Sea-Tech 4-H
Skagit Exploration And Marine Technology 4-H Club

Skagit County 4-H Program – Washington State University Cooperative Extension Office

ORCA

Sierra McNeil

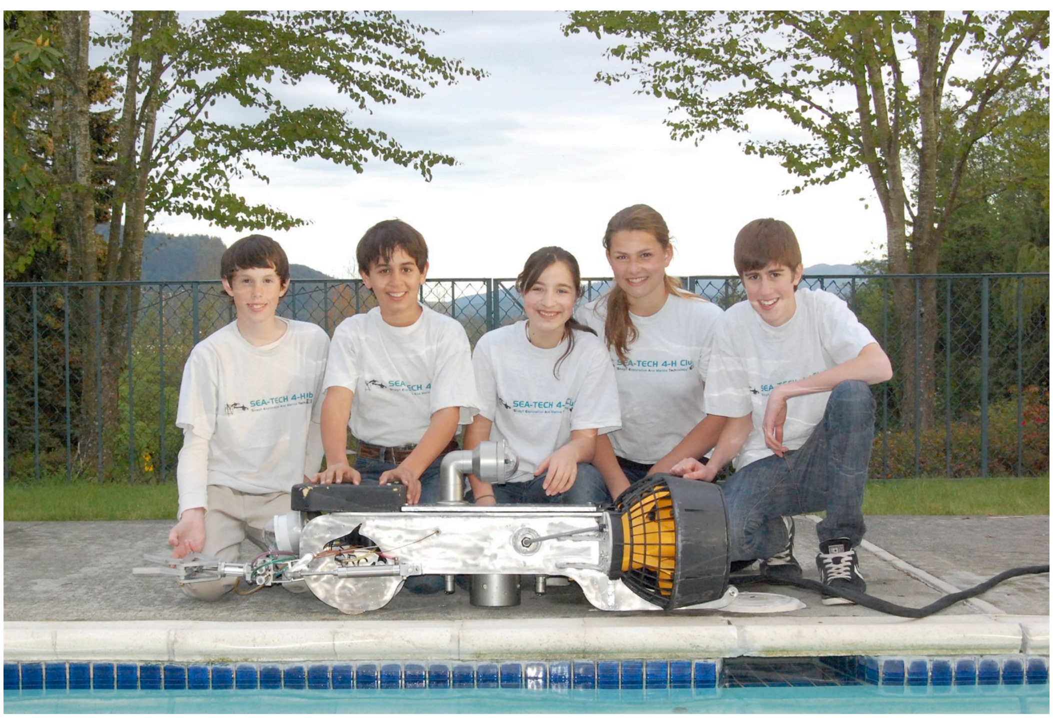
Michael Janicki

William Babcock

Madeline Anderson

Michael Thomas

Team Mentors: Peter Janicki and Lee McNeil



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Abstract

ROV Orca was built in 2009 by members of the Sea-Tech 4-H Club of Skagit County. The machine was built for specific missions in the year 2009. This year our team modified it so it could accomplish any mission that was put in front of it.

When team Orca received the missions to accomplish at the 2010 Marine Advanced Technology Education (MATE) competition. They modified the existing ROV Orca to meet these tasks. This modification process included adding a rear-facing camera to optimize mission time; redesigning a robotic arm that could hold various things; adding two sensors, one to take a temperature of a new vent site simulation, and another for hearing the rumbling site; and refitting the machine with new fore and aft thrusters for more power to complete the missions in a steadier rate.

The design consists of an aluminum frame, to which are mounted manipulators, thrusters, cameras and foam floats to achieve the desired ROV missions. Two customized, 12-volt, trolling motors provide the vertical thrust, while two modified Sea-Doo thrusters provide forward and backward thrust. The arm operates on three double-acting, pneumatic actuators. One actuator tilts both the camera and arm 90 degrees vertically; a rotary actuator generates a swiveling action; and another actuator opens and closes the claw. Two hydrostatic-proof, polyurethane, foam floats provide positive buoyancy for the ROV.

The 2010 competition theme *"Science Erupts on Loihi Seamount"*, Hawaii's undersea volcano, has helped this team come together and figure out difficulties and challenges.

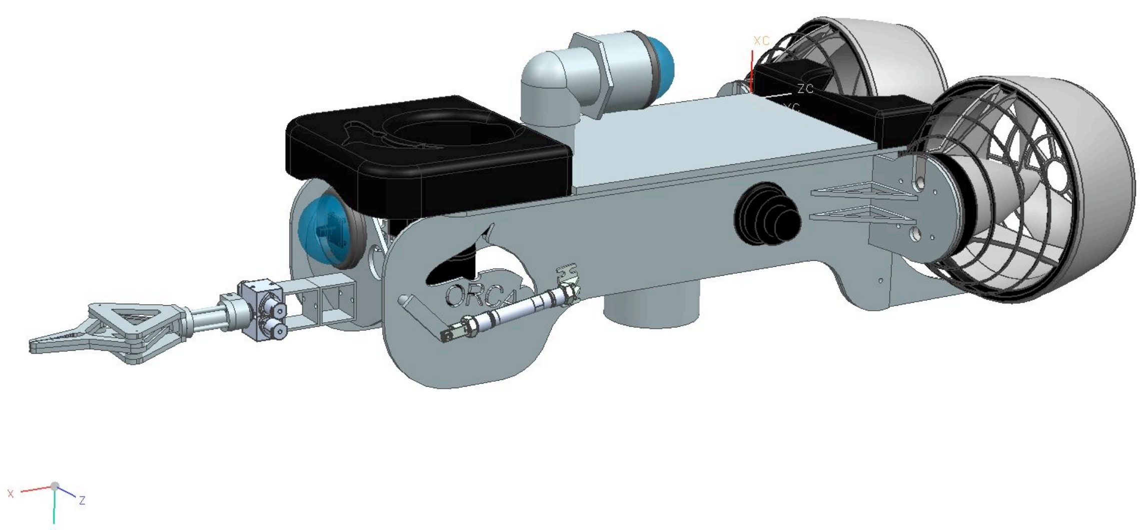


Figure A.1 side view CAD Model of ROV Orca

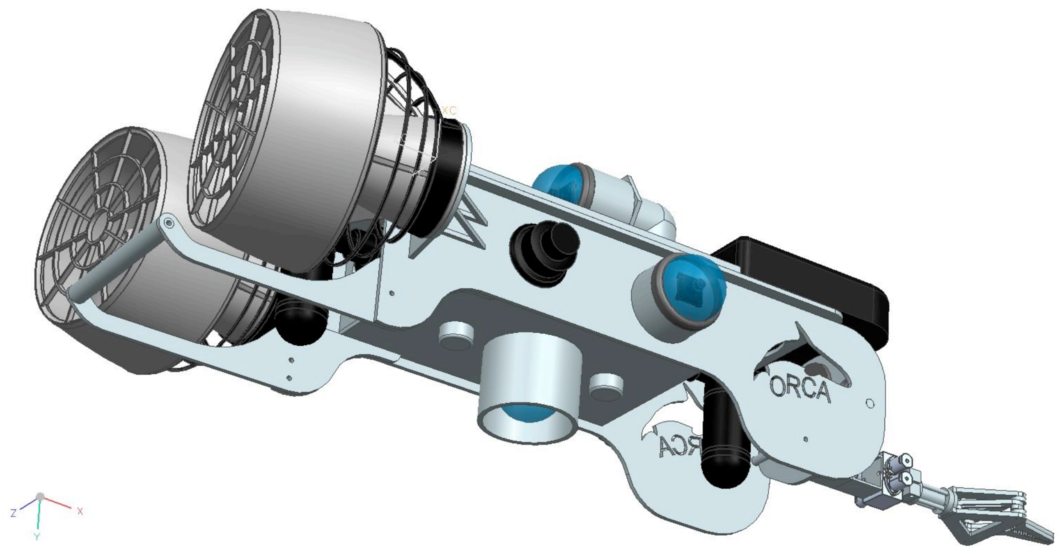
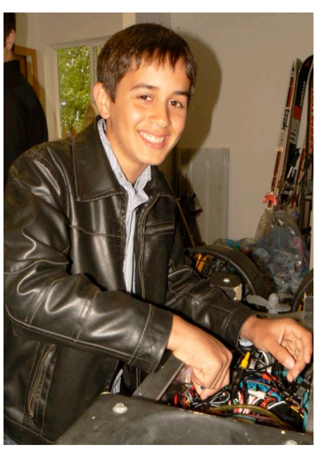


Figure A.2 CAD Model showing main thrusters

1. Team Orca

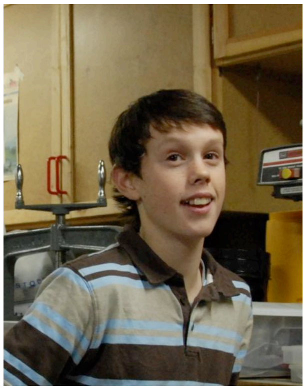
Sierra McNeil
Team Responsibility: Motor assembly, modifications to the frame, and technical report coordinator
Competition Role: Team Capitan

Sierra McNeil is a 13-year-old, eighth grader who is home-schooled and strongly self-motivated. For three years Sierra has designed and constructed ROV's through the Sea-Tech 4-H club. She is very privileged to be the club's instructor's daughter because it has brought engineering home in every day life. She greatly enjoys the friendly competitiveness of the MATE program and is honored to be able to come to Hawaii as a competitor. She is currently considering going into interior design after graduating from high school.



Michael Janicki
Team Responsibility: electronics, control system, team coordinator, frame and written documentation
Competition Role: Pilot

Michael is a "get her done" kind of guy. With an engineer as a dad, he has been building things ever since he was a little kid. He has been in Sea-Tech for two years and has been in the MATE ROV competition two consecutive years. Michael is in seventh grade and is currently home schooled.



William Babcock
Team Responsibility: Putting together the manipulator
Competition Role: Manipulator Operator

William was inspired by Sea-Tech to learn technical, hands-on skills. William is fifteen, in the ninth grade, and home schooled through an online private school. This is his second year in Sea-Tech 4-H club and second year in the MATE competition. He has learned many things about working with tools, software, and electronics through his experience in Sea-Tech and MATE.

Madeline Anderson
Team Responsibility: Mission specialist, Thrusters and written documentation.
Competition role: Mission specialist

Madeline is a fifteen year-old, ninth grader who attends Sedro-Woolley High School. This is her first year in Sea-Tech and first year with MATE. Madeline was introduced to Sea-Tech through the McNeil family and joined because she wanted to learn more about building and working with ROVs. Through the Sea-Tech 4-H club, she has gained valuable experience working with tools and electronics.

Michael Thomas
Team Responsibility: modifying cameras, and helping with electronics
Competition Role: Tether Tender

Michael had been interested in Sea-Tech for several years but just joined this year. He enjoys working with mechanics and learning about electronics, but also supplies the team with a variety of other skills. He is home-schooled this year, but is planning on going to Stanwood High School this upcoming school year.

2. ROV Orca Design Rationale

2.1 Mechanical Structure

Collaborative Design

When we brought a new Orca team together at the end of fall 2009, we immediately began collaborating on our design and discussing ideas. We wanted to change the ROV so that it would stay stable, be easily maneuverable, and well suited for the new mission tasks. After several weeks of much discussion and many sketches, we began reworking the CAD models. We modified the ROV so that it would be faster and perform the mission tasks for this year and even other years in the future.

Frame

Most of the past Sea-tech ROVs have been made of Poly-Vinyl Chloride (PVC) pipe, but the lack of room in the control housing made maintenance very difficult. Our team chose material that would give us a bigger control box that would be easier to use. We decided on aluminum plate, because it was strong, light, readily available, and easy to machine. We also wanted plenty of extra plate area, to which we could attach floats, weights, etc.

Pressure Housing

The ROV design is centered on the pressure housing, which we made large to accommodate wiring, relays, and pneumatic controls. We also included a spacious opening in the top to easily access everything inside for maintenance. The housing is covered by an aluminum lid and sealed with an O-ring. We drilled holes in the box for new thruster connectors, cameras, and sensors.

Floats and Ballast

According to our calculations, the ROV would be negatively buoyant due to the aluminum. Thus, we designed two hydrostatic-proof polyurethane foam floats and attached them to each end of the ROV for maximum stability. Due to the weight of the pneumatic actuators and manipulator arm, the front end was much heavier than the back. Thus, the float in front is more than twice as big as the one aft. Removable aluminum weights, of varying sizes, minutely trim for stability and neutral buoyancy. These can be attached to each of the four corners at the lowest points on the frame.

2.2 Tooling

Arm Structure and Composition

It was plain to see we would need a versatile manipulator to accomplish all the missions. The base of the manipulator arm is attached to the same rotating plate as the front camera (discussed Section 2.5). Since the camera and manipulator rotate together, the claw is always in view. We attached a rotary actuator at the end of the arm to spin the wrist 180-degrees. We extended the arm and put a slight upward kink in it to improve the operator’s view of the wrist action and claw operation. The air actuators are powered by one airline that feeds a manifold assembly of pneumatic valves. Two solenoid valves control a single double-acting actuator.

Payload

For the 2010 MATE competition, Team Orca had to modify its claw to help accomplish the desired mission tasks. Previously, Team Orca had a claw that was C-shaped providing more of a round gripping action. This year, however, we brainstormed as a team and modified the claw to be more L-shaped with a longer nose making it easier to pick up more delicate items, such as the crustaceans or a spire. It was designed, by the student members of Orca, in UGS NX6 and cut out of aluminum on a water jet provided to us by Janicki Industries. After the pieces were cut, the claw was assembled, and then attached to a pneumatic actuator which opens and closes the claw.

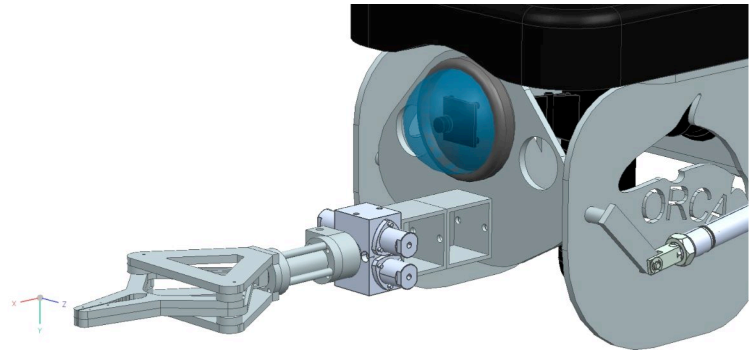


Figure A.3 CAD Model showing Arm and main Came

2.3 Propulsion System

Thrusters

At the beginning of this year, Team Orca decided to replace its old fore and aft thrusters with significantly modified Sea-Doo Sea-Scooters that each generate 12 pounds of thrust. We modified the Sea-Scooters by cutting them in half and sealing them with an acrylic lid. The thrusters were then mounted to an aluminum plate canted inwards at a 2.5-degree angle to enhance our turning capabilities and to reduce the overall width. For the vertical thrusters, we used two modified Sevylor trolling motors that generate 3.5 pounds of thrust each. These two vertical thrusters are wired independently, which gives us pitch control. With this function, we are able to pitch the ROV nose up, and then using their fore and aft thrust to breach the water, just like an "ORCA."

Figure A.4 Unmodified Sea-Doo Sea-scooters.

2.4 Cameras

Cameras

Originally, Orca had three cameras: one in the front mounted to a 90˚ rotating plate, one on the bottom inside a docking skirt, and one on the side. One of the flaws of the original design was that our front camera was not completely sealed, so it got water in it. As part of this year's modifications, we changed the leaking, main camera to the club's new standard, which is fully water proof and can be replaced with standard club parts. We also replaced the bottom camera with a hydrophone. The side camera is not used but was left to avoid the risk of leakage. After carefully considering the tasks, we decided the ROV needed a camera facing backwards to maneuver the ROV out of the cave. This camera was mounted to the control box lid using PVC pipe fittings.

2.5 Electronic Control System

Electronics and Power

The electronic controls are based on 12-volt, DC relays. Each relay switches power from the 10-AWG (American Wire Gauge) power supply cable to the thruster motors at the ROV. Two relays are needed to control one reversible thruster. Each of the four thrusters is controlled individually, providing four degrees of freedom; fore and aft, left and right, up and down and pitch control.

Schematics of control systems can be found in **Appendix A**.

Sensors

Because of the need to locate sounds and measure temperatures in this year's mission tasks, we had to add two sensors: a hydrophone and a thermocouple. The hydrophone, mounted on the bottom of the ROV, is used to determine which site is rumbling in mission task one, "Resurrect HUGO". The second sensor is a thermocouple mounted on the claw to measure temperatures in mission task three, "Sample a New Vent Site".

2.6 Tether

Tether

As part of the original design, ROV Orca has a 15-meter tether that feeds power and communications from the poolside to the ROV. The power runs from poolside batteries to the ROV via a 10-AWG copper power cable. The cameras are powered using their own supply, two tandem coax cables with power. Another camera cable is devoted to the hydrophone. The control cable is a twenty conductor cable that that feeds communication from the poolside to the ROV. A 6.35mm, urethane air hose delivers pressurized air to the pneumatic valves and doubles as a flotation device within the sleeving. A thermocouple wire sends a signal from the thermocouple sensor on the ROV to the poolside to measure temperature on mission task three, "Sample a New Vent Site".

3. Expenditure Summary

Because Team Orca was a returning ROV, we were able to work within a much smaller budget than if we were constructing a completely new ROV. Our mentor, Mr. Janicki gave us a budget of $500 to keep our modifications within a reasonable scope.

The following is the amount of money used for modifications to ROV Orca for 2010:

1. **Arm** – $0.00
2. **Sea-Doo Thrusters** – $259.98
3. **2 Camera's built by Team Orca** – $94.60
4. **Sensors** – $43.99

5. **Total** – $398.57

A fully detailed expenditure spreadsheet can be found in **Appendix B.**

4. Troubleshooting

Sea-Tech club leader, Lee McNeil, always says, “When your ROV is completed and ready to put in the water, you are only half-way done.” Team Orca first experienced this when we put our newly modified ROV in the testing pool and noticed a major leak. As we practiced the pool missions, the ROV started to become negatively buoyant. When we took off the lid to the pressure housing, the control box had at least two inches of water in it.

We decided to find the leak in an unusual way. As a team we placed the ROV in the water without letting go and without the lid on. At first the leak seemed to be coming from the welding at the connection for the motors. We potted both motor connections, but the ROV was still leaking. This time, we found that the leak was coming from the check-valve that is used to dump excess pressure from the solenoid valves. We changed out the valve and tested it before putting the lid back on. There were no leaks, and the problem was successfully solved.

5. Challenges Faced

5.1 Motor Challenges

The original Orca design featured two sets of Sevylor thrusters. However, these drew to much power to comply with the competition regulations. This year we replaced the Sevylor fore and aft thrusters with large, modified See-Doo thruster motors, which produce more thrust and have less amperage draw.

The vertical thruster ducts were designed specifically to fit the Sevylor motors, so replacing them with larger thrusters was not an option. To fix the excessive amperage draw, we separated the control of these two motors. The control box had two extra relays, so we wired the vertical thrusters independently. This also provided us with pitch control.

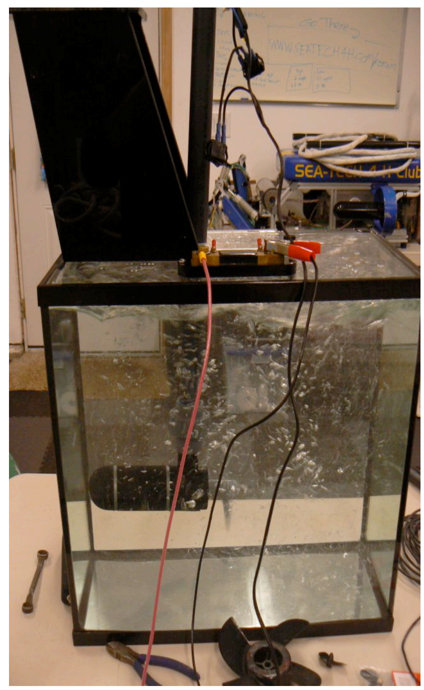


Figure A.5 Testing the Sevylor thrusters

5.2 Hydrophone Difficulties

The mission specifications required a hydrophone, a water-resistant device that could hear rumbling noises. The original ROV did not have this feature so this year we had to add it. But not everything works out as planned.

On the night before the competition, our hydrophone suddenly did not work. We had tried to practice with it but could not here anything. The next morning, before the competition, we bought a new hydrophone and amplifier, but it still did not work. Thus, we had to sacrifice the points for that portion of the mission.

During the time before the international competition, we bought a new, professional hydrophone to replace the former one. With any problem there is a solution.

6. Lessons Learned

Sierra McNeil: I have learned that a team is not just a group of people that get together and work on the same ROV. Rather, it is a group working together. They make decisions as a team, and they perform as a team.

Michael Janicki: I learned that keeping track of things and working together is the key success.

Madeline Anderson: Learning how to work together and communicate well with others helps the team members to trust each other in any circumstance.

William Babcock: I enjoined learning about Unigraphics and CAD modeling. I also learned that it is very important to communicate well with each other.

Michael Thomas: This year, I learned through Sea-Tech how to solder wires together. It was a fun and great experience.

This year has been a fun and stressful time for our team. Yet, through the hardships, we learned what it meant to be a team. In a team, each person has a job based in his or her skills, interests, or abilities. Thus, the first step in teamwork is getting to know fellow team members. Even in the hard times, a team comes together and, together we can break through that challenging barrier that is in front of us.

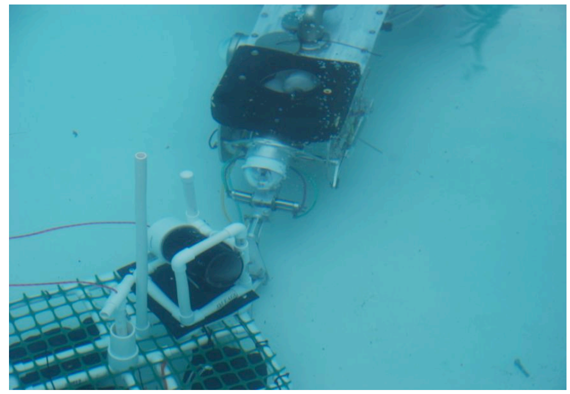
7. Future Improvements

Each year, some things work out and some do not. Because we did not start practicing early, we were forced to cram all our practicing time into just a few weeks. If we could stay focused and not get tunnel-vision and elaborate with our modifications, we would have more time to practice. Next year we plan to make little modifications in stead of big ones which will give us more time to be ready for the competition.

During our troubles with our control box, this year, we found that it would be better if we did not have such a hang over on the side of the box. Inside the box, on the surface we screw the lid on there is an unnecessary layer of aluminum. If we were to sand it done for next year we would be able to work in our control box with more room to move things.

8. Mission Strategy

Figure A.6 Orca performing Task #1



Task #1: Resurrect HUGO
Task #2: Collect samples of a new species of crustacean
Task #3: Sample a new vent site
Task #4: Collect a sample of a bacterial mat

This year, our mission strategy is based on ease of competition. We plan to first complete Task #2, Collect Samples of Crustaceans, because the speed of our motors allow us to move very efficiently. Once we have collected all of the crustaceans, we will then go to Task #3, Collect Samples of Vent Spires. After taking the temperature of all three vents and a sample of a vent spire, we will return the crustaceans and spire sample in our basket to the surface. After that is finished we will proceed to complete Task #1, Resurrect Hugo. Since our Agar extractor is not attached to our ROV, we will return to the surface and have our tether tender attach the custom made extractor to the ROV for task #4, Collect Bacterial Mat. The order in which we have decided to do the missions was decided by the way we can perform them.

A fully detailed Task spreadsheet can be found in **Appendix C.**

9. Loihi Seamount

The Loihi Seamount is located on the island of Hawaii. Before 1970, Loihi was thought to be an old and dead seamount volcano. Scientists led an expedition, in 1996, to investigate an earthquake swarm (repeated intense seismic activity) that had just occurred there. They discovered that the Loihi Seamount was a young and active volcano, venting hydrothermal fluid.

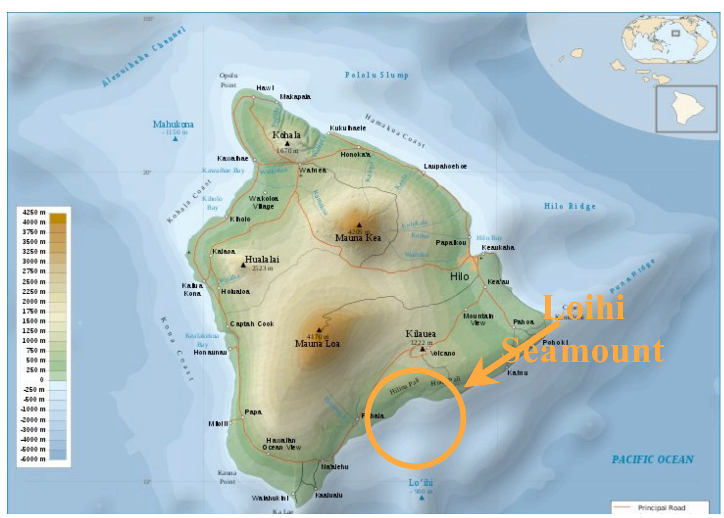


Figure A.7 Location of Loihi Seamount

Over 4,000 earthquakes were recorded at the seamount between July and August of 1996. Through these earthquakes, the Loihi Seamount came back to life. Multiple research parties launched and began investigating the site. More detailed studies of the Seamount took place in September and October of that same year. With these studies, researchers found “Pele's Pit”, named after the Hawaiian goddess of volcanoes, had collapsed. A new crater was formed, measuring 1km in diameter.

This year for the MATE competition we are re-enacting the investigations that took place at the sea-mount in 1996.

10. Reflections

In the year of 2009-2010 Team Orca has taken challenges and proved that they could be done. As a team we have figured out the missions that we thought were impossible to do. We took the challenges that had been put in front of the 2008-2009 Team Orca and have proved that they were a simple twist to fix. This year has been both beneficial and exciting.

We would not have thought of putting a hydrophone on an ROV if it wasn't for MATE to step up to the plate and make a competition for kids that has enabled them to learn more about undersea life and how they can construct an ROV just out of PVC pipe and other material. Mate has been an inspiration to this team.

11. Acknowledgements

Team Orca would like to recognize the companies, organizations and individuals who made this year possible. Without their support, the completion of this project would have been impossible:

• Peter Janicki, our leader and our mentor who gave us advise when no one else had any.

• Lee McNeil, our mentor and advisor, for your expertise and dedication to the team members as well as the project.

• The McNeil family, for opening up your home (and dinner table) to the team for work.

• Trevor Uptain, for his help and advisement on the technical report.

• Stanley Janicki, a fellow club member, for help on the 3D models. And also a thanks for helping us get together our report.

• Janicki Industries, for their generous sponsorship of this project through financial and in-kind contributions, including donating the use of their water-jet and welder.

• Jacque McNeil for her help and advice on technical writing techniques.

• Clippard Instruments for greatly discounting our pneumatics order.

• Mrs. Annie Janicki for letting us use her pool to practice.

• The friends and family of the team members, whose supported us and graciously gave us rides to meetings.

•Aquarian Audio for their generous donation of the hydrophone.

• To Mrs. Susan Janicki for her help on written documents and feeding us when we got hungry.

•Puget Sound of the Marine Technology society, for their generosity in giving us $3,000 for taking first place at the MATE Northwest Regional competition.

• The MATE Center. The opportunities you've created are amazing, especially the opportunity for competition, which has continued to be motivational and inspiring.

12. Bibliography

www.soest.hawaii.edu/GG/HCV/loihi_j_a_1996.html
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http://oceanexplorer.noaa.gov/explorations/02hawaii/background/plan/plan.html
Weirich, Jeremy Office of Ocean Exploration National Oceanic and Atmospheric Administration.

13. Appendix

Appendix A – Electronic Schematics

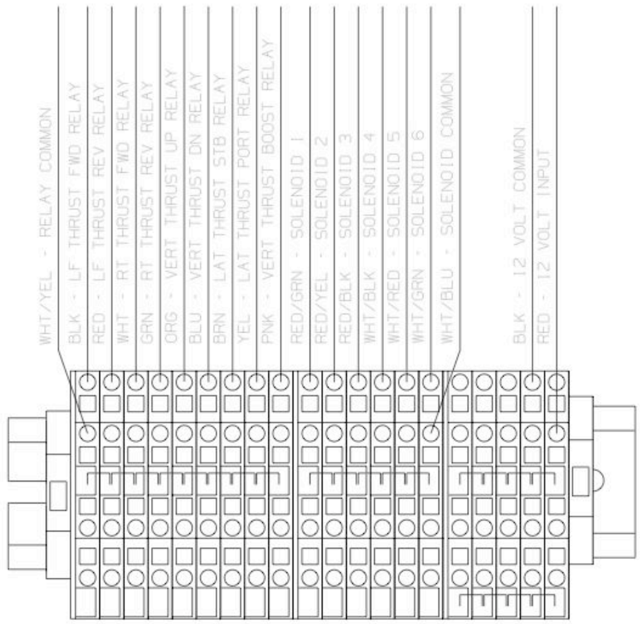

Figure A.1 Waygo Terminal Strip

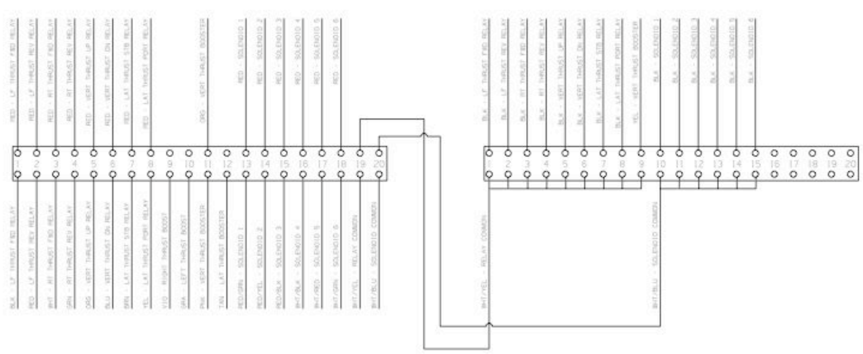

Figure A.2 Wire Layout

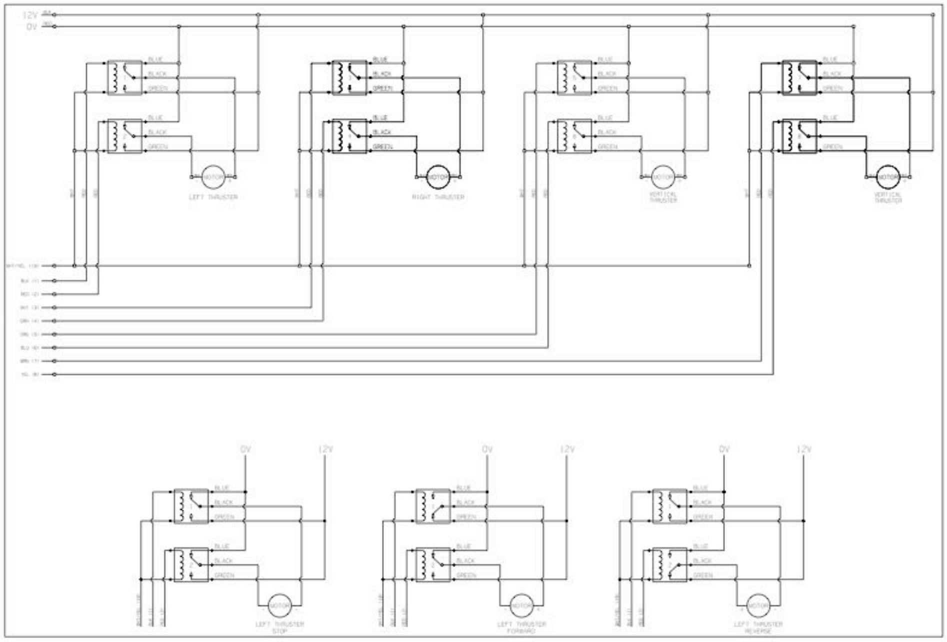

Figure A.3 Motor Relay Layout

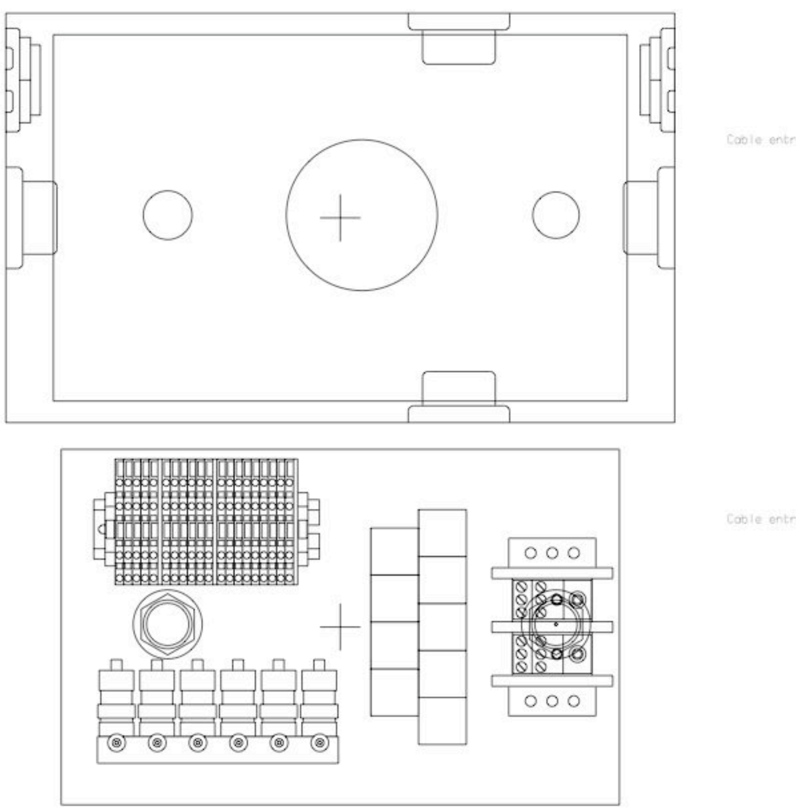

Figure A.4 Control Board Layout

Appendix B – Expenditure Summery

Item Description:	**Source:**	**Cost:**	**Donation:**
Manipulator Arms:			
1/2" Aluminum plate	Janicki Industries		$15.50
Water-jetting	Janicki Industries		Labor donated
Mounting hardware	Lee McNeil	Owned by club	
	Sub-total:	$0	$15.50
Thrusters:			
Two Sea-Doo Sea-Scooters	Sea-Doo Express.com	$259.98	
Acrylic plate	Lee McNeil	Owned by club	
1/2" Aluminum plate	Janicki Industries		$3.50
Mounting hardware	Lee McNeil	Owned by club	
Water-jetting	Janicki Industries		Labor donated
Welding	Janicki Industries		Labor donated
	Sub-total	$259.98	$3.50
Camera's:			
Two Widescreen CCD board cameras	Super circuits	$79.98	
Compass Dome Port: Voyager Series replacement dome	Ritchie Nav	$9.05	
Check Valve, 1/8” MNPT inlet; 1/8” FNPT outlet; rated for air, oil, or water	Airtronics	$5.57	
	Sub-total	$94.60	$0
Sensors:			
Hydrophone	Aquarian Audio	$25.00	$100.00

Thermocouple	Omega	18.99	
	Sub-total	$43.99	$100
	Grand total	$398.57	$119

ısks	points	mission	(1-5)	of points)	(1-5)
ısk 1 / Resurrect the Hugo	100		3	0	
Remove pin, release HRH. (High rate ·drophone)		10			
Remove the HRH.		10			
Identify which site is rumbling (out of ·ee.)		20			
Install HRH at site.		20 total. 5 for wrong one.			
Remove cap from port on HUGO ınction box.		10			
Retrieve HRH power/communications nnector from elevator.		10			
Insert HRH power/communications :o port on HUGO.					
ısk 2 / Collect samples of crustaceans.	60		1	10	
Enter cave.		5			
Touch back of cave.		10			
Back out of cave.		15			
Return samples (three total), to the rface.		5/per returned sample.			
ısk 3 / Sample vent site.	80		4	0	
Take temperature on vents (three total).		10 per sample 30 total.			
Create graph of temperature vs. imney height.		20			
Collect spire sample.		20			
Return sample to the surface.		10			
ısk 4 / Take sample of bacteria mat.	60		5	40	
Collect sample of Agar.(101mL to 5mL)		20			
Return to surface. (touch side of pool!)		20			
Retrieve correct amount. (101mL- 5mL)		20			

Appendix C – Task Spreadsheet