RE-CREATING THE SINKING OF THE EDMUND FITZGERALD

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Re-Creating the Sinking of the Edmund Fitzgerald

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Over the course of the school year, we intend to create a short film centered around the sinking of the *S.S. Edmund Fitzgerald*. Up until this point, there has been thorough research in the conditions surrounding the sinking of the ship, as well as a single video-based recreation. However, this research remains to be properly visualized in a manner that is historically accurate, emotionally compelling and rendered photo-realistically. Depicting it accurately would do justice to the scientific feat of this storm and memorialize the memory of the ship and its crew. The main tool that we will use is Dr. Jerry Tessendorf's proprietary rendering software Gilligan, which is able to simulate oceans, waves, splashes, and mist with a high level of scientific accuracy. By pushing Gilligan to its limits, we can create a short film that, in the process of its creation, will be a deep dive into both the history of this ship and the technical process of creating a comprehensive film pipeline from scratch.

DEDICATION

To the friends and families of the crew.

ACKNOWLEDGEMENTS

Foremost, we would like to express our sincere gratitude to our advisor Dr. Jerry Tessendorf for the continuous support of our research, for his patience, motivation, enthusiasm, and immense knowledge.

Our sincere thanks also go to Annie Suther and Som Goswami for creating the pipeline tools, Professor Giramadji of Ocean Engineering and Felipe Castro of Nautical Archaeology for sharing their expertise, and the Department of Visualization and the LAUNCH: Undergraduate Research Program for funding.

Last but not least, we would like to express our profound gratitude to our family and friends that provided us with unfailing support and continuous encouragement throughout this project.

SECTION I

RESEARCH QUESTION/MOTIVATION/ARTIFACT

As Gilligan is a relatively young software, full examinations of its workflow and potential have not yet been studied at the comprehensive level. We plan on testing its capabilities at a large scale by creating a short 3D film about a historic shipwreck on Lake Superior. The S.S. Edmund Fitzgerald sank in the midst of a powerful and sudden storm on November 10th, 1975. Weather data and verbal radio reports are available from that November storm (National Transportation Safety Board). These weather conditions are further refined in storm models based on re-analysis of the storm with today's technology (Hultquist et al.). Additionally, later forensic investigations analyze the physical breakdown of the ship and the forces necessary to produce the damage caused (Kery and Fisher). The circumstances supported by these papers help to further refine the chain of events leading up to the sinking. Previous animations of the sinking of the Edmund Fitzgerald were not found by our team to be both accurate and visually realistic, making it the perfect case subject for testing Gilligan.

Wave size, wave direction, wind speed, wind direction and more are known for the storm and will be input into Gilligan's environmental variable parameters to create digitally accurate water volumes and waves. Despite this, enough randomization is built into the program so that the waves don't appear overly patterned or predictable. Because these waves are automatically generated, rather than created by hand as would be necessary to make waves as accurate as Gilligan's, the overall production process will be more efficient. Effects artists, in particular, will be saved time. The level of control over these variables is much finer than that of other environment builders, which makes Gilligan unique.

By accurately re-creating the storm that sank the S.S. Edmund Fitzgerald, this project will help demonstrate Gilligan's scientific usefulness. It has the potential to be of interest to meteorologists, ocean and naval engineers, and other scientists curious about visualizing certain hypothetical or historic weather conditions and their possible implications on ship strength. By creating a highly photorealistic and beautiful film, this project will also demonstrate Gilligan's artistic use to other visual artists, and particularly those working to depict maritime environments.

SECTION II

LITERATURE REVIEW/BACKGROUND/HISTORY/SOURCES

The S.S. Edmund Fitzgerald was a 729 foot lake freighter (Schumacher, 9) that carried bulk cargoes of materials across the Great Lakes for 17 years (Charles River Editors, 7). The size, vast storage capacity, and performance was unlike anything seen previously on the Great Lakes and was a feat for sailors and civilians alike (Schumacher, 9). Unbeknownst to the crew, on the afternoon of November 9th,1975, the S.S. Edmund Fitzgerald set out on its final voyage (Andra-Warner, 48), encountering an unexpected and vicious storm that condemned the crew and ship to the bottom of Lake Superior. After nearly 50 years, a conclusive reason for the ship's sinking remains unavailable (Ellison).

Past research on the S. S. Edmund Fitzgerald's history, conditions surrounding the November 1975 storm, and debated theories and the physics of the sinking are widely available and must be considered together in order to correctly depict the sinking. Three published books (The Sinking of the Edmund Fitzgerald: The Loss of the Largest Ship on the Great Lakes from the Charles River Editors; Edmund Fitzgerald: The Legendary Great Lakes Shipwreck by Elle Andra-Warner; and Mighty Fitz: The Sinking of the Edmund Fitzgerald by Michael Schumacher) and one popular source, webpage "Fitz Timeline" from the site "S.S. Edmund Fitzgerald Online," presented the bulk of information regarding the history of the Edmund Fitzgerald. These books were highly similar in content and in most instances corroborated one another. Schumacher notes that the Fitzgerald may have been doomed from its start, despite breaking haul records in the region, as on its christening day three tries were needed to break the ritual champagne bottle against the side of the ship (p 15). This ominous remark influenced some of the foreshadowing and cinematographic choices; overall, the sources above provide a timeline of events which was a crucial to the filmmaking process, as this timeline would go on to influence the shot breakdown for the film. The book The Legend Lives On: S.S. Edmund Fitzgerald by Bruce Lynn and Christopher Winters, and David A. McDonald's Great Lakes Ore Carrier S.S. Edmund Fitzgerald blueprint provided much of the visual reference for the ship, which was crucial to constructing the high-detail 3D model.

On November 10th, 1975, a storm that had been forming in the lower portion of the country made it to the Great Lakes Region, according to famed meteorologist Steve Ackermann, who examined the storm in an article titled "The Sinking of the SS Edmund Fitzgerald – November 10, 1975." "Recreating the Monster Storm That Sunk the Edmund Fitzgerald" by Ellison and Torregrossa similarly detailed the conditions, and included a NOAA graphic showing reconstructed weather charts for the entirety of the storm over Lake Superior. This NOAA recreation provided the basis for our direct weather inputs for the different shots in the film. Hultquist et al.'s peer-review study, "Reexamination of the 9-10 November 1975 'Edmund Fitzgerald' Storm Using Today's Technology," strengthened what others had proposed – that the ship was at the worst possible place at the worst possible time and the storm was at its maximum intensity at the point of sinking. This knowledge would heavily influence the mood and action of the final scene of the film. Visual reference included: seasons 1-4 of Deadliest Catch (camera work drew heavily on the "chase boat effect" commonly seen in the show) as did special effects for splash and wisp generation; and Filip Kulisev's "Navy Ships in Huge Heavy Seas" which also helped visualize the effects of a storm on a large ship.

Lastly, theories behind the sinking and the physics behind one of the more likely scenarios were also well-represented in the literature. Many theories exist for the ship's sinking, and those that did not rest on crew failure or complacency were considered for this film. Garret Ellison's news article "What Sank the Edmund Fitzgerald? 6 Theories on What Caused the Shipwreck" summarizes some of the popular ideas, which include: unsecured hatches that caused flooding, sudden hatch collapse, hull damage from ship grounding, complete coverage of rogue waves, past body damage, and carrying more of a load than was safe. The official document, "Marine Accident Report SS Edmund Fitzgerald Sinking in Lake Superior" from the National Transportation Safety Board, was helpful in determining background information of the ship and the storm, and focused on cargo hatch collapse possibly as a result of crew error. Kery, Sean, and Fisher's recent paper entitled "A Forensic Investigation of the Breakup and Sinking of the Great Lakes Iron Ore Carrier Edmund Fitzgerald, November 10, 1975, Using Modern Naval Architecture Tools and Techniques" provides a new idea based on physics-based calculations of ship stress, crashing wave weight, and green water from previous splashing on deck. This theory of a "failure cascade" (p 30) of progressive damage and successive, overtaking waves seems consistent with known conditions and the state of the ship remains on the lake floor. This theory of multiple large waves taking down an already suffering ship heavily influenced the ship's depiction in the last three scenes of the movie and allowed us to avoid any direct references to crew failure.

From these readings, the history of the ship, the meteorological conditions during the two days of the Fitzgerald's final voyage, and theories on why the ship sunk were made clear. This creative work is unique from other simulations of the sinking of the S.S. Edmund Fitzgerald and other 3D animations in that we are utilizing the software Gilligan, created by Dr. Tessendorf, project advisor. Real world information (reports of the waves and wind) from the storm is used as direct input parameters to depict the conditions. These effects are being created and rendered more efficiently in Gilligan than they would be in other rendering softwares and show a higher quality depiction of the sinking of the Fitzgerald than did other readily-found online 3D animations. The success of the software in this project could encourage the film industry and others to choose Gilligan as an environmental scene simulator.

SECTION III

METHODS

Background

A timeline of events was constructed which included: radio reports detailing ship location, storm conditions, and increasing ship damage (McCall); national storm warnings (National Transportation Safety Board); and a modern-day re-creation of the November 9-10th storm (Ellison and Torregrossa, 2015). The timeline was spatially organized from 2:00 PM on November 9, 1975 to 9:00 PM on November 10, 1975, and included all events from the SS Edmund Fitzgerald setting sail to two hours after it is presumed to have sunk. A simulation shown by Ellison and Torregrossa and made by scientists at the National Oceanographic and Atmospheric Administration (NOAA) provided specific incremental wind speeds, wind directions, and wave heights. These weather conditions were laid out above the timeline to directly correspond to the known events. A rough map of the ship's general path was drawn and hand plotted against these NOAA storm maps to provide a more clear picture of what the ship was up against.

Bearing in mind the hand-mapped path, a high-quality digital map (over 4k resolution) was created. The area of interest was centered and assigned Esri's ocean basemap (located at http://www.arcgis.com/home/webmap/viewer.html?layers=6348e67824504fc9a62976434bf0d8d5) in the desktop program ArcMap 10.5.1. Reference labels were removed for graphic clarity in the final production. This map was exported at over 5000 dots-per-inch and was then taken into the GNU Image Manipulation Program. Custom stationary graphics were designed to resemble sonar beacons seen on ships. One graphic was made for each of the separate 6 sequences and times represented throughout the film, as this map serves as the transition element between scenes. The time and date were added and the beacon's sweeping arm was customized for each time to point in the direction the ship was known to travel. Each sequence's beacon graphic was placed in the approximate location of the SS Edmund Fitzgerald for that particular time. These enhanced map graphics, totaling 6 in all, were exported at the same high resolution as the original base map.

Collaborative Story Design

The six key moments mentioned above became the basis for each of the six sequences or scenes. Various animation ideas were brainstormed for each sequence, with the most popular being chosen. Artists drew storyboards (Figure 1, Figure 2, Figure 3), or simple comic-strip-like cartoons of the chosen idea, and paid particular attention to camera movement and shot description. The six storyboards were broken up into separate shots using Apple's iMovie video software and were edited together into a simple 2-dimensional cartoon, or animatic. This animatic represents the approximate total short film length as well as the intended flow and length of each shot. It was used as reference to direct rough layout in Autodesk Maya 2018 with a simple ship model. Camera work was refined to near-final product quality. The rough layout for each sequence was sent to animators as a starting point.

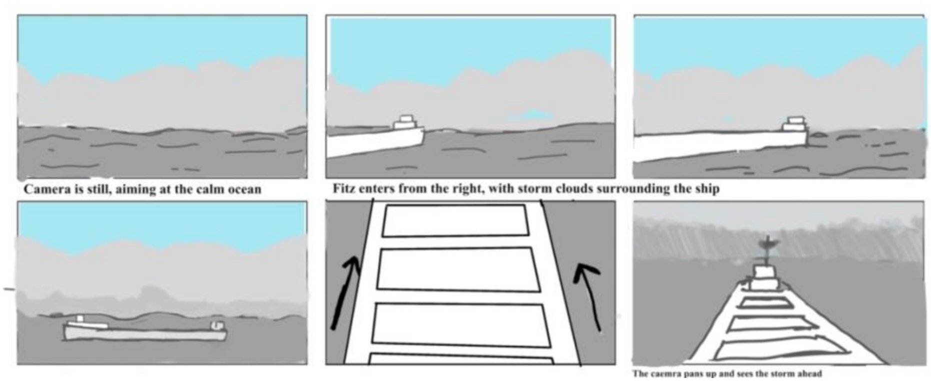


Figure 1

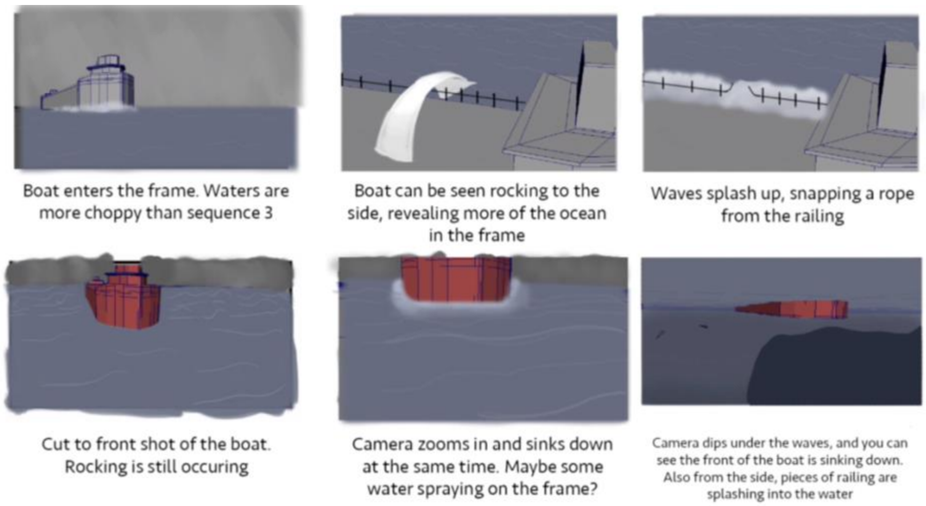


Figure 2

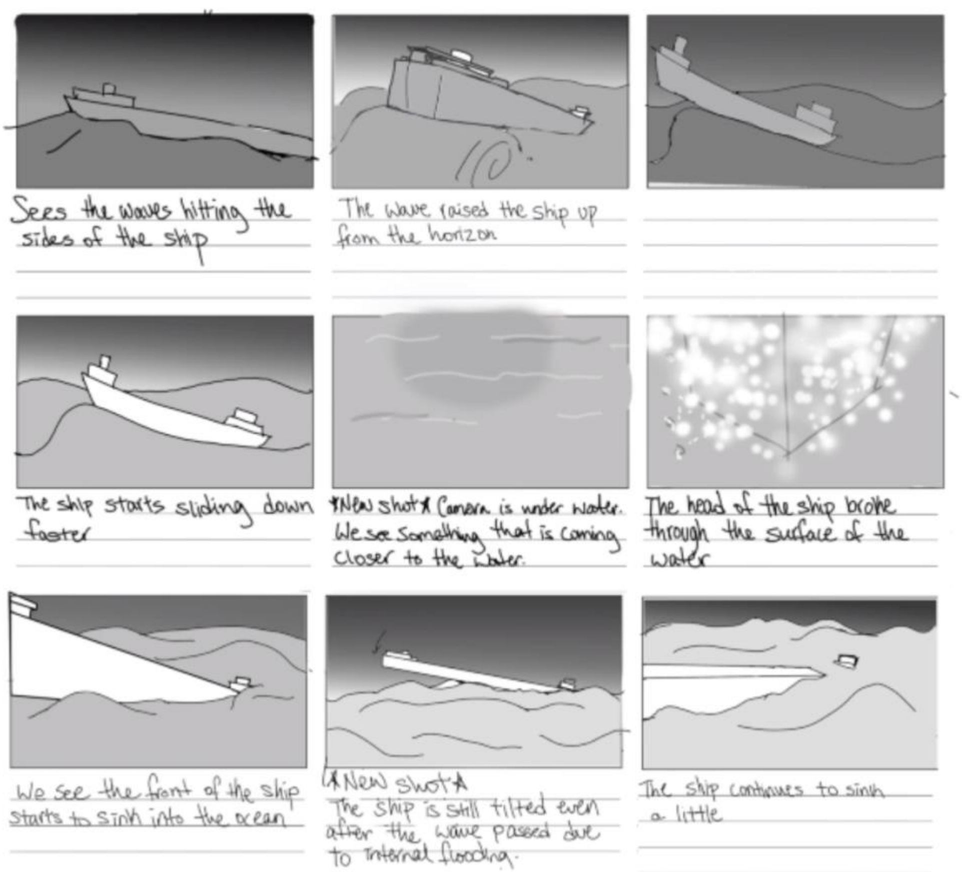


Figure 3

Modeling

In the beginning of the project, the team decided to model the *S.S Edmund Fitzgerald* to scale. Due to the overwhelming size of the ship, it was split up in 3 parts so there are a team of three modelers working together on the ship. One would model the Pilot House, one would model the hull, and the other would model the stern superstructure. Computer modeling is similar to doing constructions in real life. The modelers need reference pictures with correct measurements, so the team reached out to a university and they provided one with measurements. Then the blueprint would be imported into Autodesk Maya and the modelers would use geometries to render out the ship as accurately as we could.

As for the other details on the ship, the modelers relied on reference pictures that we found on the internet and books. Because the team did not scale down the ship at all, it was easy to follow the blueprint and referenced pictures to get accurate sizes on the parts of the ship. There are four orthographic views for the modelers to work with. The modelers mainly use the side view to align the ship with the blue print. The modelers would model one side of the ship and mirror it across an axis later so both sides would be symmetrical. After the overall structure was completed (Figure 4), they would add dents make the ship more life-like, and less computer generated.

Because it takes a while to model out the whole ship, the modeler made a proxy model, which is a very simple ship that has the basic structures so we can tell which side is the pilot house and which end is the stern, for storyboard artist to use to make an animatic. Then, the modeling team moved onto modeling the ship to be used in the film. They made two different iterations, one with more details and the other with less details because there are some shots that are really close up to the ship. They decided to make two different versions of the ship so that it would not take as long to render and to prevent crashing while modeling or animating, while still providing enough details on the close up shots (Figure 5, Figure 6, Figure 7, Figure 8).

Figure 4

Figure 5

Figure 6

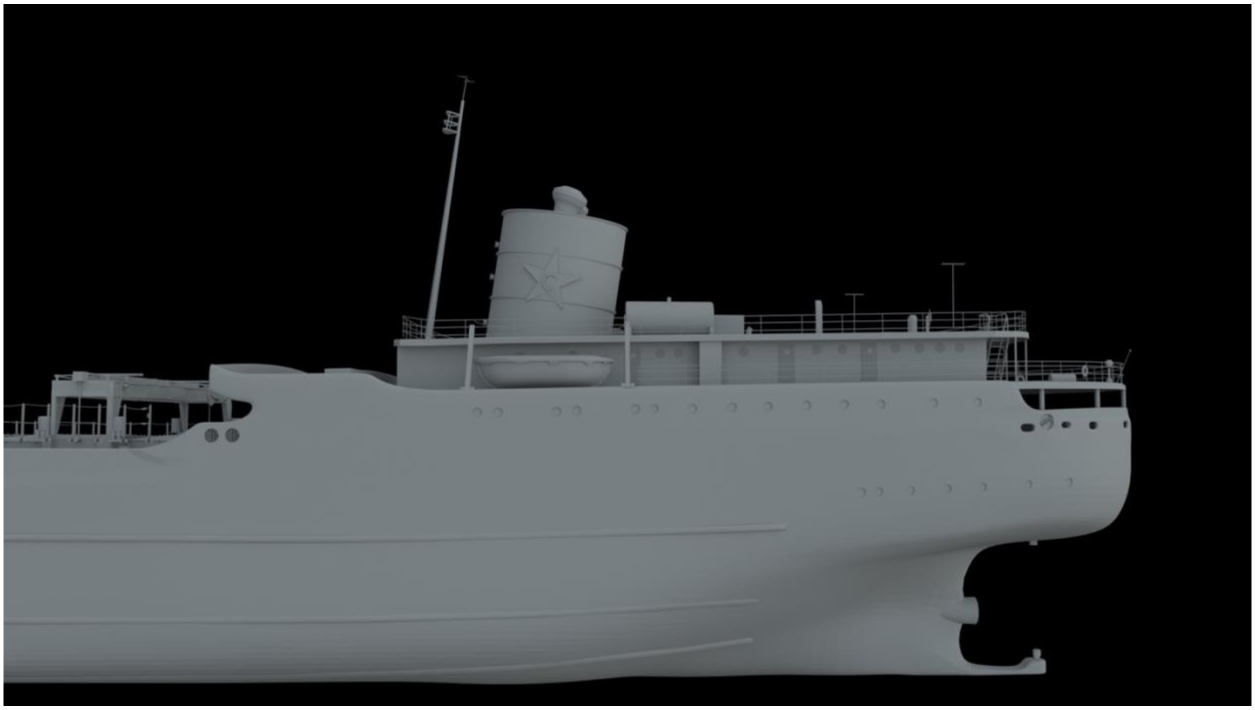


Figure 7

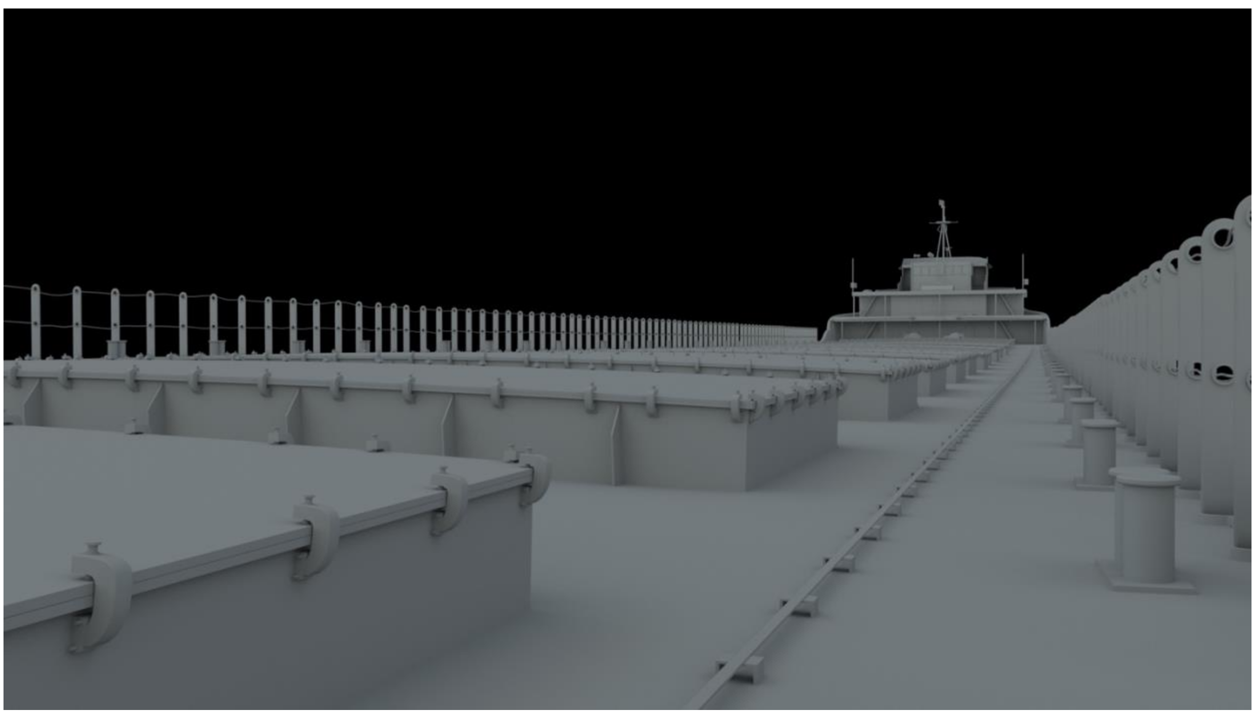


Figure 8

Rigging & Animation

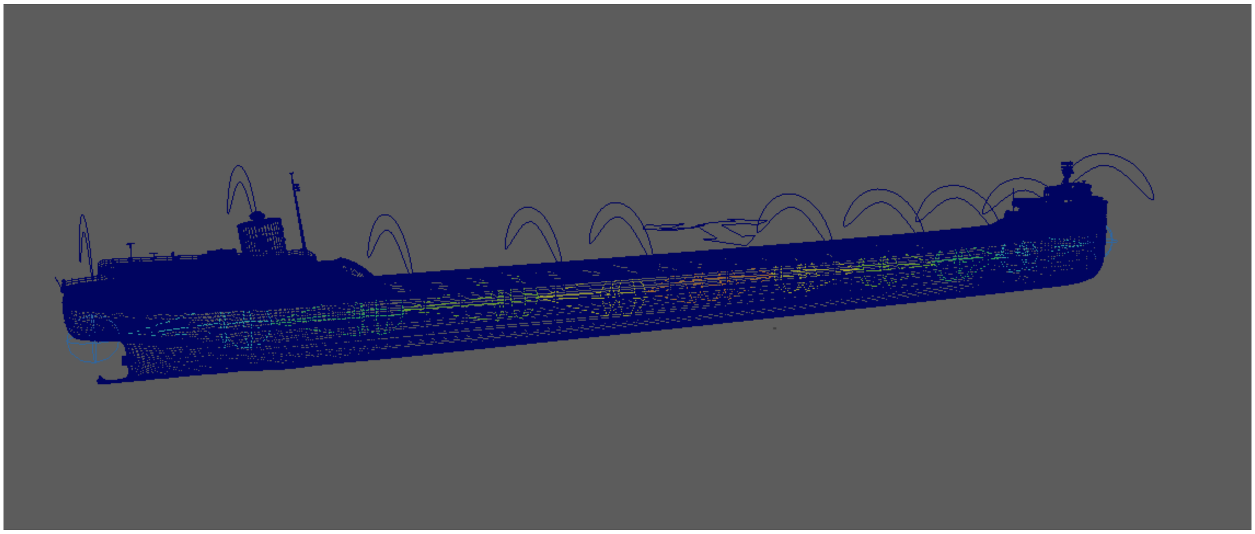
In order to bring the ship to life, a bone structure needs to be created and inserted inside the geometry. This bone structure is known in the industry as a rig. Rigs are composed of a series of joints connecting to each other, just like bones. Typically the creator chooses for the joints to follow the physics and computer coding of forward kinematics or inverse kinematics. Forward kinematics (FK) lets the animator manipulate each joint individually, which is useful for models like doors, a person's spine perhaps, or any piece of geometry that you want fine detail movements. Inverse kinematics (IK) lets the animator move one joint that decides the movement of the following joints in its chain, which is good for animating a person's arm or leg. IK rigs use math to decide the chain movement. The rig for the model of the *SS Edmund Fitzgerald* combines both FK and IK ideas by using a spline curve. The spline curve allows the boat geometry to bend and twist in organic ways that would mimic the true motion of a large ship trekking through different weather on the water. So it is comparable to the way that an IK rig uses math to move the whole chain, however the animator has more control over each individual joint, which is different than an IK rig.

A spline curve is created by first inserting joints lengthwise down the ship's geometry. These joints will act as the control points of the spline curve. In Autodesk Maya 2018, there is a tool that inserts the curve onto the joints. This tool then calculates mathematically how the curve will function when the animator moves certain joints. To clarify, when the spline curve is attached to the joints in the ship, it is not already curved, it just has the ability to once moved. After the creation of joints and attachment of the spline curve to them, controls are made. A normal industry practice for riggers is creating controls for the joints so when it is time to be animated the animator can't touch or move the joints directly, they move the controls. This is a desirable task because it the animator was to move the joints, they could possibly break the rig, meaning it would no longer function as once originally created to. Controls consist of outlines of circles, arrows, cubes, or whatever is a helpful indicator that this object can move this piece of geometry. After creation of the controls, they are placed individually over their specific joint. Then the joint is parented to the control. The act of parenting is telling the computer and software that however the animator moves the control, that's how the joint needs to also move. The final step for creating a rig is binding the skin to the joints and controls. Binding allows the rig to attach to the geometry and physically move it.

After rigging was completed, it was passed on to the animators. The animation process involved team looking up video references on YouTube of cargo ships and cruise ships sailing through different weather. This is important for making the movement of the *SS Edmund Fitzgerald's* geometry to appear accurate and life-like. After understanding how a large ship would move in calm waters or even in bigger storm waves, the animation process can begin.

Animations are done typically in either 24 frames per second (fps) or 30 fps. This means that there are basically 24 or 30 still pictures in each second that convey motion to the viewer. 120 fps were chosen for overall better detail and movements in the short film.

The actual act of animating then is fairly simple and tedious. Typically an animator will go in and place when big movements will happen along the timeline and then after that go in and carve in detail. This is done by keyframes, which means that the computer and software will remember how the control was oriented in 3D space at this exact time. Each control for the rig has its own timeline which can contain many keyframes. Because of this, many controls can be moving simultaneously and they won't overwrite other information from other controls.



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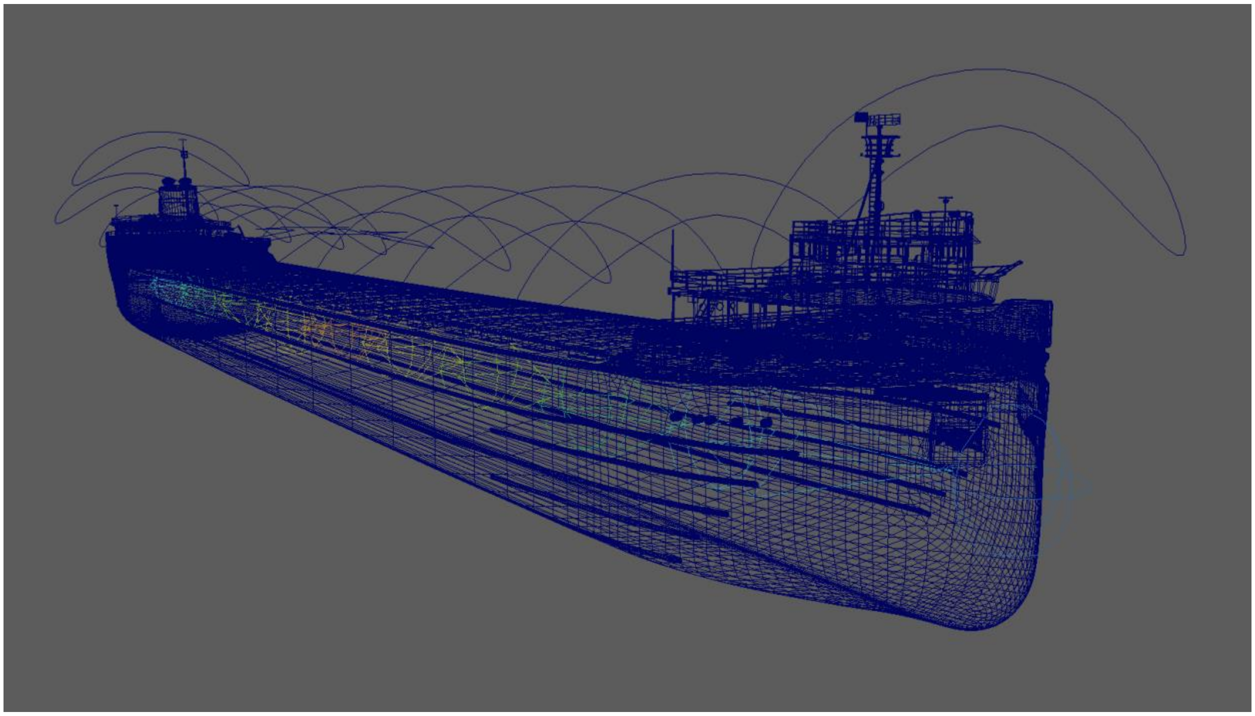

Figure 10

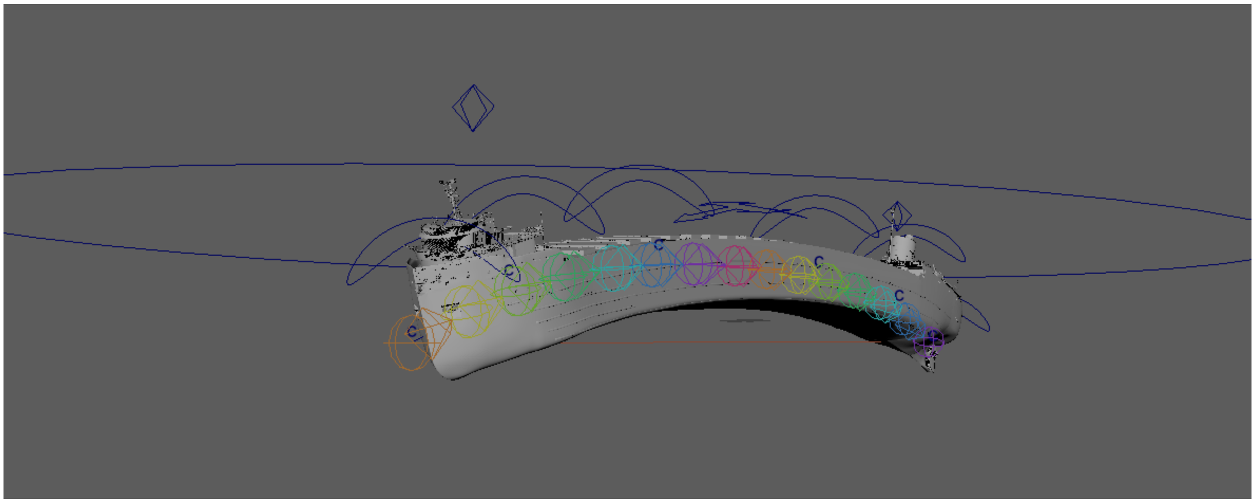

Figure 11

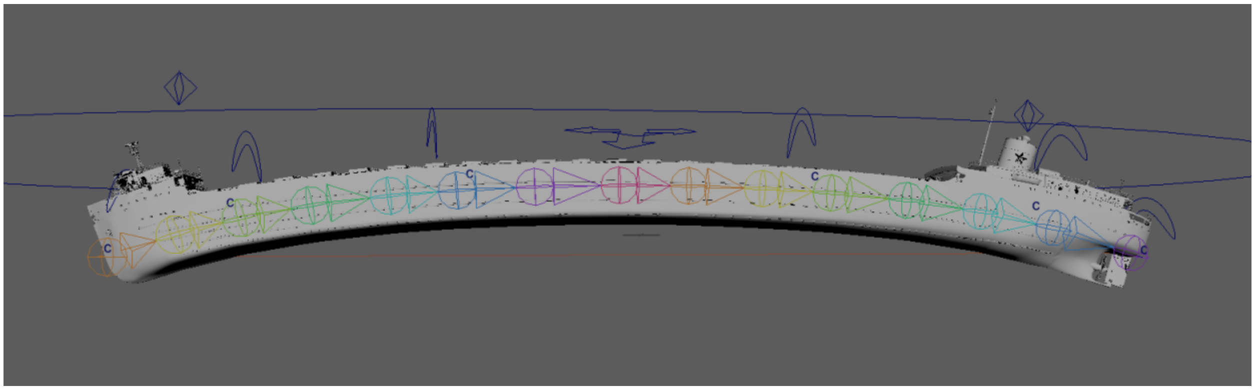

Figure 12

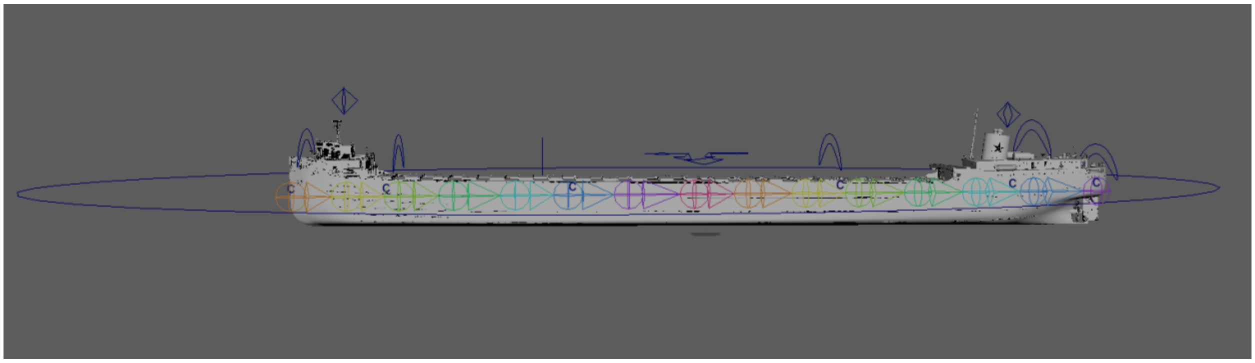

Figure 13

Texturing

Before attempting to emulate the texturing of the *SS Edmund Fitzgerald* in the computer-generated scene, the team curated reference images that highlighted areas of deformation, surface polish, and material warping. A texture profile was created in order to determine the rust grade, base material, and paint type of the ship. During the construction of the *SS Edmund Fitzgerald*, the paint system applied to any part of a ship was dictated by the environment of which that part of the structure was exposed. Traditionally the painting of the external ship structure was divided into three regions. The first section occurs below the water-line and the region is continually immersed in seawater. The second section is the boot topping region where abrasions occur throughout. The third and final region is the topside where the ship is exposed to atmospheric damage and human impact such as acid rain and damage through cargo handling. In order to best replicate this workflow in 3d space, the team decided to utilize a secondary software that supported a metallic/roughness workflow. A metallic/roughness workflow allowed the team to identify which parts of the ship were metal by painting a white color (Figure 17), and dielectric by painting a black color (Figure 16). This was also beneficial because the maps within this workflow can be compressed to a small file size without losing quality. Alternative workflows would allow the artist to manipulate precise reflectance values needed to keep accurate to ensure a physically plausible result.

After concluding the research portion, the team began UV unwrapping all 3d surfaces. UV unwrapping is the process of translating the surface area of a 3D model to a 2D space given the parametric directions u and v. U represents the horizontal direction in 2D space, while v represents the vertical direction in 2D space.

The next step was to create a procedural shader (Figure 14). The procedural shader incorporated the surface properties of the ship such as rust grade, and scratch intensity, but could also achieve variations of visual design through art directable parameters. This procedural shader allowed us to create several iterations based on different environmental conditions (Figure 15). Greater nuance was added through texture painting.

This process produced a series of maps that described physical properties of the 3d surface. These maps were then used in conjunction with the physically-based shader found in the primary software, Gilligan (Figure 18).

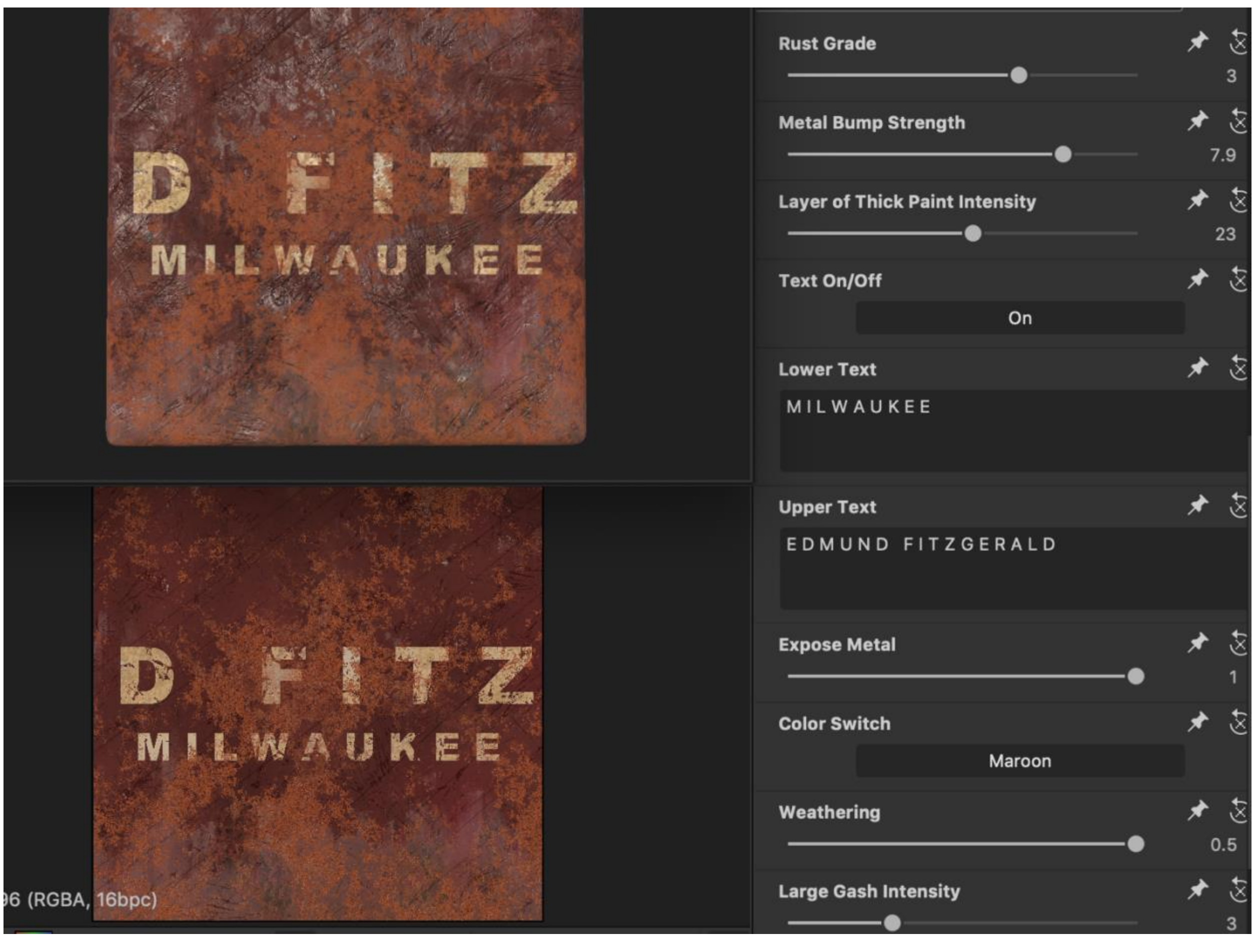

Figure 14

Figure 15

Figure 16

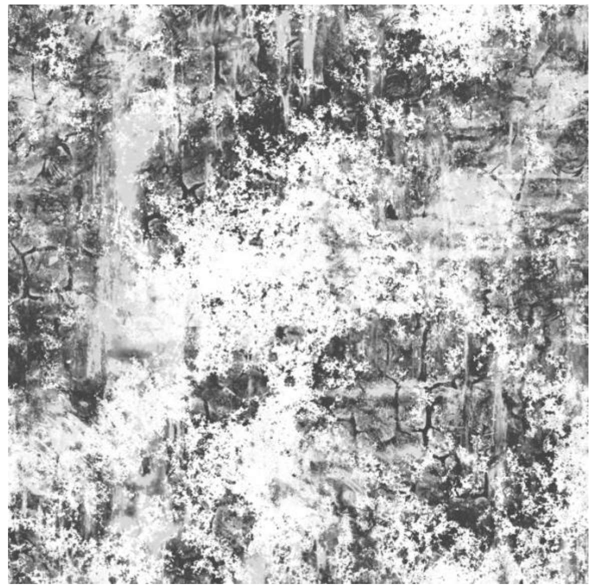

Figure 17

Figure 18

FX

Given that most of this film is taking place on choppy and stormy waters, an important aspect of was to create realistic particle simulations that can illustrate the waves and splashes of the ocean. The software used to implement this is Houdini, a special effects software package that handles particle simulations extremely well.

The first step to creating a particle simulation is using a proper input mesh. The splashes needed to be on and around the ship, so it needed to be known where and how the ship was moving. In order to do that, the animated file of the moving ship was imported into Houdini. The file was an FBX alembic cache, which was a simple way to read in animated geometry in Houdini. However, due to the sheer size and complexity of the ship, the file need to be converted into a geometry cache, a lightweight system that saves an individual .bgeo file per frame. The next step is computing the rest position of the ship. The rest position is simply the initial x,y, and z position of the ship at the first frame of the animation. This data is saved onto every vertex of the geometry. Now that the boat has both its rest position and current position, velocity and acceleration can be calculated automatically.

For this particle simulation, collisions are calculated by checking each point in the simulation against each vertex in the boat geometry for overlap. Because there are hundreds of particles in a simulation, and tens of thousands of vertices on the boat, this calculation would be impossibly complex if the entire boat mesh was implemented. Therefore, only the part of the mesh that would be interacting with the surface of the ocean (for example, stern and left side of the hull) was isolated on a per-shot basis, and then omitted the rest of the geometry. Now amount of vertices that needed to be checked for collisions is down to hundreds instead of tens of thousands, which drastically improves performance and efficiency. That small sliver of the boat is also exported as a geometry cache, to maintain consistency and optimize calculations for Houdini. As a result, there are two outputs of this process: a lightweight animated full resolution ship, and a simplified collision area in which the hull of the ship actually interacts with the ocean.

All splashes from the boat are implemented as particle simulations, and they are generated from a pre-designated curve. All that needs to be done is simply creating a curve in a desirable area of the ship by connecting 3D points in Houdini. This curve cannot be stationary; it needs to move in time with the ship. Using VEX scripting language, the curve was attached to the side of the ship such that with every translation and rotation of the ship, the curve also translates and rotates in the same way.

Instead of leaving the motion of the particles up to chance, a system was created that lets the user control the velocity of the particles in an artistic and intuitive way. Because velocity is a 3-float tuple (x, y, and z), it is possible to visualize it as color by remapping it to r,g, and b. The RGB values are then remapped again from -1 to 1, to represent both positive and negative velocities. So making the generator curve a pale green would represent a strong splash blowing away from the ship. The intensity of the velocity is meant to historically match the wave speed during the actual time that corresponds with each shot. Therefore, the velocities can be multiplied by an intensity parameter that will bring the particles from their normalized velocity to something more realistic. These controls are used as an asset, meaning that someone with artistic vision can use this tool and intuitively create a wave in any shape that they want.

The next step from there is to send the curve into a particle simulation. Before simulation, noise was added to the control curve as well as the velocity values in order to avoid a wave that looks too uniform, rather than organic and chaotic. Because many of the aspects that affect particle simulations were already taken care of beforehand, the actual simulation itself is quite simple. The initial velocities of the particles affect the shape of the wave, but then that shape is affected by adding modifiers such as the velocity of the ship, the wind speed and direction, and the wave direction. From this information, we can have a simulation that is realistic and historically accurate.

Now that there's a working particle simulation, it simply needs to be rendered. The rendering process doesn't happen in pre-existing proprietary software such as Houdini or Autodesk Maya. Instead, we are using Dr. Tessendorf's renderer Gilligan. Gilligan is an environmental simulation software that takes data and turns it into highly-realistic images. So for example, one can put in data about the wind speed and wave height of an ocean, and then Gilligan will create a highly-realistic ocean simulation. In the case of the particle simulation, we need to give Gilligan information about how we want each particle to look, and then it will create photorealistic wisps (Figure 19). At this state, we have a particle simulation that is represented as 3-dimensional points flying through space. Each point has information about its position and velocity, but there is more information we need to add in post-sim that will affect the final rendered output, such as number of wisps, wisp scale, opacity, color, and radial group. We added these values in as another parameterized asset, which makes controlling the shape of the final render simpler. This also makes it possible to animate controls of the wisps. For example, having wisps that are 100% opaque and slowly become transparent over time

This point cloud information needs to be sent over from Houdini to Gilligan. Gilligan has a terminal and python based interface, with no GUI. Therefore, Gilligan no simple "import" or "export" button that will move the Houdini data over easily. Therefore, we wrote a script that exports information about the Houdini particle simulation as a CSV file. CSV (comma separated values) files are lightweight, and they essentially list every single particle in the simulation, as well as all the information about each particle, in a sort of spreadsheet. There is a CSV file created for every frame in the simulation, so the CSV for the 2nd frame would not have as much information as the CSV for the 200th frame. When all of the CSV files have been generated, Gilligan is easily able to understand this information and generate wisps.

Our entire filmmaking process is terminal-based, meaning that we access and edit our files using a command line on a computer rather than a user-interface. Because all of our files are on the same server, that means that we can access our data from any computer that is connected to it, instead of having assets saved locally on a hard drive. Using this system, we are able to publish the data from the CSV files, and use VIM to access Gilligan's rendering scripts through the terminal. In the script, there are final adjustments that need to be made to the quality of the render, each of them that affect the render-time and quality of the final image. From there, we can input the file path of the CSV file into the rendering script. Once everything is finalized, then we run the render commands in the terminal.

Rendering is a very complex and graphics card heavy process. Once a render is taking place, the computer is processing millions of pieces of data to turn into a final image, and the computer is considered unusable while it is making all of these calculations. In order to decrease render times, we utilized parallel processing to run the script on 5 different machines at once. Even with all of these optimizations, a 3-second scene takes about 6 hours to render.

All of these steps are just as intricate as they are time-consuming, especially when taking into consideration the fact that splashes need to be applied to multiple parts of the boat, in multiple shots and scenes. For the sake of efficiency, we turned our process from a complex series of steps in a node-network into an easy and intuitive asset that can be reused on any shot. The only input necessary is the boat and the curve, and then the rest of the process is done completely automatically. The user can go in and make fine adjustments to the noise and wave shape, and the process is much simpler. Because of this, creating future shots will not only be significantly faster but also easy to hand off to other members.

The goal for future work is to continue to create splash simulations. The process has been both implemented and simplified, so all that's left is repeating the same steps multiple times. In addition to creating the simulations in Houdini, we hope to find ways to optimize the rendering process in Gilligan such that we can see full renders of the splash simulations before the end of the semester.

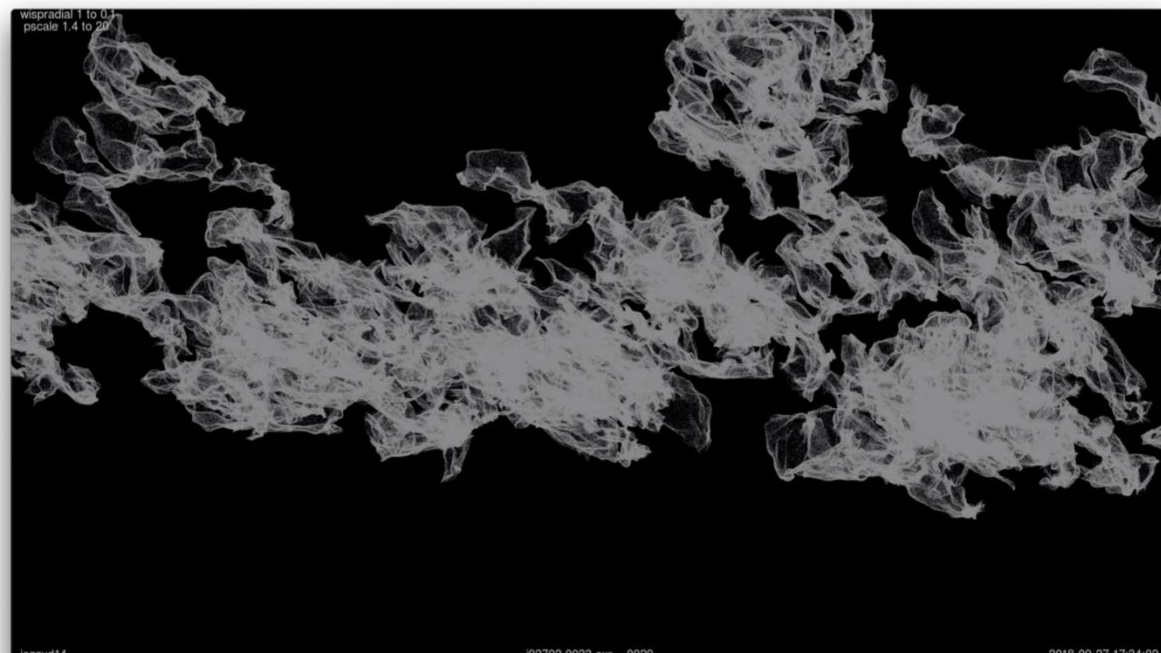

Figure 19

SECTION IV

REFLECTION

General Research Process

The process for researching the Edmund Fitzgerald was intricate and required all team members to work both effectively and efficiently. We began by examining old maps and organizing photographs and logs of the Edmund Fitzgerald into a chronological timeline. From that information, we were able to definitively determine the moment the ship departed the harbor and when it reached its final resting place. Blueprints and pictures of the ship during construction informed the creation of the three dimensional model of the ship. When it came to physically accurate particle simulations, we used video reference of real ships under similar conditions as the storm to examine their movement. During the storyboard and layout process, we tried to achieve a cinematic look and feel by creating dynamic cuts, blocking, and movement. Every element of our research process was tailored to ensure our target audience would leave informed and entertained.

Public Presentation

We received positive feedback regarding the high visual quality of the ship. This project was intriguing to and well received by many of the conference attendees, especially those from the Great Lakes region and marine-related professions. Overall, we gained a broader understanding of oceanography research and respect for interdisciplinary approaches. Presenting this project for multiple audiences in various settings also allowed us to develop better public speaking skills. We learned how to answer tough questions from audience members we had not considered before. It was also helpful to present the project to those from other fields as it forced us to consider differing perspectives and not rely on technical jargon alone.

Feedback

Although it was very rewarding to bring this piece into fruition, if given the opportunity we would change the scope of the project, reducing the number of shots and the duration of the film. Our initial research led us to have 6 lengthy sequences, but with some forethought, we could have lowered this number to 3 or 4 key sequences. By doing so, at this point we would have a more complete and higher-quality product, although it wouldn't be as long. The initial stage of our research, attempting to construct a 3D model from a minimal amount of reference photographs, was the most time-consuming. A single blueprint had architecturally accurate measurements and diagrams of the ship, which we received about two months into modeling. Obtaining this blueprint earlier in the process would have saved us a massive amount of time, and helped us to produce a more accurate ship model. We worked very hard to achieve the highest amount of accuracy possible, but we still had to take creative liberties or attempt to draw visual conclusions in certain areas. Our model of the *S.S Edmund Fitzgerald* was created to be physically accurate in scale. That is, the ship was modeled to be 729 feet long. Although that aided in efficiency for the ocean simulations, it also resulted in memory capacity issues during the animation, texturing, and special effects processes. By shrinking the size of the ship, we would reduce overall rendering time and minimize the amount of potential software crashes.

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CREATIVE ARTIFACT

All creative artifacts can be found at https://people.cs.clemson.edu/~jtessen/fitz/