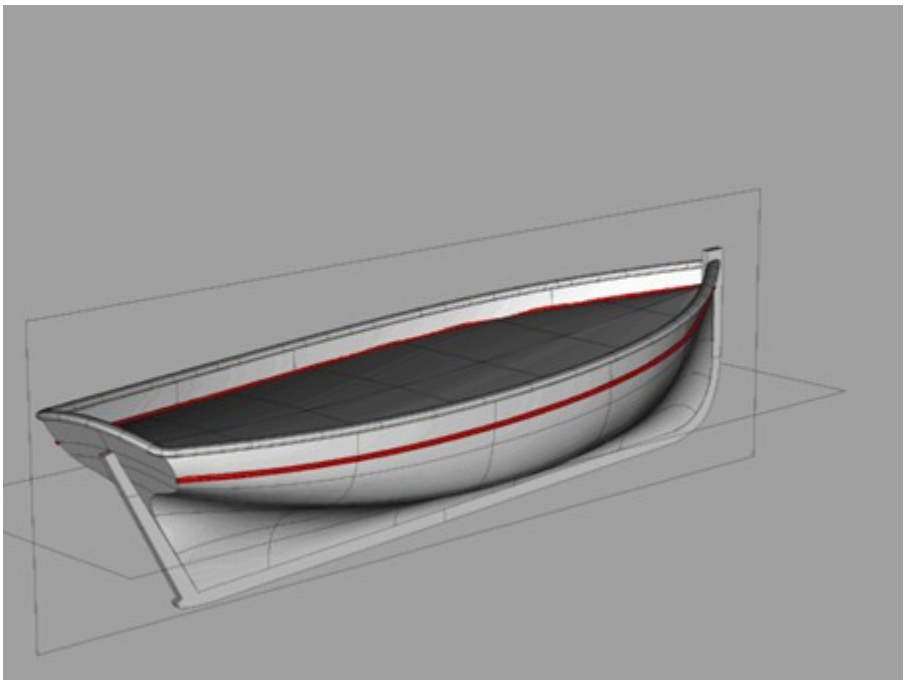
> **NOTE:** The curve #1 in the background image may be difficult to see, because several areas of the curve are poorly reproduced on the blueprints. This curve runs down the middle of the boat (from the top view) and forms the crown or curvature of the deck.
>
> **Note:** Line #2 is the same line we made earlier and forms the edge of the deck from where we jumped ahead in the backbone construction section. Refer to the blue line shown below.



Trace over the #2 curve and **Trim** it off at the hull ends.

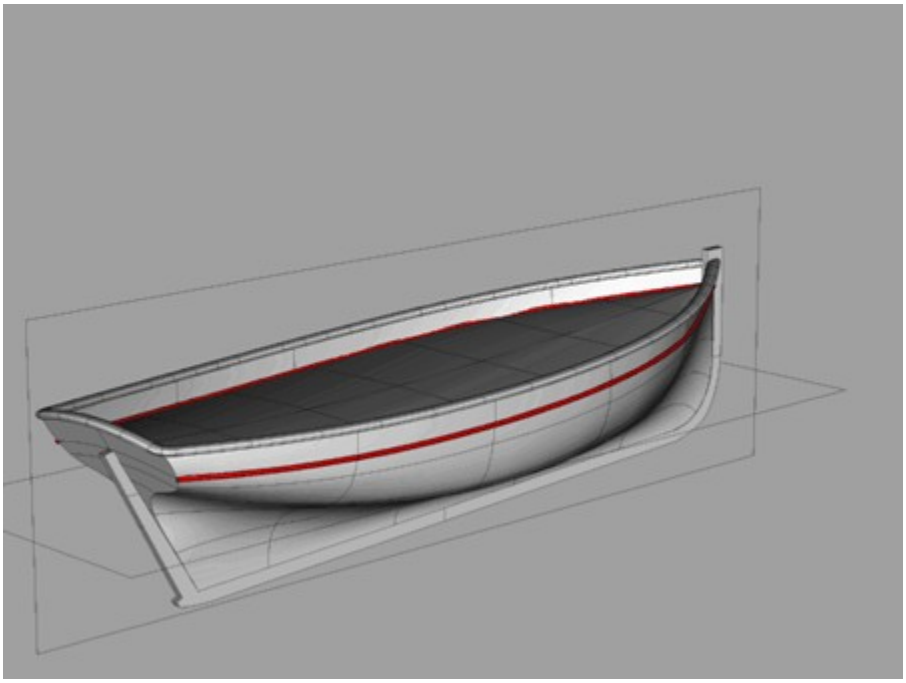
Project it to both hull sides.

Select the three curves and **Loft** with normal and 'Rebuild with 8 control points' as shown below.



Save your work

The red line below indicates the location where a protective "rub rail" will be built.



Select the **Pipe** (Solid/Pipe) command, click on the edge of the deck and use a value of **1.5** for both the beginning and end radius.

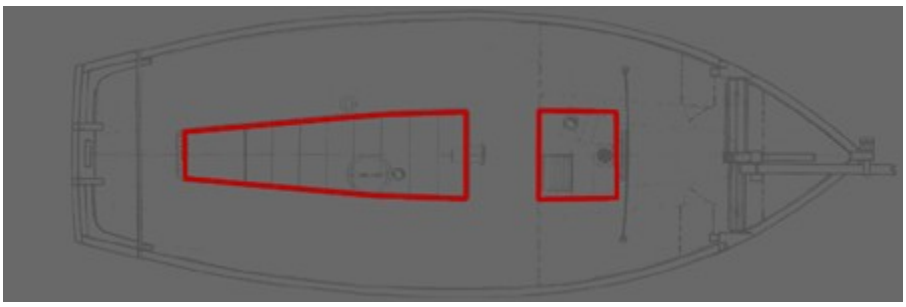
A boat could actually look this way, but the pipe currently ends rather abruptly at the bow stem. As an alternative to the first method, you could **Dupedge** the side of the deck and **Extend** (Curve/Extend/Extend Curve) the curve until the pipe ends inside the bow stem.

> **NOTE:** Capped pipes can create a lot of mesh geometry if the cap is joined to the pipe. If you are exporting the boat as a mesh, explode the pipes first, but don't delete the caps.

Create a new layer with the name 'rails' and **ChangeLayer** the rub rails to that layer.

Save your work. The hull and deck are complete.

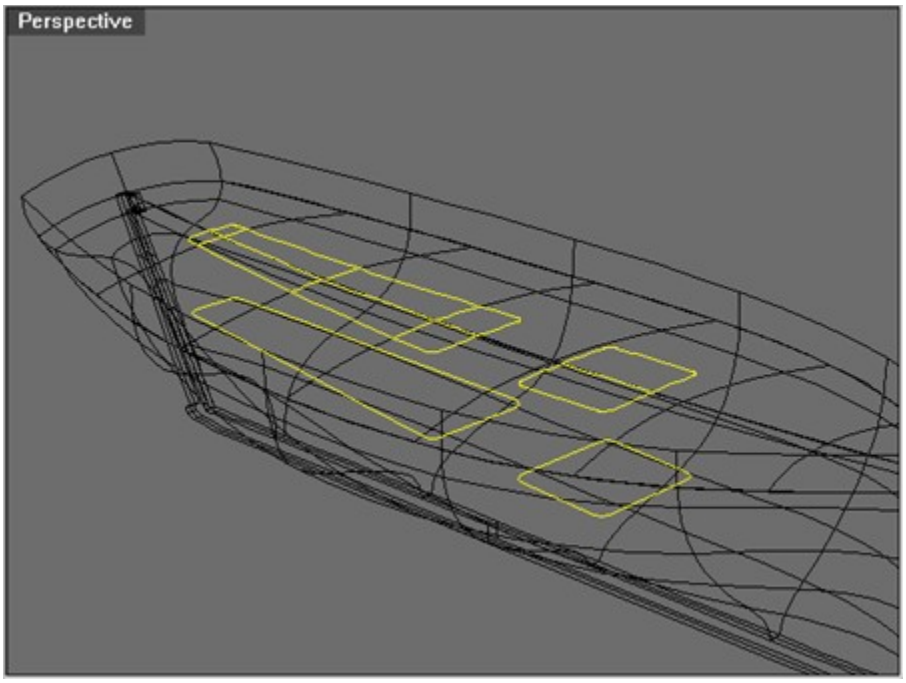
Save your file and merge the b8.3dm file or open boat8.3dm. The file b8.3dm contains many of the curves used to create the deck detail objects on the 'deck details' layer, and are there for reference or **use** at any time.
The red lines shown below indicate the cabins going by the plans.



Draw rectangles around the cabins, and on the left-hand cabin turn on CV's and **Scale1D** (Transform/Scale/Scale 1-D) the left most points towards the center. **Explode** (Edit/Explode) both the rectangles and **Fillet** (Curve/Fillet) the corners with a '**R**adius' of **4**.

From the perspective view hit **Split** the deck with the filleted rectangles.

> **NOTE:** The curves don't actually have to be on the deck surface to get a **Split**. Projection from the construction plane is automatic, so since the CPlane in the Perspective view is the same as the Top view you can split the deck with the curves from the perspective view as shown below.



Important Note: It is necessary to **ShrinkTrimmedSrf** (Surface/Edit Tools/Shrink Trimmed Surface) the cutout part of the surface before you **ExtrudeSrf** (Solid/Extrude Surface) them up to the height of the rail. To see what **ShrinkTrimmedSrf** does, select the cabin top and control points **PtsOn,** notice that the control points go all the way out to the edge of the deck, defining a larger surface than is needed. Turn off the points, use **ShrinkTrimmedSrf,** and note that the geometry will be cleaner and less likely to give you bad objects (**SelBadObjects)** after filleting.

Select the trimmed deck surfaces and **ExtrudeSrf** (Solid/Extrude Surface) with '**C**ap=Yes' option and drag them up to the height of the rail.

Explode the new cabins and **Delete** the bottom surfaces.

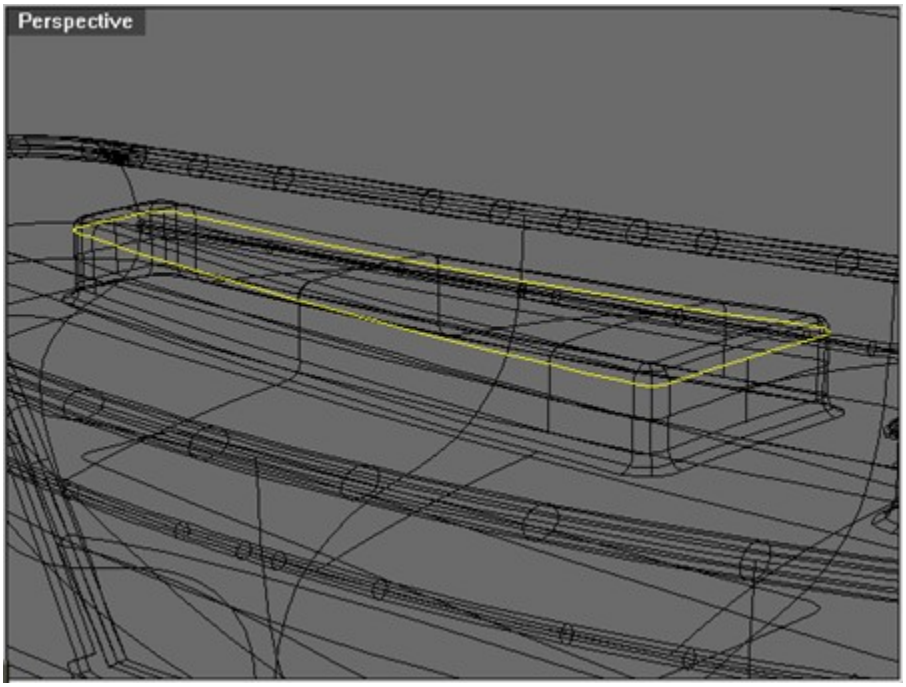
Select the cabins and the deck and hit **JoinSrf**.

Hit **FilletEdge** (Solid/Fillet Edge) the tops with a '**R**adius' of **3**.

Hit **FilletSrf** (Surface/Fillet) where the cabins meet the deck with a '**R**adius' of **3**.

> **Note:** To check for mistakes, hit **SelectBadObjects** (Analyze/Diagnostics/Select Bad Objects) after making fillets.

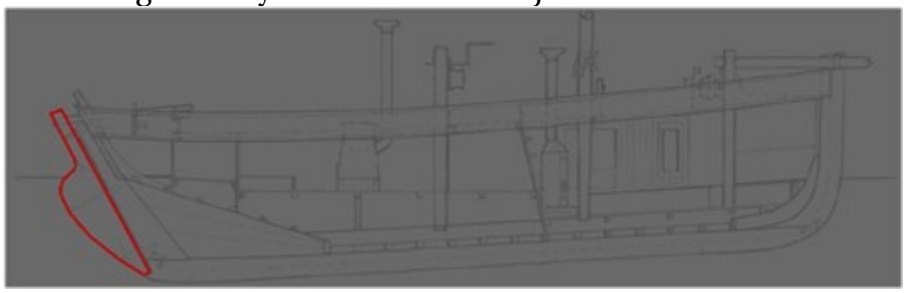
Put a **Pipe** (Solid/Pipe) on the lower edge of the fillets with a **1** '**D**iameter' shown below.



Select the cabin rails and **ChangeLayer** them to the 'rails' layer.

Save your work.

Modeling the rudder may be difficult because of the tight corners, which can sometimes create bad geometry when used in conjunction with a fillet.

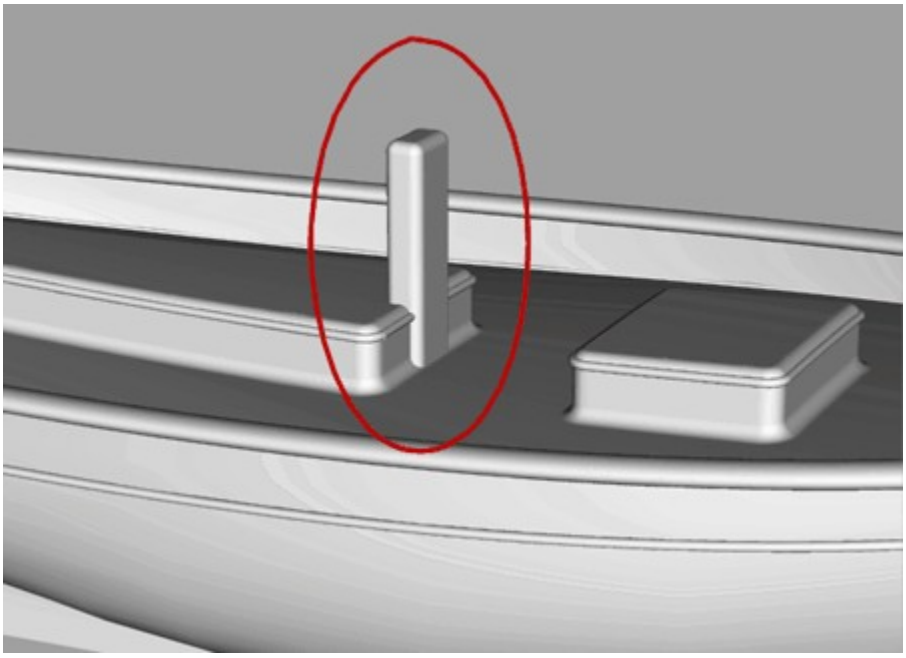


In the front view, zoom in on the rudder and trace over the background curve indicated by the red line above. Use a **PolyLine** for most of the curves, an **InterpCrv** for the left curve, and then use **Fillet** with a radius of 2 on the sharp corners.

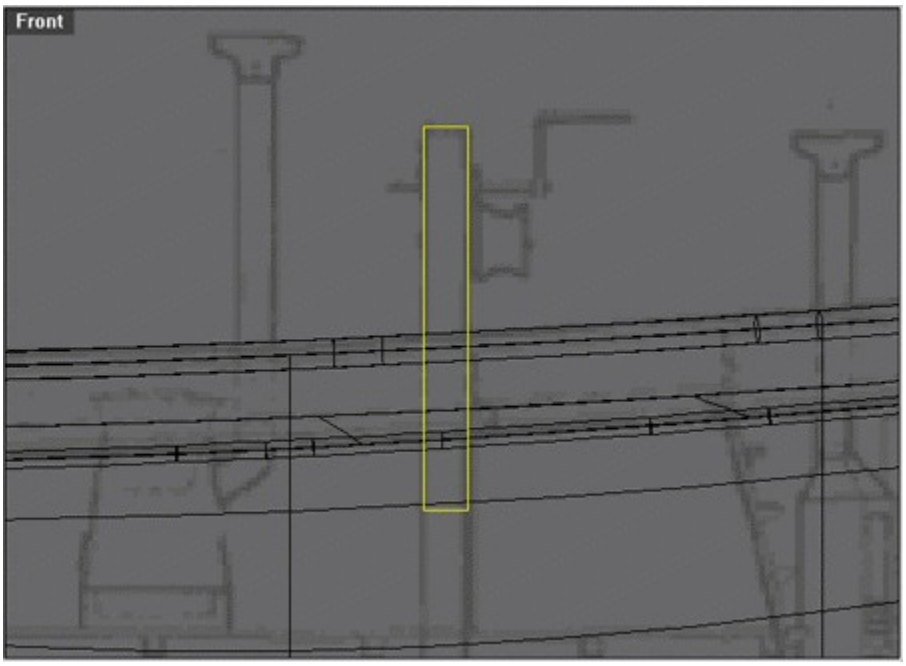
Extrude (Surface/Extrude/Straight) with the '**C**ap=Yes' and '**B**othSides' option activated and type in **2**, which will give a thickness of 4.

> **Note:** If you don't see a cap option, it means that the original rudder curves you made did not snap to each other's ends to form a enclosed area. Check the curve corners to see if they meet exactly end to end.

FilletEdge the rudder with a '**R**adius' of **1.5**.

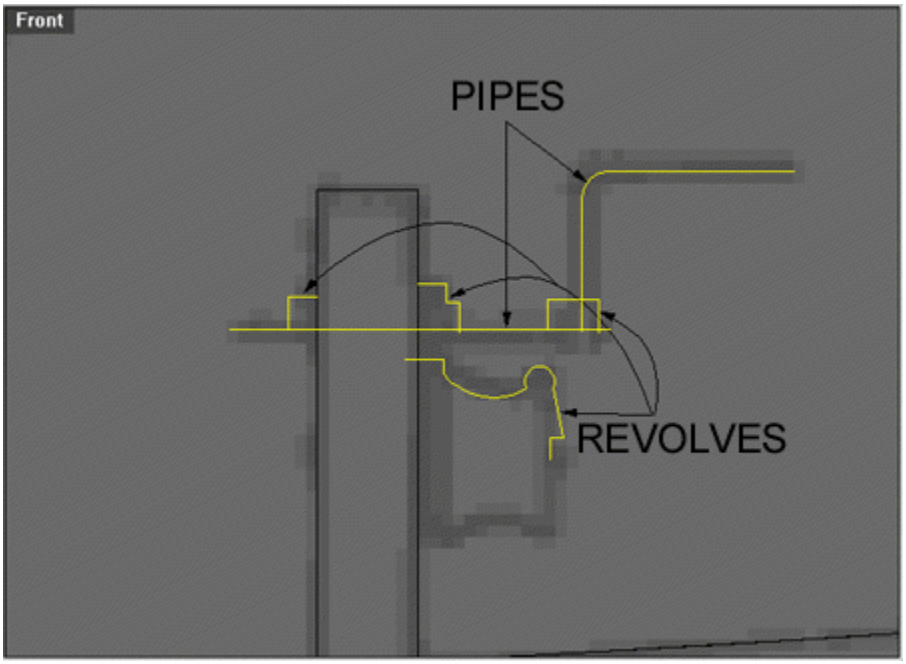


From the front view, make a **Rectangle** (below) that goes from the top of the post to below the deck, **Extrude** (Surface/Extrude/Straight) with '**C**ap=Yes' and '**B**othSides' activated, about **8** units. **Explode** the object and **Delete** the bottom cap.

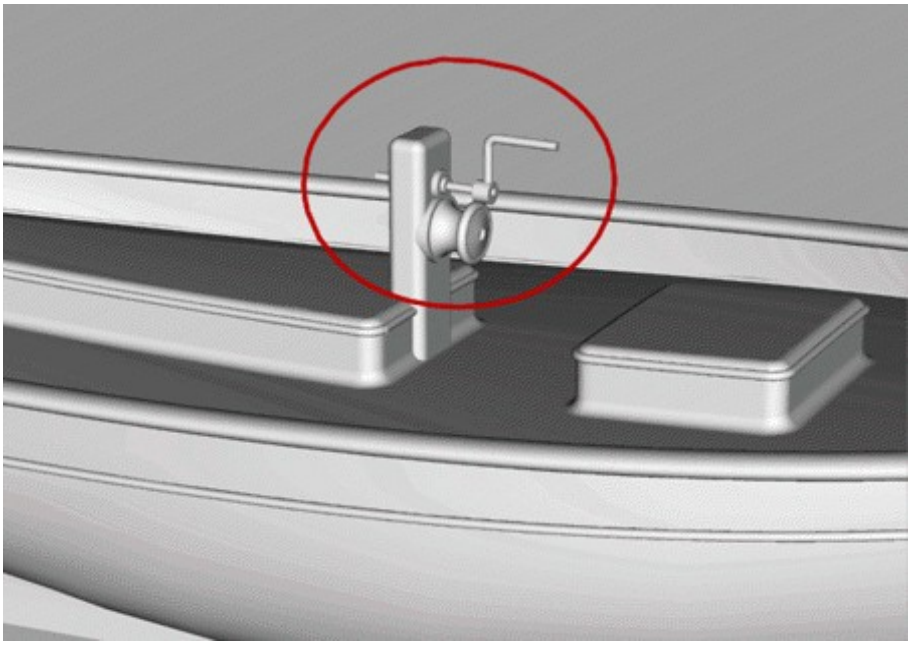


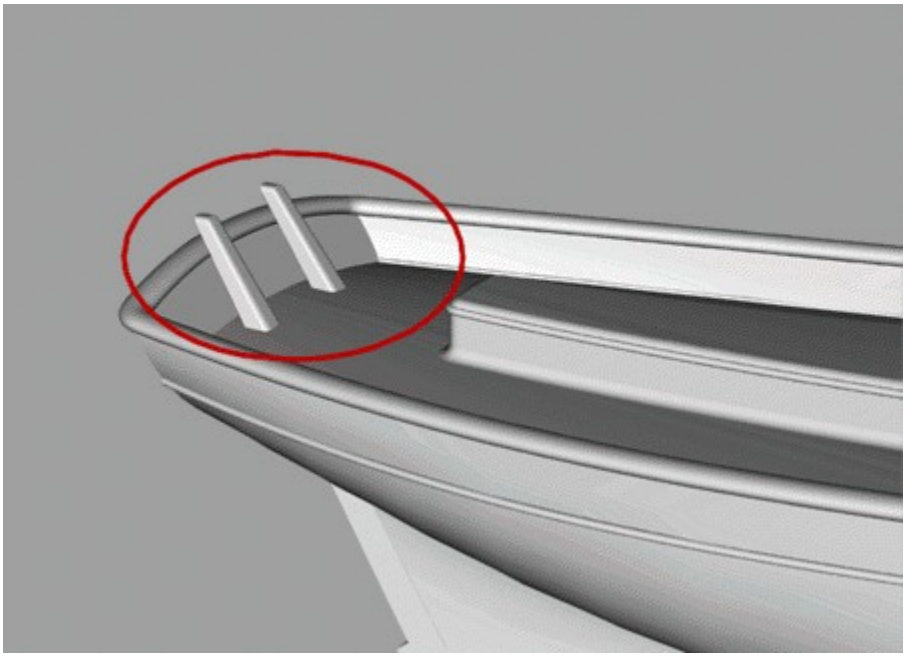
JoinSrf the faces back together and **FilletEdge** all the edges with a **2.5** '**R**adius'.

If you turn on the 'deck curves' layer you will find the curves shown below. (You could have used used **Arc, DirArc,** and **PolyLine** to draw these construction lines yourself.)



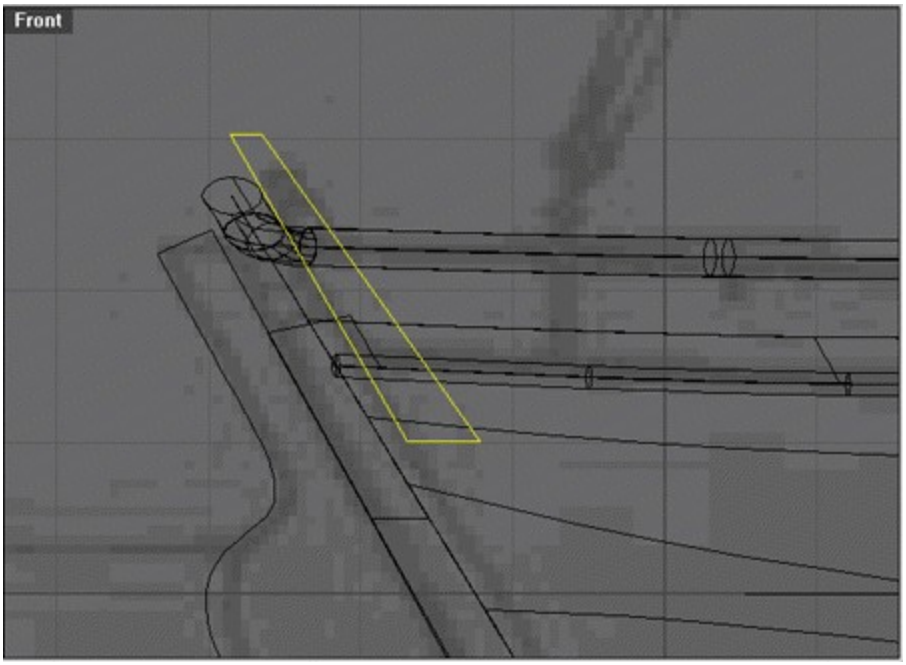
Use the **Revolve** command on the curves indicated by the "REVOLVES" arrows above, and use the **Pipe** command on the handle and shaft indicated by the "PIPES" arrows, to produce the main winch shown below.





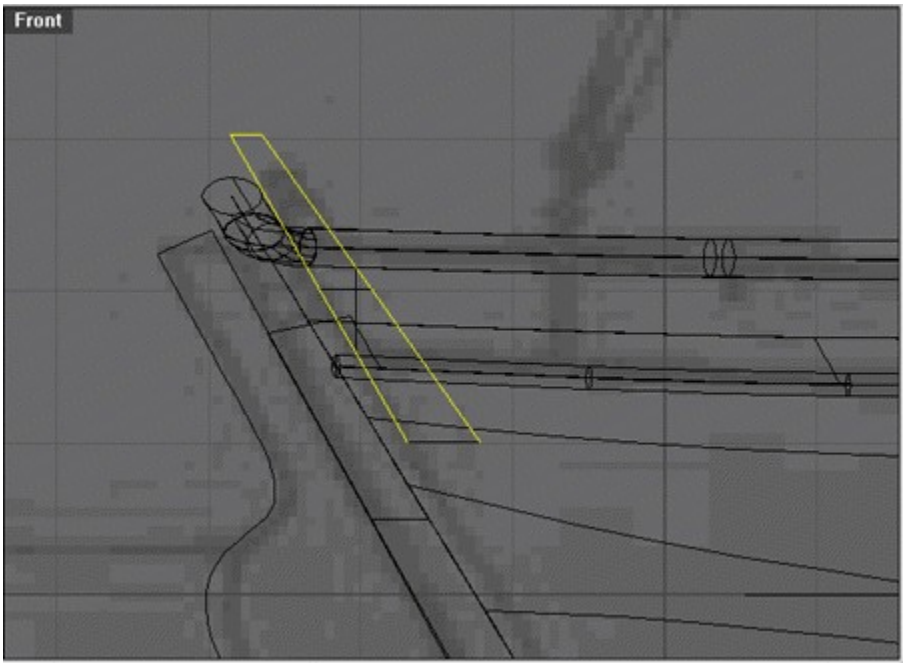
Draw a **PolyLine** tracing over the background to make a line as shown below.

> **NOTE:** There isn't much of the stern post showing in the back ground image but there is a reference curve on the 'deck curves' layer.

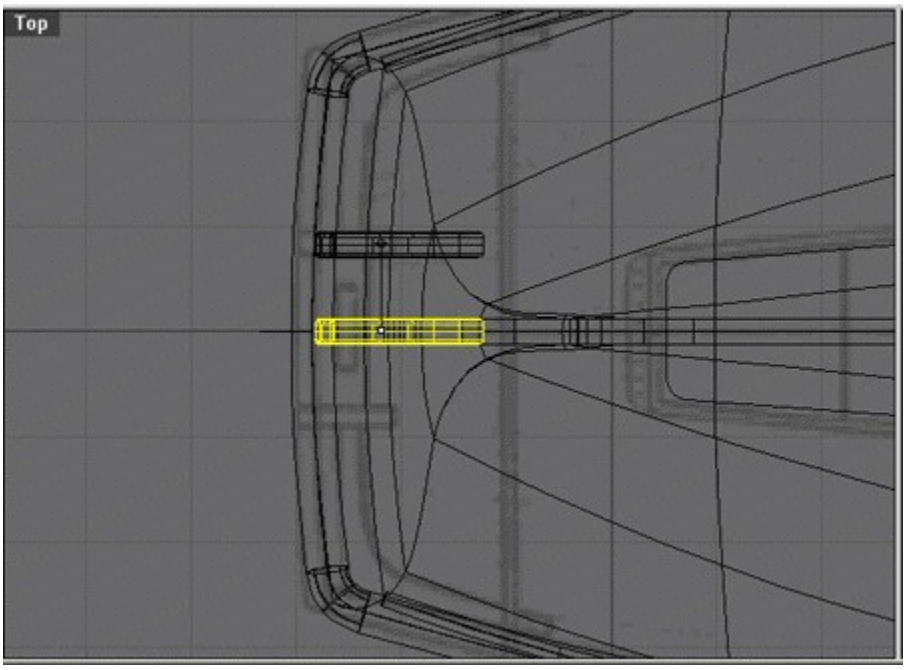


Extrude the curve with '**C**ap=Yes' and '**B**othsides' options a '**D**istance' of **2.5**.

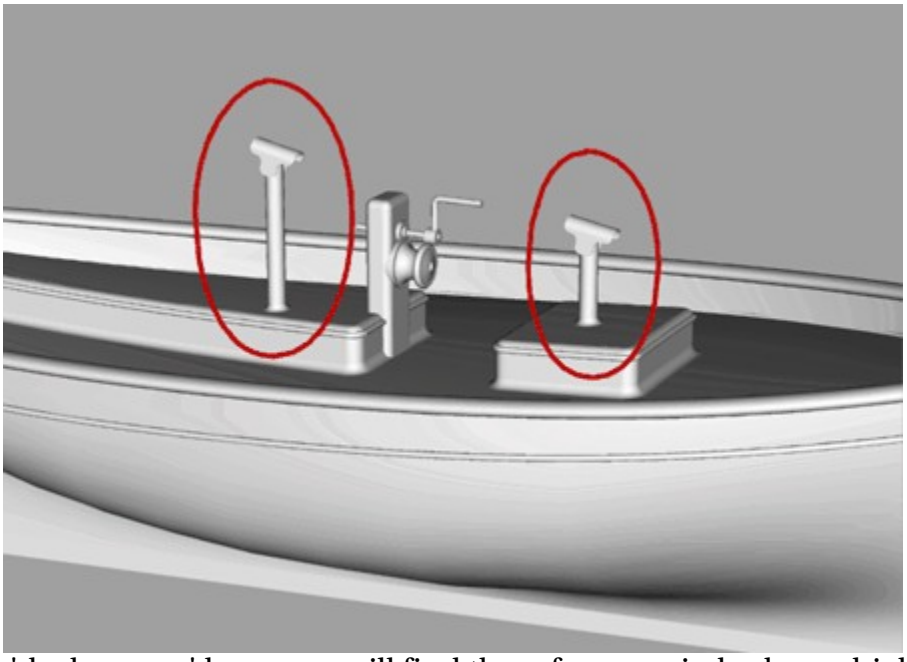
Hit **FilletEdge** with a '**R**adius' of **1** and select all the top and side edges of the stern post with a window selection going from right to left as shown below and hit Enter to execute the command.



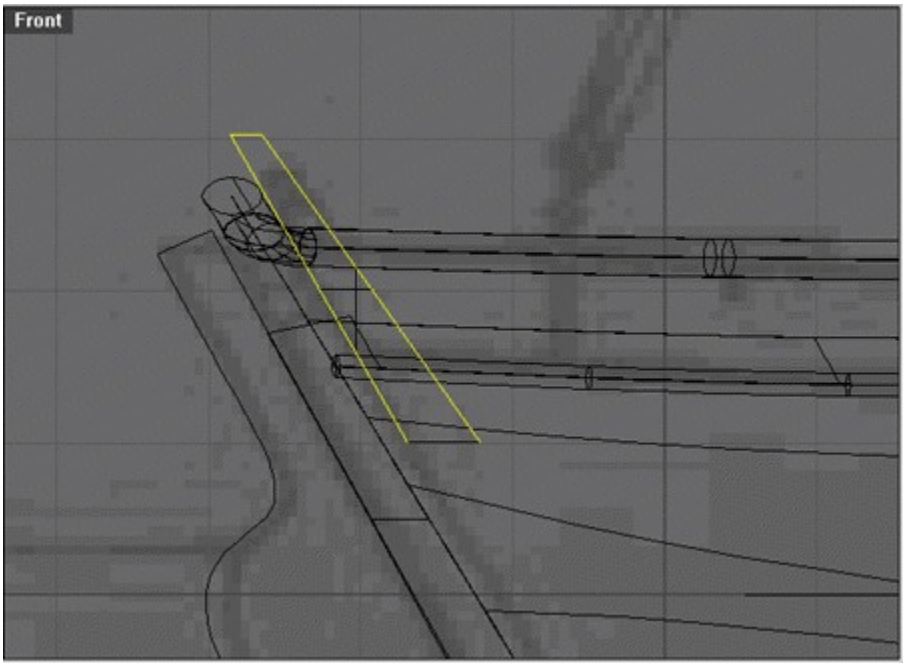
From the top view and with temporary **Ortho** on (Shift key), drag the 'stern post' to be in line with the stern post in the background image as shown in progress below.



With the 'stern post' still selected, **Mirror** the post from the top or right view using the center of the boat as the reflection axis.



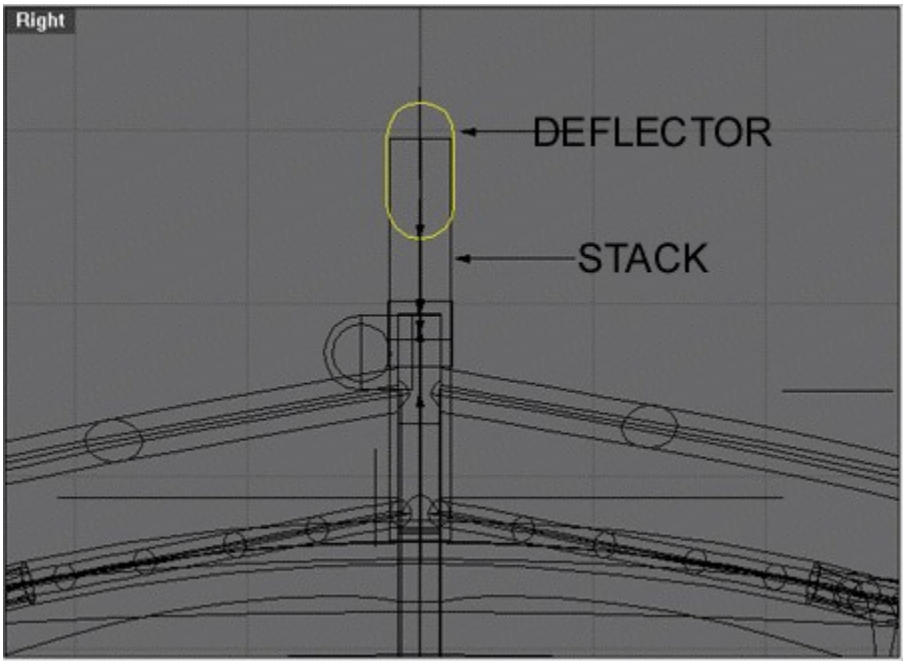
If you turn on the 'deck curves' layer you will find the reference circle shown highlighted below. As mentioned before, you can use the reference curves at anytime.



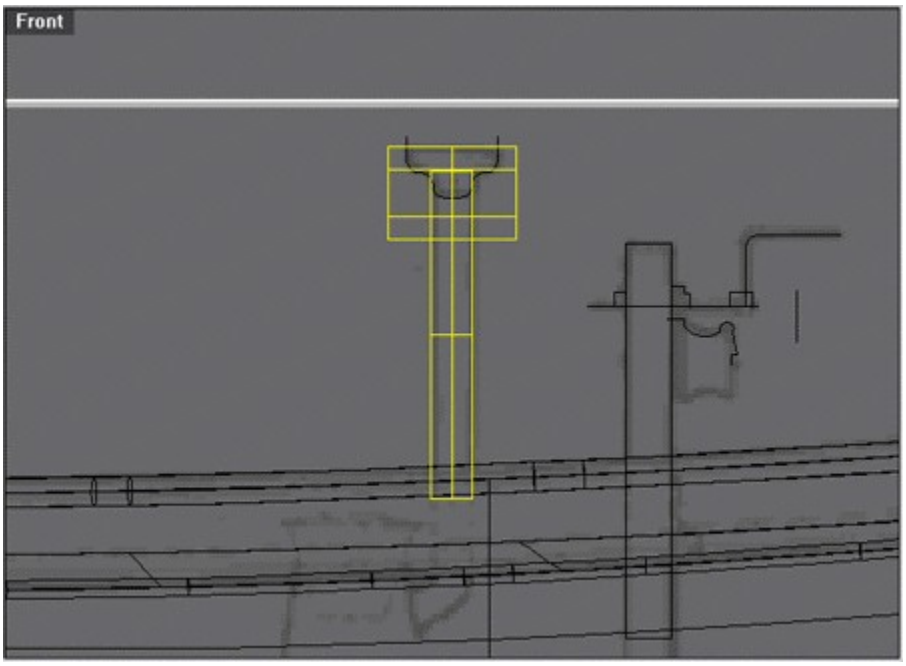
From the top view, draw a **Circle, Extrude** it a '**D**istance' of **55** (Surface/Extrude/Straight) to form the stack and in the front view drag it into place going the the background image.

From the right view draw a **Rectangle** with the '**R**ounded' option. Make it little wider than the stack and have it start above the top of the spark deflector.

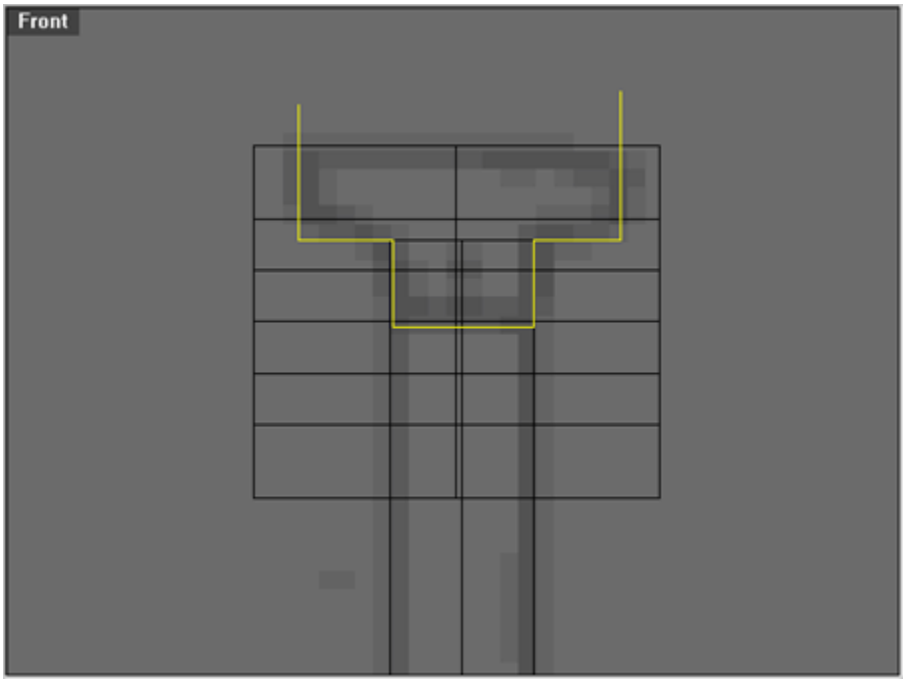
From the right view **Extrude** (Surface/Extrude/Straight) with '**C**ap=No' a '**D**istance' of **20** units.



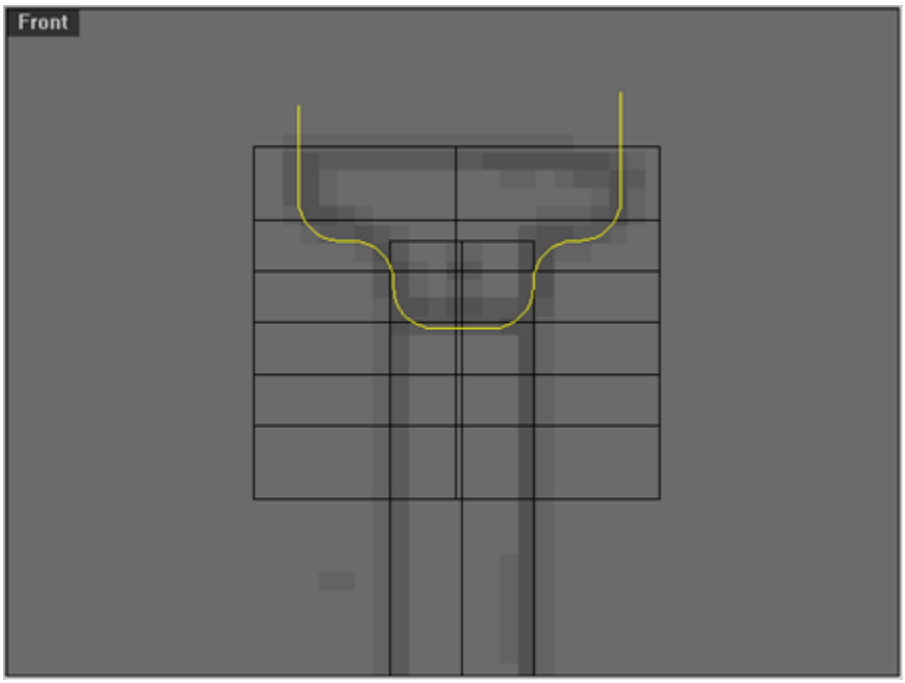
From the front view drag the stack and deflector into position shown below.



From the front view and draw a **PolyLine** that is the shape of the deflector but squared up and without the fillets as shown below.



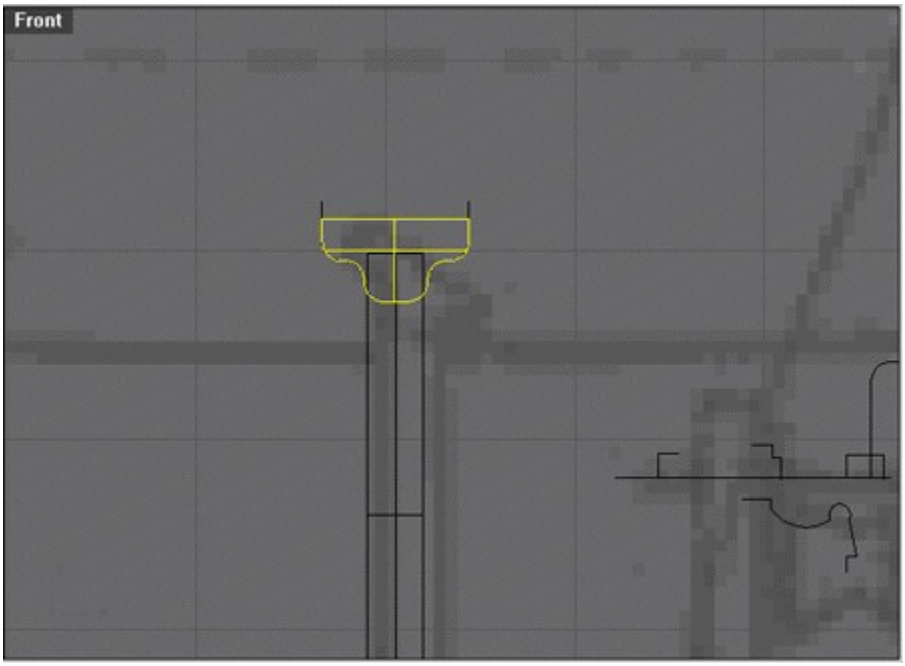
Fillet the line with a '**R**adius' of **2** and with the '**J**oin=Yes' options. Shown below.



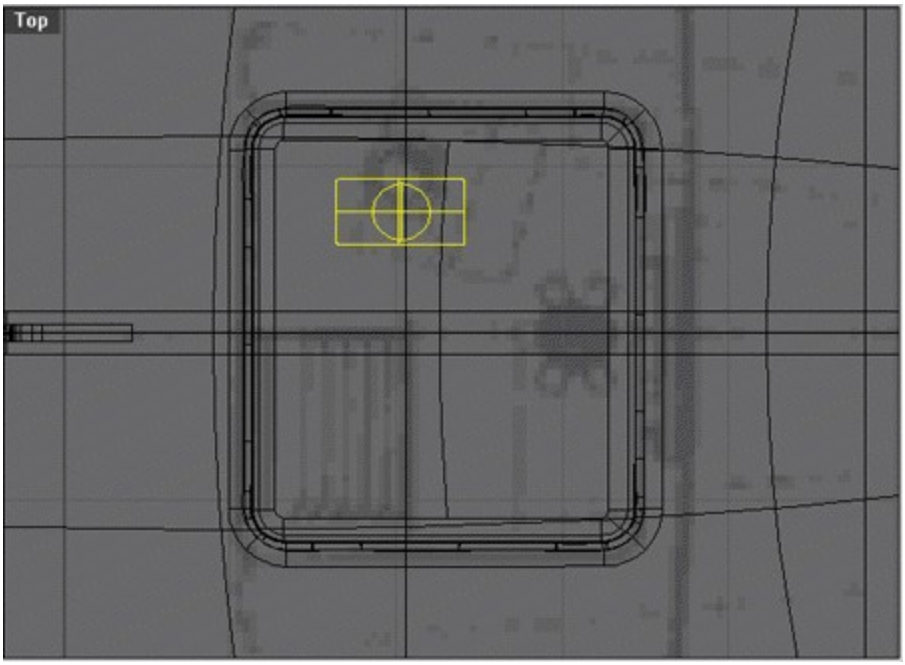
Split the rounded rectangle and **Delete** outer surface.

ShrinkTrimmedSrf the new deflector.

Delete the extrusion curves and the splitting surface so that all is left is the stack pipe and the deflector as shown below.



Copy the stack and drag the copy to the right while in the front view and from the top view drag it to the upper left hand area of the right cabin a little lower than what the background image plan calls for. As shown below



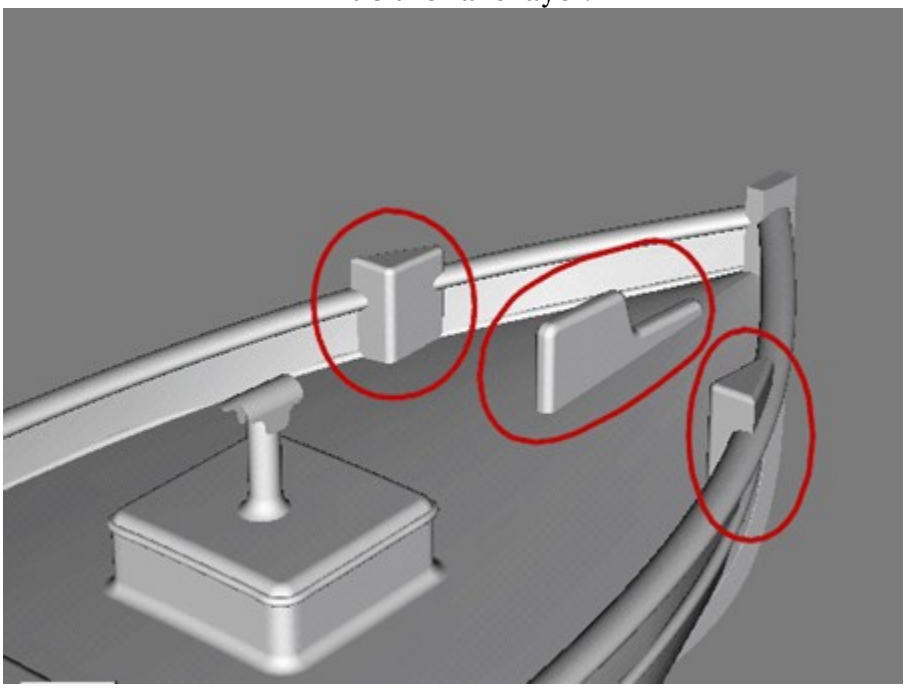
In the front view drag the copied stack down about ½ grid to place it according to the background image.

BooleanUnion the stacks going through the cabin tops. If you have any problems with the Boolean use the **Dir** command to make sure the normals are pointing outwards.

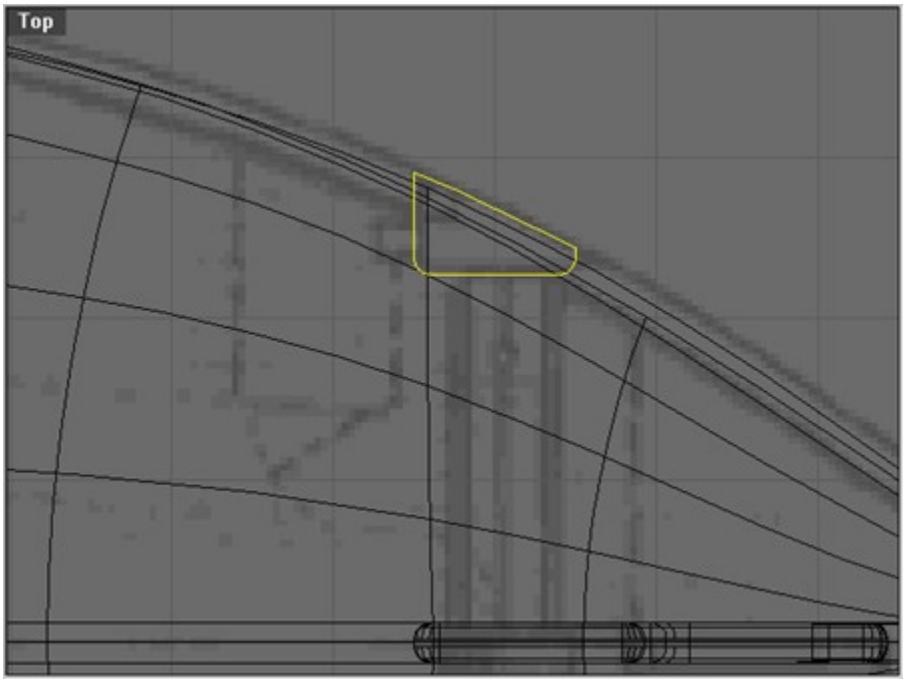
Optional: BooleanUnion the trim rails going around the cabins to the cabin.

Hit **ExtractSrf** and select the deck. The deck will get a different material, which will be covered later.

Hide the rails layer.



Go to the top view and **ZE** zoom extents and **Z** zoom in on the triangle in the background as shown below or locate this curve on the 'deck curves' layer for reference.

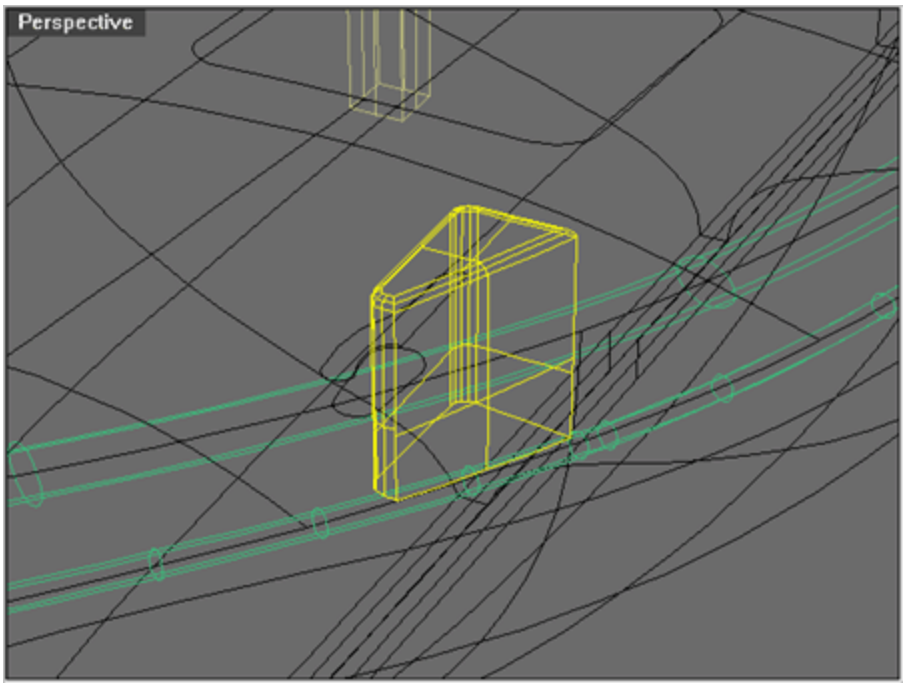


Trace a **PolyLine** over the background and **Fillet** the two lower corners with a 2 radius at the corners.

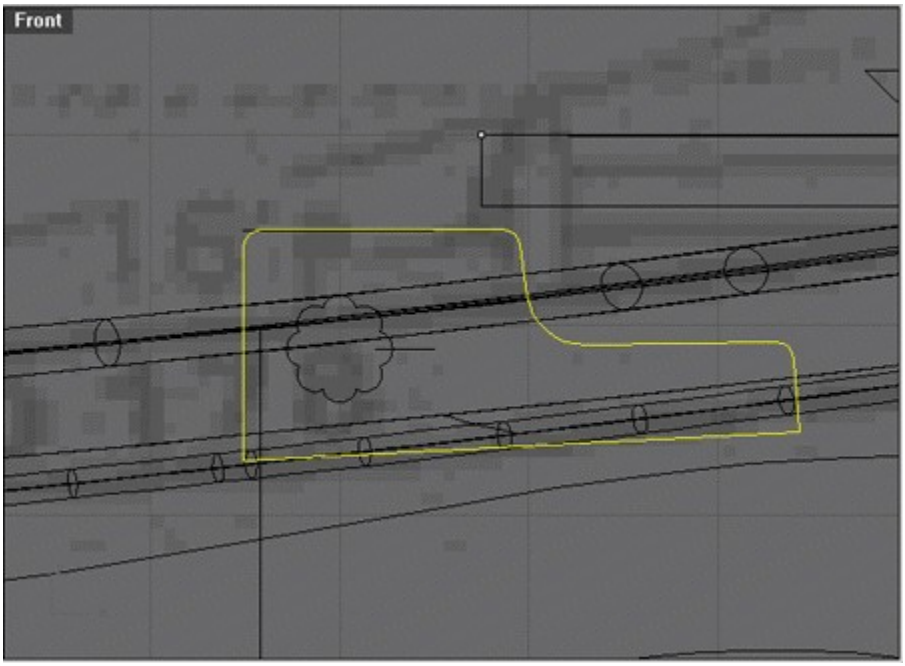
> **NOTE:** You may wish to move the posts towards the center of the boat such that the curves stay within the edge of the hull.

Extrude (Surface/Extrude/Straight) the post right through the hull and **Split** it, with the deck as a cutting object.

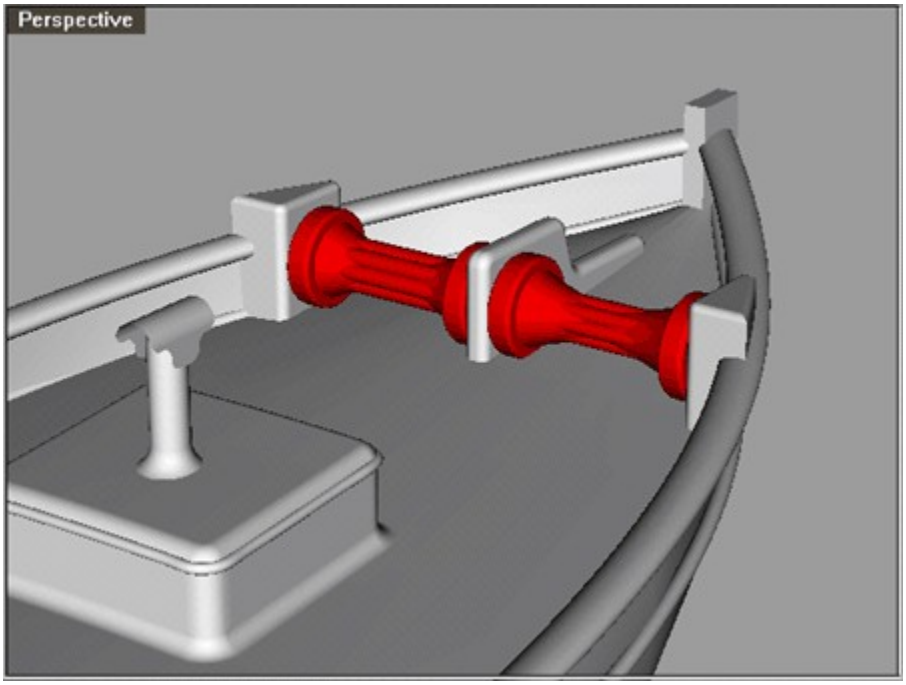
Change the 'Absolute tolerance' to **.1** and **FilletEdge** the top with a **1.5** '**R**adius'.



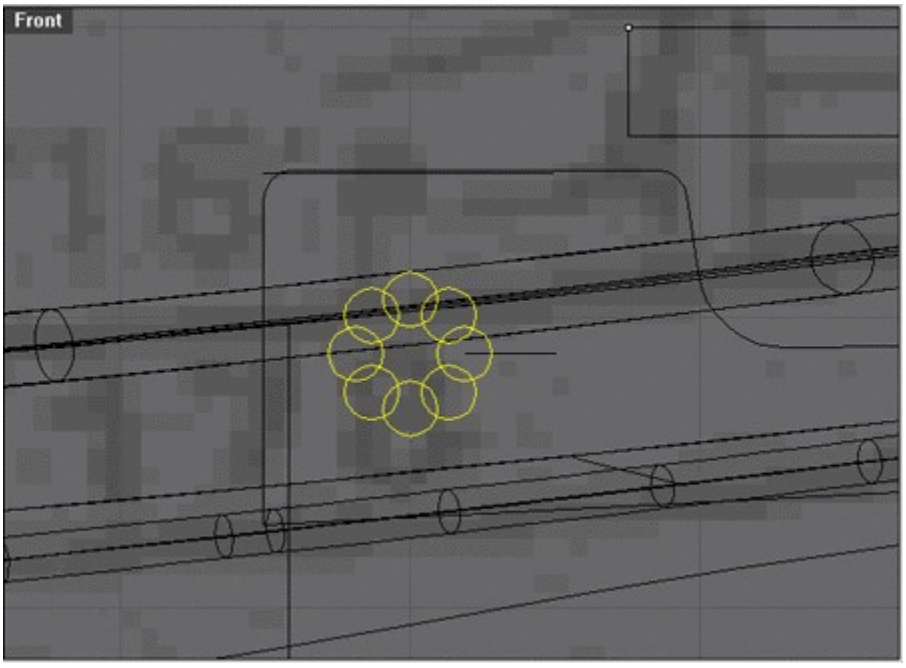
There is another winch post in the middle of the two side posts. Zoom in on this area in the front view and trace over the post with a **PolyLine**. Use the 'deck curves' layer for reference, shown below. Close the PolyLine and fillet it with three **2** unit '**R**adius' and one **5** unit '**R**adius' as shown below. **Extrude** with '**C**ap=Yes', and '**B**othSides' activated, a '**D**istance' of **5**. **FilletEdge** all the edges except the bottom edge, with a fillet of **2**.



Overview: There are larger Winches across the bow that can raise anchors, or raise fishing nets on some boats. Usually winches of these proportions have some ribs on them for better grip.

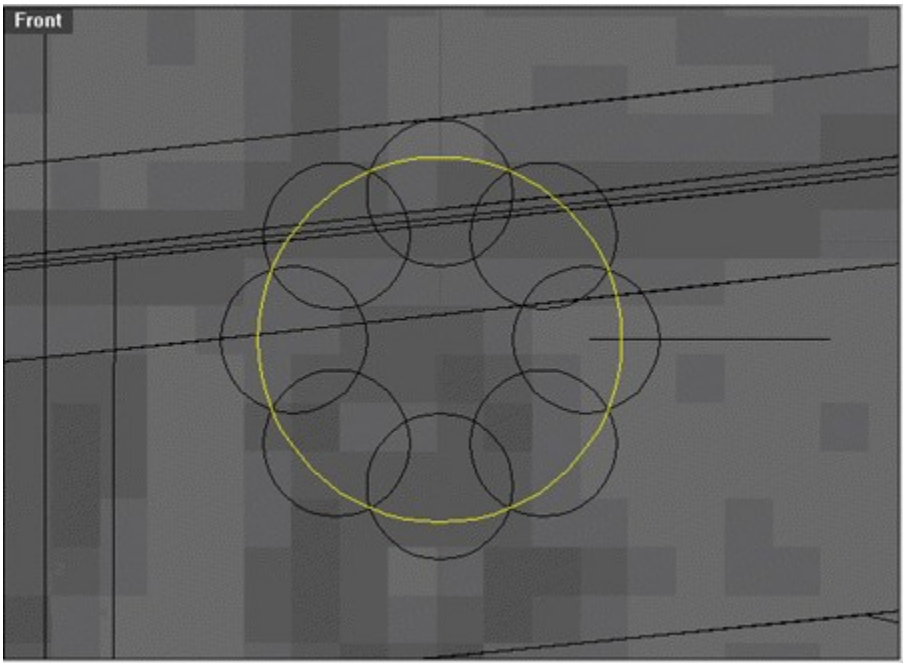


On the 'deck curves' layer locate the curves shown below.



NOTE: The following steps are necessary to optimize these overlapping curves before they are extruded to make the 'ribbed' winch.

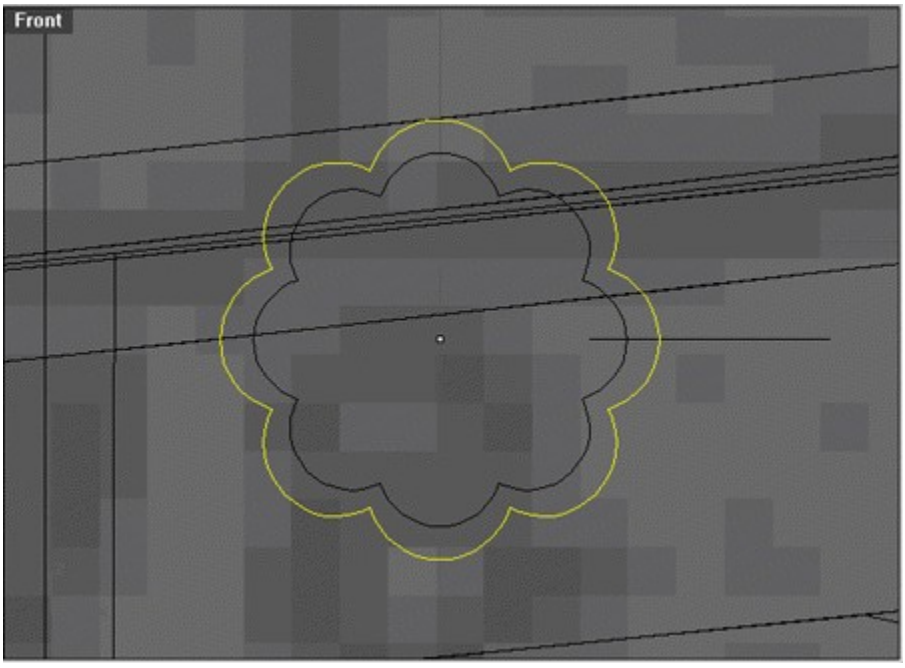
Turn on 'Int' osnap. Make a curve going through outer intersections of the circles as shown below.



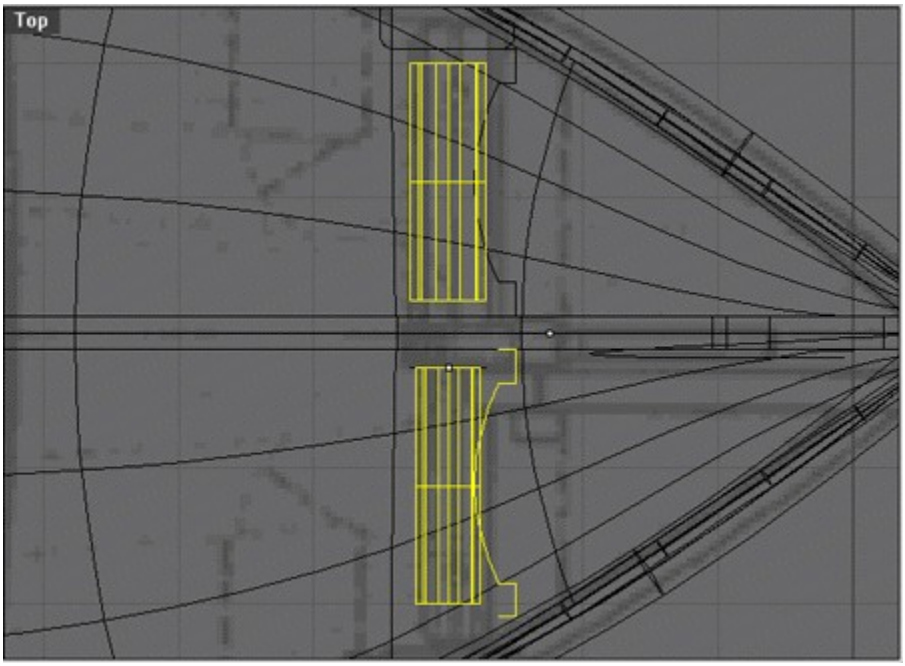
Trim the inner circles with the new curve as the cutting object.

Join the curves together and **Extrude** '**C**ap=No' with an extrusion '**D**istance' of **-35**.

Turn **GridSnap** (**s**) on and with the new extrusion selected hit **Scale2d** use the the '**C**opy' option and select the center of the ribs. At the 'scale factor' prompt type **.85** enter and then hit **Esc**. This will create 2-winch ribs, 1 for each winch, one smaller than the other. Shown below.



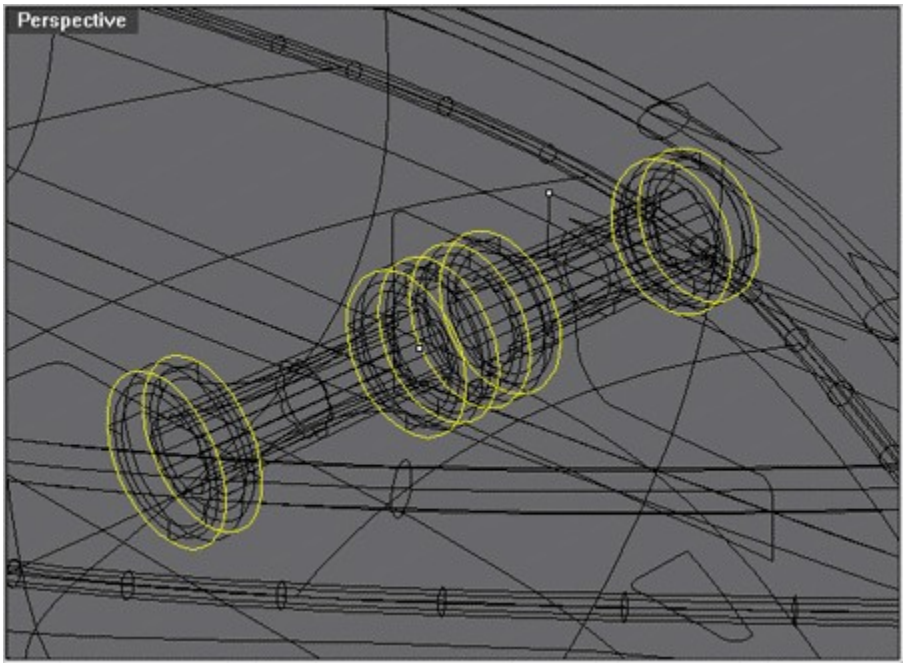
Select the outer ribs and in the top view drag the ribs to the opposite side of the boat so that you have the result shown below.



Draw or select the curve from the 'deck curves' layer shown above.

SrfRev the curve with the axis being the center of the ribs. **Mirror** the 'SrfRev' object across the center of the boat.

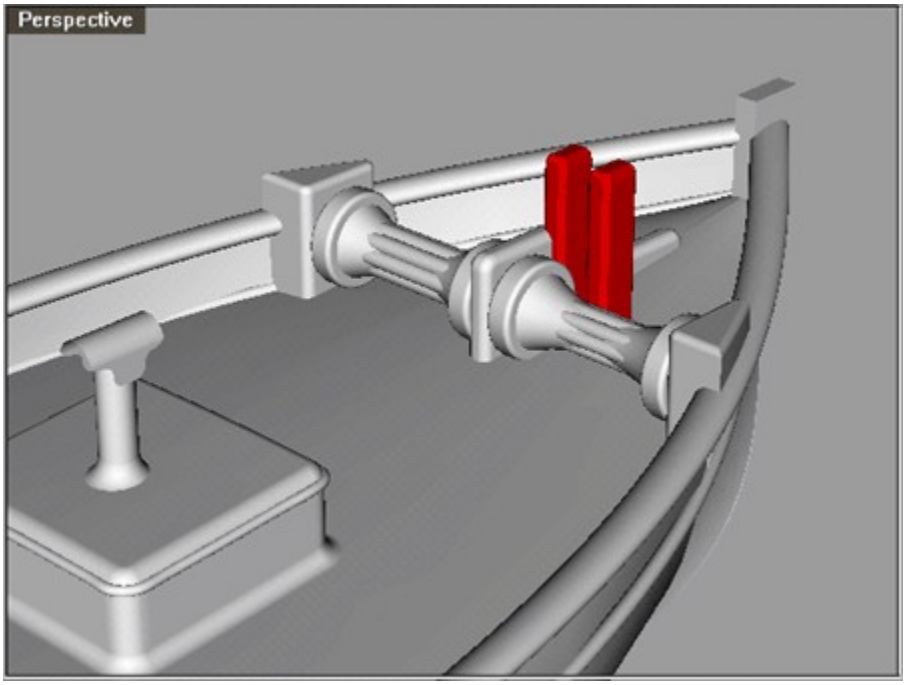
Fillet the edges of the large outer rings shown below with a **1** '**R**adius'.



The anchor winches are complete.
There are two identical posts called sprit posts (The sprit is a long post that will stick out from the front of the boat, that will be built on the next page. These sprit posts, shown in red below, will hold it in place.)
Copy the main winch post (built on page 20), **Scale1D** it to the right size, and drag it into place to form the left sprit post.

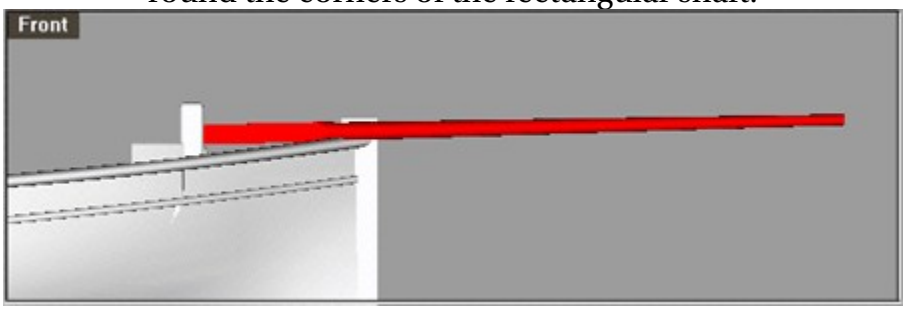
Copy the left sprit post and drag the copy to the right to make the right sprit post, positioned as

shown below.

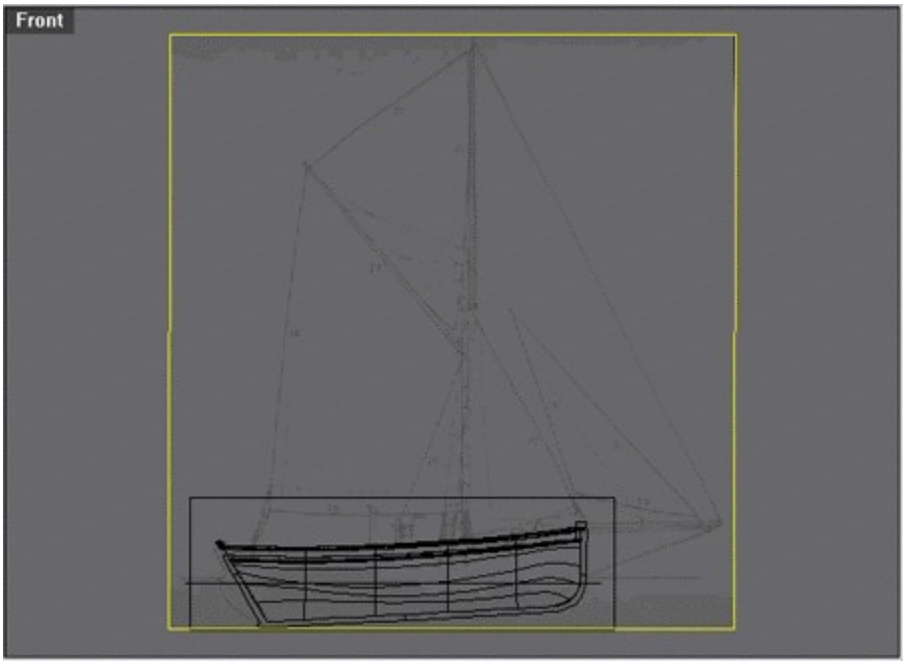


Make a few new layers: call them 'anchor winch,' 'stacks,' and 'main winch.' **ChangeLayer** the appropriate objects to the appropriate layers.

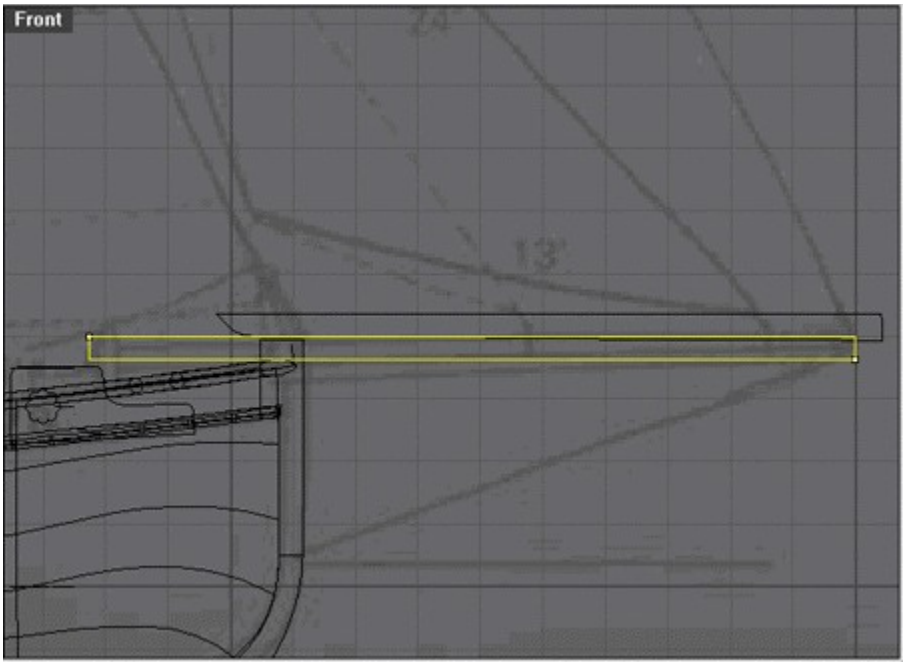
The sprit is shown in red below. Where the sprit goes between the 2 sprit posts, it is square, but the sprit tapers to a circle before it passes the bow stem. You can use booleans like a lathe, to round the corners of the rectangular shaft.



Turn on the Layer 'picture frames' and replace the the image side.jpg with sails.jpg, using the larger picture frame as a guide.



In the front view, with the snap setting still at **2.5**, start tracing a **Rectangle** at the upper left corner of the sprit as shown in the background and dragging the rectangle to the end of the sprit. There are a couple of points on the 'deck curves' layer that can be 'Point' osnaped to. Click the lower right corner of the rectangle three snaps down to complete the rectangle as shown below.

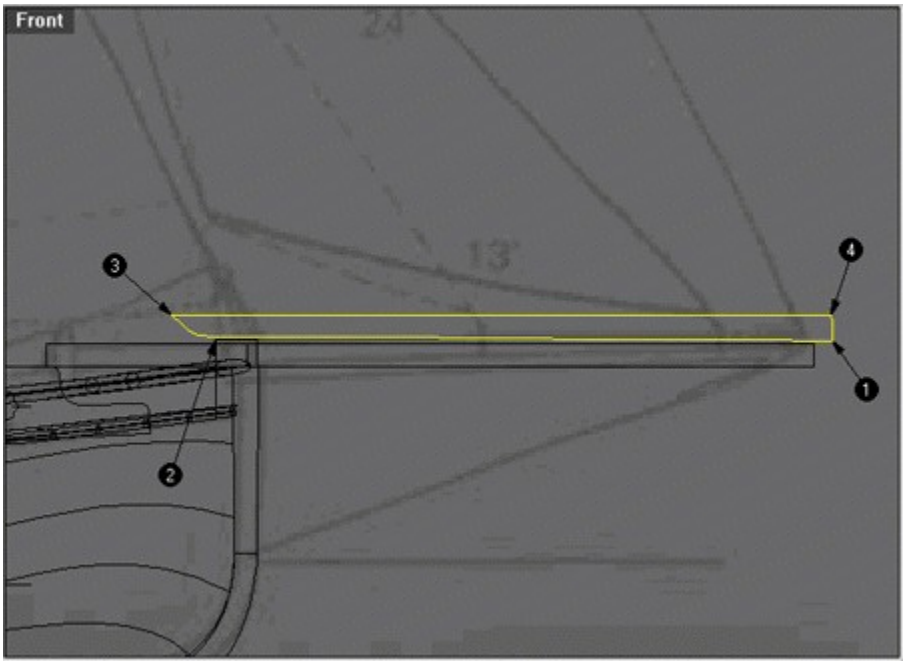


Extrude (Surface/Extrude/Straight) the rectangle with '**C**ap=Yes' and '**B**oth sides' active, a '**D**istance' of **3.75** (which is half of the height.)

> **NOTE:** The sprit is still just a square piece of lumber, and needs to be cylindrical and tapered towards the end. One way to do this is to make a curve as shown below and revolve it to make a clylindrical pipe that can then be Boolean-differenced to leave a tapered end. This curve is critical: inspect the curve on the 'deck curves' Layer for reference.

Make a curve that starts past the end of the sprit (1) that you just made, about a quarter of the

way down. End it so that it is flush with the top of the post, just after the bow stem (2).



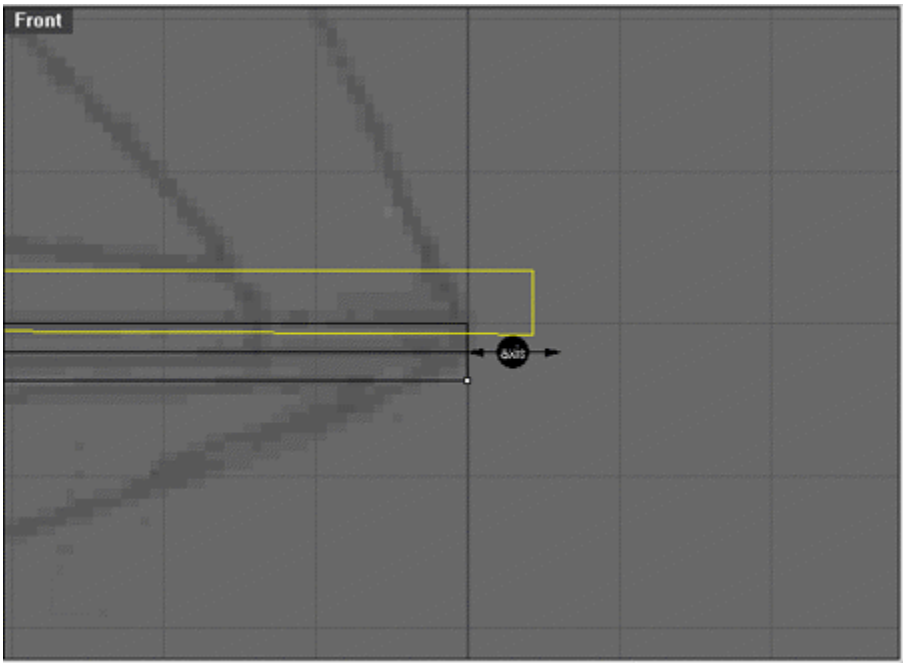
With 'End' osnap on start another curve from the end of the previous curve, that gently sweeps upwards, and end it at location (3).

Start a **PolyLine** that that goes from that curve, straight outwards, and then back to the start of the first curve at location (4).

Draw a curve from location (4) to location (1).

Select and **Join** all four curves together. **Z**oom in on the right end of the post.

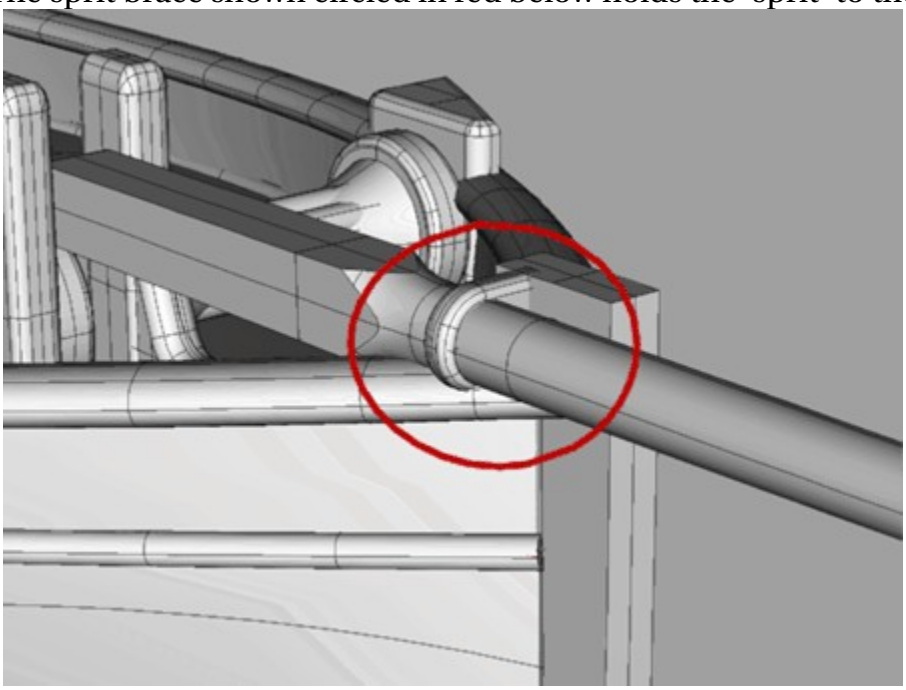
With the 'deck curves' layer on and 'Point' osnap turned on, **SrfRev** the newly joined curve with the axis being center of the post and the axis running horizontally holding shift down for temporary **ortho** as shown below.



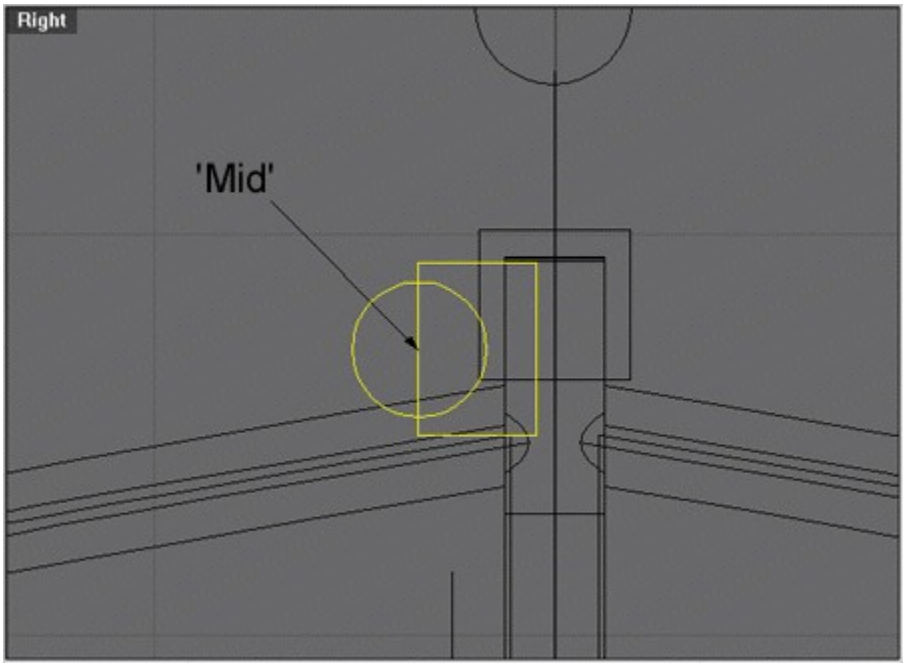
BooleanDifference the outer cylinder from the inner post selecting the inner post first.

Copy the result and move the copy up out of the way, this extra sprit can be used later for the mast. **Rotate** the original to conform to the background and drag it off center from the top view

Overview: The sprit brace shown circled in red below holds the 'sprit' to the stem post.



With the sprit hidden, there is a reference circle that shows where the sprit will pass through at the bow stem shown highlighted below. Draw a **Rectangle** in the position indicated by the selected rectangle.

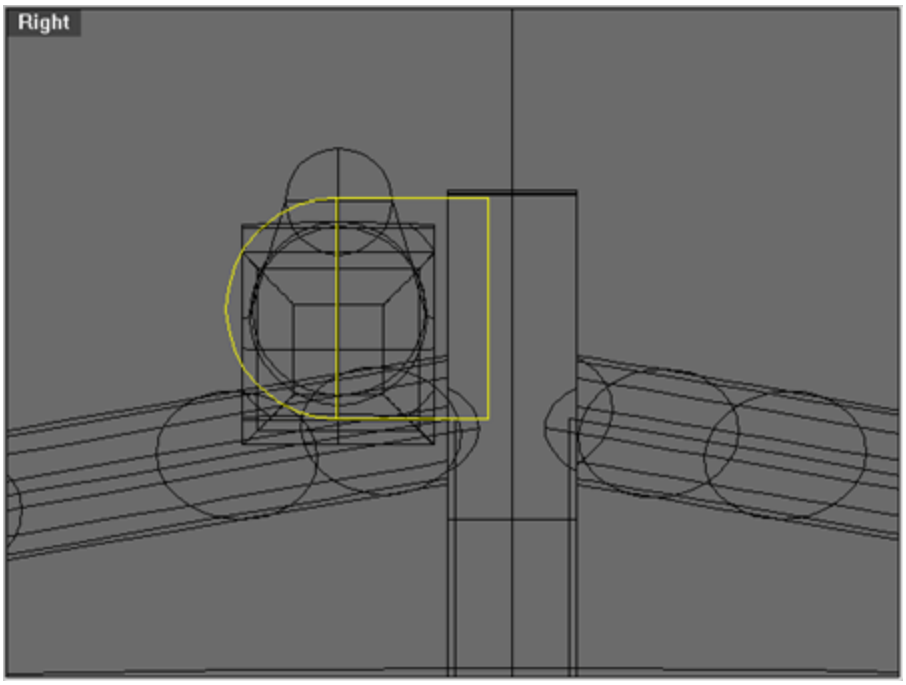


Explode the rectangle.

Hit **Arc** and start the Arc by 'Mid' osnapping to the mid point of the vertical curve indicated by

the 'Mid' annotation above and 'End' osnap to the top end of the same curve and finish the arc at the bottom of the same curve as shown below. **Delete** the curve that you used 'Mid' osnap with and **Join** the remaining 4 curves.

Extrude the newly joined curves a distance of **5** and **FilletEdge** the resulting object and drag it into place from the front view.

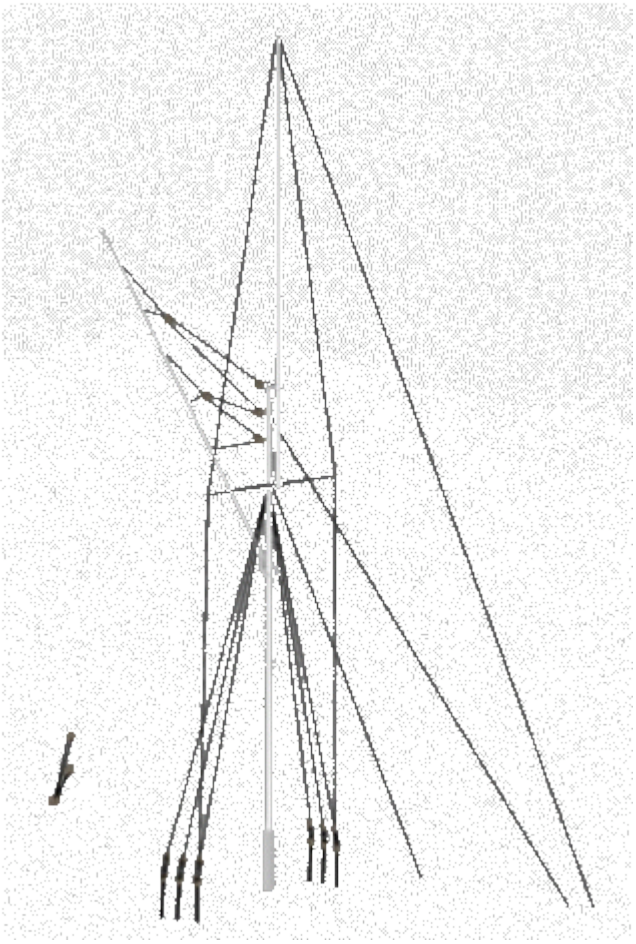


Select the anchor winch posts, cabins, main winch post and winch and **ChangeLayer** them to a new layer named 'deck details'. Also make a new layer named 'masts' and **ChangeLaye**r the copy of the sprit to that layer. Add some color to the layers you have remaining.

And that's it for the deck detail.

Be sure to save out your work.

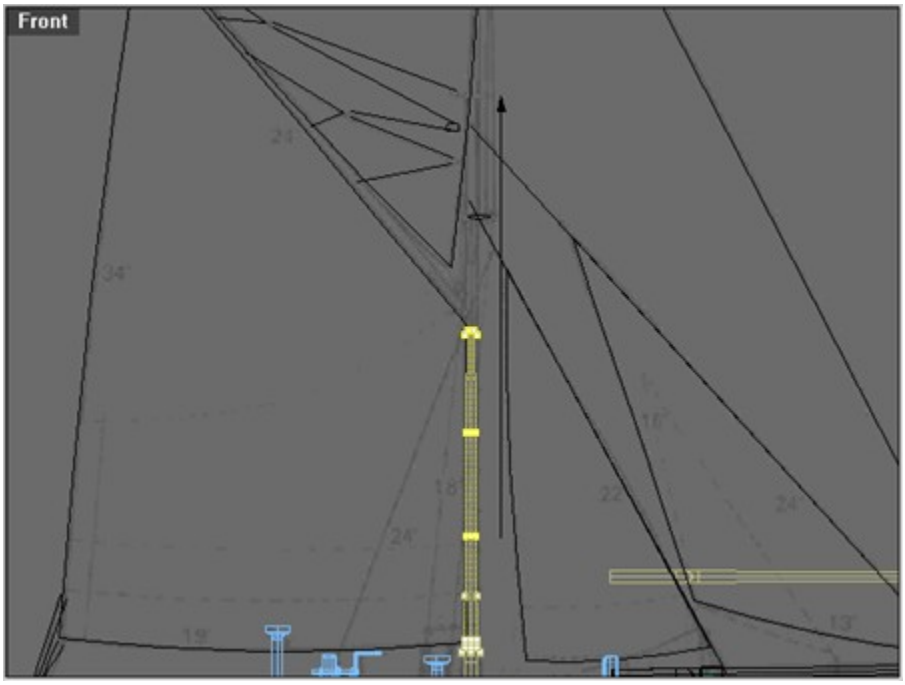
Overview: The hull and deck are done and the masts and the rigging will be covered in the following 'Rigging' section. First thing to cover is the masts.



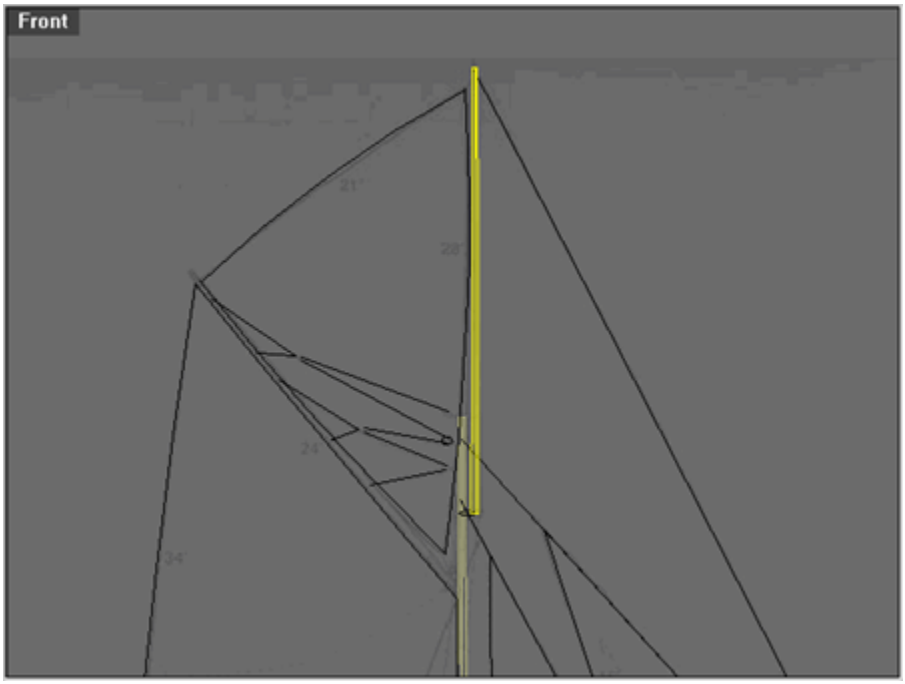
Save your file and merge the b9.3dm file or open boat9.3dm.

Select the copy of the sprit on the mast layer and **Copy** and **Rotate** the mast **90** degrees and place it over the background mast from the top and from the side view make sure it goes just below deck.

Explode the mast and select the top part and show control points **PtOn**. Select the top 3 rows of control points and drag them up so you have the correct height indicated by the arrow shown below.



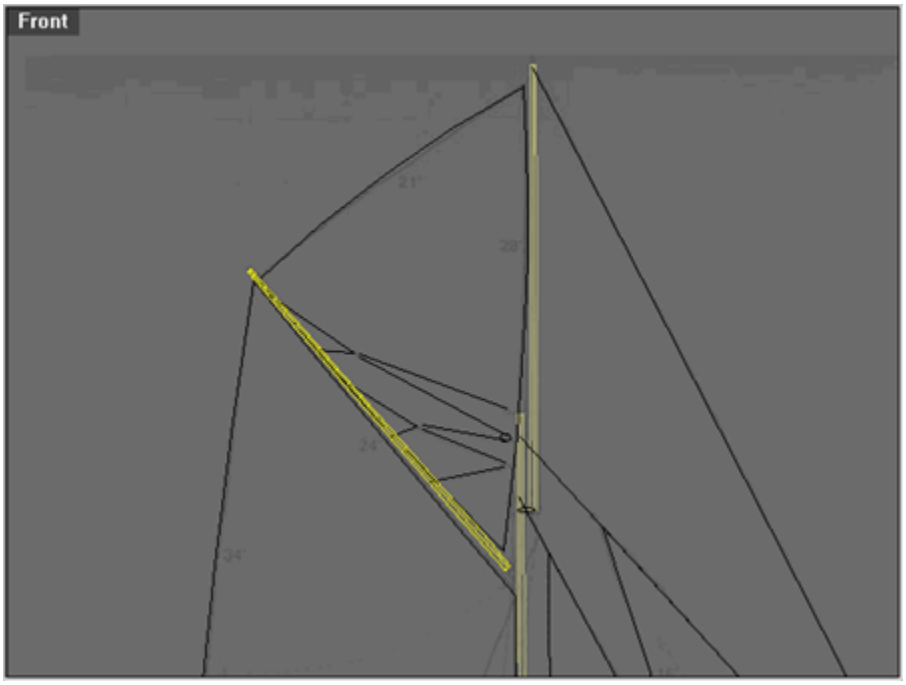
Turn off control points with **PtOff** and select the top part of the mast again and **JoinSrf**. With the mast still selected, **Copy** it and drag the base of the new copy to where the base of the top mast according to the background image as shown below.



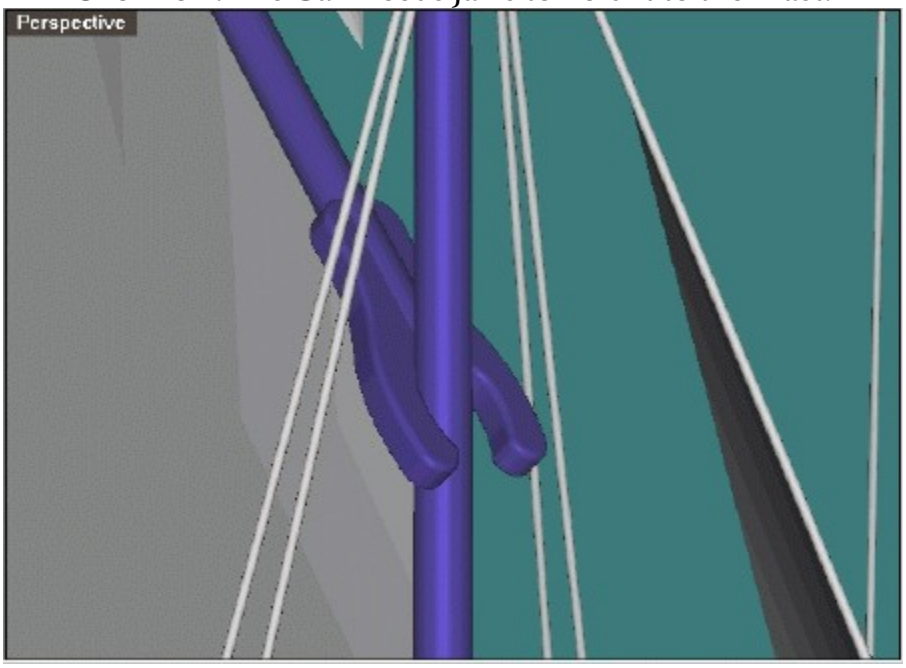
Notice that there's a little flair at the base of the top mast that needs to be trimmed off. Put an **ExtractIsoparm** just above the flair in the U direction and **Trim** off the flair. **ShrinkTrimmedSrf** the result.

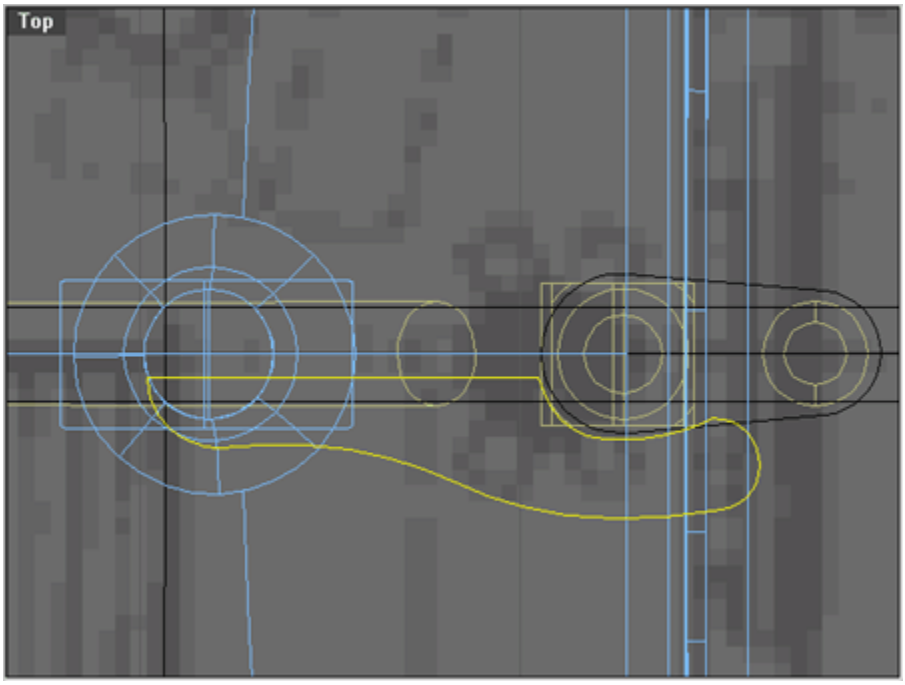
In the top view **Scale2d** the top mast down just a little by eye or type in **.8**

Copy the top mast and drag it over and **Rotate** it to be in line with the third, and last mast that is called a 'gaff' which holds up the main sail shown highlighted below.



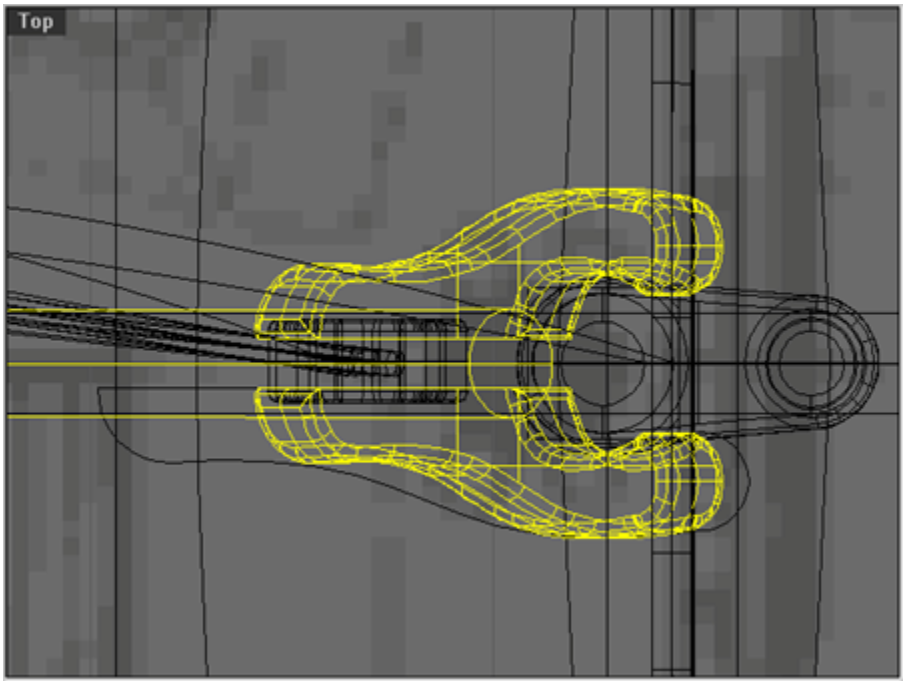
Overview: The Gaff needs jaws to hold it to the mast.



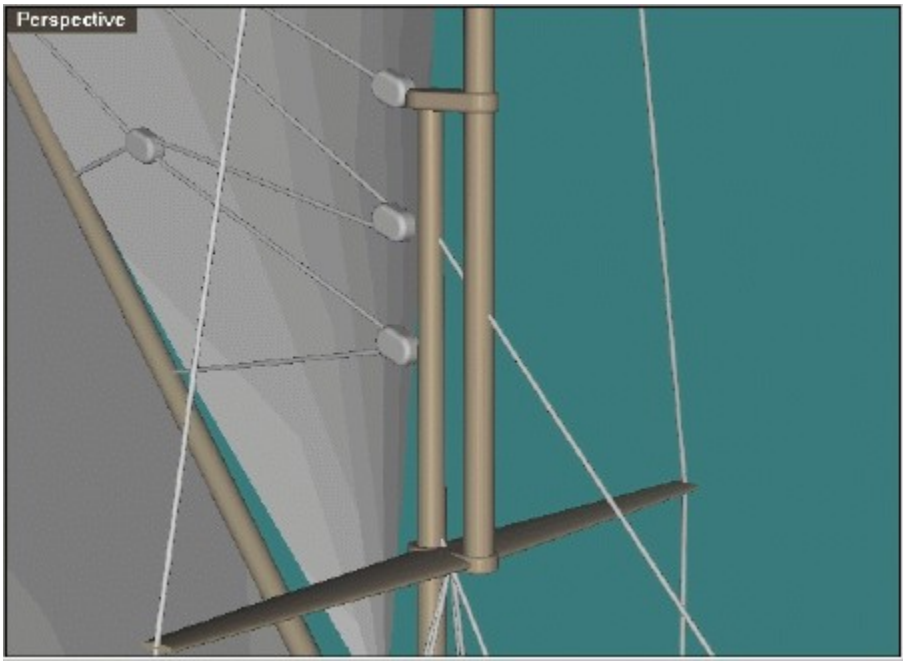


Locate and **Extrude** the reference curve shown highlighted above, a '**D**istance' of **4** and give the edges a **FilletEdge** '**R**adius' of **1**.

Select the jaw and drag and rotate it to the end of the gaff so that the jaw wraps around one side of the main mast and mirror it over to the other side to get the results shown below and at the top of the page.



Overview: In the front view, zoom **Z** in on the area where the two masts overlap, and notice that there are two braces that hold the two masts together need to be built.



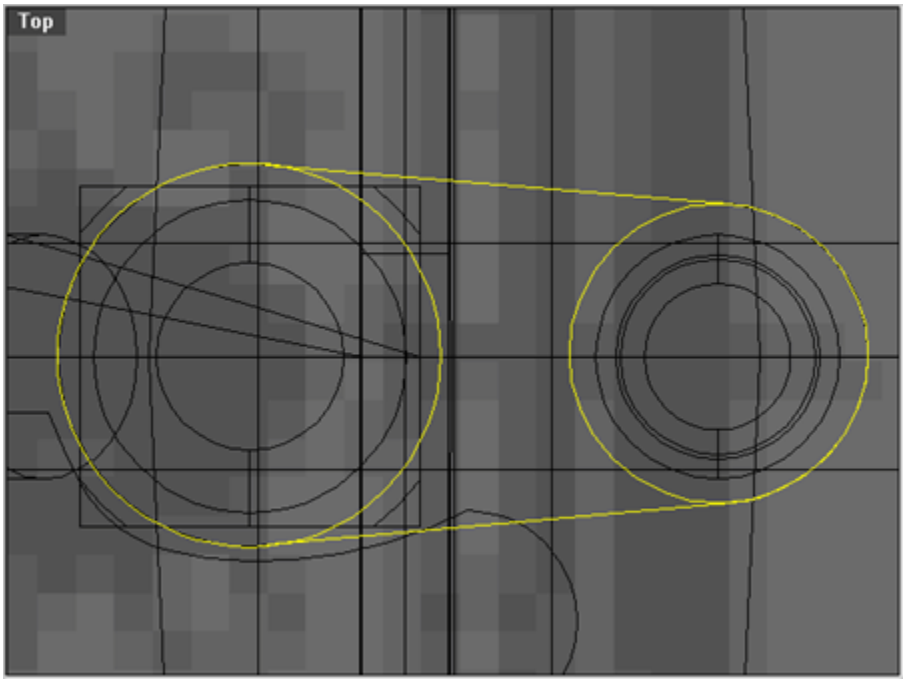
Select the two masts and go to the top view and zoom selected **ZS**.

For this next part there are completed reference curves on the layer 'sail curves.'

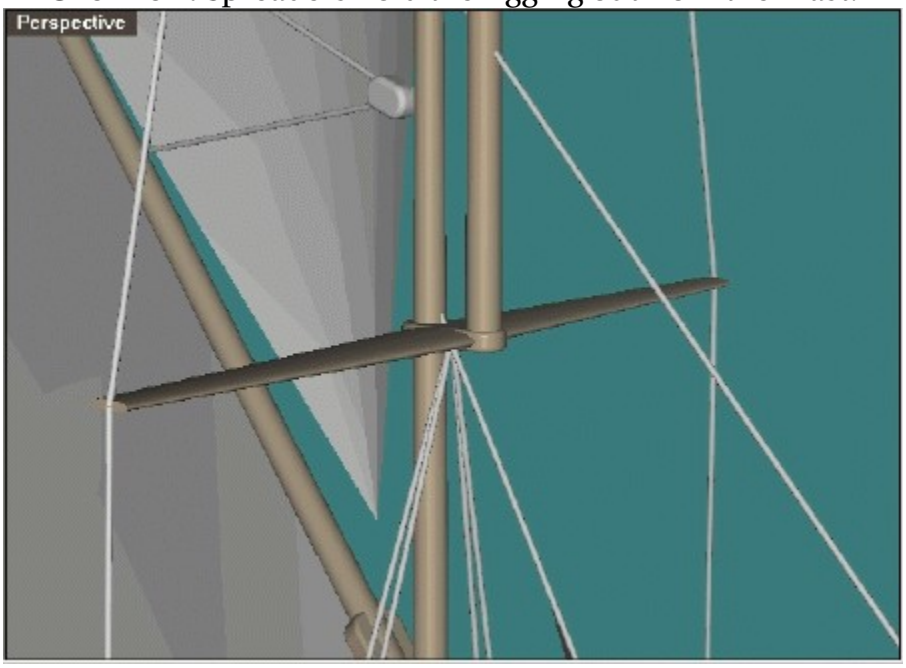
Draw a couple of circles as shown below that are centered and a little larger than the main and top mast.

Connect the circles with tangent lines **lineTT**.

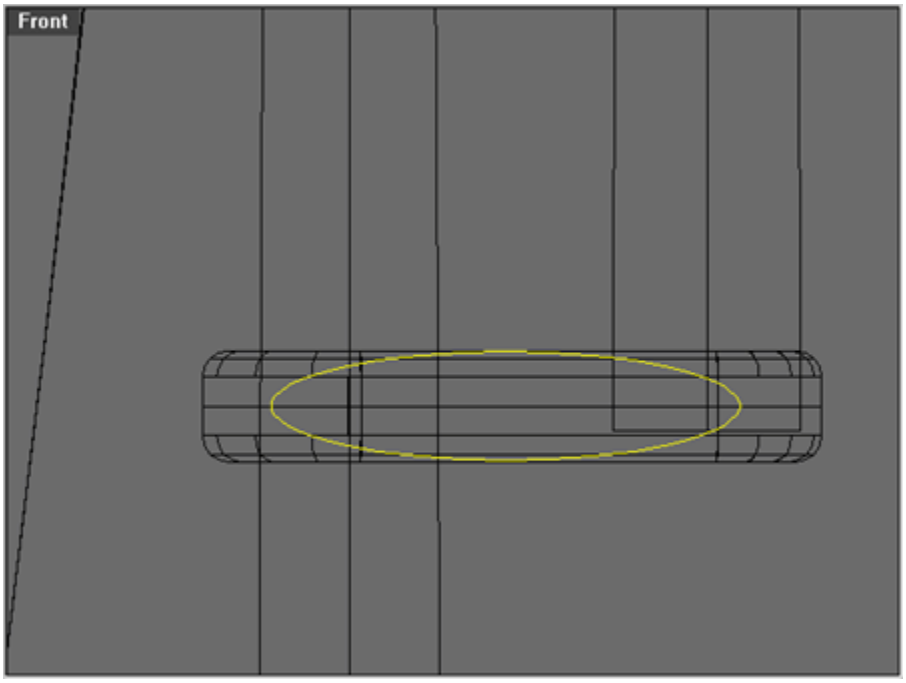
Trim off the two inner parts of the circles by making the two tangent lines the cutting objects and picking the inner parts of the circle. **Join** the four remaining curves. **Extrude** a '**D**istance' of **3** and give it a **FilletEdge** '**R**adius' of **.75**



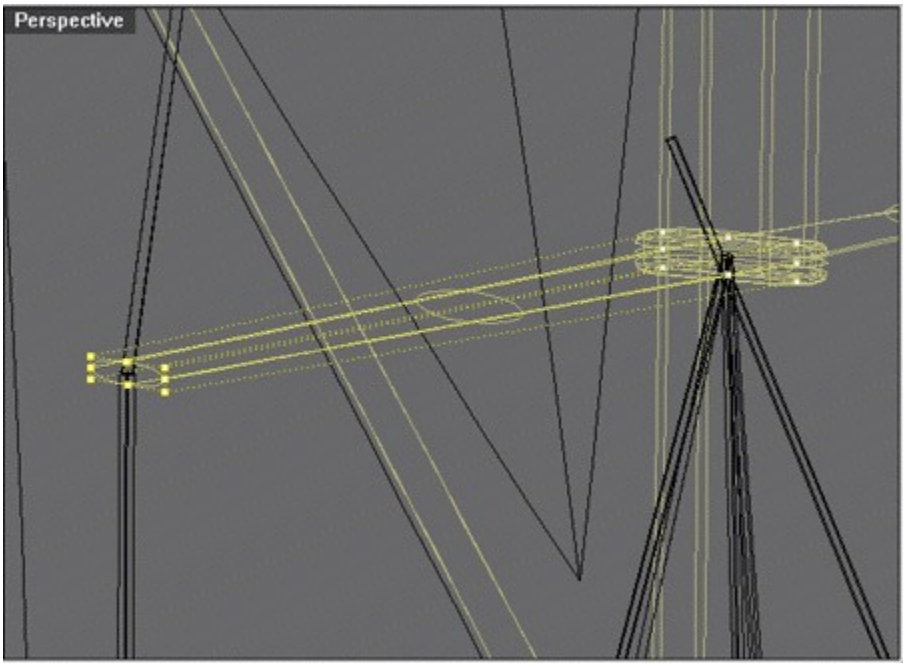
Overview: Spreaders hold the rigging out from the mast.



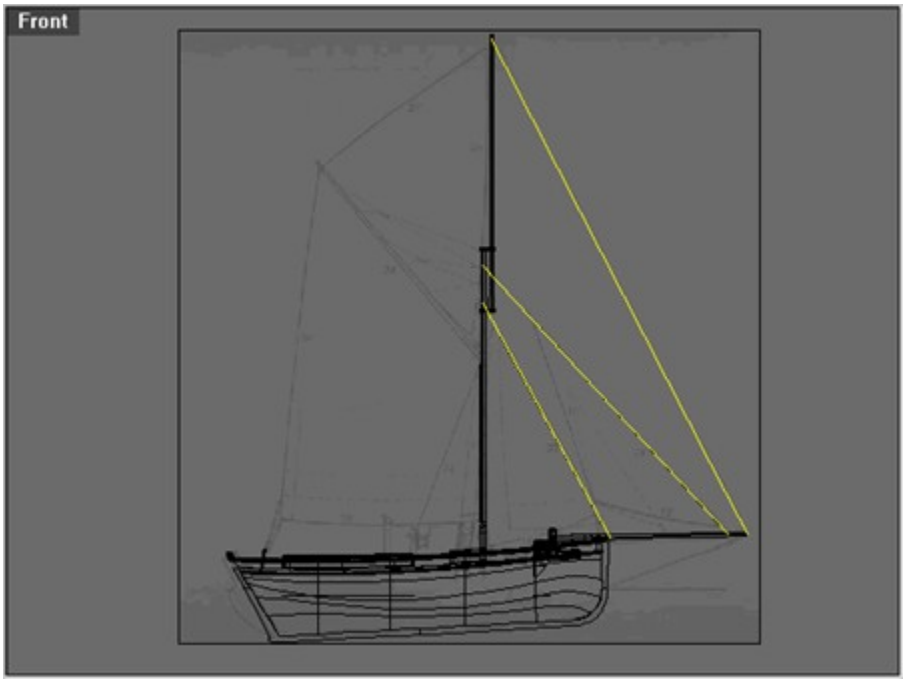
Make an **Ellipse** as shown below at the upper mast block in the right view and **Extrude** it with the '**B**othSides' option activated out a '**D**istance' of **70** units, select it and show control points **PtsOn**.



Select the outer most control points and from the front view use the **Scale2D** and select the center of the **Ellipse** and type in a 'scale factor' of **.5**. Result shown from the perspective view below.



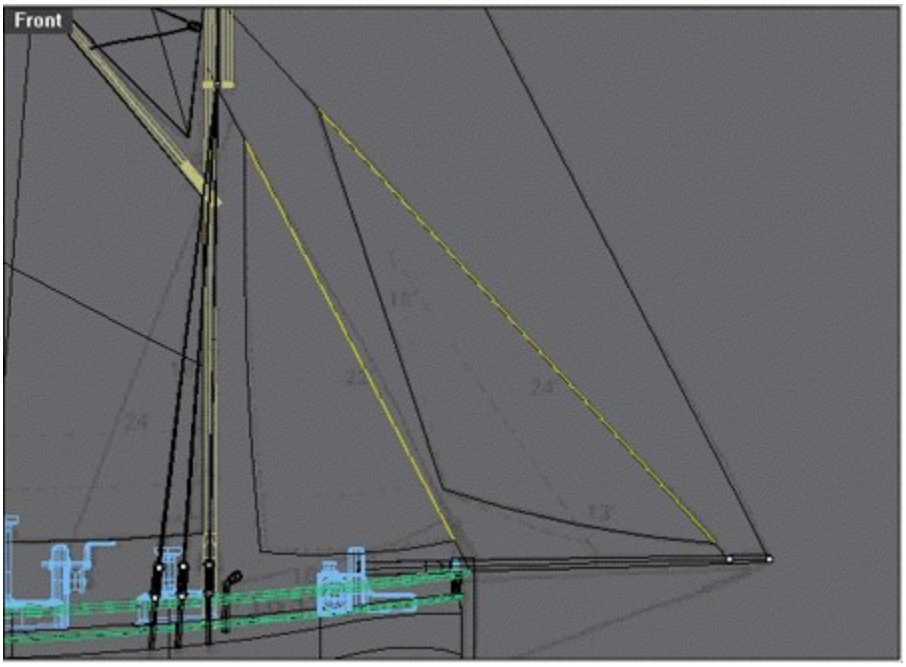
Turn off control points with **PtOff** and **Mirror** the spreader over using the center of the boat as the reflection plane and cap the ends with a **PlanarSrf**.



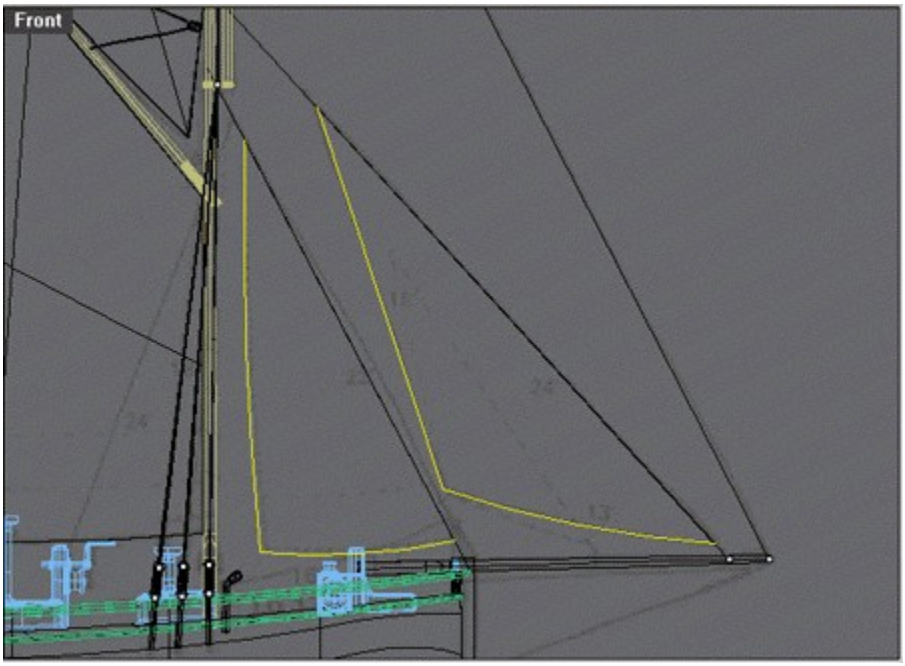
You can either use the curves on the 'sail curves' layer or turn off the 'sails' layer and follow the tutorial.

With the front view Maximized trace over the three 'stays' as shown above. Now remember that the sprit is not on the center of the CPlane but the mast is. One way to approach this is to put some **Points** where you want the lines to end and use 'Point' Osnap to draw the lines.

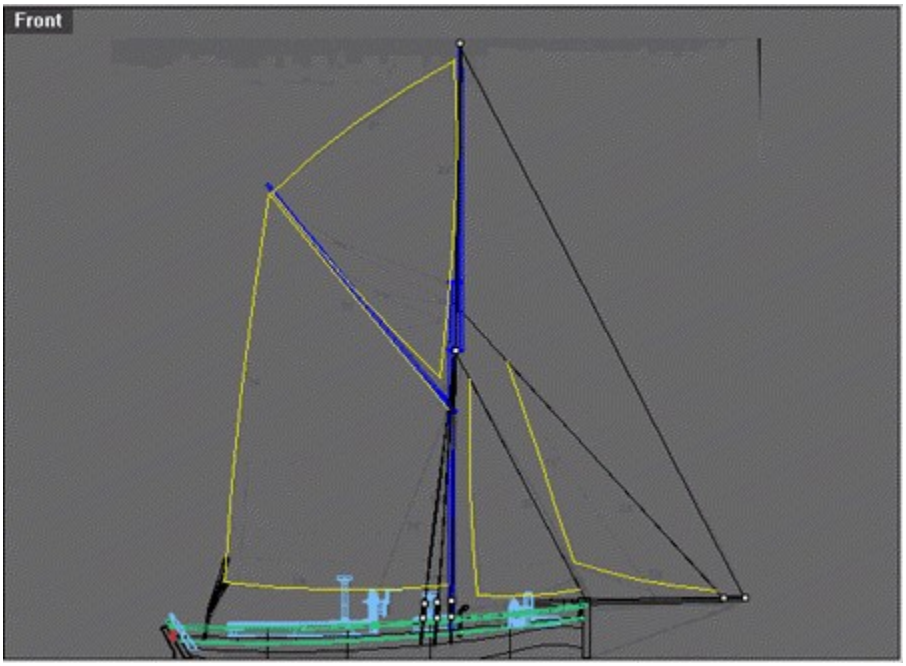
For the right hand side of the two fore sails, you need to use the command **Line** and should put the 'Near' osnap on to make sure the front part of the sail line up with the 'stays' as shown below.



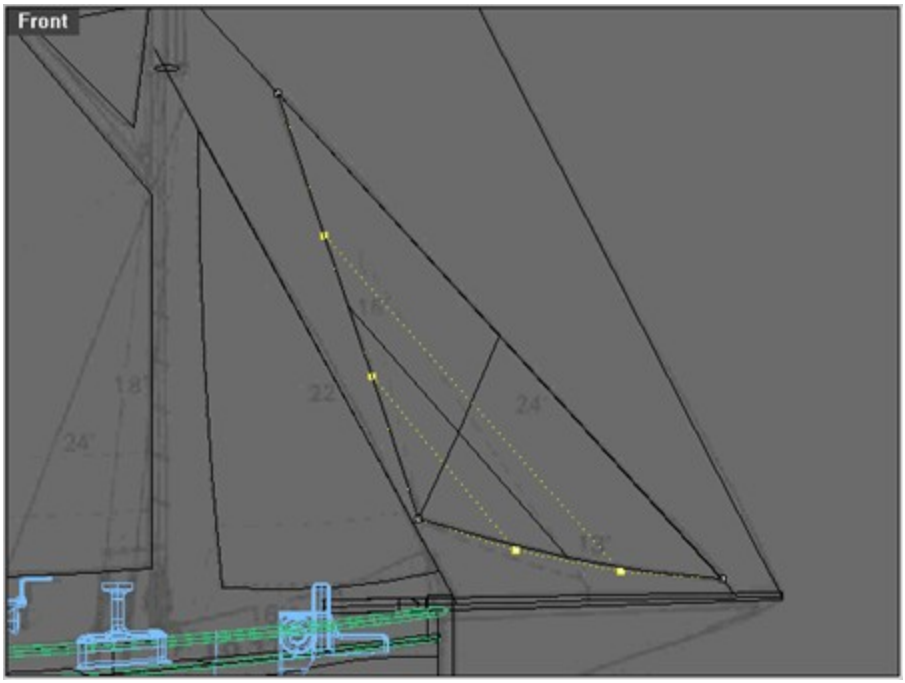
Use **InterpCrv** for tracing over the other sail lines shown below. You'll have to toggle the 'End' snap off and on to make sure that the corners of the sail connect but turn 'End' snap off so that you don't snag onto some other geometry for the other curves. If you don't have a hotkey setup for locking and unlocking persistent osnap now would be a good time. I use the 'alias' '**f**' (short for freeze) to toggle 'Lock' Persistent Osnap. See Help/Modeling Aids/Shortcuts/Aliases for information as to how to set up alias keys.



After you trace all four sails from the background image, select the curves shown highlighted below and **Rebuild** them with a point count of 4 except for the two long lines that hold the sail to the boat. This will keep the sail geometry as simple as possible.



On the two foresails hit **EdgeSrf** and pick the right hand (longest edge, but not the 'stay') of the sail first and then the other two to finish the triangle. Order is important for this operation. **EdgeSrf** the other foresail. Below is the finished sail with **PtOn**.



On the top sail select the top most edge first.

On the mainsail, because it is a four sided surface, it doesn't matter which edge you pick first. We'll put some shape into the sails, but before rotating the sails, it would be better to finish off the rigging first.

NOTE: We don't want to **Rotate** the main and top sail until we finish the block and

tackle that hooks up to it, but we can add shape and Rotate the foresails sails as follows.

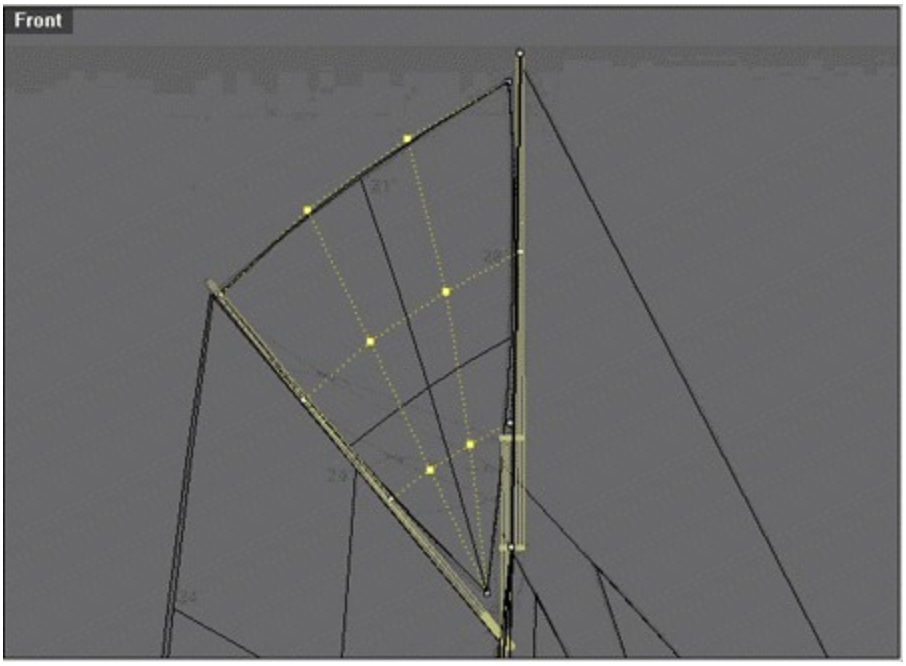
Select the foresail and show control points **PtOn** and select the four control points shown above.

In the right view make sure osnaps are off and gridsnap is on and move the cv about **6** snaps or **15** units. Go back to the front view and move the control points about the same distance to the right. Repeat the same procedure with the other foresail.

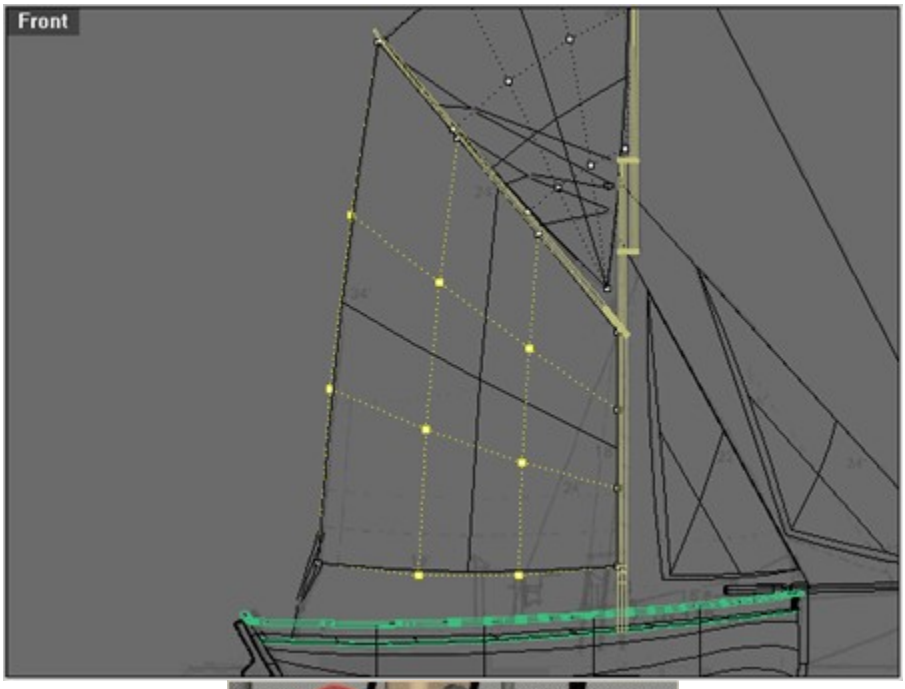
In the perspective view hit **Rotate3d** and with 'end' osnap turned on, select the top and bottom of the foresail and enter **25** for the angle. Repeat for the smaller staysail with a angle of **20**.

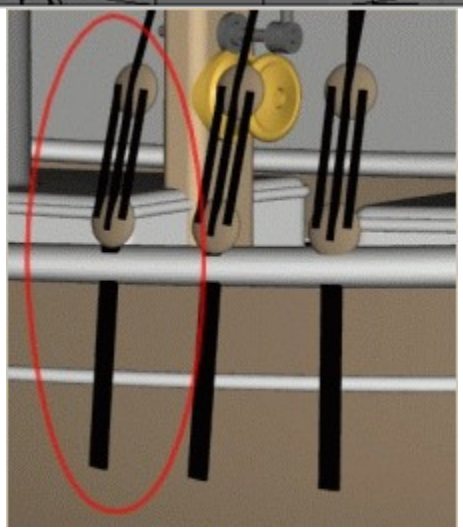
Let's put some shape in the top and main sail also.

Show control points **PtOn** on the topsail and select with the lasso the six middle control points and in the right view move them about **15** units.



On the mainsail select the four control points in the middle and the two control points in the middle of the back edge and lower edge, shown above, and in the right view move them **20** units.





Save your file and turn on the layer 'dead eye sample'.

Overview: The deadeyes are ellipsoid-like fat pancakes as shown above. The lanyards are the three ropes that hold them together. The lower deadeye is strapped to the hull and the upper deadeye connects to a 'stay', which are lines that hold up the mast. We'll use an ellipsoid for the deadeye and PolyLines for the lanyards and stays, which we will later turn into pipes.

Let's make the deadeyes, lanyards, and straps in the area of the view, which has no other geometry.

From the front view make an **Ellipse** that has is first axis about **3.5** units in the second axis of **3.5** and **1.5** for the 3d axis. Select the ellipse and **Copy** and drag **16** units straight down using the shift key as a temporary ortho.

Use the **Line** command to make the lanyards that connect the two deadeyes with the middle **line** a little longer than the two side lines.

Make pipes **Pipe** from the lines with a **1** unit '**D**iameter' and from the side view move them to the left until they're showing just outside the deadeye.

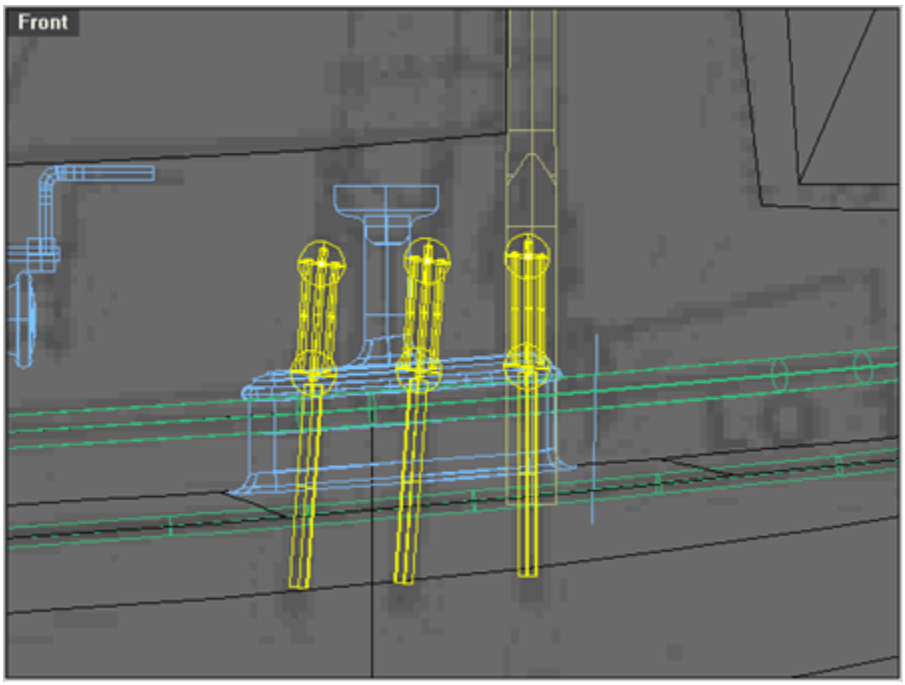
Select the deadeye and lanyards and drag them into position from the front view to be in line with the mast and that the lower deadeye is just above the rail.

Make a strap to hold the lower deadeye to the hull using a **Rectangle** and **Extrude** from the front view and in the side view center it to the deadeye.

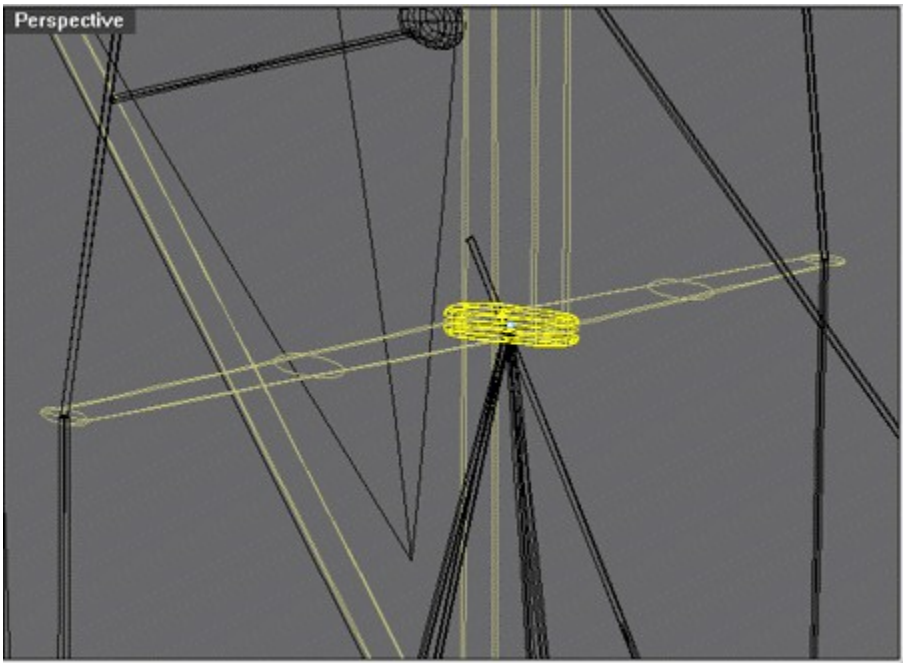
In the right view **Copy** all that we just made; deadeye, lanyards and strap (we'll call this the 'assembly') and move it into a position so the strap is lined up to the outside of the hull.

From the front view and with the 'assembly' still selected **Copy** and drag to the left to roughly line up with the deadeye assembly in the background bitmap.

Copy again and repeat as above to get the third deadeye assembly and move it roughly into position according to the background bitmap to get the result shown below.

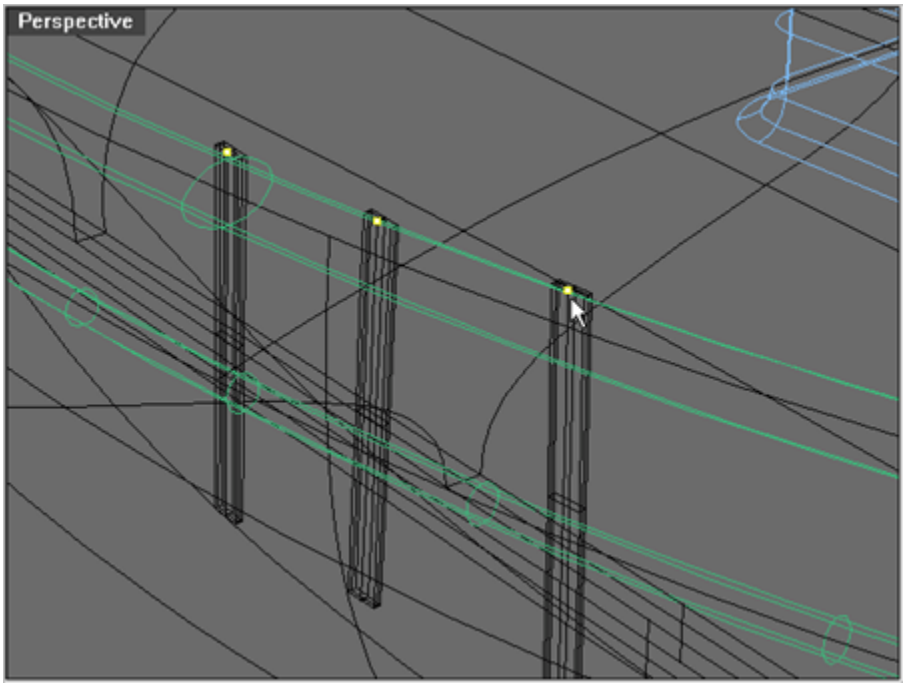


Go to the spreaders and select one of the end caps and go to Analyze/Mass Properties/Area Centroid, which will put a point in the middle, do the same for the opposite cap.
Select the lower mast brace that is between the spreaders and hit **AreaCentroid** shown below.



Note: We are going to use these points to create the stays that hold up the mast and get the correct angle of the deadeyes.

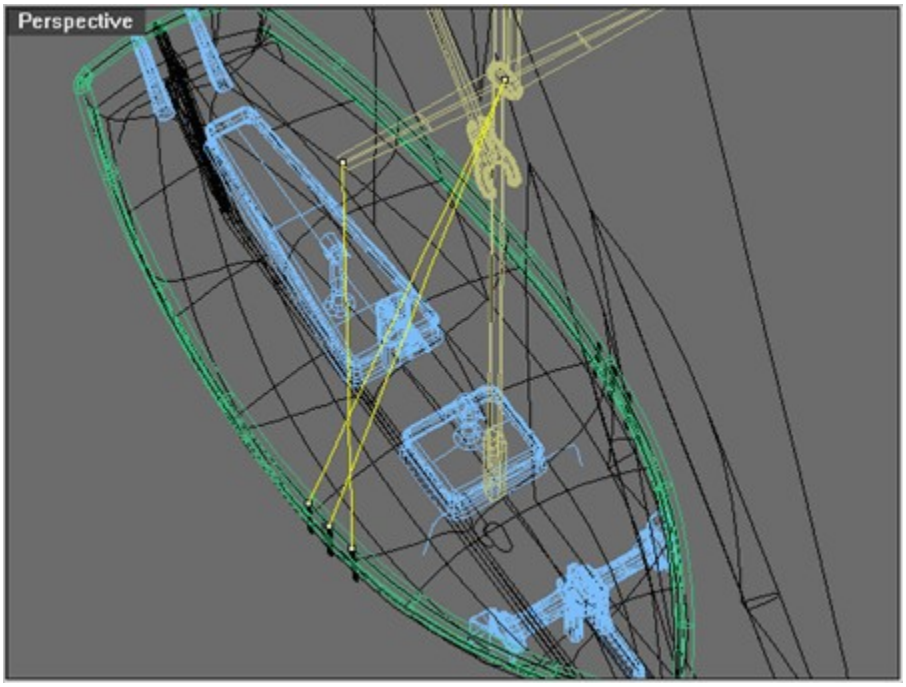
Select all the deadeyes and lanyards and hide them but leave the straps. With 'Mid' osnap on, place a point at the end of the straps as shown below.



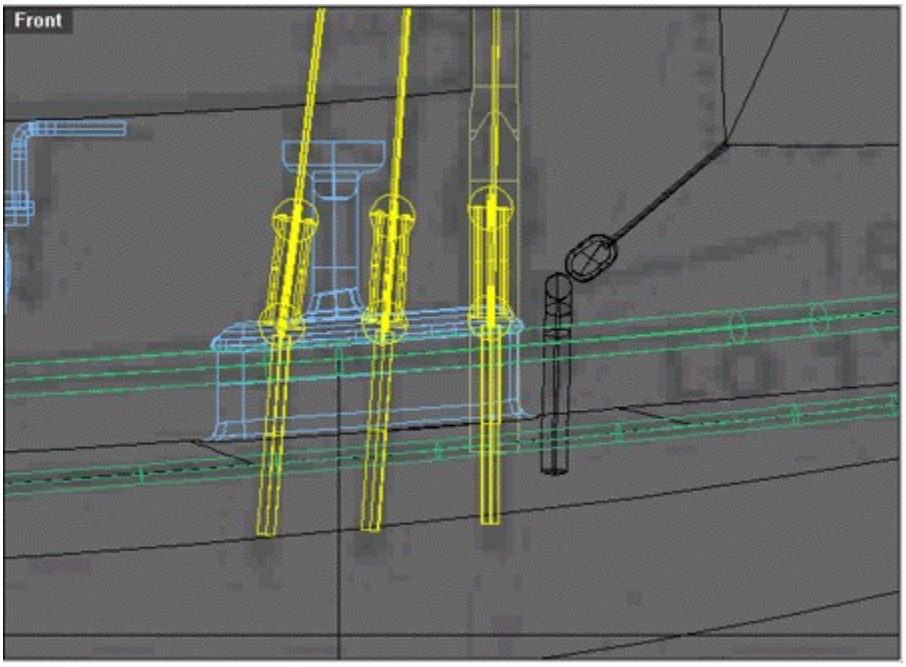
With all the views open, right click and drag to tumble the perspective view so that you are looking rather steeply down at the deck with the ends of the straps and spreaders are in view.

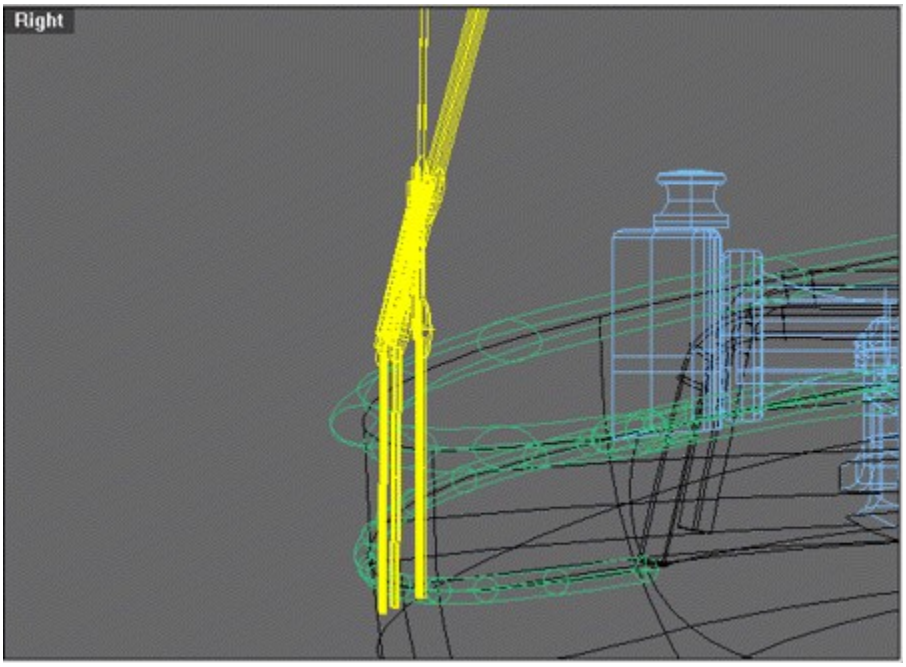
With only 'Point' osnap on, connect the forward strap with a **Line** to the point at the end of the spreader. Connect the center strap to the point at the center of the spreaders.

Connect the last strap to the point of the center of the spreaders as shown below.



In the front view select the deadeyes and lanyards of the middle assembly and **Rotate** them to be lined up with the new line with the base point of the rotation to be the point at the top of the strap in the right and front views.

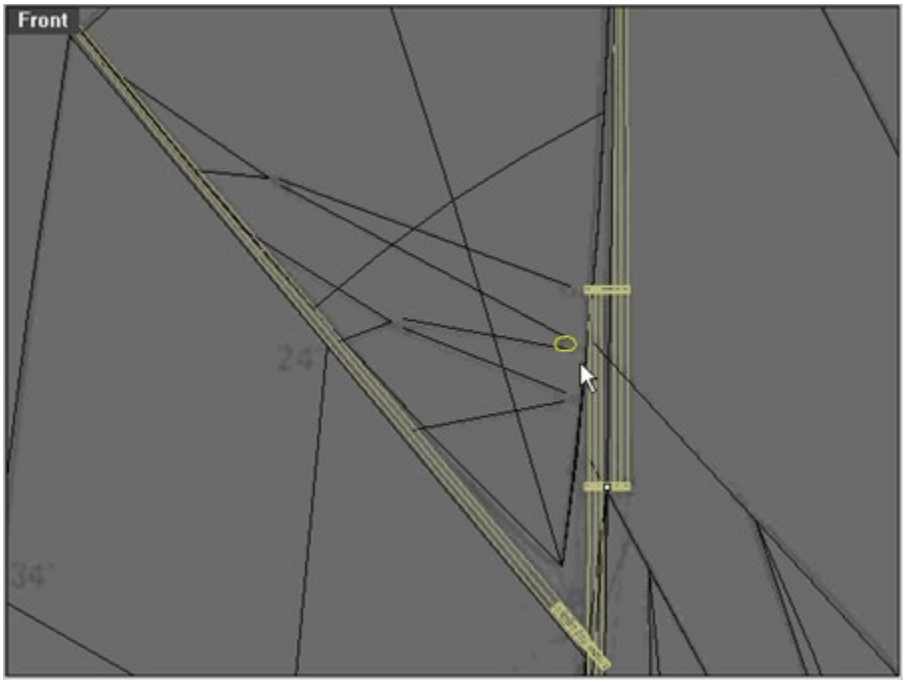




This completes the dea**Overview:** Now we need blocks and lines to hoist and trim (adjust) the sails. The reason why we kept the main and top sails on the centerline is so that when the sails are rotated the blocks and lines will all rotate with it, and less troublesome to line up.
You can either use the 'sail curves' layer curves or create your own and reference the sail curves layer. I'll just explain how to use the sails curves layer.

On the sail curves layer select the rounded rectangle shown below and **Extrude** it with the '**C**aps = Yes' and '**B**othsides' option a distance of **2**.

FilletEdge the block with a '**R**adius' of **1**.

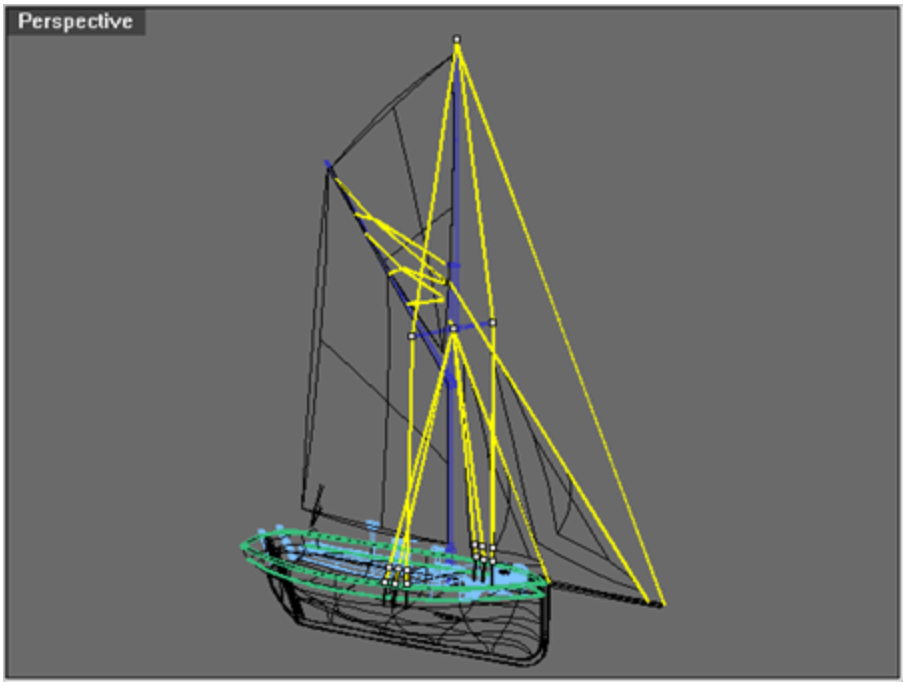


Hit **Copy,** drag and **Rotate** the block to where you see them in the background image in the area

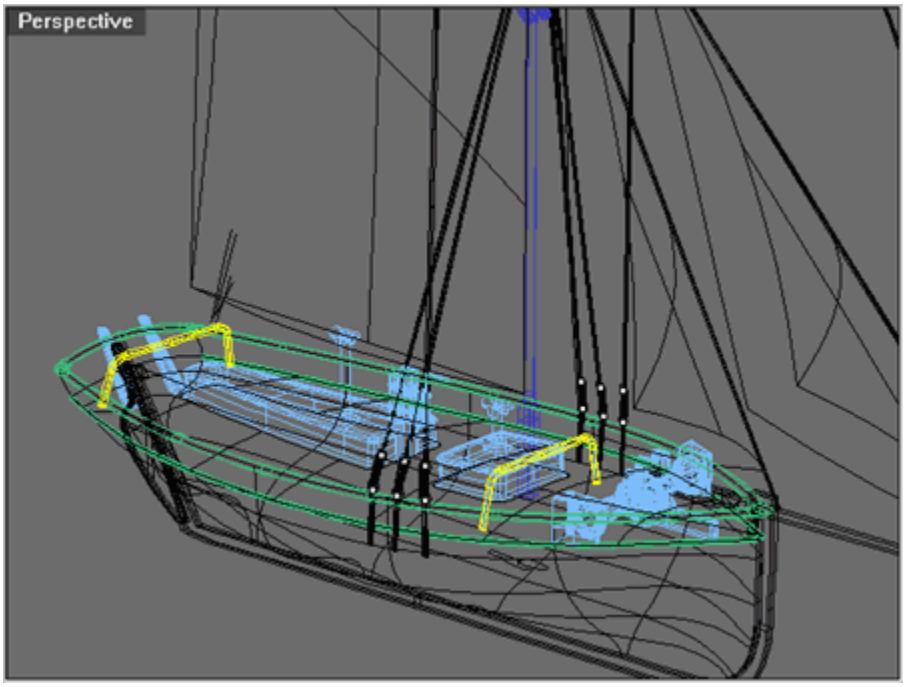
of the topsail (a total of four). Make one more copy and drag it down to lower left hand corner of the main sail for use later.

Overview: The ropes that adjust the sails are know as 'lines' or as the 'running rigging.' The 'stays' are known as the 'standing rigging' which hold up the mast. These are all going to get a 1 unit diameter pipe.

Use the **Pipe** command with the '**C**ap=No' option to make pipes from the selected curves highlighted with a '**D**iameter' of **1**, one at a time. The mast color is changed for more clarity.



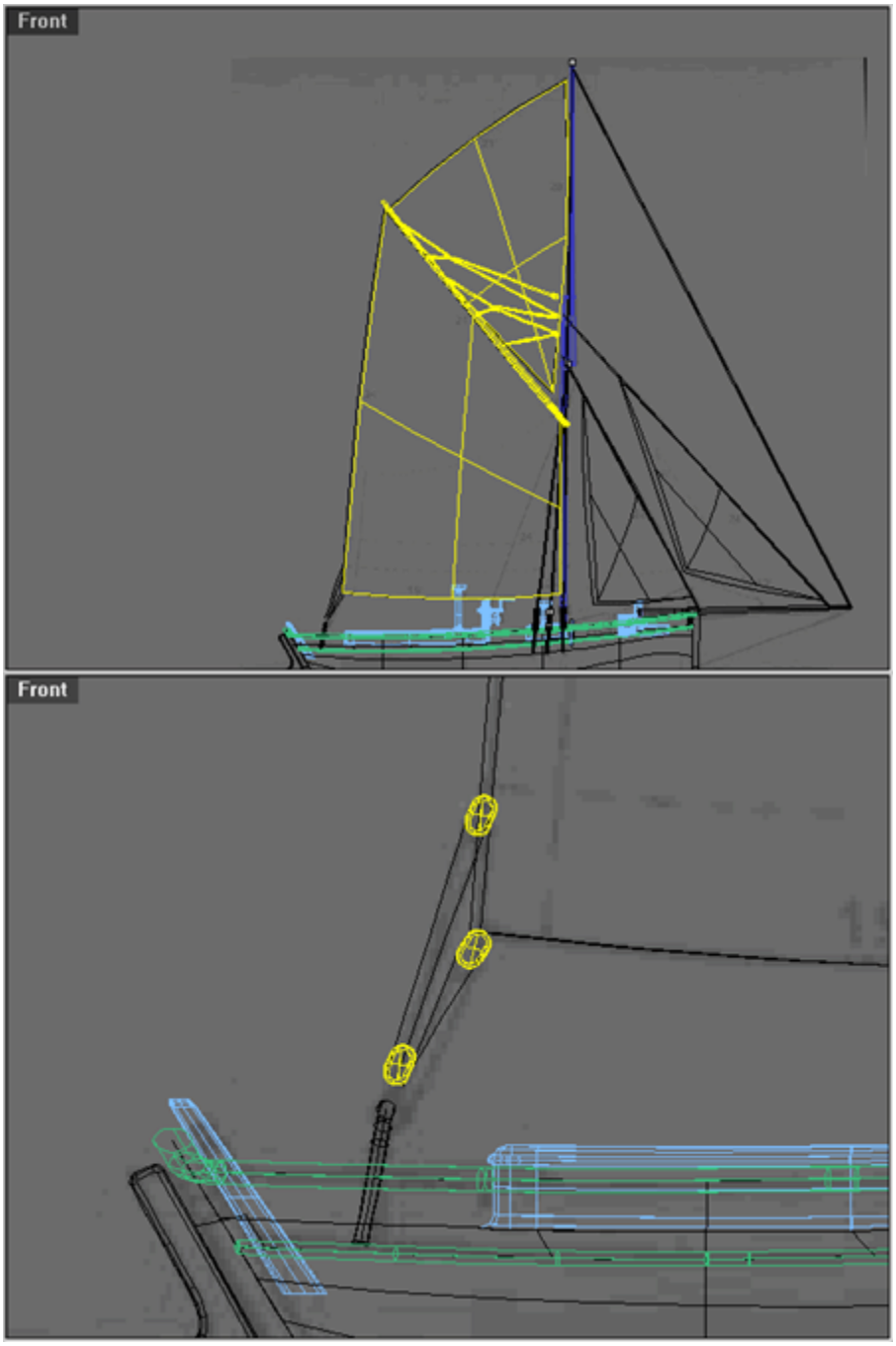
There is also a couple of bars that loop across the deck that need a to be piped with a '**D**iameter' of **2.5**. Shown selected below.



Overview: These bars hold the blocks that hold the running rigging which is attached to the lower

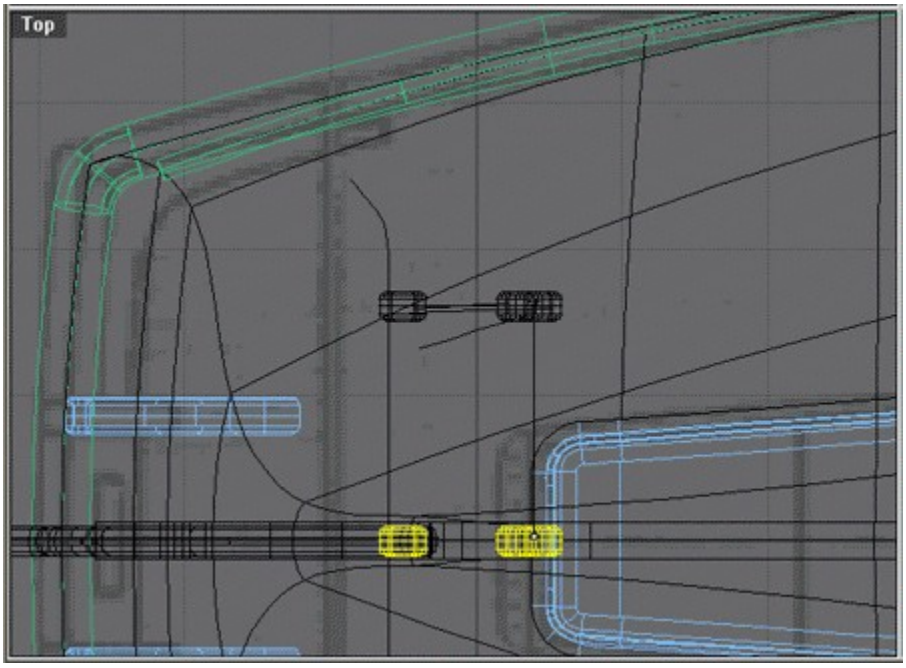
back corner of the sails and slide across the deck when tacking the boat.

In the front view, select the topsail, mainsail, the topsail blocks and lines and the gaff and the gaff jaws. Shown selected below, and hit **Rotate3D**. With the 'Point' osnap on, select the point at the top of the top mast, and for the second reference point drag down with Shift for temp ortho and click and enter in **7** for the angle.

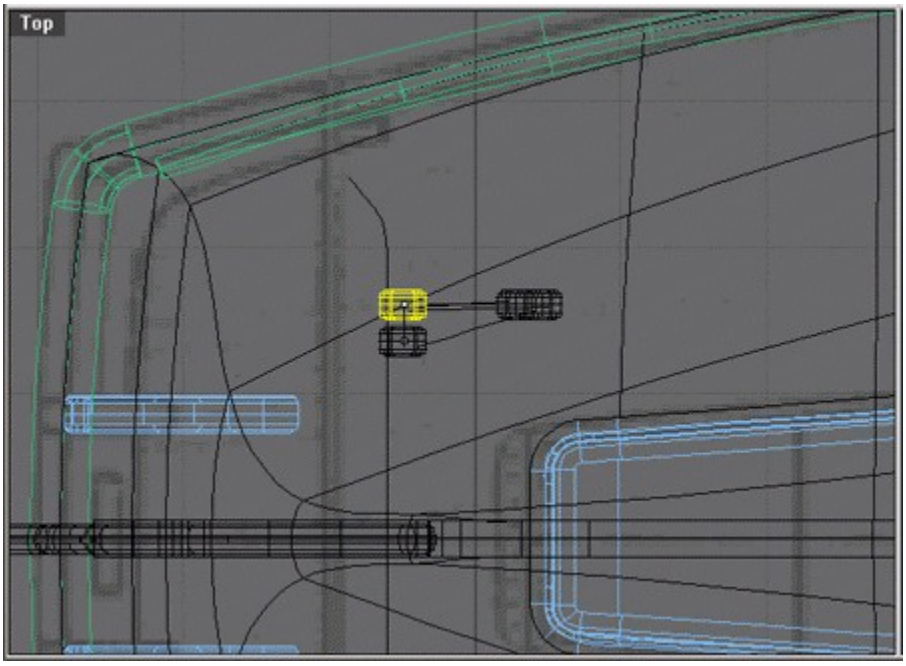


Zoom in on the lower left corner of the main sail and copy the block to the positions shown above.

From the top view drag the block up to meet the polylines on the 'sail curve' layer as shown in progress below

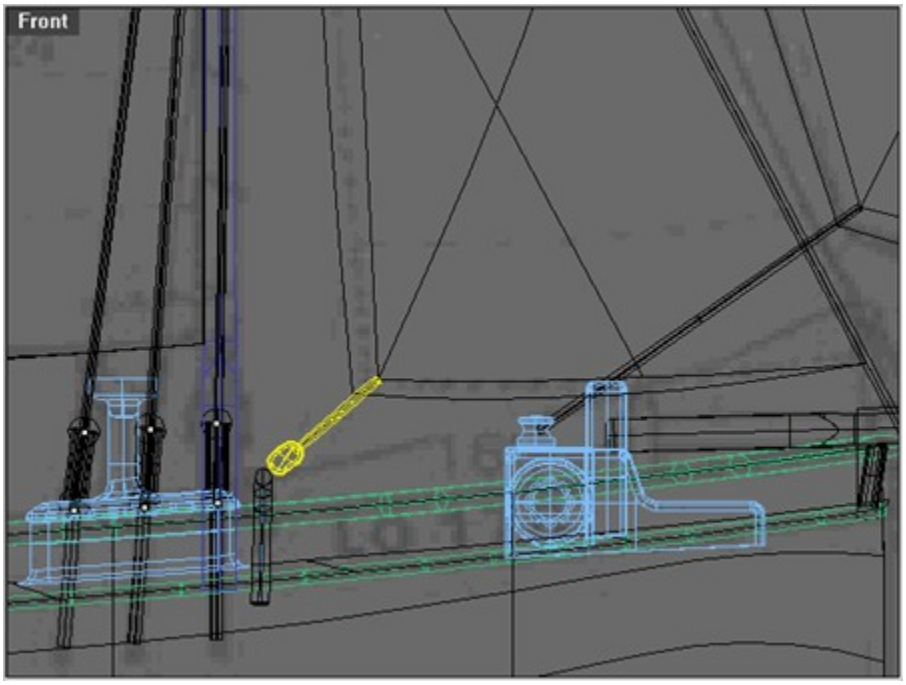


Copy the left block and drag it down next to itself as shown below.

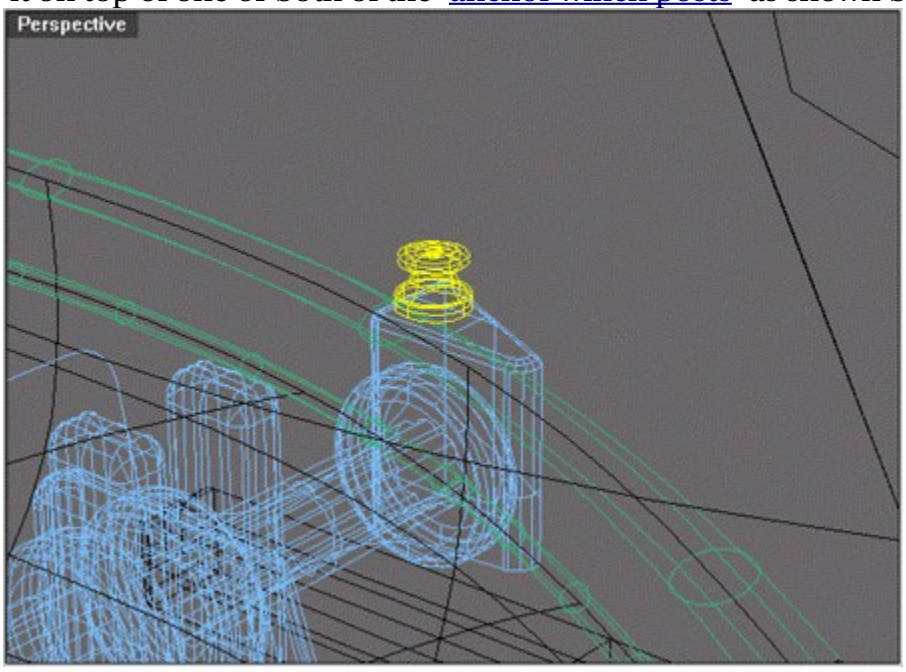


Make **Pipe**(s) from the polylines with a **1** unit '**D**iameter'. What you're going for is the appearance of the lines going through the blocks. It may not look perfect, but unless you have a camera close up you won't notice it.

Copy the last block and drag if forward to the other bar that goes across the front of the mast as shown below.

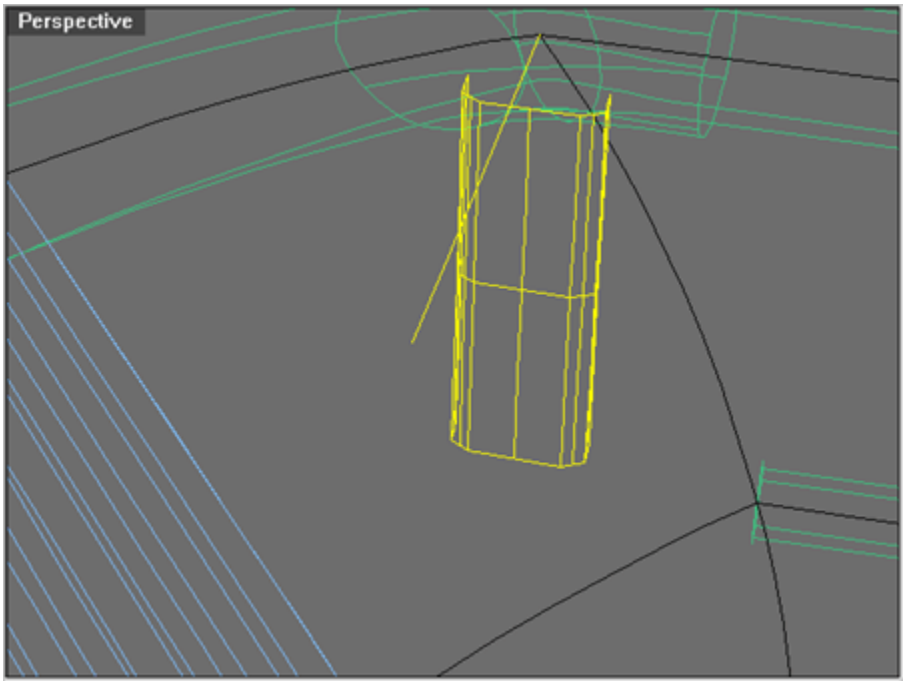


Another detail you may want to add is to **Copy** the 'main winch' and drag, **Scale** and **Rotate** it to place it on top of one or both of the 'anchor winch posts' as shown below.



Hit **SelCrv** and hit **Delete** or **ChangeLayer** them to a new layer and do the same with the points **SelPt**.

There's one final detail, and that is the ribs that run down inside of the rail. Turn on the 'ArraySrf' layer and hit **SelLayer** and select the 'ArraySrf' layer and with the perspective view active hit Zoom Selected '**ZS**'. Shown below.

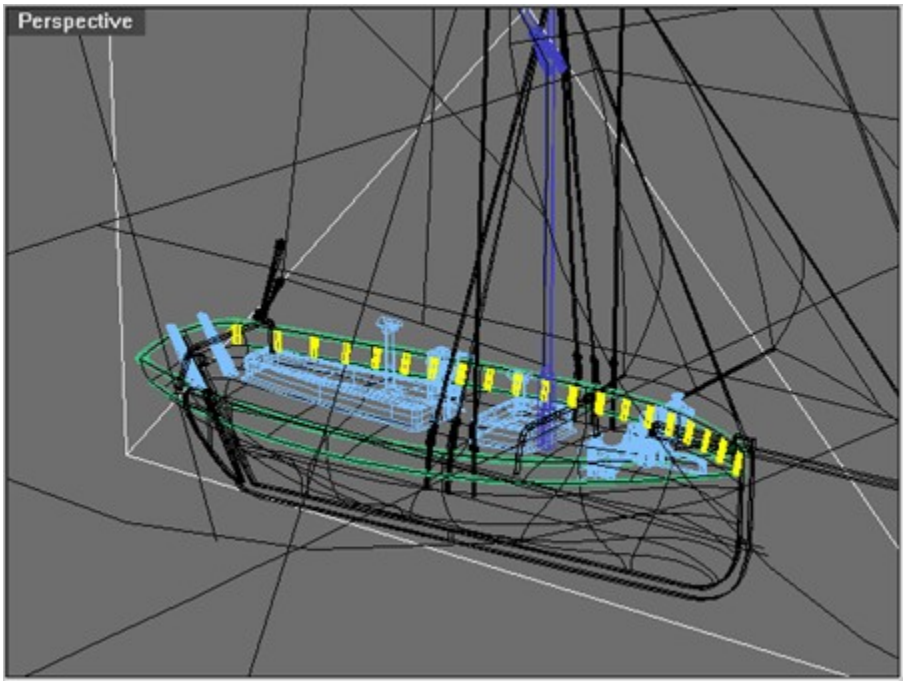


With 'End' osnap on, select the rib and hit **ArraySrf**. When prompted for the 'Base point for arrayed objects:' select the upper end of the red curve and when prompted for 'Reference normal for arrayed objects:' pick the other end of the line and when prompted to 'Select surface to array along:' select hull side. When prompted for 'Number of elements in surface u direction' type **20** and when prompted for 'Number of elements in surface v direction' type **2**.

> **NOTE:** if the ribs array themselves on the wrong side of the hull, **Undo** the ArraySrf and flip the direction of the surface normals of the far side of the hull only, using the **Dir** command and repeat the ArraySrf command as described above.

There are also some posts arrayed at the bottom of the hull so you will need to select them and delete them.

You can **SelLayer** the ribs and **Mirror** them to the other side but if you aren't going to show a view from the other side I wouldn't bother. Result shown below.



Congratulations, you're done modeling this sail boat.

If you went through this tutorial without following the Option links, you might want to check out some of the other possiblities at your leisure.

To best present your boat model with realistic lighting and textures, you can check out the Lighting and Rendering section of the Options index page which will give you the results shown on the first page of the tutorial.