1. ABSTRACT

This Technical Design Report highlights the Engineering Design Process (EDP) Team Kraken used to create the Kraken Remotely Operated Vehicle (ROV) and the successful design features. This report will review the challenge course, obstacle course, new mini course tasks and how they influenced the team's engineering design approach. Analysis of experimental results included in the report demonstrate how detailed testing was used to decide on the final design. Additionally, the report describes the team's reflection of the SeaPerch journey to this point and future plans for the Team Kraken ROV design and team members. The Kraken ROV is extremely unique and stands out in the SeaPerch community because of the following design features:

- **Modular Frame Vehicle (MFV):** The frame is 3D designed and manufactured as multiple parts. This enables easy interchange of frame parts for design improvements or rapid repairs.
- **Adjustable Buoyancy/Trim:** Test tubes, travel bottles, and 3D printed buoyancy caps that can be interchanged are used to adjust buoyancy between positive, negative, or neutral. The buoyancy bottles also move easily forward or backwards to adjust the ROVs trim (Bowditch N. 2002). This enables quick adjustments based on the complex tasks the course contains.
- **Ultralight Design:** The frame is 3D printed and weighs 1.12 ounces to provide maximum thrust to mass ratio (Wing, Charlie, 2004, 2007) for peak ROV speed. The frame itself is also buoyant.
- **Gripper:** The ROV gripper is used to lock mines or trash in place to prevent dropping items.
- **Innovative Parts:** The ROV forklift used for the beacon tasks is reversable to shorten the ROV and make it more maneuverable through the obstacle course. The servo and other parts can also be stored onboard the ROV to reduce drag.
- **Brightly Colored:** A variety of bright colors are used on the ROV to easily identify components and orientation underwater.

2. TASK OVERVIEW

The pool challenge consists of four tasks. By following the EDP, Team Kraken is able to successfully navigate the challenges in the time limits required to achieve maximum points on all tasks.

- **Challenge Course Beacon-** Requires turning arming device to deactivate the mine or remove the arming device for full points. 3D printed forks are designed and manufactured with a curved recess to cradle the beacon.
- **Challenge Course Vault-** Requires turning a lever arm to open a vault to reach the sunken trash/mines. Later, a mine is placed on the same lever arm to allow returning the vault to the closed position. The fork discussed above turns the vault well and does not require any redesign.
- **Challenge Course Sunken Trash/Mines-** Requires the ROV to pick up and transport bottles, balls, and a can, drop them through the vault and onto the platform below. The fork was redesigned to sit on the bottom of the platform to easily scoop up the sunken items. Because items on the fork would fall off, the gripper is designed to lock items in place.
- **Challenge Course Floating Trash-** Requires moving trash under or over a floating ring. This was the toughest design challenge Team Kraken experienced. Originally the gripper was used to hold the items while the horizontal motors pulled the trash under the ring. This worked well with the full challenge course because it maintained control of the items during transport to the pool deck. When the mini course was released, a bulldozer attachment was added to push the items over the ring, therefore increasing speed for the task.
- **Obstacle Course (Removed 2021)-** Requires diving, surfacing, and travelling through five vertical and horizontal hoops in the least time possible. Team Kraken's enhanced hydrodynamics (Lucas J., 2014), motor improvements, and ultra-light frame resulted in an obstacle course run of 26 seconds.

3. DESIGN APPROACH

Team Kraken consistently approaches the EDP with detailed techniques focused on innovation for each design iteration.

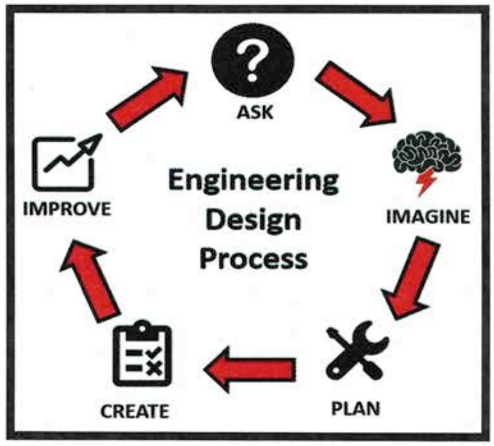

Fig. 1 - EDP Diagram

ASK- The first step of the EDP is to survey tasks and ask what improvements are needed to complete the course most efficiently. Team Kraken identifies the following questions with each design iteration: How can the ROV's speed be maximized? How can buoyancy (OpenStax College, 2013) be adjusted for different situations? How can items be lifted and transported?

IMAGINE-Team Kraken brainstorms ways to solve the questions from the first stage of the EDP with these priorities:

1) Improve attachments for the challenge course.
2) Reduce frame size and drag (Wing, Charlie, 2004, 2007).
3) Increase motor Revolutions Per Minute (RPMs) (Kemp, Peter, 2005).

PLAN- Team Kraken creates a plan for each design feature imagined. The plans include drawings, materials, building techniques and testing methods.

CREATE- After planning the improvements, Team Kraken transitions into a building/testing phase for each iteration. The team tests each improvement so informed design decisions can be made.

IMPROVE- Test results for design iterations are analyzed and final decisions are made. Sometimes this involves considering design tradeoffs such as the additional capability of grabbing and locking sunken items vs the additional weight added to the ROV.

KRAKEN 1.0- The standard SeaPerch frame was built to establish a baseline. Because the frame was so stable, Team Kraken decided to base the next design on it but make it smaller.

Pros: Very stable and easy to drive. **Cons:** Slow, sluggish maneuverability (Moore S.W., 2010).
Frame Weight: 16.24 oz. **Speed:** 1.20 FT/SEC

KRAKEN 2.0- Mirrored the SeaPerch frame but built using Chlorinated Poly Vinyl Chloride (CPVC) and Cross-Linked Polyethylene (PEX) pipe to reduce frame size. This design verified that speed increases as size and weight are reduced. It was stable and maneuverable, but the team decided to redesign to test how improving hydrodynamics (Lucas J., 2014) effects ROV performance.

Pros: Easy to navigate hoops course. **Cons:** Dives slowly.
Frame Weight: 8.18 oz. **Speed:** 1.34 FT/SEC

KRAKEN 3.0- Built with a pointed front, this design iteration validated that improved hydrodynamics increases speed. However, the ROV was hard to control when diving and surfacing. The team believed the control issue was based on motor location and center of buoyancy so the ROV was redesigned to adjust these factors.

Pros: Increased speed **Cons:** Difficult to control
Frame Weight: 5.46 oz. **Speed:** 1.66 FT/SEC

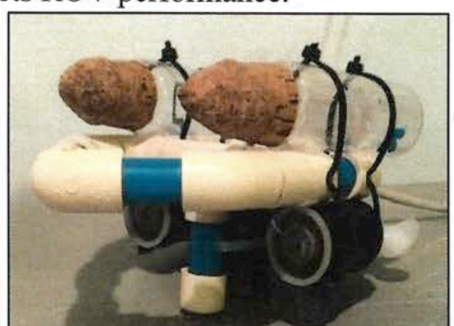

Fig. 2 - Kraken 3.0

KRAKEN 4.0- Shortened the ROV frame and moved the vertical motor forward. This design justified that reducing size and drag increases speed and motor location affects ROV control. Most importantly, this iteration identified a need to redesign with lighter materials to improve ROV performance.

Pros: Increased stability and maneuverability.
Cons: Overall performance limited by material.
Frame Weight: 4.5 oz. **Speed:** 1.76 FT/SEC

Fig. 3 - Kraken 4.0

KRAKEN 5.0- 3D printed the ROV frame to reduce ROV weight.
Pros: Increased stability (Wing, Charlie, 2004, 2007).
Cons: Long build/print times.
Frame Weight: 3 oz. **Speed:** 1.82 FT/SEC

This design showed symmetry improved ROV stability and control (Wing, Charlie, 2004, 2007). 3D printing provided flexibility, but the six-hour print times caused delays with redesigns or repairs.

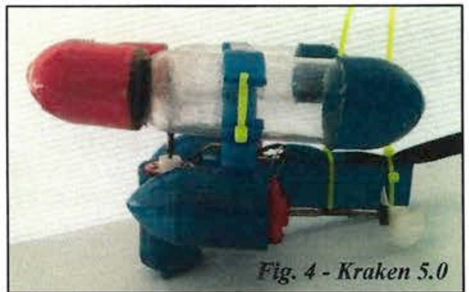
Fig. 4 - Kraken 5.0

KRAKEN 6.0- A 3-part frame design to reduce 3D print times.
Pros: Increased speed, quick 3D printing times.
Cons: Difficult to see, weak frame strength.
Frame Weight: 1.70 oz. **Speed:** 2.04 FT/SEC

This design was called the Modular Frame Vehicle (MFV) because it is made of small interchangeable parts. This feature reduced print time by more than 50% for repairs. The ROV performed well but when the servo gripper was added, it reduced hydrodynamics.

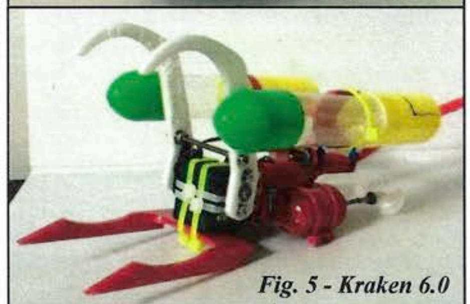
Fig. 5 - Kraken 6.0

KRAKEN 7.0- A single bottle MFV designed to reduce drag.
Pros: Increased speed, improved lifting power.
Cons: Slower turning, poor stability on the surface.
Frame Weight: 1.34 oz. **Speed:** 2.20 FT/SEC

The buoyancy attachment was changed from two bottles to one, which reduced drag. The vertical motor was also inverted to face down, which provided more thrust to pick up items and reduced surface ripple. Although the ROV was fast and could complete the challenges, it was redesigned to improve ROV stability and control.

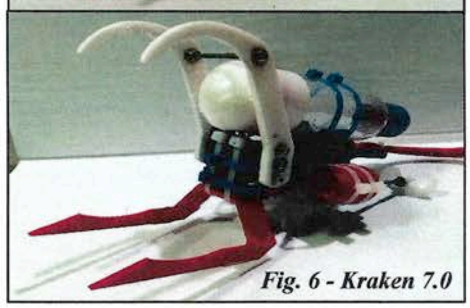
Fig. 6 - Kraken 7.0

KRAKEN 8.0 (FINAL DESIGN)– A three small bottle MFV design with the servo behind the vertical motor to further improve lifting capability and hydrodynamics.
Pros: Stable ROV, stowable servo. **Cons:** Time consuming to stow servo.
Frame Weight: 1.12 oz. **Speed:** 2.78 FT/SEC

FINAL DESIGN DISCUSSION/FEATURES The new frame allows the servo to be stowed behind the vertical motor to reduce drag for the obstacle course. Adding a servo gripper was the most difficult design feature on the ROV. Despite the added weight (1.95 oz.) and drag on the ROV, the increased capability provided makes it necessary. Additionally, having the servo control from the pool deck with the line tender improves Team Kraken's poolside teamwork and communication. All the improvements combine to make Team Kraken's most innovative ROV. Additional unique features include:

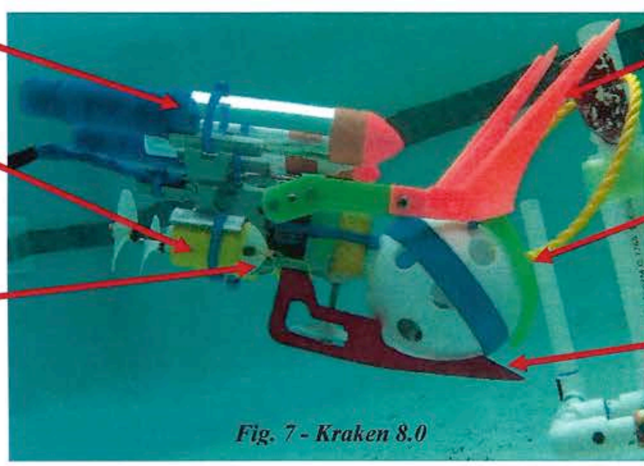

Fig. 7 - Kraken 8.0

4. EXPERIMENTAL RESULTS

Speed Test: For Team Kraken the most important ROV design factor is speed. The team conducts in-water testing of each ROV with three runs of 50 feet for each ROV design. Then the team calculates each ROVs speed in FT/SEC. Figure 9 demonstrates as the ROV size/weight is reduced, thrust to mass ratio and ROV speed increases. Speed testing is key in determining the ROV final design.

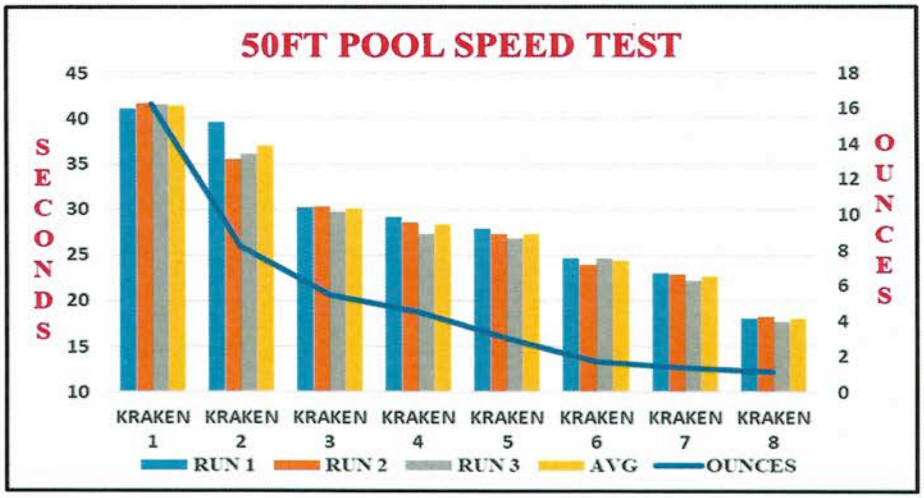

Fig. 9 – 50FT Pool Speed Test

RPM Test: RPMs establish a good measure of motor performance and the team uses a digital tachometer to measure RPMs of motors. Team Kraken's observations include:

- Higher battery voltage produces higher RPMs. The team standard is to test and only use batteries above 13 Volts.
- RPMs range from 10,500 to 11,600 on new motors. Having right and left motors with equal RPMs help the ROV drive straight.
- Decreasing electrical resistance increases current (Moore S.W., 2010) to the motor. Team Kraken utilizes solid CAT 5 wire instead of stranded, doubles up CAT 5 wires from the RJ-45 connector to the positive motor terminals and reduces cable length from 50ft to 15ft. These modifications, on average, reduce resistance from 1.8 Ohms to 0.8 Ohms and increase RPMs from 11,500 to 12,400.

Fig. 10 - Digital Tachometer

Drag Test: With a dedicated focus on improving hydrodynamics, the team tests ROV drag. After completing a drag test (Moore S.W., 2010) using spring scales for ROV design iterations the team confirms that forward surface area on the ROV directly affects ROV drag and correlates to ROV speed. Utilizing the EDP Team Kraken creates thinner ROV designs, reduces use of zip ties, and curves forward facing surface areas on all design reiterations. Additionally, to further evaluate the effect of drag compared to ROV speed, the team measures forward-facing surface area. The standard SeaPerch ROV is 179.7cm² and the final design Kraken 8 is 55.1cm². Overall surface area was reduced by 69.4% and speed increased by 131.6%. As surface area drag is reduced, speed increases. However, motor improvements on design iterations make it impossible to calculate an accurate ratio of drag vs speed increase.

Prop Test: A 50-foot pool speed test of propellors is conducted to analyze performance of various propellers. Testing includes the standard SeaPerch, 3 bladed, 4 bladed, and 3D printed propellers. Testing evaluation demonstrates the standard SeaPerch propeller provides maximum speed.

Functionality Test: To verify ROV functionality a full mockup of the challenge course including the beacon, floating trash, sunken trash, and mines is used. The course provides the ability to test the gripper, forks, and redesign as necessary to improve the ROVs ability to complete all tasks.

5. REFLECTION AND NEXT STEPS

The EDP steps below are key to the innovations applied to the Kraken ROV:

- **Ask-** First, the course was built and tested with each ROV. This enables the team to take note of all the requirements that each design is not meeting. Once the team identifies imperfections, the following questions are raised: How can ROV speed be improved? How can motor performance be increased? How are challenges navigated?
- **Imagine-** When imagining and brainstorming, Team Kraken's coaches challenged them to use different materials and to not rule out any idea until it was attempted. This led to innovations in 3D design, motor improvements, and the creation of the Kraken gripper.
- **Plan-** The team had to research and plan for materials, timelines, and new innovations. This EDP step helps the team be more prepared.
- **Create-** Building and constructing each ROV and its parts is the most time-consuming step. This step led to creation of the MFV which decreases the ROV manufacturing, repairs, and redesign time.
- **Improve-** According to Team Kraken, the most important part of the EDP is to improve. Eight different ROV design iterations were constructed and each time the team assessed how they worked and ways they could be improved. Each design iteration went through additional adjustments for its attachments.

In the end, the EDP led Team Kraken to success in previous years and continues to help as they push towards their goals.

Teams Future Plans:

- Team Kraken's members will be going to high school next year. The team hopes they can come together and compete in the 2022 International SeaPerch competition open class.
- Research RoboSub and SeaMate and possibly compete in the nearby regionals.
- Return to Mayport Middle School club to teach everything the team has learned to new 6th graders and club members so the Kraken legacy can continue.

ROV Future Plans:

- Team Kraken built a capable open class ROV. One of the biggest problems is how big the controller is, which makes it difficult to hold. In the future, plans are to 3D print a controller that is easier to hold and operate. They intend to try different types of controllers by printing circuit boards and/or coding an Arduino microcontroller so joysticks can be used to control the ROV.
- Continue working on open class ROV innovations including adding a camera, because one of the biggest challenges Team Kraken faced is identifying the ROVs proximity to objects prior to picking them up.

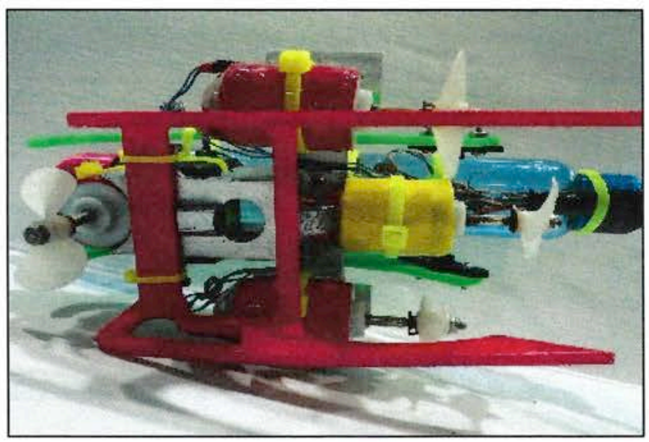

Fig. 11 - Open Class 4 Motor ROV

- Team Kraken plans to continue to improve the ROV's speed to get under 20 seconds on the obstacle course by adding an additional booster motor.

Lessons Learned: Team Kraken learned many valuable lessons and it has been a lot of hard work. The most valuable lesson learned is that failure is the best teacher. An untimely propellor detachment during 2019 internationals taught them that failures happen but true engineers can reduce them. Most importantly, failing to reach their goal at the last Internationals taught them that ROVs can always be improved, and success comes with hard work.

6. ACKNOWLEDGEMENTS

We would like to thank everybody who helped us get to where we are today. We are truly fortunate to be able to compete in this challenge and have this experience. First, we want to say thank you to all our amazing coaches. They helped us get through all the challenges that we faced through the years and taught us a lot about robotics. Mr. Hudson, who started the robotics program at our school, has helped supply us with new materials to try for our ROV. He also showed us many things that helped us when designing our ROV. Another coach that helped us a lot along the way was Mr. Shanklin who helped us stay organized, helped with supplies, and really pushed us to get the work done. We could not have done this without him. Mr. Felice is our final coach and our ROV would be completely different without him. Mr. Felice taught us 3D design and printing. Thanks again to all our amazing coaches, we don't know where we would be without them.

Sponsors are also super important to our team. Without them we would not have been able to afford materials and transportation, we literally would not have been able to be here without them. Our sponsors are TIAA bank, Worlds Finest Chocolate, and parents who donated to the club. With the help of our sponsors, we were able to travel and compete in the 2019 International SeaPerch challenge. Last year, Worlds Finest Chocolate helped us set up a fundraiser to sell candy bars to earn money for registration to the competition. Thanks to all our sponsors and everyone who helped donate to our club.

Last, but certainly not least, we would like to thank all the parents of the club. They help with transportation, by driving us to practice every Thursday and Saturday. They also help with funds, by donating money and materials, help and organize events and club meetings. It was a parent who organized the World's Finest Chocolate fundraiser. That is why parents are essential to this club, so big thanks to our parents, sponsors, and coaches for all your contributions to our team.

7. REFERENCES

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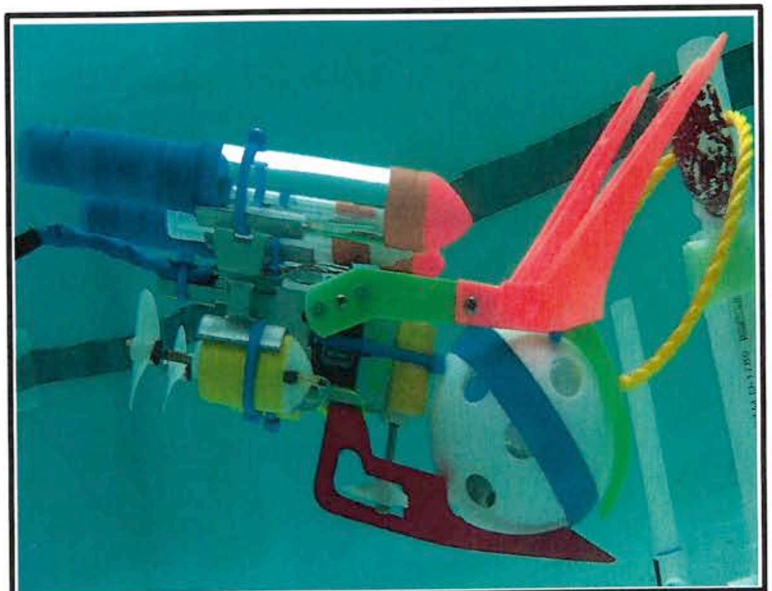
APPENDIX A: Budget

Component	Vendor	How was component used?	Cost (in USD)
3D Printed Frame (32 Grams)	N/A	Frame	$1.60
3D Buoyancy Bottle Caps (2-3 Grams Each)	N/A	Buoyancy/ Hydrodynamics	$0.30
3D Motor Caps Front (2-2 Grams Each)	N/A	Motor Waterproofing and Hydrodynamics	$0.20
3D Motor Shaft Caps Rear (3-1 Gram Each)	N/A	Motor Waterproofing	$0.15
3D Bottom Fork (12 Grams)	N/A	ROV Accessory	$0.60
3D Top Gripper Forks (2-6 Grams Each)	N/A	Servo Gripper	$0.60
3D Bulldozer Attachments (2-8 Grams Each)	N/A	Servo Gripper	$0.80
3D Cable Floats (3-6 Grams Each)	N/A	Cable Buoyancy	$0.90
3D Frame Buoyancy Block (1-5 Grams Each)	N/A	Frame Buoyancy	$0.25
Battery Case Holder (1)	AMAZON Amazon.com: Ogrmar On/Off Switch 4 x 1.5V AA Battery Case Holder Leads Black w Cap 2Pcs: Home Audio & Theater	Power to Servo	$3.00
Additional CAT 5 Cabling - Solid (15FT – 1.5% used)	AMAZON Amazon.com: 1000ft Cat5e Orange Solid 24AWG Cable UTP Cat5 Bulk Network Wire (Unshielded (UTP), Orange): Computers & Accessories	Doubling Power to Motors	$0.74
Servo MG 995R (1)	ALIBABA High Speed Torque Servos Digital Towerpro Mg996r Mg996 Mg995 Metal Gear Servo For Futaba Jr Rc Model Helicopter Boat Car - Buy Mg996r Servo,Mg996r Mg995 Metal Gear Servo,Towerpro Mg995 Digital Metal Gear Servo Product on Alibaba.com	Drive Servo Gripper	$1.97
Servo Controller (1)	EBAY DC 5V-9V Dual Servo Motor Drive Module Controller for SG90/MG995/MG996 Robot | eBay	Operate Servo Gripper	$4.28
Batteries AA (4)	AMAZON Amazon.com: Amazon Basics 100 Pack AAA High-Performance Alkaline Batteries, 10-Year Shelf Life, Easy to Open Value Pack: Health & Personal Care	Power Servo/Controller	$0.96
4-40 Nuts and Screws (12 pcs)	AMAZON VIGRUE 540PCS #2-56#4-40#6-32 Phillips Pan Head Screws Bolt Nut Flat Washers 304 Stainless Steel Machine Screws Assortment Kit with Wrench and Storage Case (#2-56#4-40#6-32): Amazon.com: Industrial & Scientific	Gripper and Frame Attaching	$0.51
6x32 Screw 1" (1)	AMAZON Amazon.com: #6-32 x 1" Truss Head Phillips Machine Screws, Full Thread, 18-8 Stainless Steel, Quantity 100: Home Improvement	Gripper Attaching	$0.10

6x32 3 Inch Threaded Rod" (1)	AMAZON Amazon.com: The Hillman Group 44812 #6-32 x 3" Threaded Rods, 15 Pieces: Home Improvement	Servo-Gripper Attaching	$0.42
6X32 Nuts (5)	AMAZON Amazon.com: The Hillman Group 140015 Hex Machine Screw Nut, 6-Inch by 32-Inch, 100-Pack: Home Improvement	Gripper Crossbar and Attaching	$0.30
Test Tubes (2)	AMAZON DEPEPE 30pcs 50ml Clear Flat Plastic Test Tubes with Screw Caps: Amazon.com: Industrial & Scientific	ROV Buoyancy	$0.56
½ Ounce Plastic Bottle (2)	AMAZON Amazon.com : 0.5oz Mini Clear Plastic Empty Bottle with Flip Cap Small Travel Bottles Storage Containers Jars for Cosmetic Sample Lotion Shower Gel Emulsion Toiletries - BPA-free - Set of 24 : Beauty	ROV Buoyancy	$1.16
Plastic Dropper Bottle (1)	AMAZON Amazon.com: Plastic Dropper Bottles and Funnels for DIY Crafts and Art (36-Pack): Home Improvement	ROV Buoyancy	$0.28
Packing Seal (5% used)	AMAZON Palmetto 1347AF Series Synthetic with PTFE & Lube Compression Packing Seal, White, 3/8" Square, 10' Length: Rope Seals: Amazon.com: Industrial & Scientific	Motor Shaft Sealing	$0.25
Marine Grease (2% used)	AMAZON Amazon.com : Quicksilver 8M0071838 High Performance Multi-Purpose Extreme NLGI 2 Marine Grease, 8-Ounce Tube : Boating Equipment : Sports & Outdoors	Motor Shaft Sealing	$0.19
Expandable Sheathing (15FT, 15% used)	AMAZON Amazon.com: AdlerSpeed 30m (100FT) 6.5mm Expandable Wire Cable Sleeving Sheathing Braided Loom Tubing Black: Automotive	Cable Wrapping	$1.41
Heat Shrink (12 pcs, 2% used)	AMAZON 560PCS Heat Shrink Tubing, Sevensun 2:1 Dual Wall Adhesive Heat Shrink Tubes Wire Wrap, Waterproof and Insulated Electrical Wire Heat Shrink Tube Kit with Box(5 colors/12 Sizes): Amazon.com: Industrial & Scientific	Waterproofing Terminals	$0.18
SLA Resin (5% used)	AMAZON ELEGOO 3D Printer Rapid Resin, 405nm LCD UV-Curing Resin Standard Photopolymer Resin for LCD 3D Printing Translucent 500G: Amazon.com: Industrial & Scientific	Waterproofing	$0.72
Fishing Line (2% used)	AMAZON https://www.amazon.com/South-Bend-Monofilament-Fishing-Line/dp/B000FSJZLW/ref=sr_1_10?crid=KNJ8OM01UC9N&dchild=1&keywords=fishing+line&qid=1619293750&sprefix=fishing+line%2Caps%2C184&sr=8-10	Gripper Crossing	$0.10
TOTAL COST OF SEAPERCH COMPONENTS			$22.53

Team Kraken

Mayport Costal Sciences Middle School - Jacksonville, FL



MS-STOCK OTHER MATERIALS

3 Years participating in SeaPerch

2 Times at the International SeaPerch Challenge

Our SeaPerch is unique because: (100 words MAX)

Modular Frame Vehicle (MFV): For rapid change of parts for repair/redesign.
Adjustable Buoyancy/Trim: Buoyancy moves easily forward/backwards to adjust ROV's trim. Hidden buoyancy enables instant neutral, negative or positive buoyancy.
Ultralight Design: Weighs only 1.12 oz to improve thrust to mass ratio.
Gripper: Servo gripper to lock mines and trash in place.
Innovative Parts: Capable of being reoriented or stowed to reduce ROV size.
Color: Bright design allows us to identify which direction the bot is facing.
Expandable Sheathing: Produces less kinking and more flexibility.
Cable Buoyancy: Buoys on the cable allow for less weight affecting the ROV.

SeaPerch Design Overview: (100 words MAX)

Our ROV has been successful for many reasons one being some of our new elements. Our design includes a 3D printed frame which allows for a more hydrodynamic design. Our ballasts can be adjusted to change our buoyancy from positive, negative, or neutral. With our adjustable buoyancy, we can easily maneuver through the challenge course and hoops course with the desired floatation in the front or back of our ROV. Our ROV also has a gripper that allows us to quickly pick up objects that a hook could not. Our innovative design allowed for a faster, and more efficient ROV.

Our biggest takeaway this season is: (100 words MAX)

If we try our best, it will pay off! We spent 200 hours this year and over 600 hours while in middle school on robotics. We faced many obstacles including losing team members, failed ROV experiments, changes to the course and COVID. We gave it our best through all the challenges and were fortunate to win multiple regionals, take 3rd in 2019 SeaPerch Internationals while learning a lot about engineering and teamwork. It has been a fun journey and we look forward to the experience competing in this year's SeaPerch Internationals holds.

School or club name: Mayport Coastal Sciences Middle School

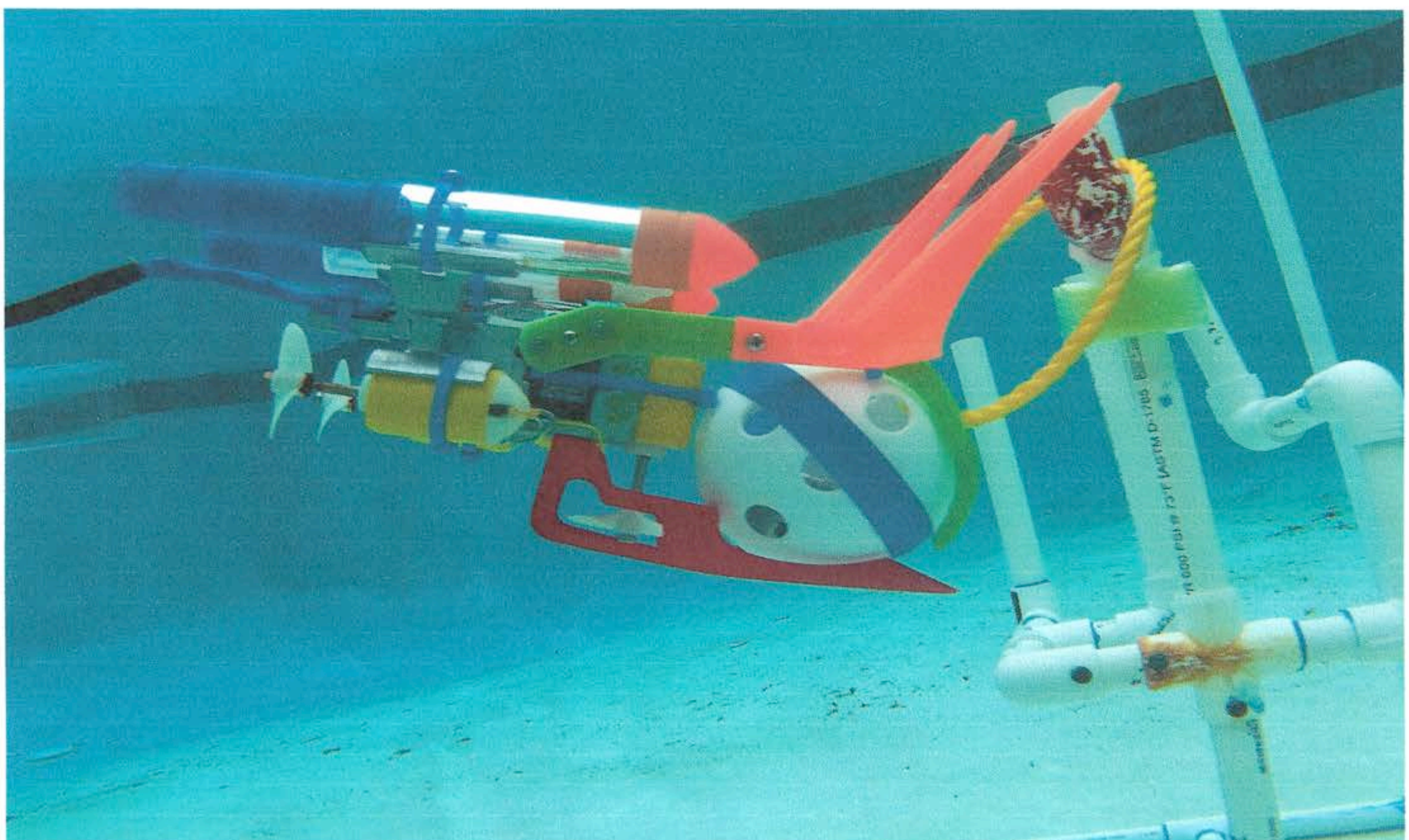
City, State: Jacksonville, Florida

Team name: Team Kraken

ROV name: Kraken

Seaperch 2020-21
Engineering Notebook

MAYPORT
COASTAL SCIENCES
MIDDLE SCHOOL



TEAM INFORMATION PAGE

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TEAM NAME:	Kraken
TEAM PARTICIPANTS:	Kara, 8th Grade Tamia, 8th Grade Tessa, 8th Grade
SCHOOL:	Mayport Coastal Sciences Middle School
SCHOOL DISTRICT:	Duval County, Florida

TABLE OF CONTENTS

Engineering Design Process

November 7, 2018

ASK: Identify the need

IMAGINE: Brainstorm, Develop Possible Solutions.

PLAN: Make a prototype.

CREATE: Testing and Evaluating

IMPROVE: Modifying and Retesting

Team Goals

1. Obstacle Course < 45 sec. ☑
2. Challenge Course < 2 min. Per video ☐
3. Win Regionals ☐ Internationals ☐
4. Have Fun !! ☑✓✓ (Had a Blast!)

Key

- = Titles
- = Design Terms
- = Photo Labels
- = Kraken Conclusion

Design Objectives

1. Decrease ROV's Size to increase thrust to mass ratio.
2. Decrease drag on the ROV to increase Speed.
3. add a tool to ROV Cabable of Picking up items.
4. Increase Motor Performance.

Design Terms

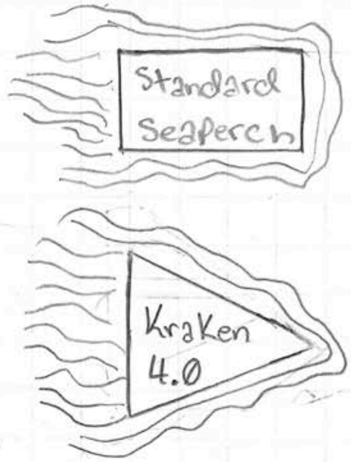
November 14, 2018

Buoyancy: The ability to float, upward force exerted by a fluid on a body in it.

Trim: The way in which a ship floats on the water, in relation to it's force and aft line.

Stability: The ability of a ship to return to an upright position.

Hydrodynamics: Movements of liquids around bodies immersed in them.



Thrust: To push or drive quickly and forcefully.

Propulsion: The act of propelling using force or acting forces.

Velocity: Rate at which an object moves.

List: The angle of list is the degree to which a vessel leans or tilts to either port or starboard (often caused by uneven loading or flooding.)

Pitch: The forward movement of a boat propeller through one complete revolution measured in inches.

Design Terms

November 14, 2018

Ballast: The Sea water Carried by a Ship is Known as ballast water. Ballast water is carried by a Vessel in it's ballast tanks to ensure it's trim, Stability and Structural integrity.

Maneuverability: Performance ability of Ships related Ship motion due to Steering.

Archimedes Principal: The upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces.

RPMs - Revolutions Per Minute.

Obstacle and Challenge Course

Tail of the Kraken

December 18, 2018

How can the ROV cable be lighter and more visible?

We could replace the original white cover with the light black sheathing.

We striped off the rubber and fed the wires through the Black Sheathing.

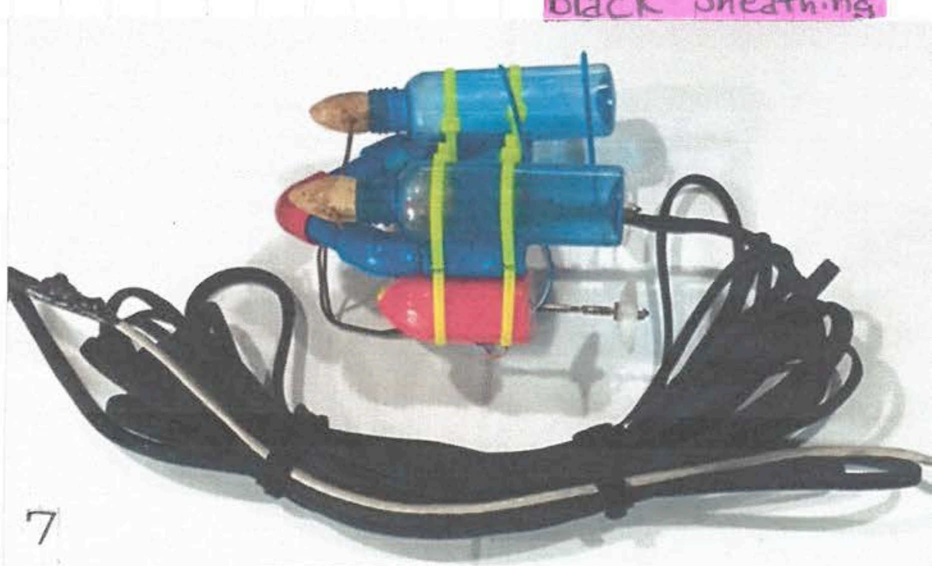
We observed that the black shething was more manuverable and visible.

We can improve by using airtubing so our sheathing is buoyant and doesn't get in our way.

Cable Photo

Black Sheathing | Seaperch Sheathing

Kraken 4.0 with Black Sheathing



Kraken Conclusion

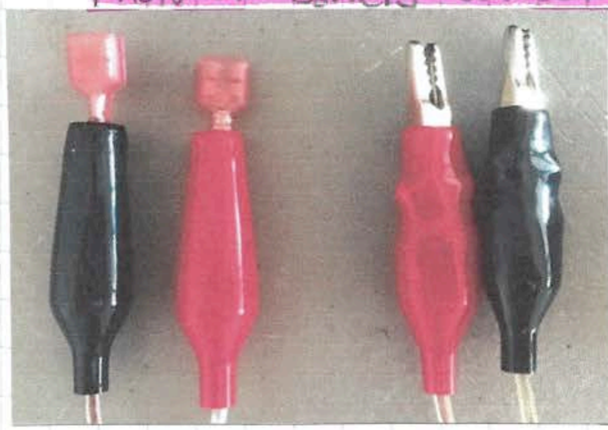
Based on the increased flexibility and visability we decided to go with the black expandable sheathing.

KraKen Power

December 21, 2018

How do We get more Power to the ROV?

Photo of battery Connections



Terminal Leads Aligator Clips

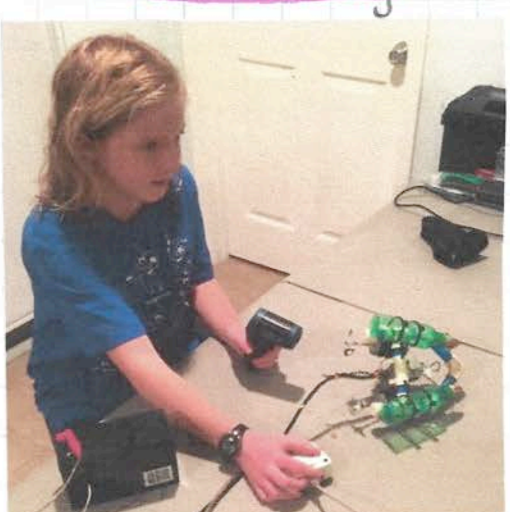
will replacing the aligator clips with terminal leads produce More Power to the motors

use a tachometer to test RPMs of a moter with clips and leads

Testing with clips and leads Produced the Same RPMs.

Will investigate more ways to get Power to the motors.

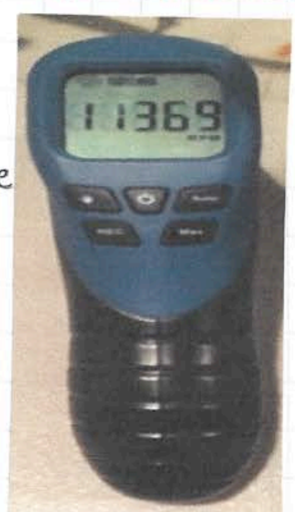
RPM Testing



Kraken Conclusion

Although there was no difference in RPMs from the Aligator Clips and the terminal leads we decided to use the Aligator Clips because they Stayed on better.

Digital Tachometer



What a Drag!!!

January 8, 2019

If we made the shape of our bottles more hydrodynamic would it increase our speed?

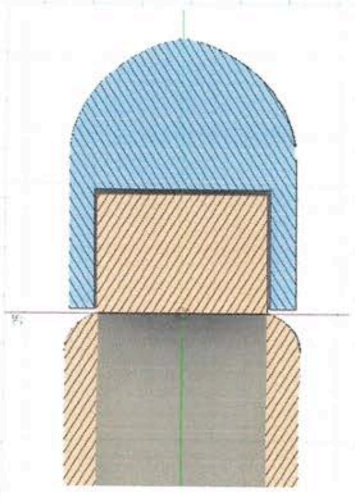
we should use different materials and shapes to build hydrodynamic bottle caps.

We used cork and 3D printing to make bottle caps for ballast tanks.

We are testing 3D printing solid ballast tanks.

Photo of Ballast Tanks

The flat bottle caps created drag. Both the cork and 3D caps cut through the water.



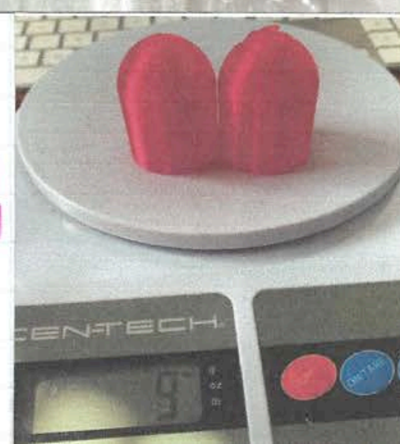
CAD-Bottle Cap

Photo of Tested Bottle Caps

Kraken Conclusion

In the end we decided to use 3D bottle caps because it is more hydrodynamic.

Photo of 3D Printed Bottle Caps



Kraken Eye

January 15, 2019

Would a camera make it easier to pick up items in the Challenge Course?

We should attach a camera to our hook that connects to a screen for the driver to look at.

We purchased a camera from Amazon and tested it in and out of the water.

The endoscope camera's cabling was rigid and too short. Also, the video footage was low resolution and the video lagged.

We are reaserching a non-wifi 50 foot cable.

Photo of Wifi Endoscope

Photo taken by Endoscope

Kraken Conclusion

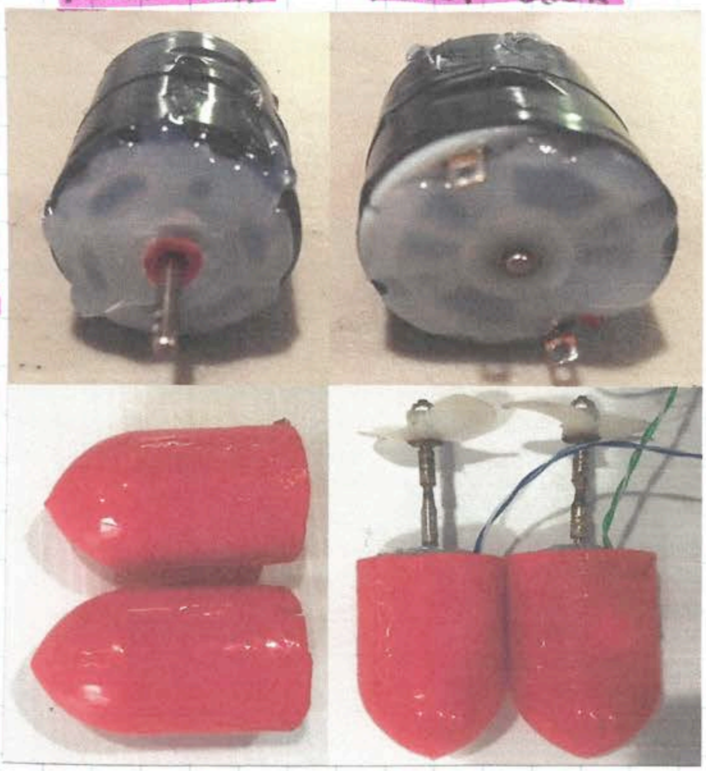
We decided to not use the camera because it went over our budget.

Kraken Fins

February 3, 2019

How do we improve Seaperch motors for more RPMs and less drag?

Motor Front | Motor Back



Photos of Motors

Motor caps | Completed Motors

We should get rid o the film canisters, wax, and replace wit hot glue, O-rings, and 3D Printed moto caps.

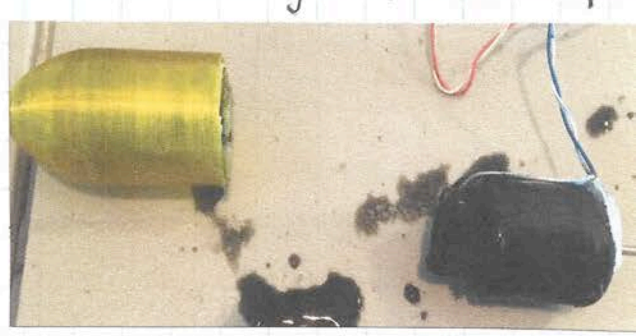
We waterproofed wi hot glue, tape, an a O-ring around th shaft and placed the motors in motor caps

We will investagate ways to improve the motor caps hydrodynamics.

RPM testing before and after waterproofing

	Seaperch Before	Seaperch After	Kraken Before	Kraken Afte
Motor 1:	12,800	10,900	12,675	12,300
Motor 2:	12,550	11,900	12,780	12,220
Motor 3:	12,675	11,760	12,820	12,560

Photo of Original Motor caps



Kraken Conclusion

We decided to use the motor caps because they increased RPM Performance, were buoyant, and decreased drag.

Propeller Testing

March, 12, 2019

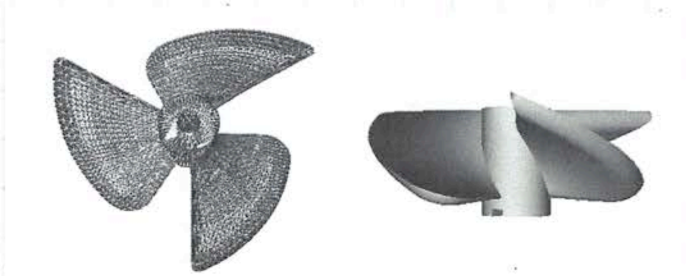
Would changing the number or size of the Propellers increase our Speed?

We Should add more blades to our Propellers and make them bigger.

We found Props of Various Sizes and Shapes.

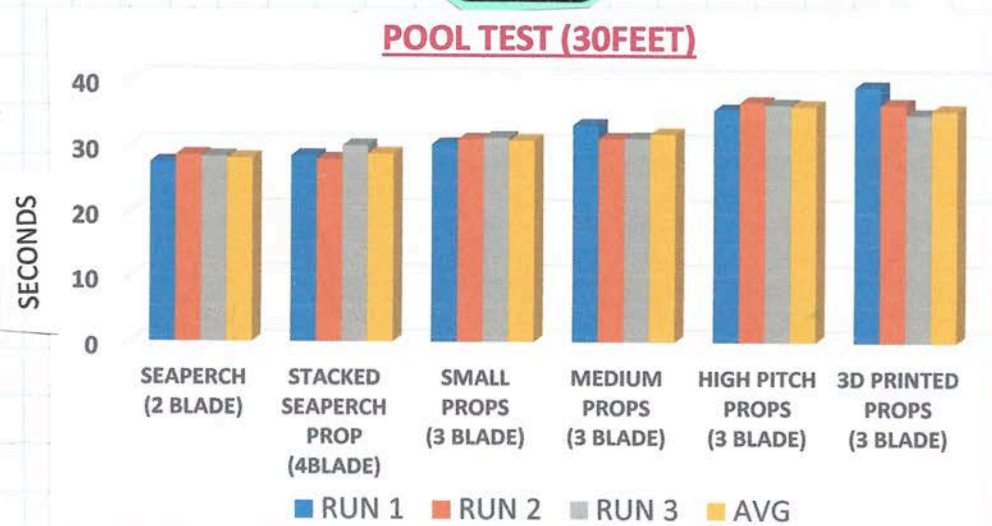
We Could try using Counter-rotating props with a Seaperch Shape.

Photo of Tested Propellers



CAD - 3D Printed Propeller

Propeller test Results



Kraken Conclusion

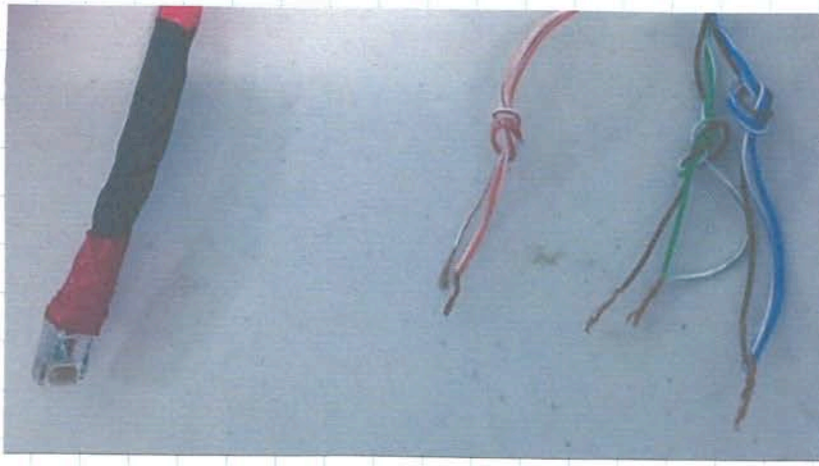
Seaperch props turned out to be the best So we'll continue to use them untill we find better props.

Kraken Current

April 24, 2019

How Can we Produce more RPMS from the motors with the limited 12 Volt battery?

We Could increase the Cable thicknes to the motor-termina to reduce resistance and increase Curren to the motor.



Picture Of Cable Doubling

We doubled up the Cat 5 Cable to all of the positive termanals and terminated the Cat 5 Cable and RJ-45 Connector using a Spare Cable and heat Shri

We used a tachometer to test RPMs of 3 new motors using identical battery voltage.

The reduced resistance improved RPMs, so we will investigate how to double up the negative terminal and fit it in the RJ-45 Connector.

Kraken Conclusion

Doubling up wires improves motor performance because it reduces resistance, increasing Current supplied to the motor

Ohms Law That's why we used this improvement on our motors.

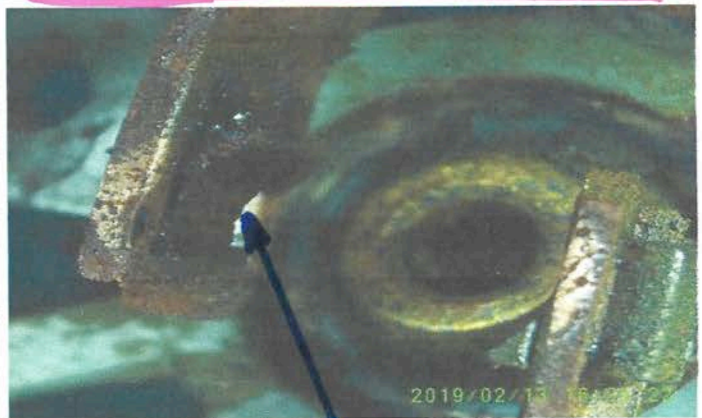
Wire resistance performance table.

CABLE	WIRE RESISTANCE (Ohms)	VERTICAL MOTOR RPM	RIGHT MOTOR RPM	LEFT MOTOR RPM
SINGLE OLD CAT 5	4.4	11,100	11,220	11,180
SINGLE NEW CAT 5	3.5	11,610	11,670	11,650
DOUBLE NEW CAT 5	2.3	12,040	12,130	12.080

Motor Lessons

April 28, 2019

Picture Of New Motor Brushes | Picture Of Worn Motor Brushes



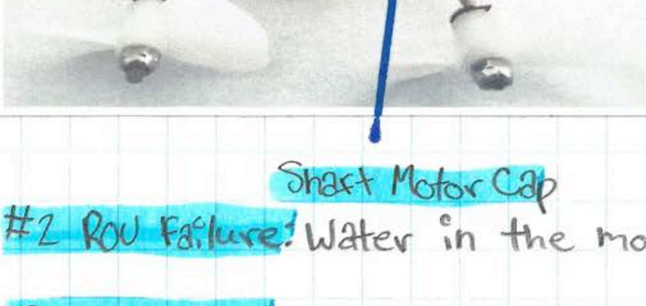
New Brush | Worn Brush

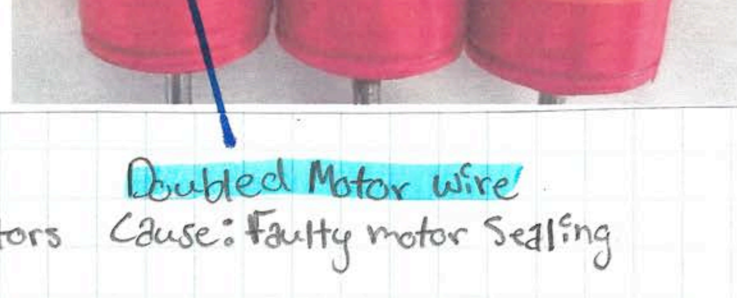
#1 ROV Failure: Motor Failure   **Cause:** Worn motor Brushes

Description: As we practiced more we found motors fail at a high rate. When motor brushes wear down, like in the picture above RPMs decrease a lot.

Lesson Learned: Inspect the brushes or use new motors before Competition.

Pictures Of Sealed Motors





Shaft Motor Cap | Doubled Motor wire

#2 ROV Failure: Water in the motors   **Cause:** Faulty motor Sealing

Description: As we pulled motors apart to figure out why they fail we noticed the motors failed when water leaked in through the shaft.

Lesson Learned: We used flat seal and marine grease under the 3D caps to reduce water intake through the Shaft area.

Hydraulics

January 25, 2020

How can we create a gripper or claw to help pick up the sunken trash and the mines?

We should use syringes and air tubing to create a hydraulic system that we can attach a gripper/claw to.

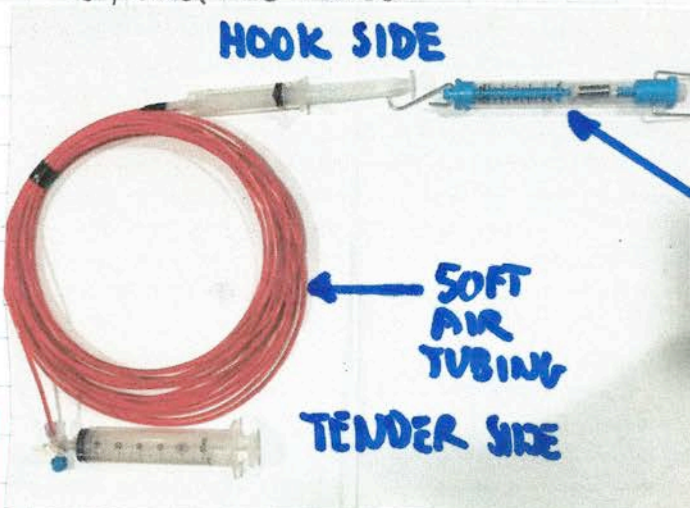


Photo of hydraulic testing

We took plastic syringes and air tubing along with water and created a hydraulic system to which we can add a gripper.

We tested the amount of time it took to extend/retract the plunger above and below the water.

Due to our failure with the hydraulics we are going to experiment with electric servos to create a stronger gripper.

Above water

Time to extend plunger (seconds):
- Trial 1: 1.65
- Trial 2: 1.31
- Trial 3: 1.25
- Average: 1.40

Time to retract plunger (seconds):
- Trial 1: 3.39
- Trial 2: 3.85
- Trial 3: 3.66
- Average: 3.63

Below water

Time to extend plunger (seconds):
- Trial 1: 1.51
- Trial 2: 1.44
- Trial 3: 1.63
- Average: 1.52

Time to retract plunger (seconds):
- Trial 1: 4.05
- Trial 2: 5.88
- Trial 3: 4.00
- Average: 4.64

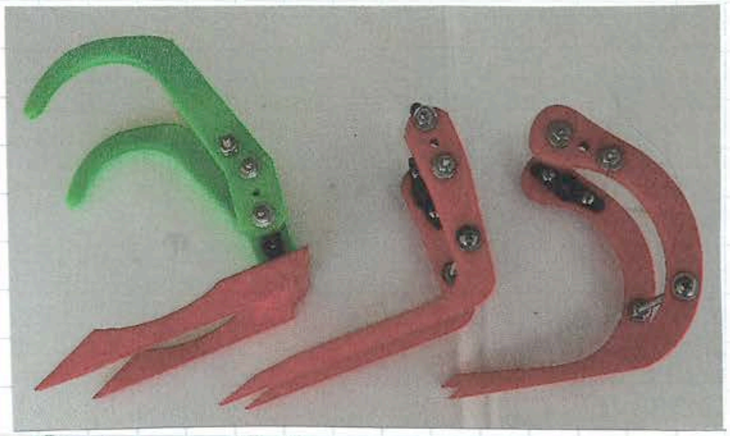
Pressure extending
12 Newtons
Pressure retracting
3 Newtons

Gripper

January 29, 2020

How can we pick up items from the top and bottom of the pool?

We could attach a servo motor in order to make a gripper.



Picture of Gripper progression

We designed a hook that could fit around the floating trash

We innovated our hook shape to better support laying our ROV on the bottom of the pool to pick up the sunken trash

Without Servo Motor	High Torque Servo Motor	High Speed Servo Motor
Items fall from the hook.	Closed onto the items and held them tight	Closed onto items faster; reduced jitter
	Had a jitter that often released items while driving the ROV	

Kraken Conclusion

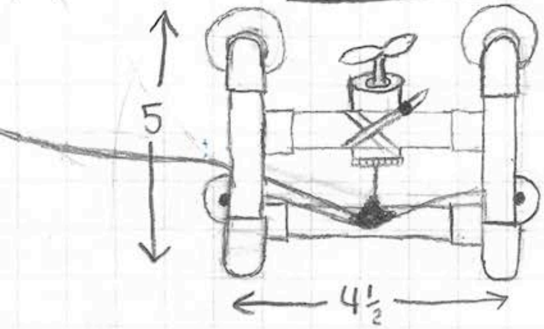
We concluded that the two part gripper is necessary

Kraken 1.0

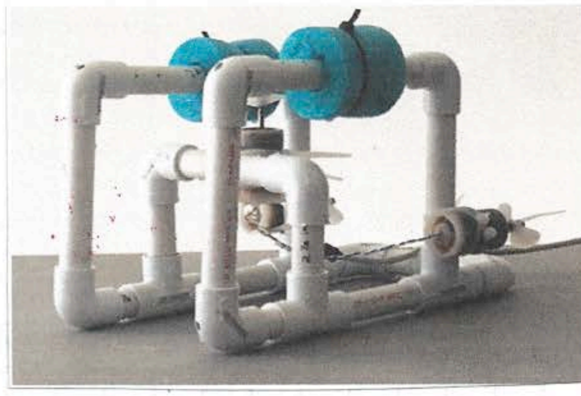
November 15, 2018

(Seaperch ROV design.)

Front View

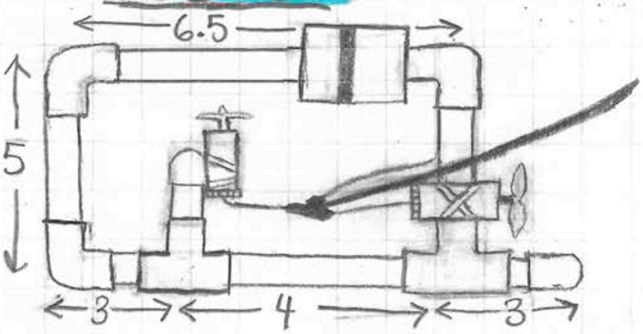


1 Block = 1 inch



Kraken 1.0
Photo

Side View



Problems with the ROV:

1. It's size would make it difficult to drive through the hoops course.
2. It does not have enough speed for Max. Points in the Challenge course.
3. Needs a way to pick up items.

Standard pool test

Stability test

Trim - Neutral
List - Neutral
Buoyancy - positive
Weight - 16.24 ounces

50 foot horizontal pool test

Trial 1 - 41.08 seconds
Trial 2 - 41.63 seconds
Trial 3 - 41.59 seconds
Average - 41.43 seconds

10 foot Vertical pool test

Trial 1 - 12.21 seconds
Trial 2 - 11.55 seconds
Trial 3 - 12.25 seconds
Average - 12.00 seconds

Kraken 2.0

November 17, 2018

Would Minimizing the mass of the Standard Seaperch design increase our ROVS Speed?

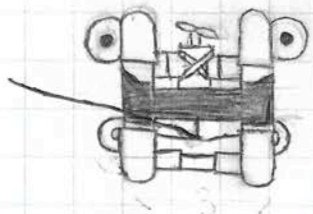
We Should use thinner and Shorter pipe to increase our thrust to Mass Ratio.

we built a Smaller Version of the Standard Seapearch ROV.

Length: 6in.
Width: 3½in.
height: 4in.

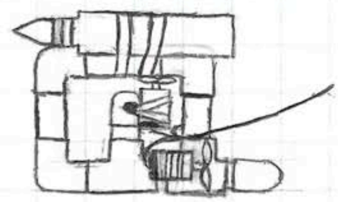
we modified the Standard Seaperch design by Replacing the foam with water bottles.

Front View



1 Block=1inch

Side View



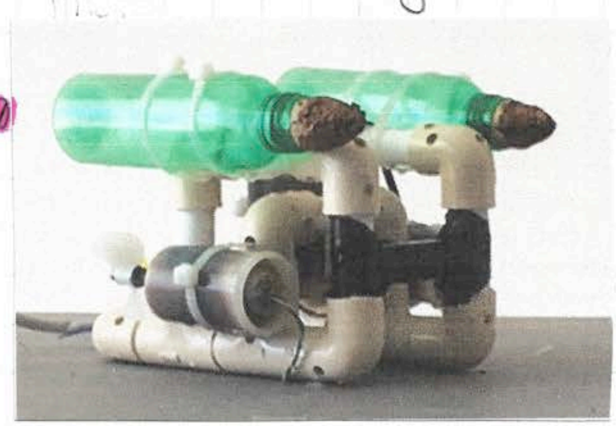
Standard Pool test

Stability test	50 Foot Horizontal pool test	10 foot Vertical Pool test
Trim-Neutral	Trial 1 - 39.63	Trial 1 - 9.68
List-Neutral	Trial 2 - 35.49	Trial 2 - 9.48
Buoyancy-Positive	Trial 3 - 36.15	Trial 3 - 9.83
Weight-8.18 Ounces	Average - 37.09	Average - 9.63

Kraken Conclusion

Kraken 2.0 Was Stable but because of its Square Front we decided to Switch to a more hydrodynamic design.

Kraken 2.0 Photo



Kraken 3.0

December 2, 2018

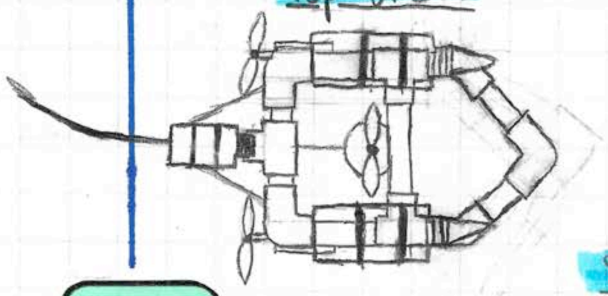
Would improving the hydrodynamics of our ROV make us faster?

We Should improve our hydrodynamics by bringing our nose to a Point.

we built an ROV that is Shorter and wider with a Pointed nose.

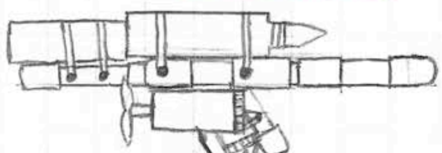
we improved the hydrodynamics Of the last bot and the manuverablity.

Top View



Scale: 1 Block = 1 inch

Side View



Standard Pool Test

Stability test

- Trim - Neutral
- List - Neutral
- Buoyancy - Positive
- Weight - 5.46 ounces

50ft. Horizontal Pool Test

- Trial 1 - 30.19
- Trial 2 - 30.33
- Trial 3 - 29.7
- Average: 30.07

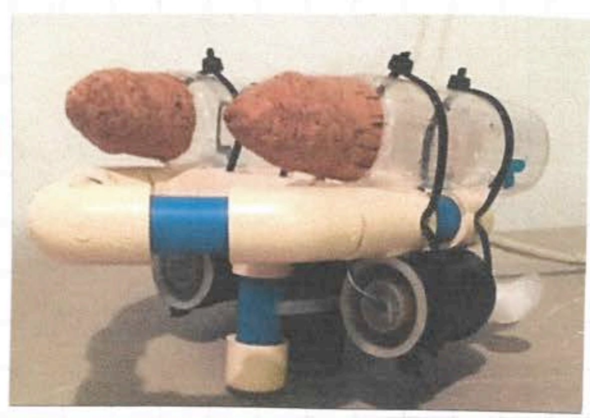
10ft Vertical Pool Test

- Trial 1 - 9.89
- Trial 2 - 10.01
- Trial 3 - 9.93
- Average: 9.94

Kraken Conclusion

Kraken 3.0 is our fastest ROV So far but it was Super hard to control So we decided to Switch to a more Stable design.

Kraken 3.0 Photo



Kraken 4.0

December 9, 2018

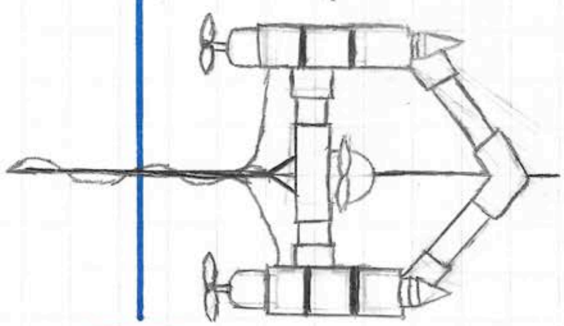
If we move the motor closer to the center of buoyancy will it improve the balance of the ROV?

We could increase the distance from bow to stern to place our motor closer to the Center Of Buoyancy.

We built a stingray shaped bot to prevent our ROV from flipping in the water.

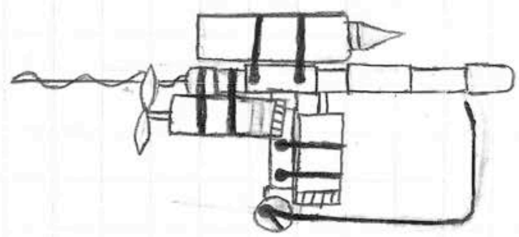
We increased the speed and vertical efficiency of our ROV.

Top View



Scale:
1 Block = 1 inch

Side View



Stability test

Trim - Neutral
List - Neutral
Buoyancy - Positive
Weight - 4.5 ounces

Standard Pool Test

50ft. Horizontal Pool test

Trial 1 - 29.13
Trial 2 - 28.54
Trial 3 - 27.34
Average: 28.34

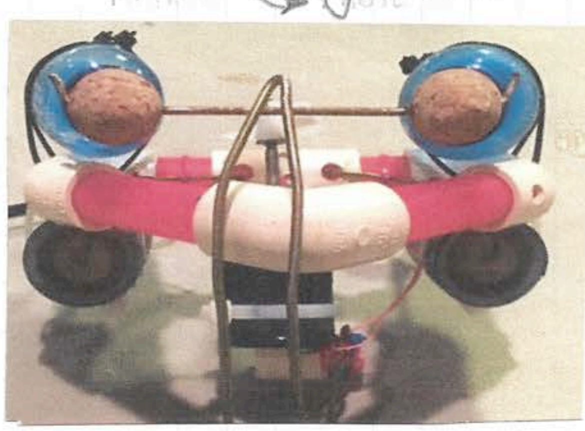
10ft. Vertical Pool test

Trial 1 - 8.64
Trial 2 - 8.37
Trial 3 - 8.42
Average: 8.47

Kraken Conclusion

Kraken 4.0 is our most hydro-dynamic, stable, and easiest to control ROV. So we will continue to use Kraken 4.0 for competitions until we create a better ROV.

Kraken 4.0 Photo



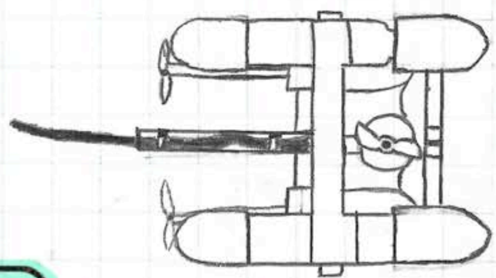
Kraken 5.0

April 27, 2019

Winning regionals was great, but how do we make our ROV faster?

We could make our ROV lighter and smaller by 3D. Designing and printing a frame.

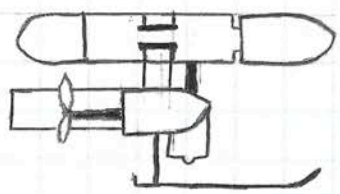
Top View



Scale: 1Block=1inch

We designed a smaller frame in the fusion 360 Program. After that we Printed our frame. This reduced our ROV's overall size by approximately 50%

Side View



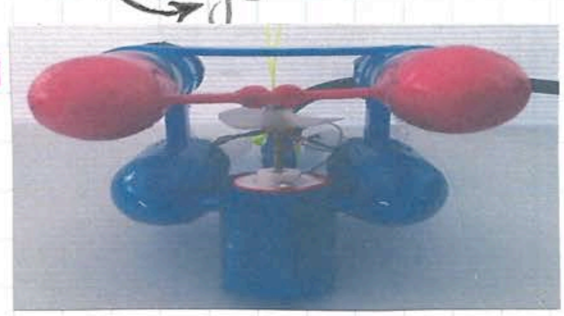
We will continue to improve our frame by adjusting motor placement for better control.

Standard Pool Test

Stability test	50ft. Horizontal pool test	10ft. Vertical pool test
Trim - Neutral/adjustable	Trial 1- 27.87	Trial 1 - 8.64
List - Neutral	Trial 2- 27.28	Trial 2 - 8.36
Buoyancy - Positive/adjustable	Trial 3- 26.81	Trial 3 - 8.42
Weight - 3ounces	Average - 27.33	Average - 8.47

Kraken Conclusion

Kraken 5.0



We decided to change this design because, by 3D. printing the entire frame we were able to increase our thrust to mass ratio and it was more manueverable.

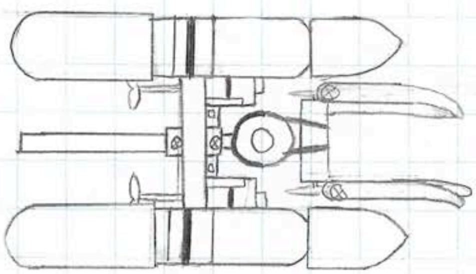
Kraken 6.0

January 25, 2020

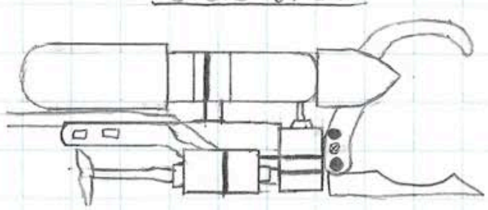
How do we efficently pick items up from the bottom of the pool

We Could make a more buoyant ROV that had an extra attachment allowing for a Servo.

Top View



Side View



We ajusted our bottle attachment and added ziptie holes to attach a Servo while still being hydrodynamic.

Kraken 6.0 worked great but would a single bottle design be faster and more manuverable?

Standard pool test

Stability test	30 ft Horizontal pool test	10 ft Vertical pool test
Trim - Neutral/adjustable	Trial 1 - 24.64	Trial 1 - 8.31
List - Neutral	Trial 2 - 23.99	Trial 2 - 8.37
Buoyancy - adjustable	Trial 3 - 24.63	Trial 3 - 8.41
weight - 1.70 ounces	Average - 24.42	Average - 8.36

Kraken Conclusion

Kraken 6.0 worked great but It Struggled with moving up/down while Carrying items and was Slower than we'd like.

Kraken 7.0

April 18, 2020

How do we increase the speed and manuverability of our ROV with a servo and gripper on it.

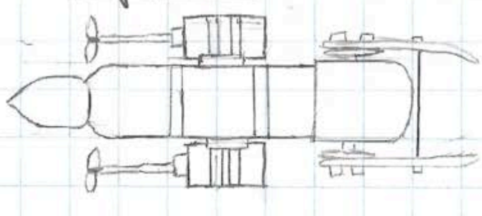
We could change to a one bottle design to make up for the additional drag added by the gripper.

We modified our buoyancy attachment to a one botte design and flipped our vertical motor.

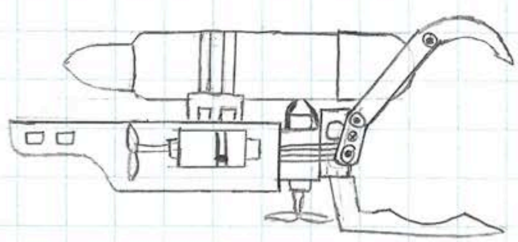
We have made a lot of innovations to our ROV. We are now exprimenting with a 4th motor for open class.

Scale: 1 block = 1 inch

Top view



Side view



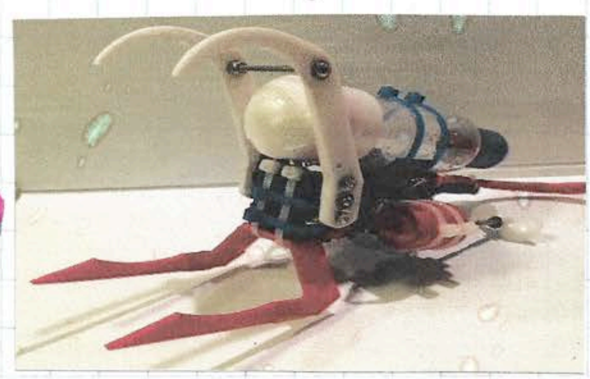
Standard Pool Test

Stability test	50ft. Horizontal Pool test	10ft. Vertical Pool test
Trim - Neutral/adjustable	Trial 1 - 22.47	Trial 1 - 9.15
List - Neutral	Trial 2 - 22.92	Trial 2 - 9.27
Buoyancy - Positive	Trial 3 - 22.21	Trial 3 - 9.31
Weight - 134 Ounces	Average - 22.70	Average - 9.24

Kraken Conclusion

Although this design was faster, it was much harder to manuver and it would list towards port when driving on the surface. So until we came up with a better design we went back to practicing with Kraken 6.0.

Photo of Kraken 7.0

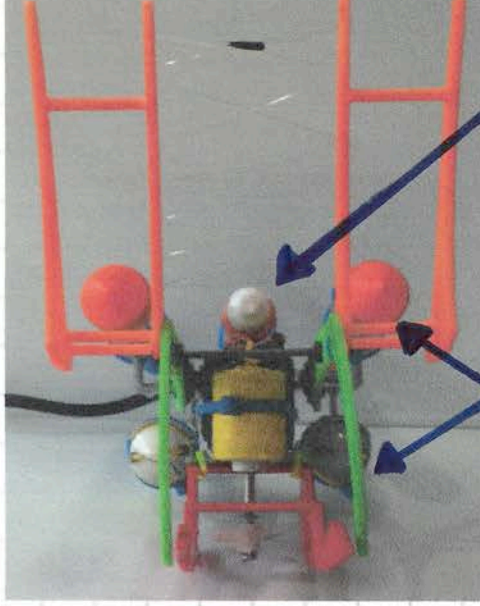


April 3, 2021

Kraken Final Design

Removable Third Bottle
Increased Stability and allows us to quickly change buoyancy.

Expandable Sheathing
Increased cable flexibility

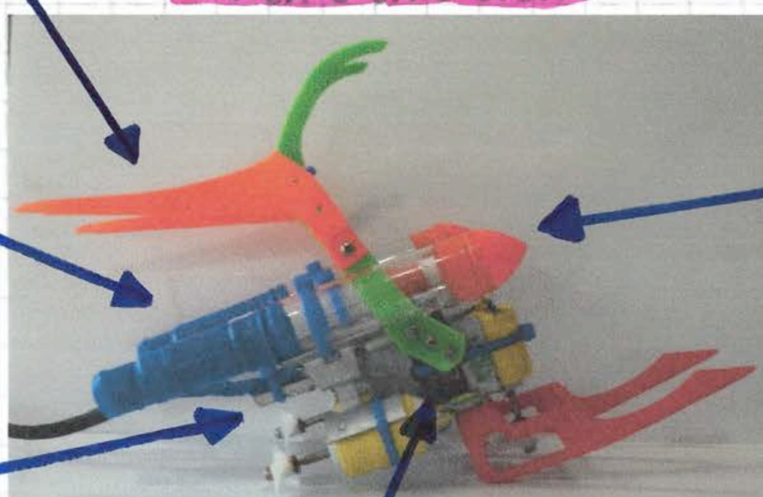


Bright Colors
helps us see our ROV. Different colors on the front and back helps us tell which direction the ROV is facing.

Kraken 8 Front View

Bulldozer forks
Pushes floating trash over hoop fast and efficiently.

Kraken 8 Side View



Electrical Tape
Prevents bottles from sliding and adds more color to help see the ROV.

Bottle Caps
more hydrodynamic and additional buoyancy.

3D Frame
Lighter/reduces drag, allows us to make any shape we want.

High Speed Servo
easier/quicker to trap items.