## Abstract:

We are the Megalodons, an 8th-grade team from Harrington Middle School dedicated to designing an Remotely Operated Vehicle (ROV) for a real-world mission. Our mission is to salvage some of the marine debris from shipwrecks and sunken vessels. This debris includes metals, like aluminum and steel, as well as plastics, wooden planks or containers. There are an estimated 3 million ships that have sunken in our oceans across our planet. As time passes, the materials from these shipwrecks deteriorate and the toxic substances and chemicals can create numerous problems for the ocean environment. According to Parliamentary Assembly of the Council of Europe (PACE), the North Atlantic Ocean alone contains one-quarter of the polluting shipwrecks in the world. If we don't clean up the debris caused by shipwrecks, the deterioration of the ship's exterior could cause drastic effects on marine life. Ships are manufactured with various materials, including aluminum, steel, or wood. Gradually over time, they start to deteriorate and corrode. This process could potentially release harmful substances and toxic heavy metals, such as lead and mercury, into our waterways. This is why we want to protect and preserve our oceans. While researching and brainstorming, we were able to come up with several unique ROV designs that will be capable of completing this mission. By analyzing the ROV's features, advantages, and disadvantages, we selected the ROV that we felt would be the most efficient and effective. Our ROV was designed on TinkerCAD to be 3D printed. We believe its hydrodynamic frame would effectively clean up shipwreck debris in a precise and swift manner.

Our company consists of 9 members, and we have 3 different leadership positions: Chief Executive Officer (CEO), Chief Technology Officer (CTO), and Chief Financial Officer (CFO). These positions are essential, as they allow us to make major decisions, be responsible for the technological needs, and manage the finances of the company, respectively. Also, different engineering roles were assigned to every team member: Mechanical Engineer (MechE), Electrical Engineer (EE), and Environmental Engineer. Each member picked their roles and these various positions allow us to split up the work productively. Some of the jobs include designing the ROV and its mechanisms or developing solutions to environmental problems.

This tech report will touch upon many things, including our approach to the Engineering Design Process (EDP). We designed three preliminary ROVs before choosing our final one. While doing so, we analyzed each and touched upon its pros and cons. Next, we explained how we would test our robot if we were given the opportunity to build it. Finally, we discussed our next steps and reflected on this year, which has taught us many things. The EDP was critical for us to design our ROV apt for our 2021 SeaPerch mission.

## Task Overview:

Our goal was to develop a mission to clean up waterways and design an ROV that can successfully recover the debris from shipwrecks in our oceans. Seventy-five percent of shipwrecks date back to World War II and have been releasing all sorts of chemicals and debris into the ocean ever since. These ships greatly impact underwater ecosystems such as seagrass beds and coral reefs. As the abandoned vehicles deteriorate, their parts continue to pollute the surrounding areas. These corroding wrecks can release harmful heavy metals, such as mercury, lead, calcium, copper, zinc, and more. Chemicals can be very deadly to any organism that consumes them and can make certain areas uninhabitable. Debris such as steel, aluminum, and fiber-reinforced plastic can also break down over time and be consumed by other species, causing great biological harm. These abandoned ships also cause severe navigational hazards and may endanger humans. We must clean up these pollutants to help keep our oceans clean and their inhabitants healthy.

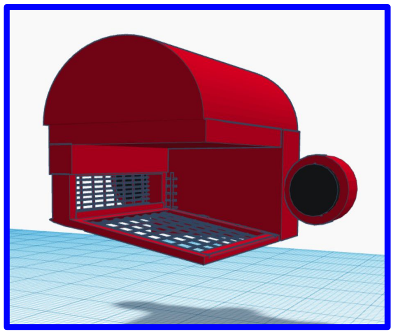
This brings us to the solution we are presenting: our specialized ROV designed to retrieve various remains of shipwrecks. To achieve this, our ROV will use a scoop to lift out pieces of metal and wood. This attachment allows our ROV to easily carry away any harmful debris from the ocean floor and to effectively clean up the ocean. Some of the debris we are planning to remove are metal hulls, wood planks, fishing gear, nets, and other harmful waste. Some modifications we've made to our ROV were changing the shape and design of our scoop. Our ROV will be able to quickly remove the debris without endangering human lives or the surrounding environment.

## Design Approach:

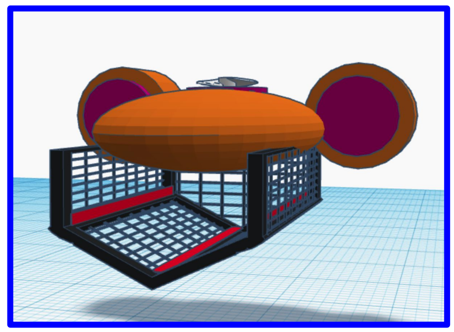
Our goal was to design an ROV that can pick up different materials and items from shipwrecks. Not only do we require a **versatile** attachment that can pick up various remains, but we also want a stable ROV that's **neutrally buoyant** to maneuver efficiently through the water. We first looked at the metals from different ships and shipwrecks. Through extensive research, our team concluded that metals from shipwrecks deteriorate as they age, thus threatening to release their contents into the ocean via the effects of corrosion. This is a natural process in which refined metals convert to a more chemical-like form. We started brainstorming ways in which the ROV could function to pick up the wide variety of materials including metals that are found in shipwrecks. Our first idea was to use big magnets to pick up metals from the abandoned and sunken vessels. Shortly after, we changed the design to include a scooping mechanism lined with magnets to pick up both magnetic and non-magnetic debris. However, after more research, we found out that most of the materials used to build ships are surprisingly not magnetic, like aluminum and stainless steel. Furthermore, the magnets would interfere with our motors, wouldn't be strong enough to pick up heavier items, and would only add excess weight to the ROV. After rejecting the magnetic scoop, we designed another, more wider scooping attachment which would be made of a net-like nylon material. This would allow us to collect larger quantities of shipwreck debris. We realized there was still room for improvement, so we then created an even larger scoop made from metal wire mesh and 3D printed parts. Although it is noticeably bigger than the first and second designs, we believe it can pick up debris more efficiently.

**ROV DESIGNS**

***1st ROV Design: Neptune***
*PVC frame with a scoop lined with magnetic strips*



***2nd ROV Design: Titan***
*3D printed frame with a nylon net-like scoop*



***3rd ROV Design: Salvage***
*More hydrodynamic 3D printed frame with metal mesh scoop*

| Name of ROV | Features | Pros | Cons |
|---|---|---|---|
| **Neptune** | *A curved scoop that would include magnetic strips to retrieve both metal and non-metal objects.* | *Can salvage a wide variety of debris from shipwrecks including metal objects, such as fragments of aluminum and steel, or non-metal objects, such as wood planks and shipping containers.* | *Magnets may be weak and could damage our motors; the design added excess weight, so less control/maneuverability; also the scoop wasn't big.* |
| **Titan** | *A larger scoop that would be created with a nylon net-like material.* | *Can recover more debris than Neptune as there is additional space in the attached scoop to store and collect many objects.* | *Some objects may fall out as the scoop isn't closed completely on all sides.* |
| **Salvage** | *A scoop with a much greater **capacity** and higher durability than Titan's design.* | *More hydrodynamic design good for retrieving numerous objects because of the scoop's larger interior and durability.* | *The attachment itself is a little bulky, but not to the extent of it causing **drag** when attached to ROV.* |

## Design Approach (Cont.):

We followed the **Engineering Design Process** throughout our mission. Here's how:

**Step 1:** We decided to **identify and explore the problem** on how shipwreck debris impacts our environment.

**Step 2:** We **researched** information about shipwrecks, including materials used for manufacturing vessels, various shipwreck debris and the effects of corrosion.

**Step 3:** After extensive research, we **imagined and brainstormed** possible ROV designs that could solve our mission. We selected what we thought was our most promising solution, which was a PVC frame with a hook-shaped scoop with magnetic strips.

**Step 4:** Then, we **designed** the ROV and an attachment on TinkerCAD**,** an application that allows us to utilize computer-aided designing software to create 3D models and prototypes. When designing our ROV, we needed to analyze some factors, like size, weight, shape, and stability. These factors are crucial as our mission requires the vehicle to submerge and resurface multiple times to retrieve debris. Also, buoyancy control is very key for stability and maneuverability in the ocean.

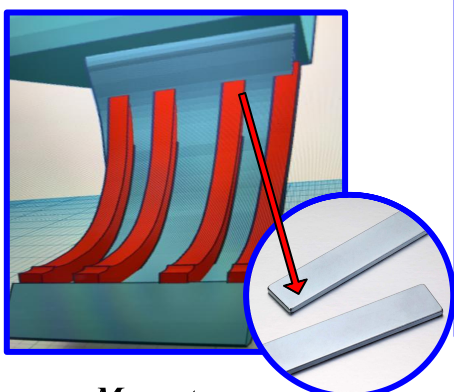
**Step 5:** We couldn't **build** our ROV. If we could build it, our frame would be made of PVC.

**Step 6:** Without an ROV, **testing** couldn't occur. However, we devised various tests, which we will explain in more detail in the results section on page four.

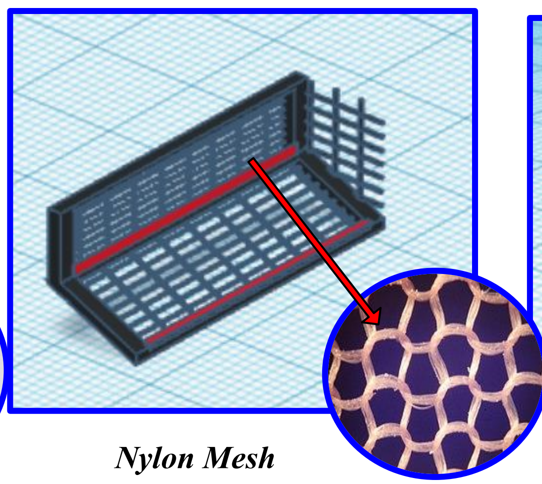
**Step 7:** We evaluated the features, analyzing the pros and cons of our TinkerCAD designs. Afterwards, we **redesigned** our ROV as it needed improvements. We repeated this step as needed until we had our final design.

**Step 8:** After designing our final ROV consisting of a **hydrodynamic** frame and compact shape, we **communicated** our results in this Technical Design Report as well as the SeaPerch interview.

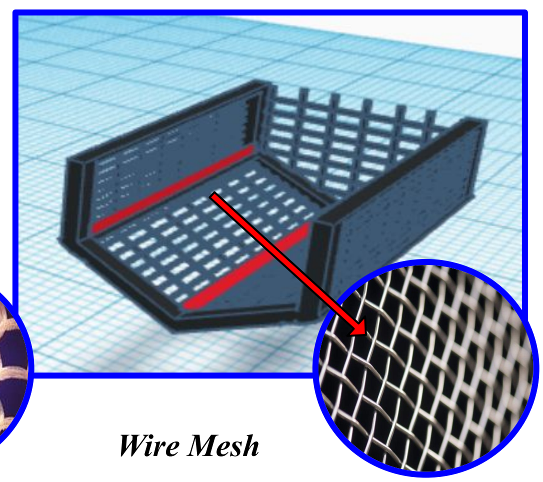
**Evolution** of our **Attachment:**



***Magnets***



***Nylon Mesh***



***Wire Mesh***

***1st iteration**: A hook-shaped scoop with **magnetic strips .***

***2nd iteration**: A scoop that would be created with **nylon** (net material)*

***3rd iteration**: A larger scoop made with **sturdier wire mesh.***

We would 3D print our frame with **Polylactic Acid (PLA)**. This material would be more resistant against water pressure and currents, which is essential for an ROV's **durability**. In addition, since we would design the ROV to be more compact, it allowed us to create a bigger and better version of a scoop while remaining **neutrally buoyant** and without compromising the vehicle's **speed**. The scoop itself would be lightweight, but it's hefty enough to pick up a wide variety of debris at one time. Moreover, we used metal mesh for the final scooping mechanism. The scoop will also be relatively durable, similar to our frame. We believe that our final ROV design with its attachment will help our team complete the mission of salvaging shipwreck debris. If we had the opportunity to create and test our custom made attachment, we feel that it would perform its job of picking up debris productively and with ease.

**Results:**

Due to the pandemic, we were unable to assemble and test our ROV in real life. However, we do have plans on how we would have tested our ROV and the hypothetical changes that would have been added based on our results. One method we may use to test our ROV is to try retrieving fake debris from the bottom of a pool or shallow part of the ocean. The testing debris should be in different shapes and sizes so we can test our ROV with a wide variety of items. We would do several test runs with a pilot to see how well we can scoop up the debris. Depending on how many items our ROV will be able to successfully pick up, we can modify and redesign our scoop mechanism to accommodate the items that weren't retrieved. We might also want to change the material of the scoop to adjust its durability and flexibility. The water currents and pressure might affect how effective our scoop performs, and adjustments may be needed once tested.

Conversely, changes might need to be made to the main body of the ROV. Speed and **agility** is an important feature for an ROV to work as productively as possible. Additionally, our ROV might need to navigate shipwrecks and other underwater structures, so it must be able to move swiftly with precision. One method we could use to determine the mobility of the ROV is by conducting a speed test. We can have our pilot run the ROV around a pool or a certain distance in the ocean a few times, timing each round. After we take the average of the times, we can then figure out if we need it to be faster. From there, we can adjust the main body to be more hydrodynamic in the water. Some adjustments, like making it smoother, smaller or adding holes in the frame to let the water flow through may be helpful. It's also vital that we ensure that the main body can handle the water pressure. The best way to test this is by sending the ROV down to the maximum depth it needs to go to and let it sit there for about 30 minutes. Afterwards, we will bring the ROV back to the surface and inspect its condition (cracks or other damage). If the ROV is severely damaged, we can be sure that it wouldn't be able to hold up against the underwater pressure. So the next logical step from there would be to find a stronger material to use to build the main body. Testing should be done in a logical and organized manner. It would be best to take notes on how the ROV fares after each test, for future improvements. One way to record our data for the speed test would be to utilize a chart such as the one below.

| Model # | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Average |
|---|---|---|---|---|---|---|
| **<Design 1>** | Insert time | Insert time | Insert time | Insert time | Insert time | Insert time |
| **<Design 2>** | Insert time | Insert time | Insert time | Insert time | Insert time | Insert time |

*Example of a Speed Test Chart*

This chart would allow us to easily perceive all the data and observe whether or not modifications are required. It would also enhance our ability to identify how much improvement was made from one model to the next. The method we'd use to keep track of the scoop's effectiveness is to observe which items the scoop can retrieve and which ones it can't. This should also be recorded in a list form and should later be consulted for redesigns. Additional factors to consider include why or why not the ROV was able to recover certain debris and how we could adjust the ROV to retrieve the particular non-recovered debris. This would greatly increase the efficiency of the ROV and the diversity of the debris being retrieved. There are plenty of other small things that should be kept in mind as the tests are being conducted as well, including the durability and buoyancy of the ROV. Until it's tested in the ocean, it is not confirmed that it will hold up under the ocean currents, temperature, or pressure. So overall, many aspects should be tested for our ROV to be in peak condition.

**Reflection & Next Steps:**

Since this season of the competition was fully virtual, we couldn't do the same tasks as we did last year, such as building and testing our ROV. Our team had to rely on research and critically evaluate designs to make sure our ROV could do exactly what we intended it to do. The research was used to accurately design our ROV so that if we were to test it, it would work properly. We learned that even when we have obstacles in our path, there's always a way to overcome them and be successful.

Our main challenge this year was to try to follow the EDP in a virtual setting. The first step of identifying the mission was not challenging because unfortunately there are many ocean problems to research. We had to brainstorm and design everything online instead of a hands-on approach. To add to that, we could not build and test our ROV in real life with a pool and a control box like we did last year. This could result in our design not working at all if we assessed it. However, we overcame this challenge by: thoroughly observing our designs, evaluating how they would work in our mission, and designing models of shipwrecks on TinkerCAD to visualize the environment. This helped us throughout our design process.

Another challenge was time. Last year, we had several months to design, build and test our ROV and go through the EDP carefully and methodically. Whereas this year, we only had about a month to complete our mission as our school district did not allow extracurricular activities to start until the beginning of March. In addition, all our meetings had to be virtual. This was a major challenge because we had so little time to plan everything. Additionally, outside of our scheduled meetings, everyone needed to put in extra work, time, and effort, which we were all willing to do.

Some things our team enjoyed during this project were researching our tasks and working on our designs. Coming up with our mission was a great way for our team to find a unique solution to the real-world problem while also expressing our creativity through our designs. Designing on TinkerCAD allowed us to explore and deeply understand our mission, which was to salvage shipwrecks. The option to select our mission allowed us to recognize many other real-world problems. This was a change from the previous year and allowed us to put our own twist on the mission. We learned a lot about environmental issues and how we could help.

The new knowledge and information we gathered from this season can help us in the future. Our team members sharpened their skills by using TinkerCAD to design the ROV and learned to work more efficiently than before. Knowing we had a short amount of time forced us to work more constructively and manage our time wisely. One thing that we could have done better was to be more effective while working in our virtual meetings. We weren't able to communicate very well since not everyone was online at the same time. Even when we were virtually together, it was difficult to collaborate. Text messages could go unread and miscommunication was common, not to mention the frequent internet problems plaguing us constantly. Also, we should have spoken out more instead of sending text messages over the chat.

In the future, our team should brainstorm more ideas to improve our ROV, such as designing a new frame. Likewise, we could add attachments that would enhance our ROV's performance and our team's ability to complete the mission. This year we mainly focused on retrieving shipwreck debris but, at some point, we can help resolve other real-world problems. For example, we could go a step further in our mission and try to clean up the toxic chemicals and oil spills caused by shipwrecks. This could be achieved by designing a skimmer or a more complex retrieval mechanism.

Our team's next step would be to build our ROV. Once built, we could conduct tests and record our results. From there, we would be able to redesign for improvement. These tasks are significant steps of the EDP, but we weren't able to complete them due to the pandemic. Once we finalize our ROV, we would be able to see how functional it is and actually clean up the marine debris. This would help us expand our knowledge of building and utilizing ROVs to help the ocean environment. All of our experience and endeavors have led us to where we are today! Thank you, SeaPerch!

**Acknowledgements:**

Many people have helped us along the way throughout SeaPerch this year. Two people who have made a significant impact are our coaches Ms. Ashman and Ms. Barrett. Although we could not work in person this year, there still was a SeaPerch team because of them. They wanted to teach students about underwater robotics, ROV designing, and collaborating with your team, regardless of how, where and when they do it. We would also like to thank RoboNation and NJ SeaPerch for having competitions during this pandemic. It's nice that even though SeaPerch was to be held virtually, we still had the opportunity to be a part of this amazing team!

## References:

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**Budget:**

As our competition was virtual, we were unable to build our ROV. However, in the chart below, you will find the items we would have used if we had the opportunity to build.

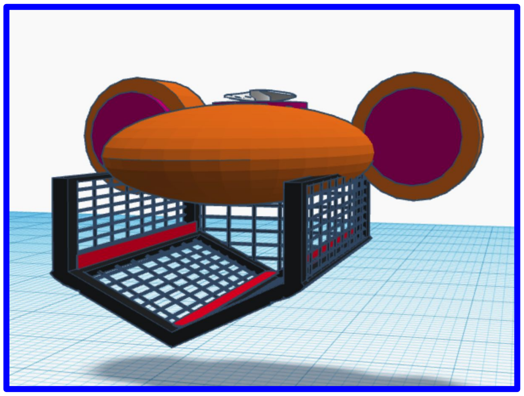
| Component | Vendor | How Was Component Used?: | Cost in USD |
|---|---|---|---|
| PLA (3D printing material) | MakerBot | It formed the frame of our ROV. | $0.25<br>(5 grams at $0.05 per gram) |
| Wire Mesh | Amazon<br>Link | The Mesh was used for the netting of our scoop. | $10.00 |
| Total Cost: | | | $10.25 |
| Surplus: | | | $14.75 |

**Fact Sheet:**

HMS Seabots, Megalodons
Harrington Middle School
514 Mount Laurel Road, Mount Laurel, New Jersey 08054

**Our SeaPerch is unique because** we have a talented team of people that devised an original ROV for a real-world problem. We believe that our ROV is fully capable of completing our mission: salvaging harmful debris from shipwrecks. Our ROV is equipped with a custom-designed scoop attachment. Overall, our design is creative, convenient, and versatile.

**Our biggest takeaway this season is** that even with a limited amount of time in such difficult circumstances, students can still come together, work hard, and achieve a goal. We were only given less than a month to finish our research, ROV design, and our technical report. However, our team finished everything that was required in that short amount of time. No matter how impossible the odds may seem, if you work with dedication and resoluteness, your commitment and effort will be worth it and you will be successful.



**Middle School**

**SeaPerch Design Overview:** We believe that our ROV model will successfully complete the mission we identified. With a hydrodynamic shape and compact size, it'd be neutrally buoyant, which is key for stability and maneuverability in the ocean. Also, our attachment has a wide and sturdy interior for many items to be collected at a time while not weighing down the vehicle too much. This can allow us to resurface and submerge the ROV swiftly without facing many issues. Overall, we think that our design is apt for accomplishing our real-world mission.


Team Photo

This is our **2nd** year participating in SeaPerch; however, our first was cut short due to COVID. This is our first year going to regionals and internationals.

Our mentors are **Ms. Barrett** and **Ms. Ashman.**

Team Members- **Andrew Zangara** (Co-CEO), **Meghna Parija** (Co-CEO), **Akshya Amarnath** (Co-CTO), **Shreeya Soma** (Co-CTO), **Adam Freedman** (co-CFO), **Harry Southard** (co-CFO), **Vishvajith Jagadeesan**, **Samraat Kadam**, and **Aditya Sriram**