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3D Mesh Cleanup Tutorial: Fossil Crab (Advanced)

In 1 collection

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ABSTRACT

This protocol details about 3D mesh cleanup tutorial of fossil crab (Advanced).

ATTACHMENTS

671-1417.docx

GUIDELINES

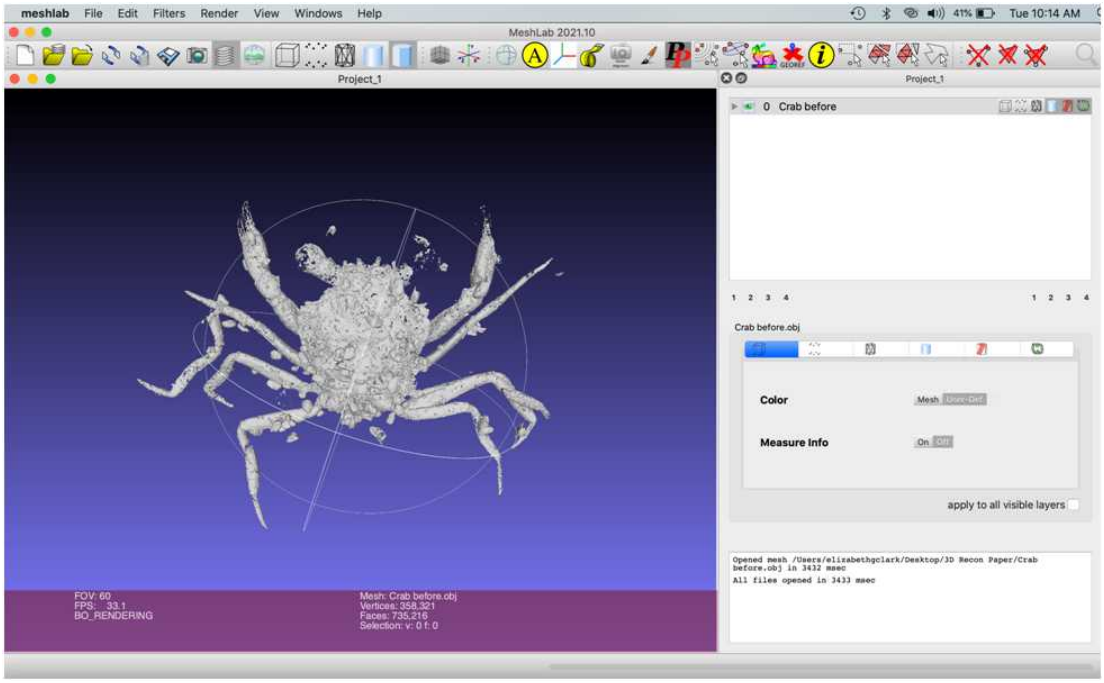
***Skills developed*: Advanced mesh editing**

3D meshes of fossil specimens extracted directly from 3D imaging data often need post-processing to be useful for paleontological analyses. Here, we present the workflow that was used to digitally process *Cretapsara athanata* (Luque et al. 2021), the most complete fossil crab ever discovered, as a tutorial. This tutorial uses two pieces of software: the opensource mesh editing program Meshlab (Meshlab.net) and the 3D modeling software Autodesk Maya (autodesk.com/products/maya) that can be downloaded for free by students or through an institutional subscription. It is highly recommended that the first two tutorials in this series are completed before beginning this one. Note that this tutorial utilizes Meshlab 2021.10 and Autodesk Maya 2017, and other versions may have slightly different layouts and functions.

When the digitized fossil crab was first exported as a mesh from the 3D processing software, a number of common issues were evident. The right eye is missing, a leg is detatched, tips of the claws are floating, isolated faces, and debris surround and abut the specimen. This tutorial will walk through how to rectify these issues.

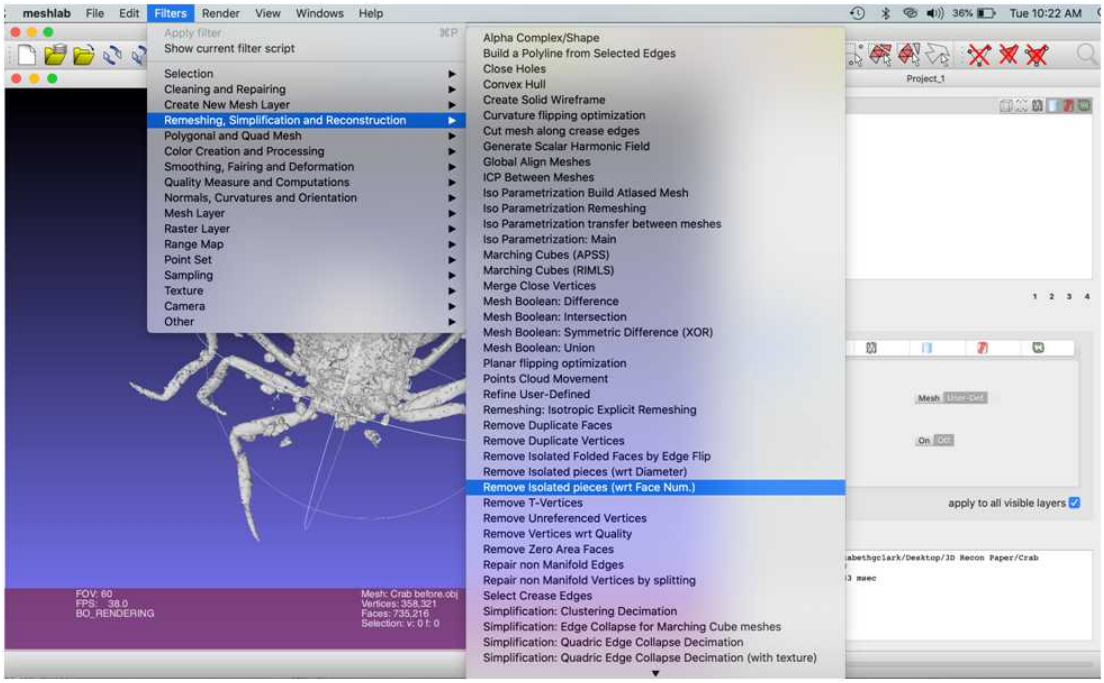
Skills developed: Advanced mesh editing

1 Import the crab into Meshlab by following Part 1 in the Cupule Cleanup Tutorial.

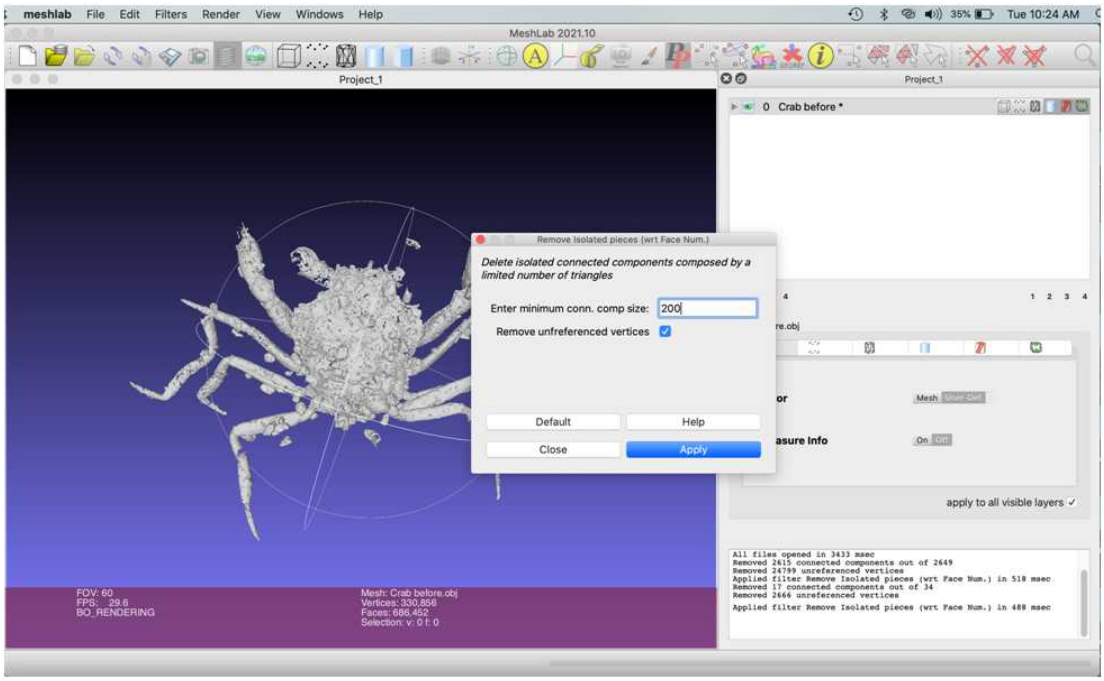


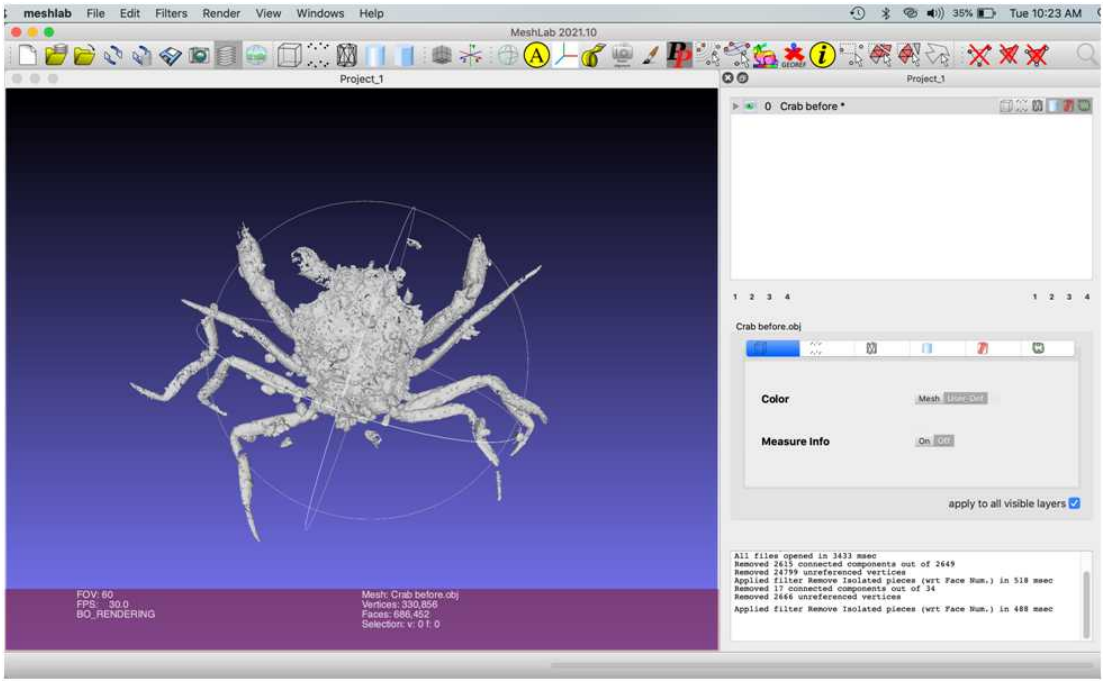
Remove External Debris

2 The imported mesh includes the crab, but it also includes other small isolated meshes that are 3D reconstructions of bits of the matrix. Remove this external debris by running a filter that removes small isolated mesh particles.
Go to Filters > Remeshing, Simplification and Reconstruction > Remove isolated pieces with respect to face number.



3 This option may be under “Cleaning and Repairing” in other versions of the software. As the 3D mesh of the crab is a large connected mesh with a relatively high number of faces, start by removing meshes with a relatively small number of faces (e.g., 200) and increase incrementally (e.g., by 50-500) until the bulk of the isolated extraneous mesh pieces are removed.



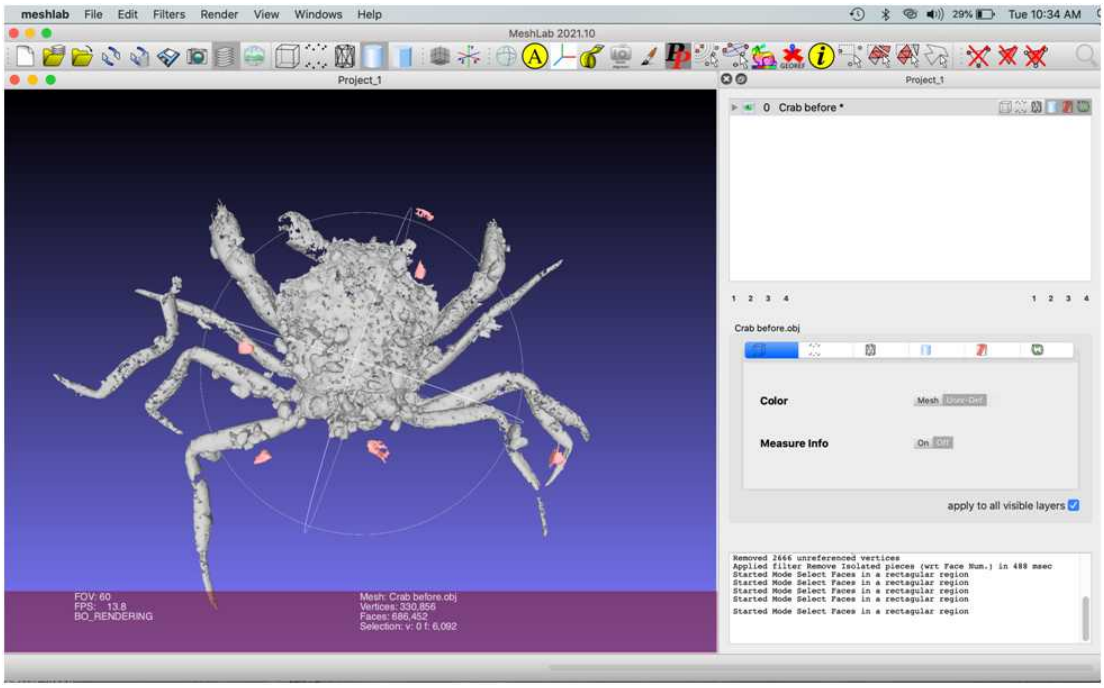


4 The scene still contains a few relatively large bits of extraneous isolated meshes. To select and delete these faces manually, first **click on the Interactive Selection tool** in the top right of the icon-based menu.

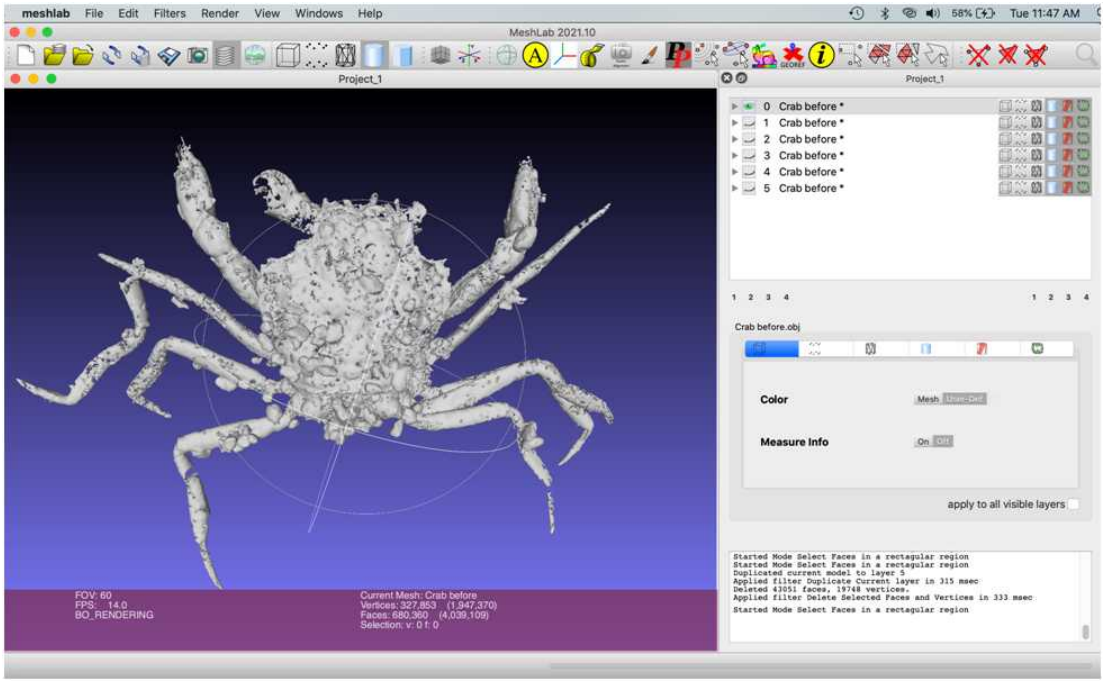
5 Hold left click and drag your cursor to select faces.

> **Note**
>
> Note that, while this tool is on, the faces you selected previously will become deselected once you click somewhere else in the project window.

To add faces to your selection, **hold command** (Mac) or **ctrl** (PC) **while you left click and drag**. To delete faces from your selection, **hold shift while you left click and drag**.



6 Delete these faces by **deselecting the Interactive Selection tool** and **selecting"Delete Selected Faces and Vertices"** on the right of the icon-based menu.



7

Next, repeat these steps to select and delete the small, rounded pebbles that are touching the crab mesh.

Note

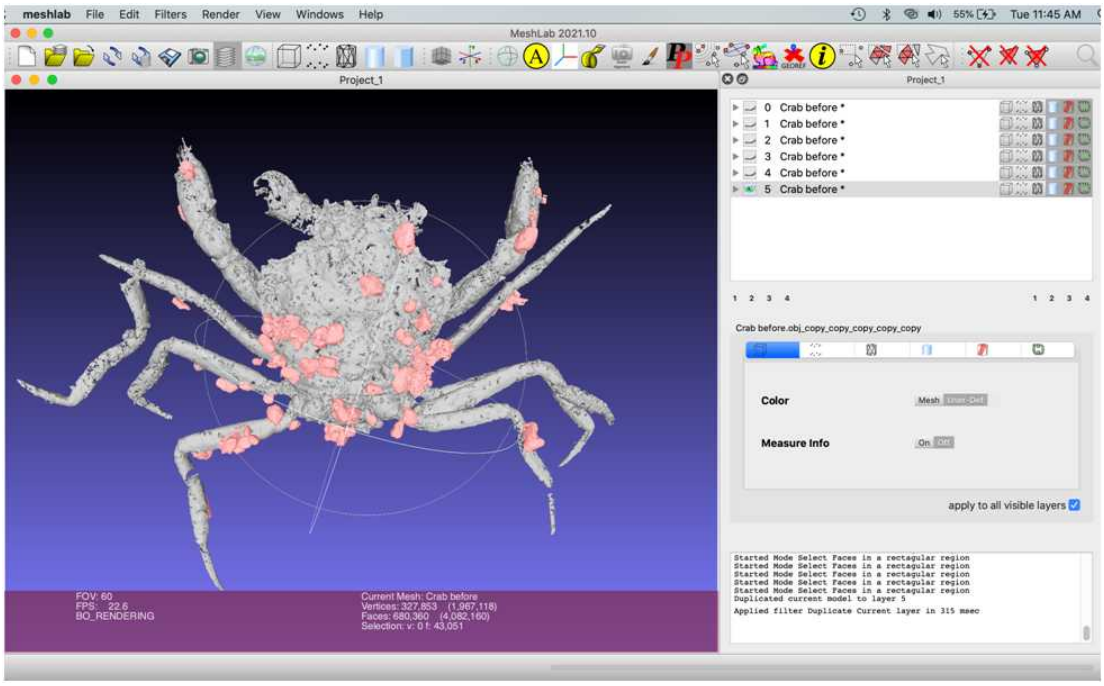
Note that your selection goes through the entire mesh in that plane of view. Be sure to minimize the number of faces of the crab mesh itself that are deleted; this can be done by turning off the Interactive Selection tool

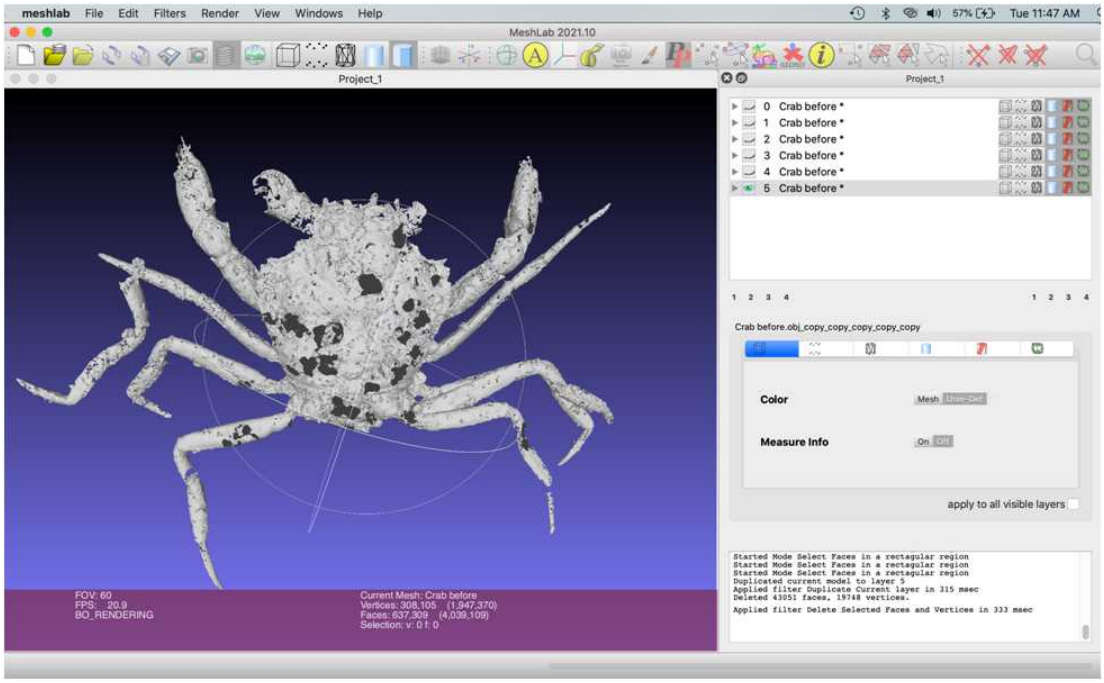
and rotating the mesh to ensure no pieces of the crab mesh were accidentally selected before deleting mesh components. We recommend duplicating the mesh, as Meshlab does not have an undo function, in case desired components of the mesh are accidentally deleted or deselected.

8

Duplicate the mesh by **right clicking the file name** and **selecting "Duplicate the Current Layer."** Select the eye icon on the original layer to toggle visibility so you can see deletions on the

new layer more clearly. You may wish to delete extraneous mesh little-by-little as you are just beginning, as opposed to all at once (as shown in the image below).





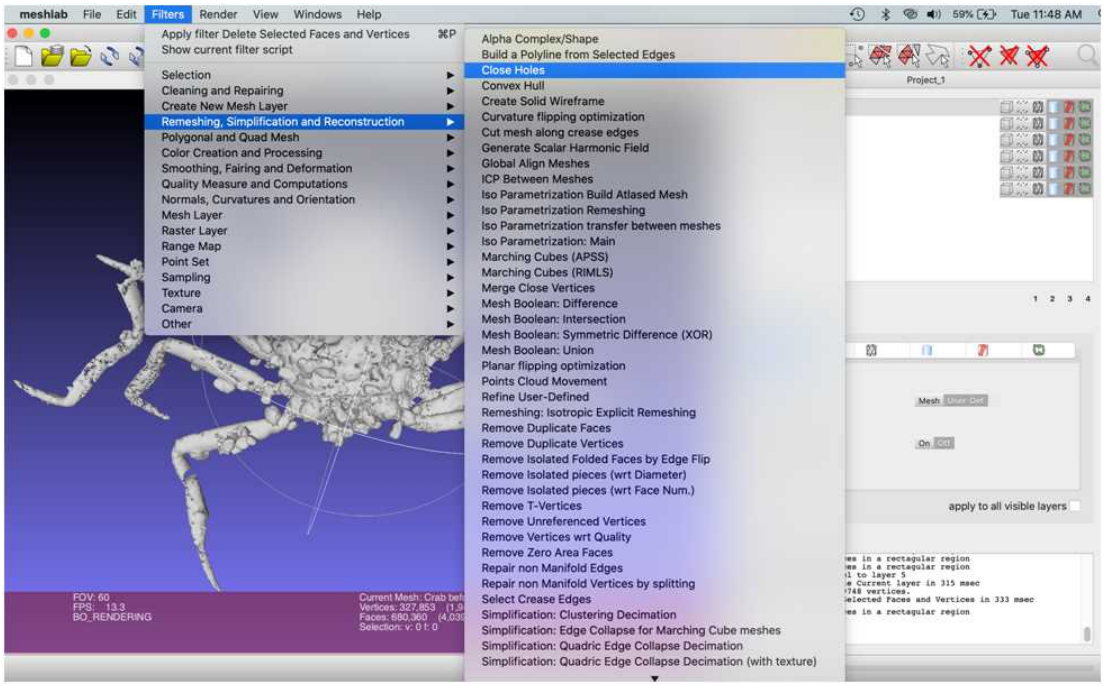
Fill Holes

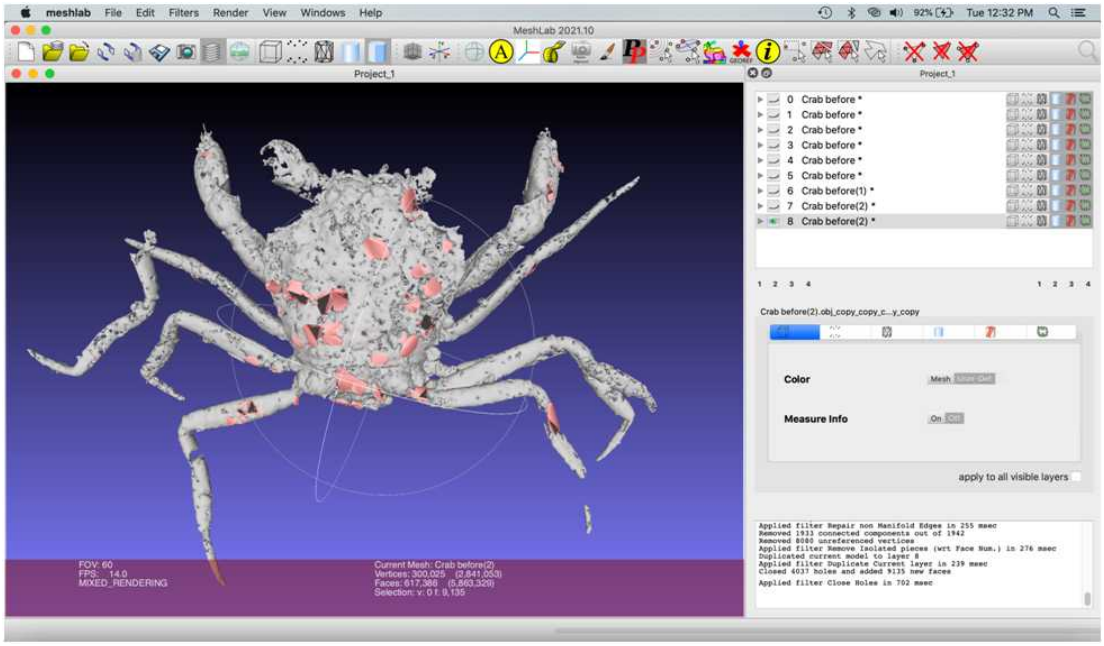
9 Clean up the mesh by selecting **Filters** > **Remeshing, Simplification and Reconstruction** >

Repair non Manifold edges. **Select Remove Faces** and **click Apply**.

10 Then, remove small isolated pieces that might have been formed during previous steps repeating **Filters** > **Remeshing, Simplification and Reconstruction** > **Remove isolated pieces with respect to face number**. Save this mesh layer by duplicating it.

11 Close holes that formed in the crab mesh during the deletion of articulating debris by selecting **Filters** >**Remeshing, Simplification and Reconstruction** > **Close Holes**. Set **"Max size to be closed" to 500** and **select Apply**. Alternatively, holes can be patched via the sculpting method described in the previous tutorial.



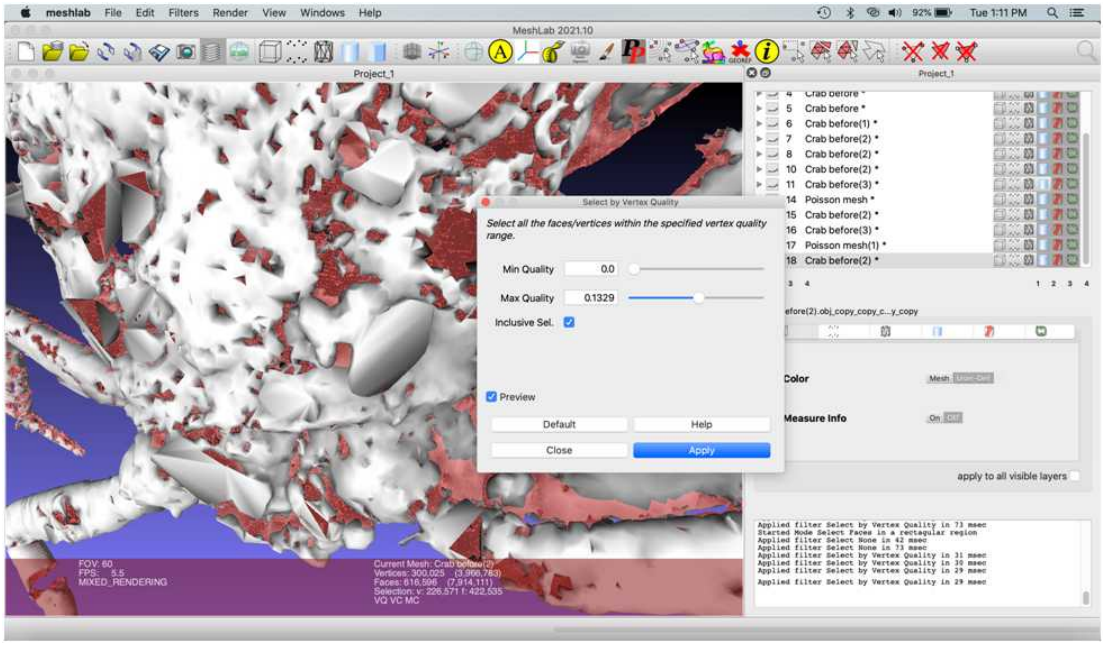


12 Deselect everything by selecting **Filters** > **Selection** > **Select None**.

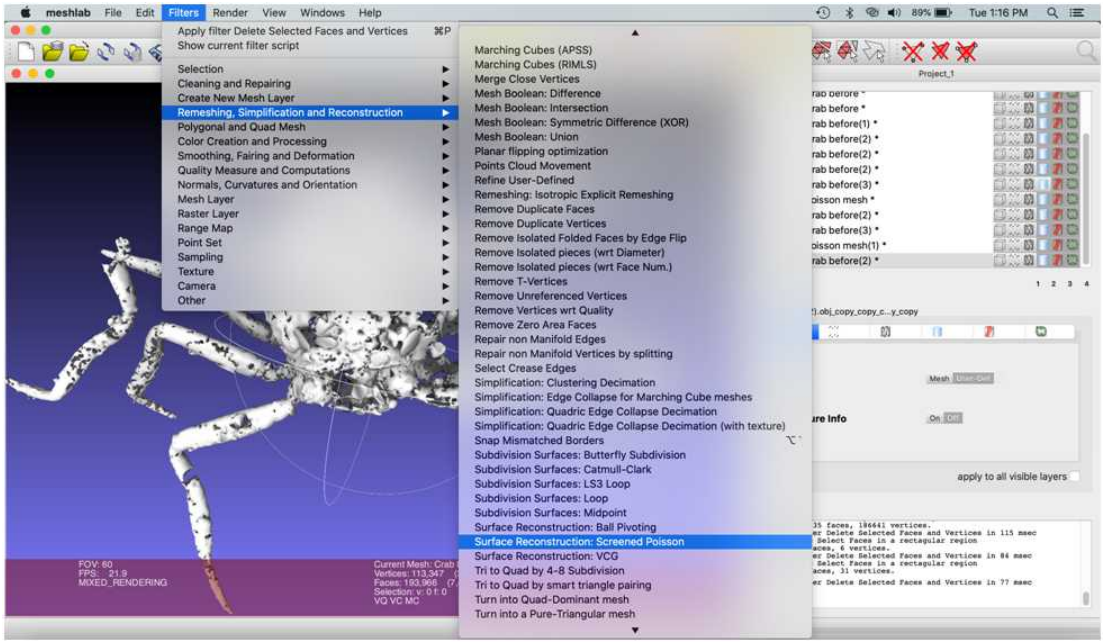
Shrinkwrap surface

13 Now, we're going to shrinkwrap a copy of the crab mesh to fill the leftover holes and smooth the surface of the crab.
The first step to do this is to hollow out the inside of the mesh. Duplicate the mesh and select **Filters** > **Color Creation and Processing** > **Ambient Occlusion.** Keep default settings selected **click "okay" on the popup window**. This tags the external faces white and internal faces dark.

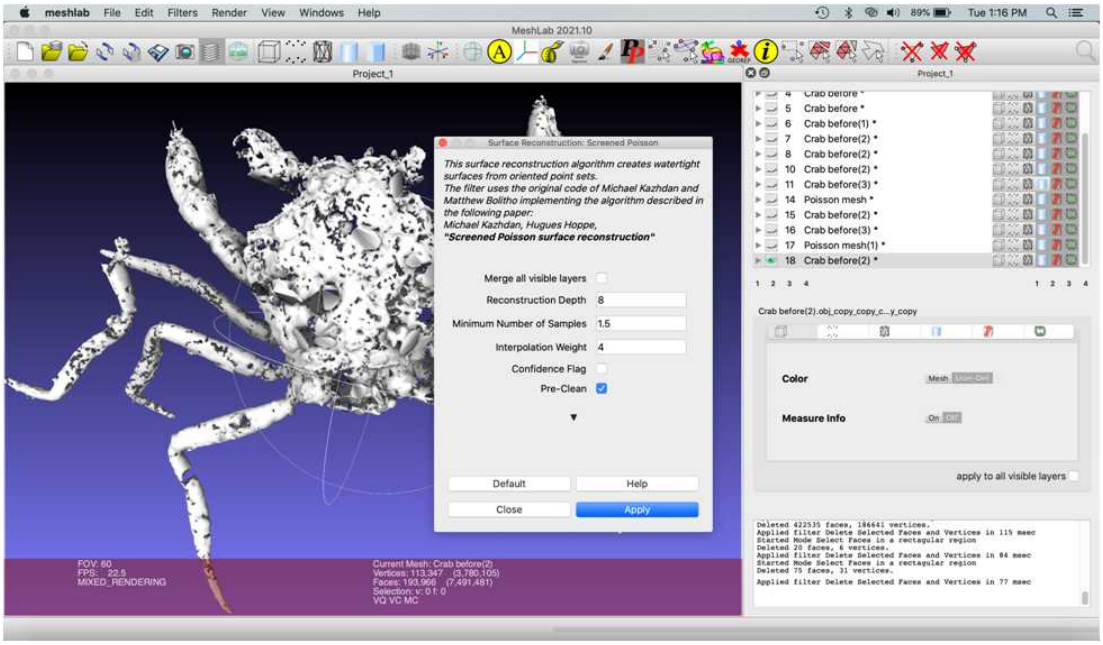
14 Next, select **Filters** > **Selection**> **Select by Vertex Quality**. **Check preview selection**. **Move the sliders to set Min and Max** to optimize the highest number of internal faces and minimal external ones **(e.g., Min at 0 and Max at 0.132944)** (review cupule tutorial for details)**. Click "Apply."**



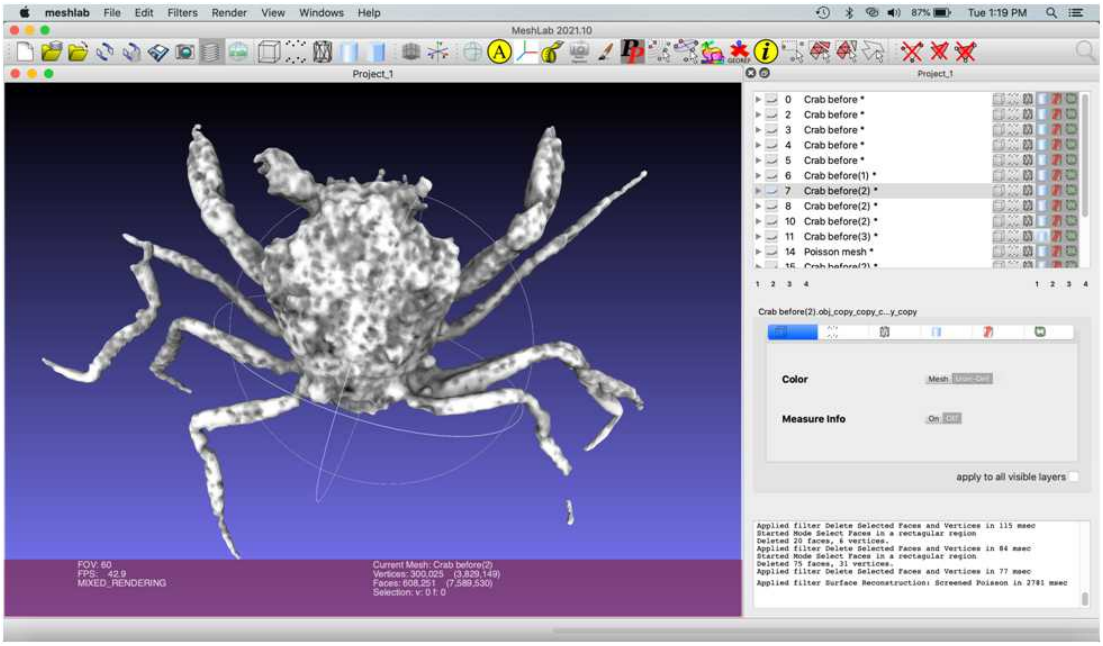
15 Select **Filters** > **Remeshing Simplification and Reconstruction** > **Surface Reconstruction: Screened Poisson.**



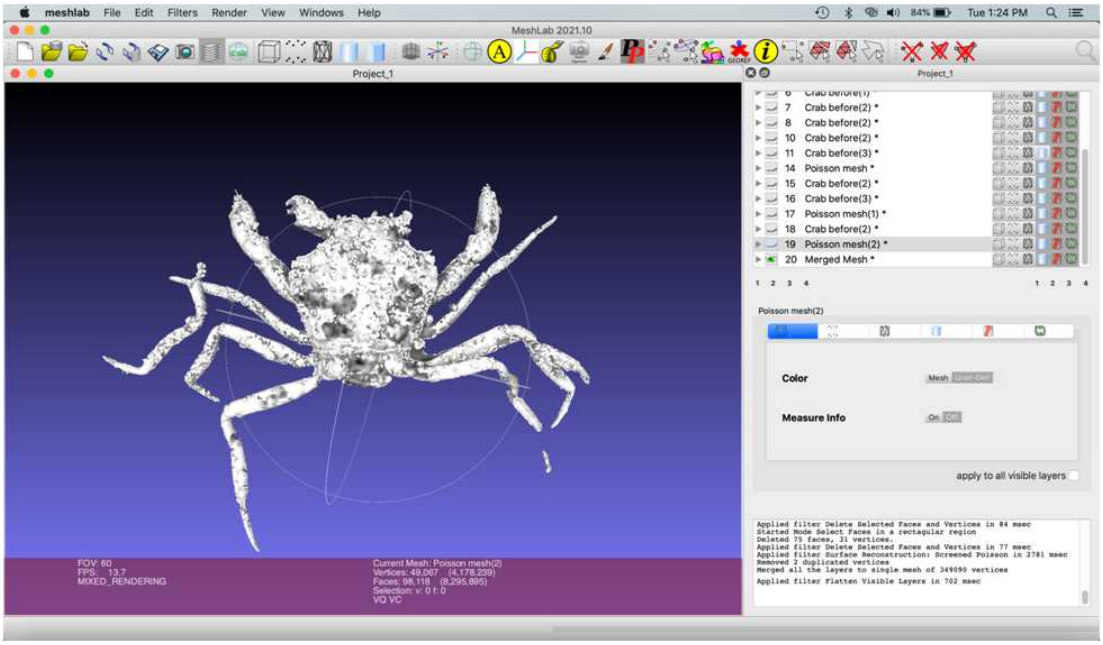
16 **Check “Pre-Clean”** and **click Apply**.



17 This new version of the mesh has filled holes and a smooth surface; however, some detail has been removed. Merge the new Poisson mesh with the mesh saved previously by making these two meshes visible and hiding any others by selecting the eye icon.



18 **Right click one of the meshes and select "Flatten Visible Layers" to create a merged mesh**. Keep default settings selected.

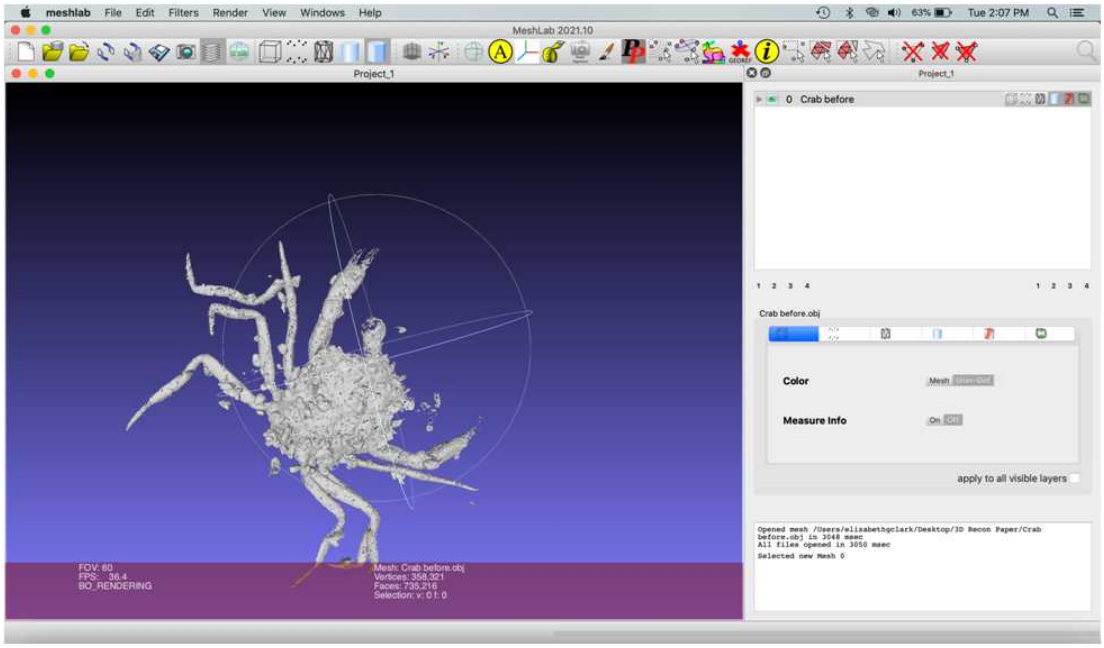


19 Save this mesh by selecting **File** > **Export Mesh**. Name the file “Body remesh.” A new pop-up window will appear. Select “none” in the bottom left corner and click “OK.”

Repair Missing Features: Eye

20 To simplify your scene and get rid of unwanted meshes, **close and restart Meshlab. Reopen Crab before.obj in Meshlab.**

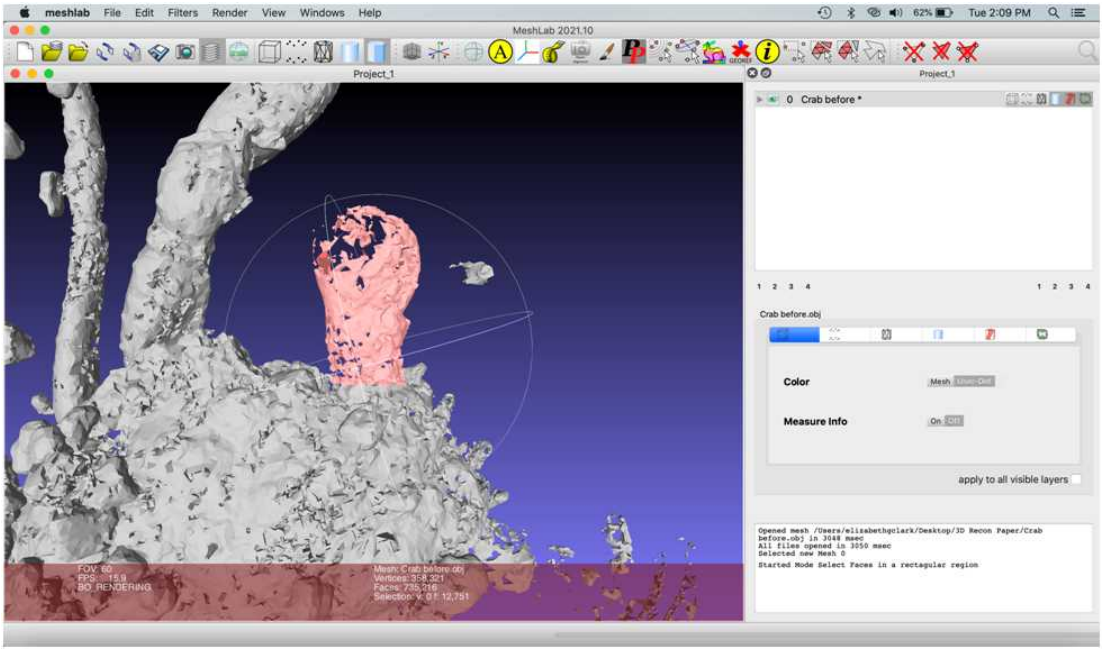
21 Position the left eye of the crab at the center of the project window by **holding Command (Mac) or ctrl (PC) and dragging the mesh**, or holding down the scroll wheel and dragging on a mouse.



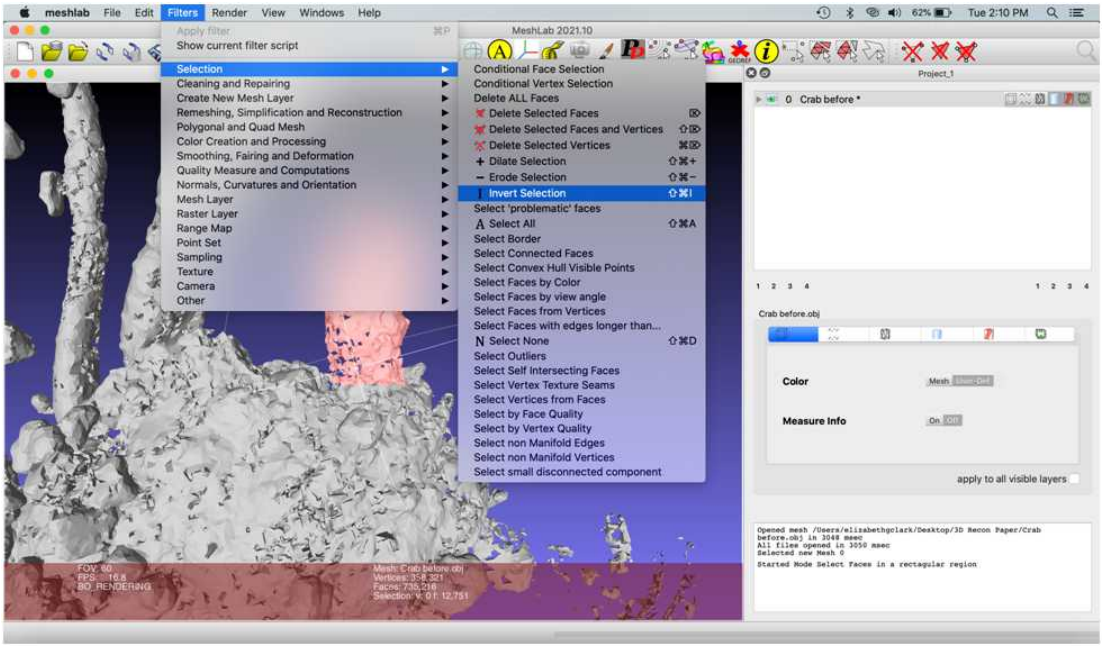
22 Zoom in using the scroll wheel on the mouse.

23 Select the eye using the Interactive Selection tool (

).



24 Select everything except for the eye by selecting **Filters**> **Selection> Invert selection**. **Check both Invert Faces and Invert Vertices, and click "Apply."** All of the mesh components except those of the eye will be selected in red.



25 Delete selected faces and vertices

26 Shrinkwrap the eye. Perform the ambient occlusion filter and delete the internal vertices. Save this mesh by duplicating it. (See “Shrinkwrap surface” section for details.)

27 Apply the Surface Reconstruction: Poisson Remesh. Enter 4 into the “Reconstruction Depth” window.

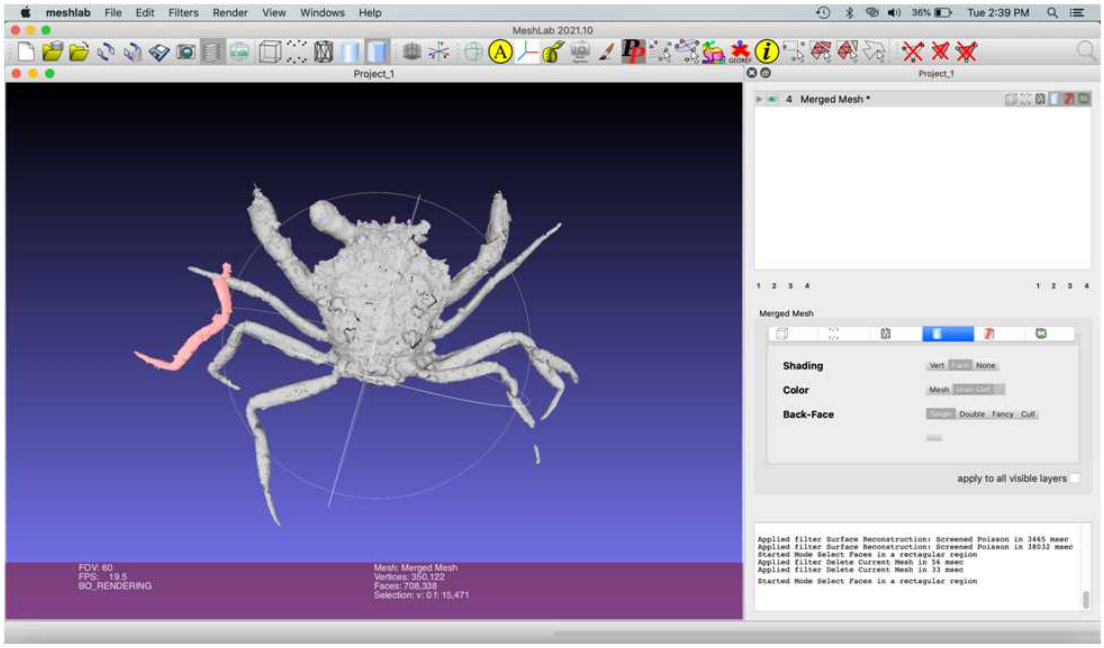
28 Merge the two meshes of the eye created here. Perform a Poisson Remesh of this new mesh: enter 5 into the “Reconstruction Depth” window. Export the file as “Eye remesh.”

Repair Missing Features: Leg

29 Close and restart Meshlab. Import and merge “Body remesh” and “Eye remesh”.

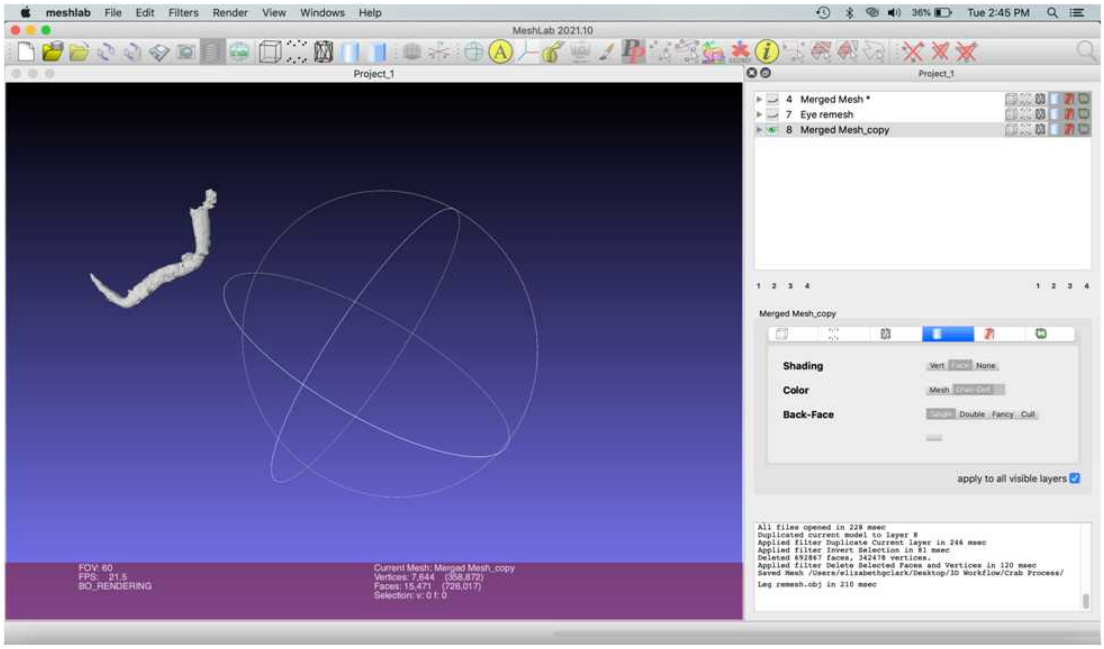
30 Select the leg that's isolated from the rest of the body.

31 Copy the mesh.

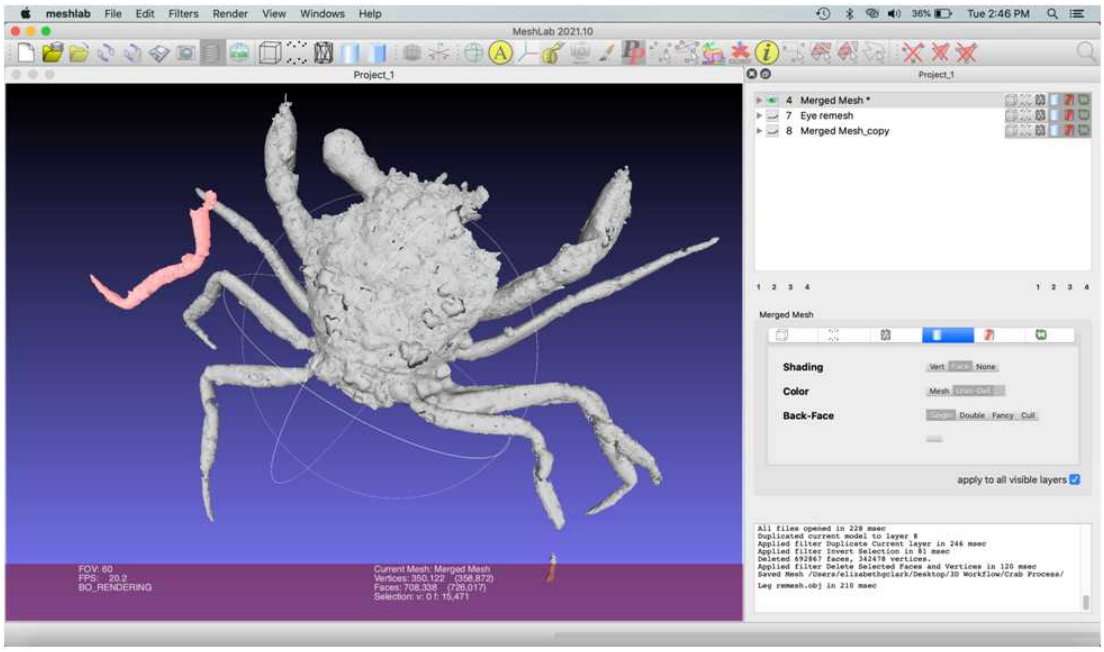


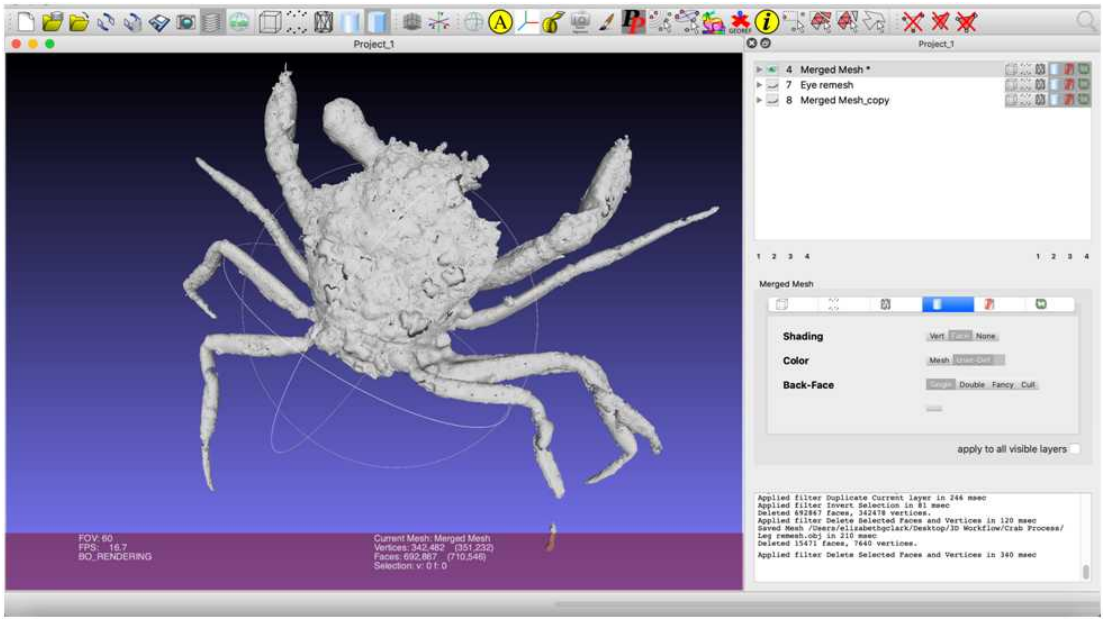
32 From the original mesh, invert the selection and delete the rest of the body.

33 Export this mesh “Leg remesh.”



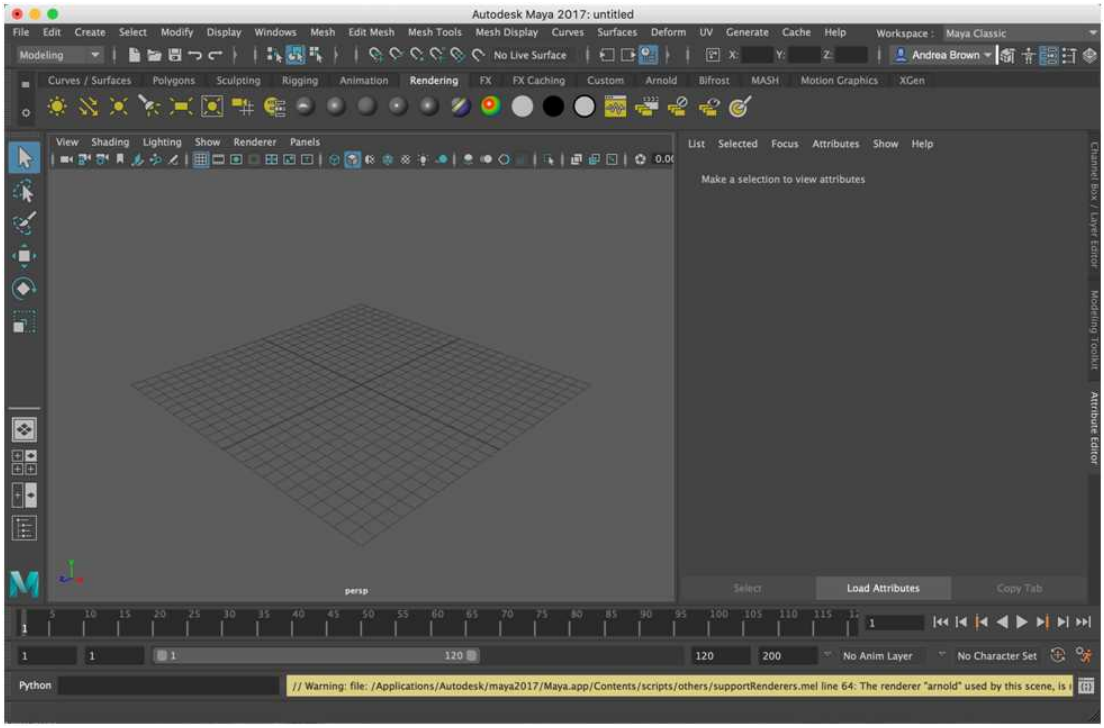
34 In the copy of the mesh, delete the leg. Export this mesh as “Crab body and eye remesh”.



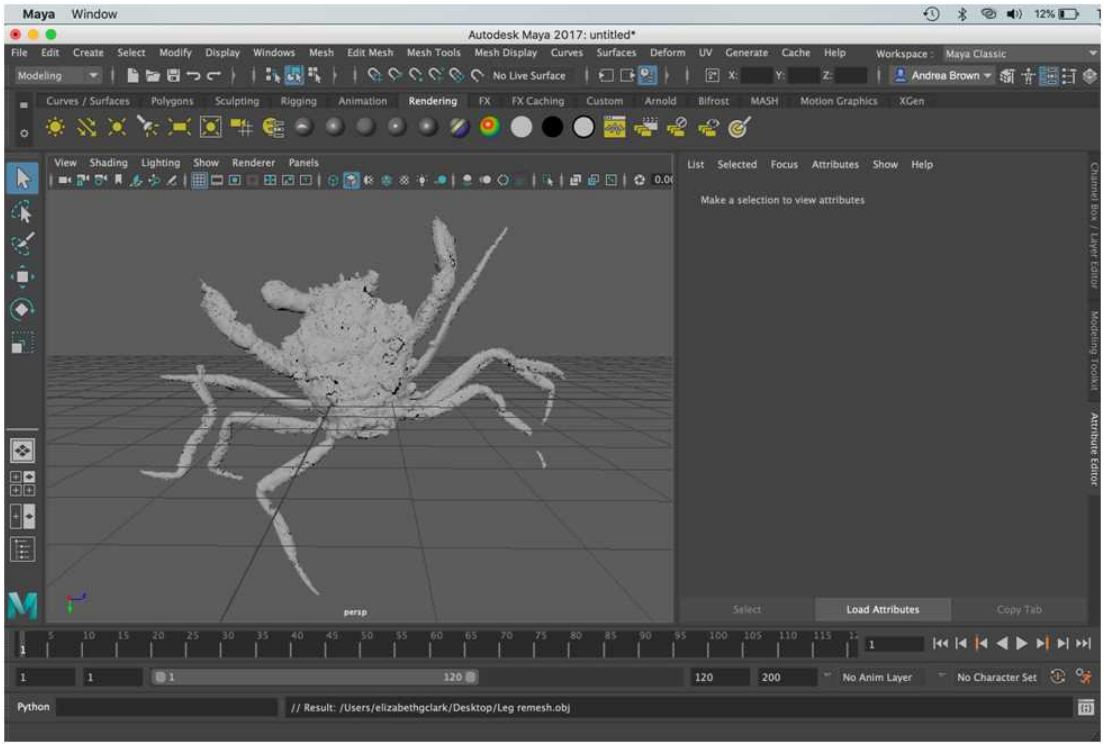


Reposition and combine meshes

35 Open Maya.



36 Import “Crab body and eye remesh.obj” and “Leg remesh.obj” into Maya by going to **File** > **Import** and selecting these files.



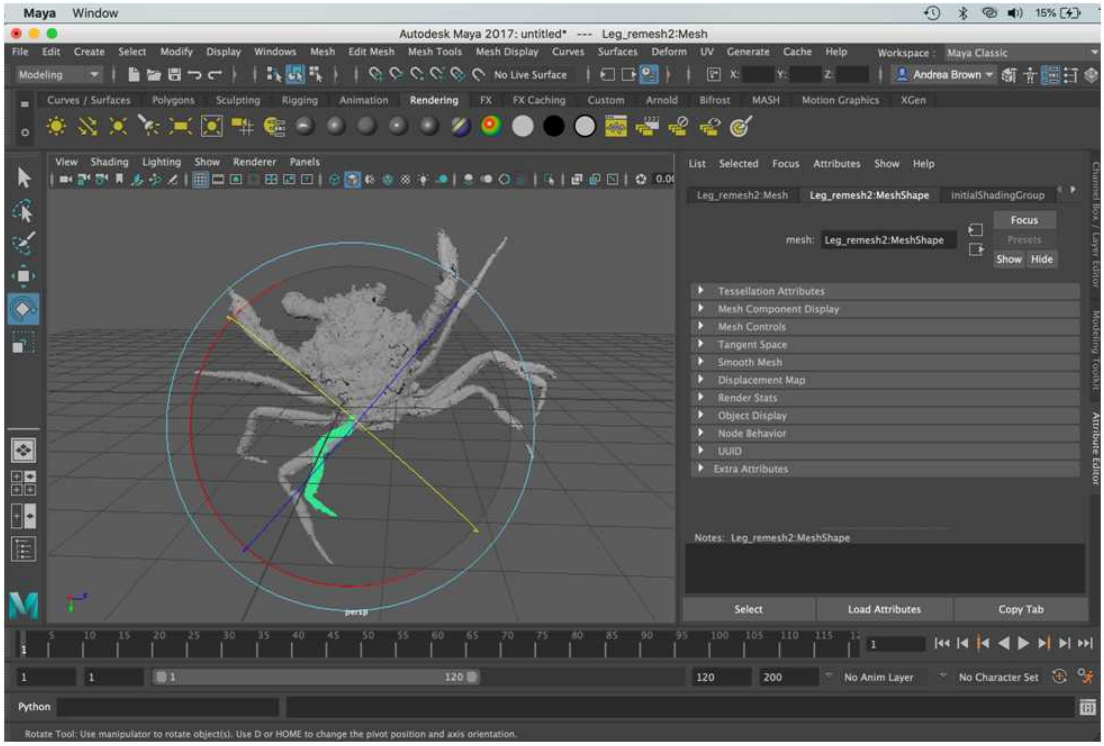
37 Click “A” to view all imported files. To rotate through the scene, hold “Alt” and left click while dragging the cursor.

38 On the lefthand side of the screen, there are tools for moving, rotating and scaling the objects within the scene.

38.1 One of them is the transform tool:

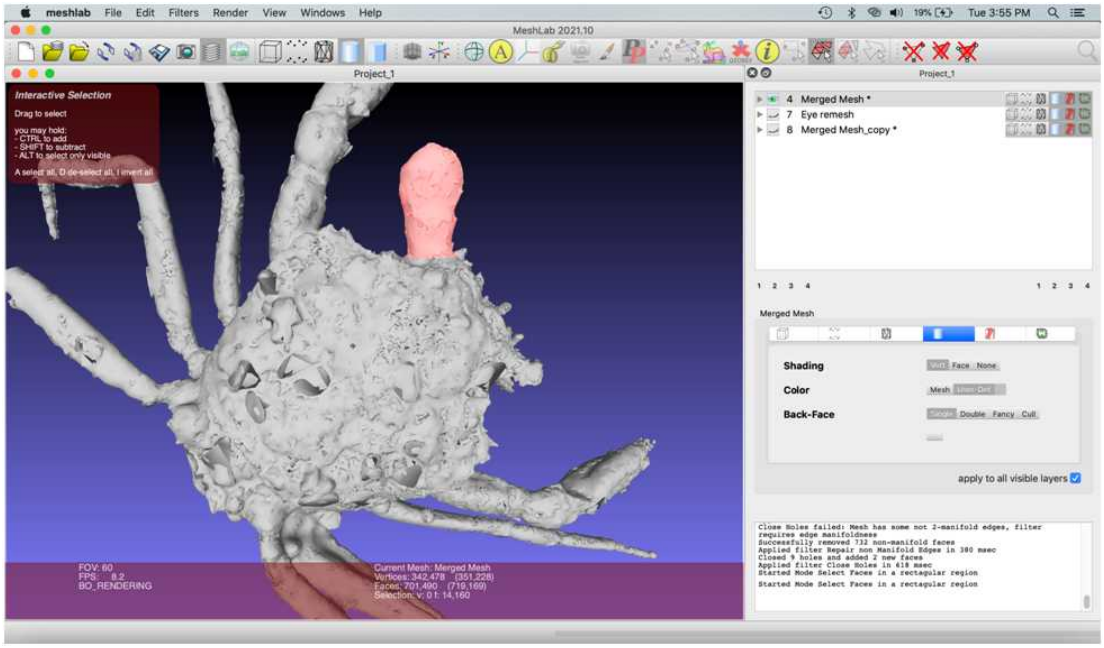
38.2 And another is the rotation tool:

39 Click on the leg, and use these tools to transform and rotate the leg to reattach it to the body of the crab.

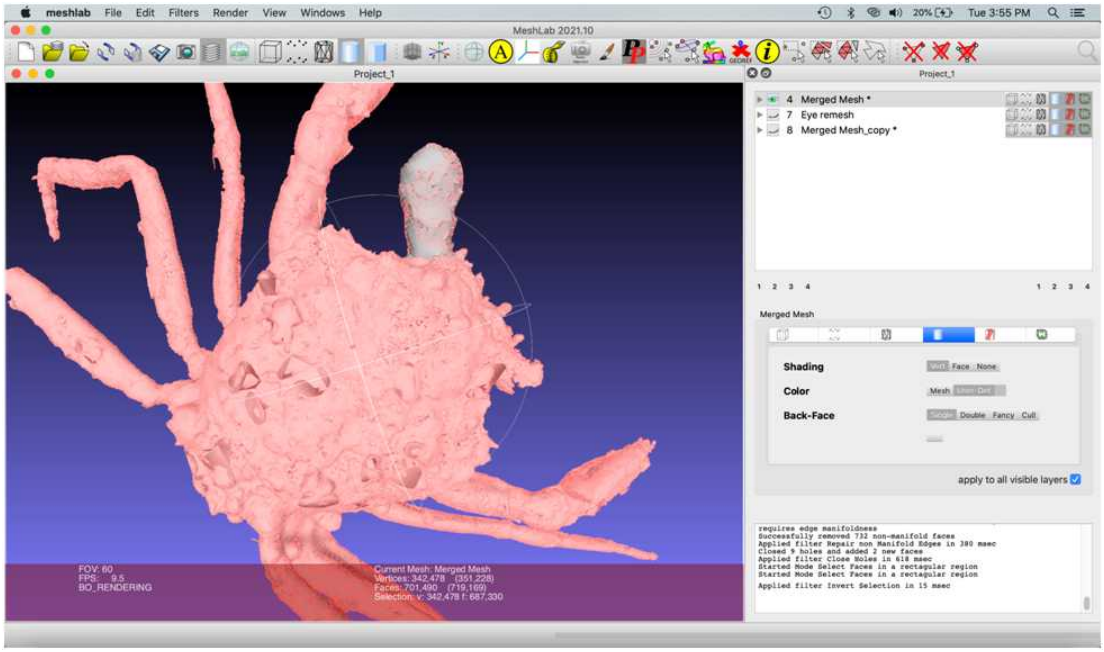


40 Now, we're going to make a copy of the left eye to use as the right.

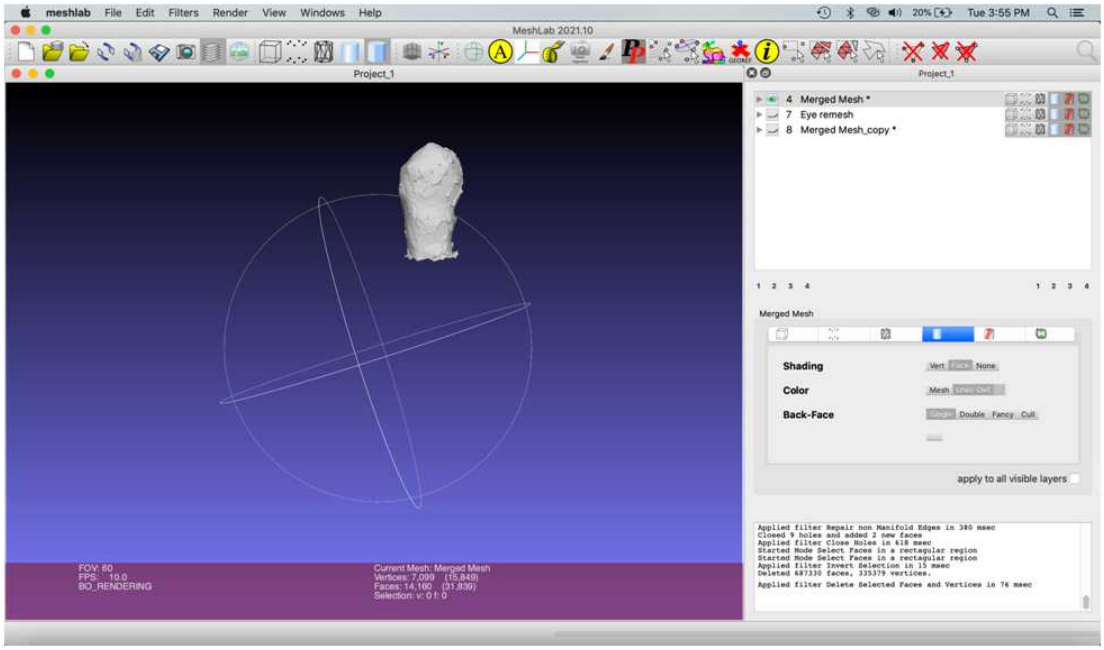
41 Reopen "Crab body and eye remesh.obj" in Meshlab.



42 Select the eye.

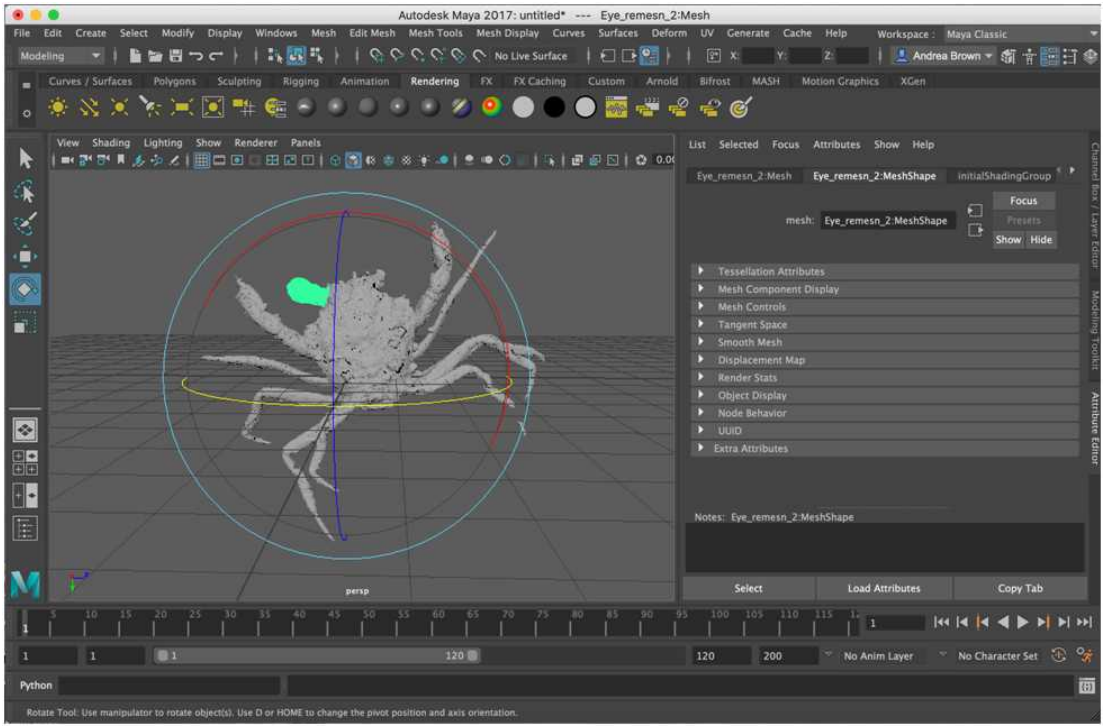


43 Invert selection and delete the body, leaving only the eye.



44 Export mesh as “Eye remesh 2.obj”.

45 Import “Eye remesh 2.obj” into Maya.



46 To mirror the eye, first, select the scale icon on the left:

47 Click the icon to the right of the X, Y, Z in the first icon-based menu at the top of the screen and set to “Relative transform”.

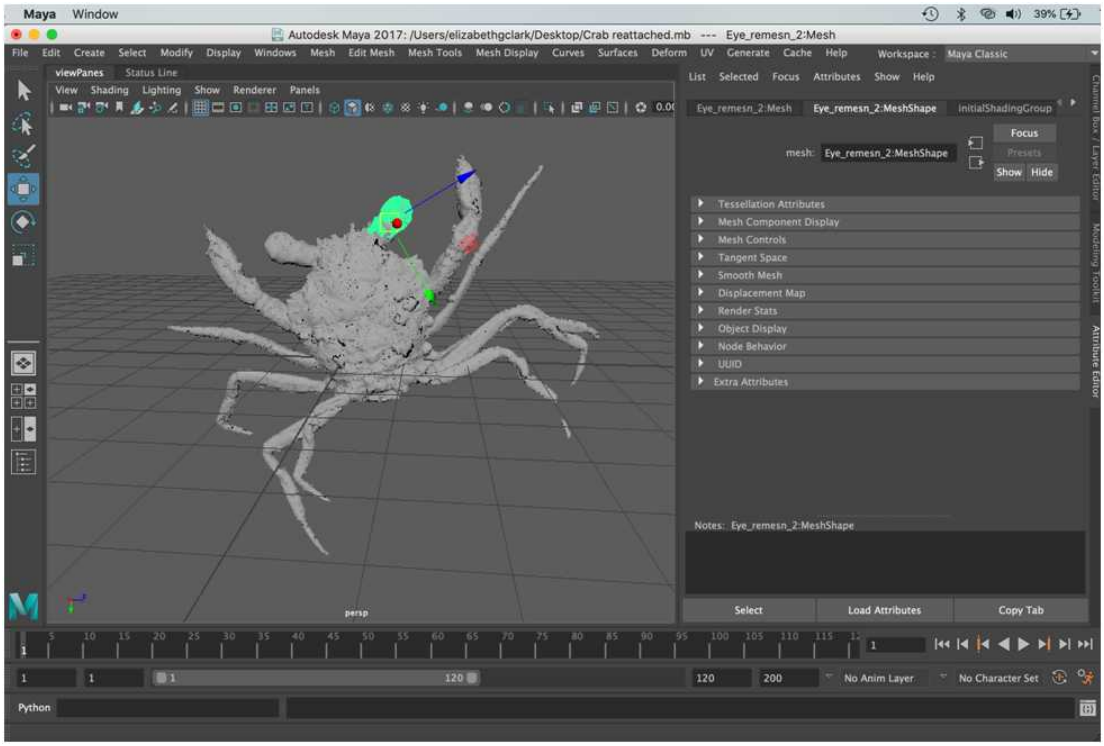
48 Type -1 into the Z box and push “Enter”.

49 Select the newly mirrored eye and move to the correct location on the crab using the transform

and rotate tools.

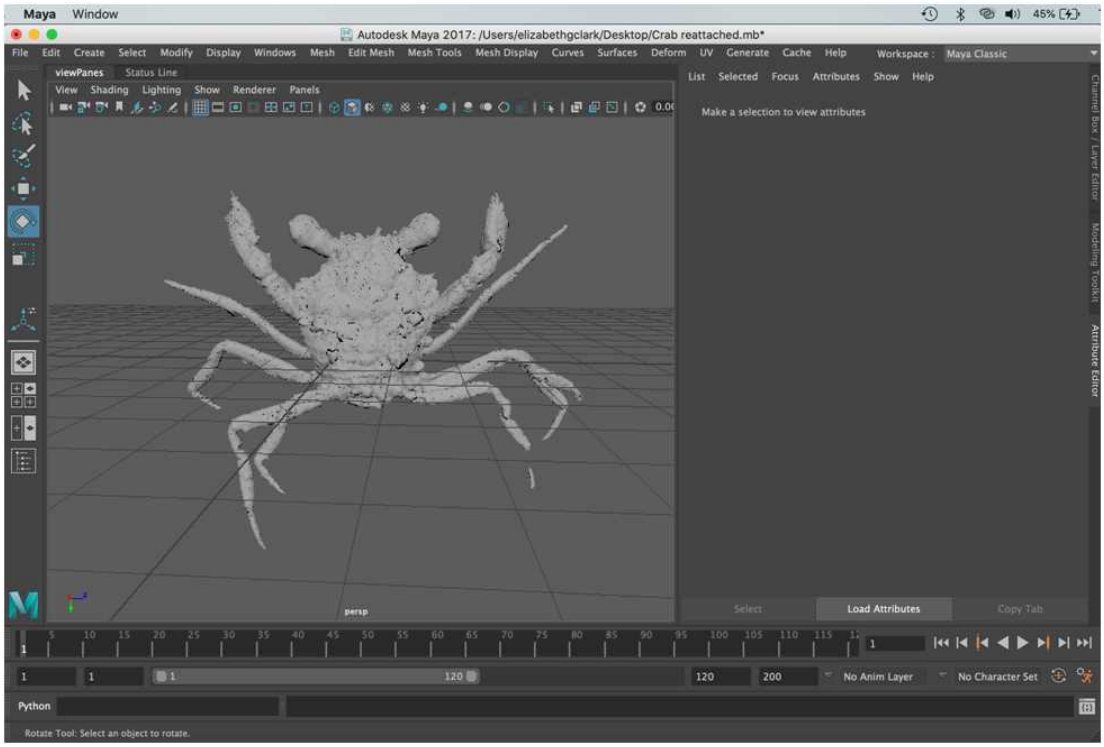
Note

Hint: it helps to move the pivot by selecting the eye and selecting Modify – Center Pivot in the top menu.



50 Next, select all mesh components by clicking the selection icon, holding left click and dragging the cursor over all of the objects. Command A also works.

51 Select Mesh – Combine in the first menu at the top to merge all mesh components together.



52 Repeat the *Repair Missing Elements* protocol for the eyes to fix the tip of the claws and legs. Congratulations on making a beautiful crab!