‘Io o Hohonu Kai

(Deep Sea Hawk)

Kealakehe Intermediate School ROV Team
74-5062 Onipa’a St. Kailua-Kona, HI 96740

Team Leaders:

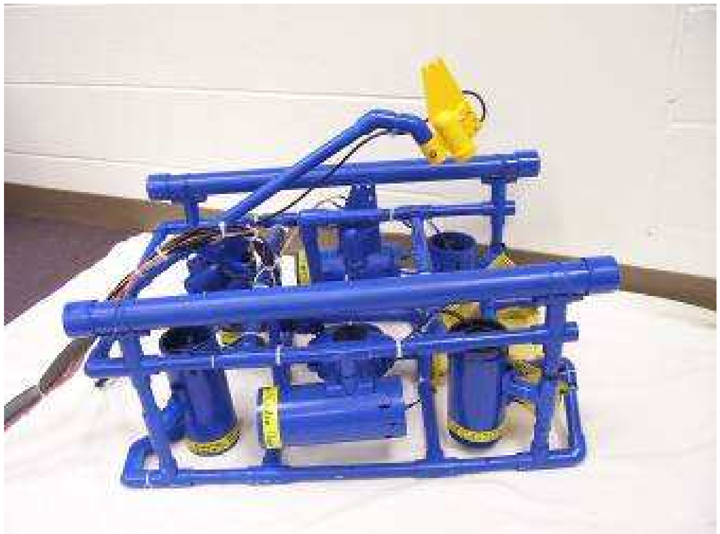
Ileana Argyris (13), Kela Hauck (13), Jonathan Kutsunai (14)

Team Members:

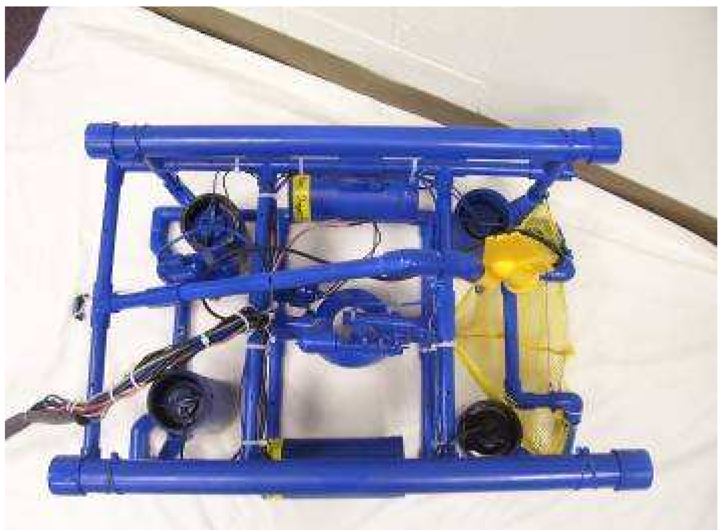
Chase Benbow (13), Cody Benbow (13), Khan Howe (12), Dana Jane Jennings (12), Davis Kauwe (12)

Mentors:

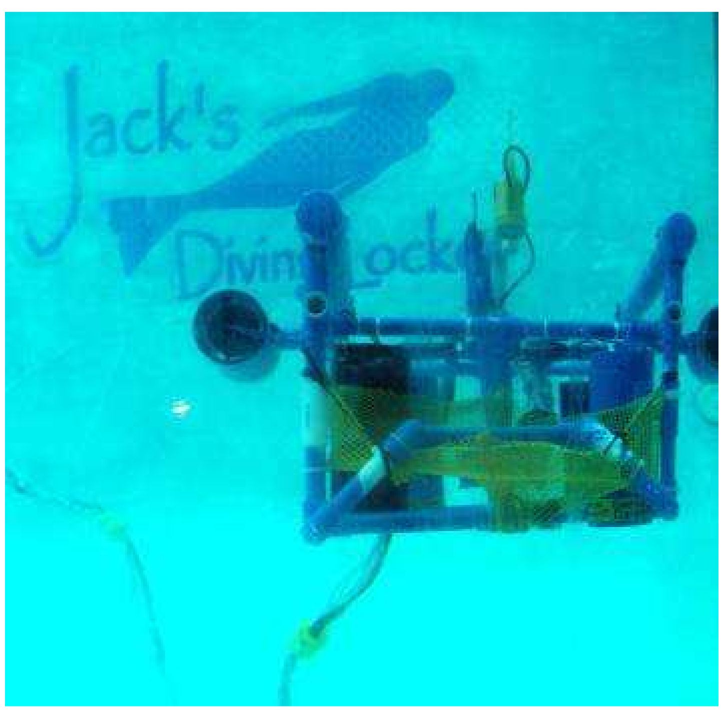
Lisa Diaz, Michael Hauck, Andrew & Terry Argyris, Rondee Miller, Jeannie Kutsunai, Brenda Overcast



Photos of intact ROV

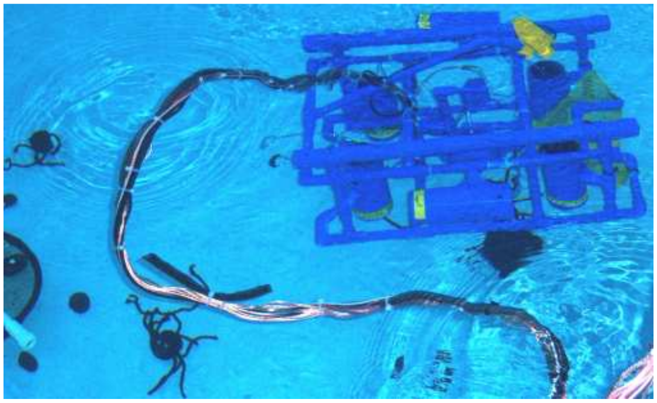


Top view of the ROV



Test dive at our sponsor's pool.

Abstract:



Kealakehe Intermediate ROV team's goal was to create a simple, low maintenance, low cost and stable submersible vehicle that operates with speed and accuracy.

Mission practice

'Io o Hohonu Kai has 5 innovative payload tools to efficiently accomplish the MATE 2008 mid-ocean ridge mission tasks:

1: Lava scraper tool
2: Lava sample net (to transport lava to the surface)
3: Crab collection tool: powered by one 1,893 LPH Mayfair Marine bilge pump motor
4: Crab collection basket (to transport crabs to the surface)
5: Temperature probe docking system to measure hydrothermal vent fluid temperature.

Design Specifications and Systems:

'Io o Hohonu Kai can dive up to 15 meters & weighs 6 Kg. The PVC frame measures 97 cm. long, 52 cm. wide and 46.5 cm high. Our tether is 15 meters long. Total amperage is 21 amps.

Propulsion:

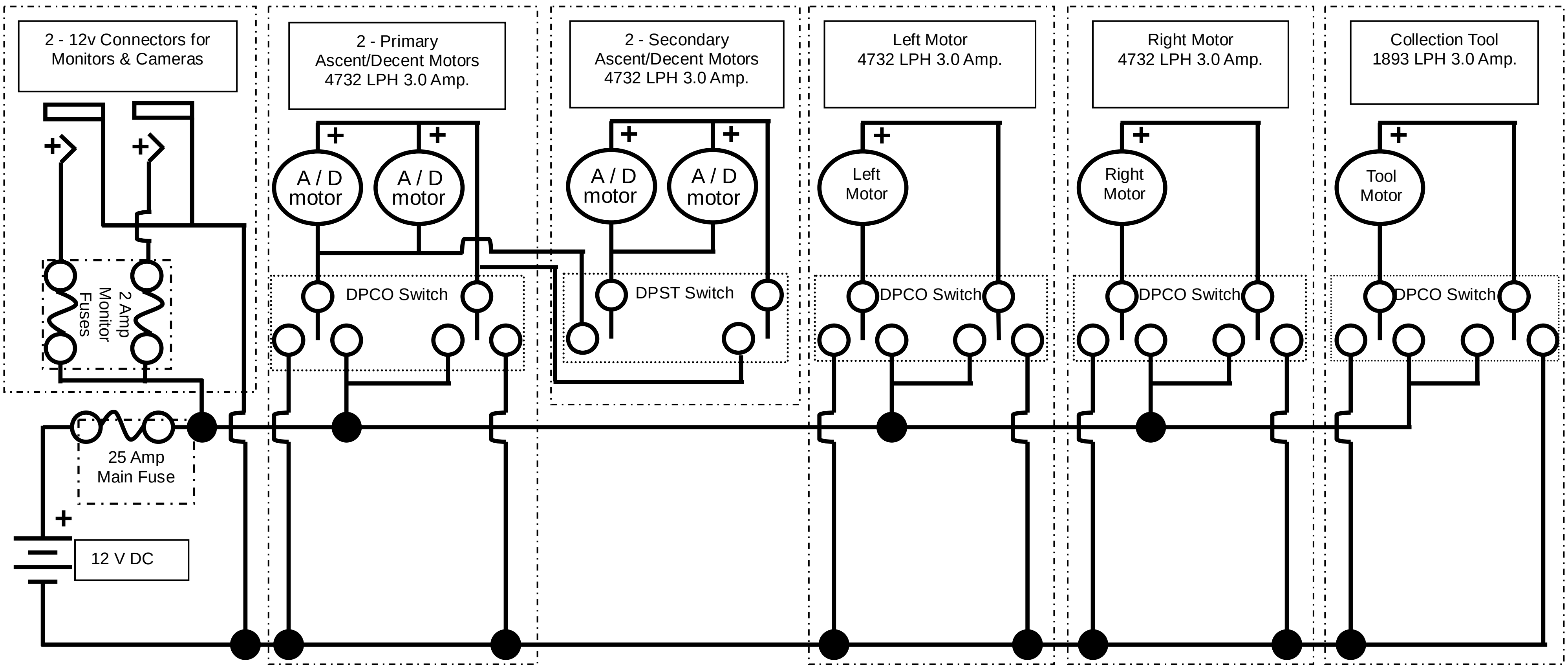
6 Johnson Pump Marine Bilge Pump Motors, fitted with tri-blade model boat propellers:
4 center–mounted ascent/descent thrusters. 2 side-mounted lateral thrusters.
Each motor draws 3 amps under a full load, at a rate of 4,732 LPH [liters per hour]. The thrust of each motor is 1.15 ± 0.05 kg.

Electrical Control System: Utilizes 2 control boxes, 18 gauge speaker wire, heavy duty toggle switches, and a 25 amp fuse for safety. Entire vehicle powered by 12 volt battery.

Sensors:

- 3 u/w video cameras, depth rated to 18 meters
- Vernier Stainless Submersible Temperature Probe connected by 15 meter cable to surface Data-Logger, which records accurate hydrothermal temperatures via Hoboware programmable software.

‘Io o Hohonu Kai ROV Electrical Schematic



'Io o Hohonu Kai ROV BUDGET & EXPENSES:

Items:	Category:	Amount:
PVC pipe, T's, elbows, end-caps, couplers, zip-ties	**Frame**	**37.38**
PVC, T's, elbows, Coupler, tongs, elastic, arm, wire, screws, Nylon line, polyester net, zip-ties. Rubber Coupler, plastic Servo arm One 1250 GPH marine bilge cartridge motor,	**Mission Tools**	**82.23**
Toggle switches, wire, cable, solder, shrink wraps, Electrical tape, control boxes, alligator clips, banana plugs	**Electrical**	**69.03**
Six 1250 & one 500 GPH marine bilge cartridge motors w/ shipping	**Propulsion/Tool Motors**	**277.61**
Temperature Probe, Data Logger, Hoboware software, cable	**Sensors**	**244.20**
Pool Noodles, tie-wraps, fishing weights	**Ballast System**	**15.79**
ACTUAL ROV NEW '08 OUT OF POCKET EXPENSES SUBTOTAL		**726.24**
PVC, ABS, elbows, couplers, end-caps, Velcro, rocks, epoxy, Pipe cleaners, screws, 2 tarps, twist ties, duct tape	**Mission Prop Supplies**	**102.95**
TOOL BOX Tape measure, Wire cutter, soldering iron, vice	**Tool Box**	**87.72**
TOTAL '08 PROJECT EXPENSES:		**$916.91**

DONATED ITEMS:	Donors /Grantors:	Estimated AMT:
Funding for parts	**NOAA BWET Grant**	**500.00**
PVC Parts for props	**Ferguson Plumbing Supply**	**83.00**
Small tool Box	**Parents/Mentors**	**~ 15.00**
'08 DONATIONS & GRANTS TOTAL:		**~$598.00**

RE-USED ITEMS from '07 ROV Project:		ESTIMATION:
3 Harbor Freight u/w Camera/Monitor kits w/shipping	**Sensors**	**229.89**
Propellers & Drive dogs	**Propulsion**	**35.00**
12 volt Marine Battery	**Power/Electrical**	**39.00**
Oil-head well (2007)	**Props**	**~10.00**
Tool box & basic tools	**Larry Rice '06 Grant**	**~100.00**
TOTAL RE-USED ITEMS		**~$413.89**

STUDENT HOURS:

TOTAL ESTIMATED STUDENT (10 STUDENTS) DESIGN/CONSTRUCTION	**HRS:**	**450**
TOTAL ESTIMATED STUDENT (10 STUDENTS) RESEARCH/TECH REPORT/DISPLAY	**HRS:**	**80**
TOTAL ESTIMATED STUDENT (8 STUDENTS) POOL PRACTICE	**HRS:**	**140**
TOTAL ESTIMATED STUDENT (10 STUDENTS) COMMUNITY SERVICE	**HRS:**	**98**
TOTAL ESTIMATED STUDENT (8 STUDENTS) FUNDRAISING	**HRS:**	**120**
	TOTAL STUDENT HOURS:	**888**

ADULT HOURS:

TOTAL ESTIMATED MENTOR (3) /PARENT (4) (Shopping/safety supervision) HOURS:	**150**
TOTAL ESTIMATED TEACHER (1) (Shopping, supervising) HOURS:	**130**
TOTAL ESTIMATED ADULT FUNDRAISING HOURS:	**100**
TOTAL ESTIMATED ADULT HOURS:	**380**

Design Rational:

'Io o Hohonu Kai has 5 tools that efficiently accomplish 2008 MATE mission task objectives. We designed a black smoker scraper tool and net to collect rock samples, a specimen collection tool to collect crabs, a specimen basket transport crabs and a temperature probe docking/monitoring system to measure hydrothermal vent fluid temperature. Our ROV was designed with a step by step process around these mission tools. First we researched, brainstormed and sketched design plans for payload tools, propulsion, frame and electrical control systems. Next we built the frame and tested payload tools before gluing them into the frame. We then completed water trials and modified our tools, frame propulsion and ballast systems. Our last step was to securely glue all frame joints. Kealakehe Intermediate ROV team's goal was to create a simple, low maintenance, low cost and stable, submersible vehicle that can complete mission tasks with speed and accuracy.

Design Specifications:

'Io o Hohonu Kai can dive up to 15 meters and weighs 6 kilograms. Our PVC frame measures 97 cm long, 52 cm wide and 46.5 cm high and our tether is 15 meters long.

Vehicle Systems:

Frame: For frame ideas, the Kealakehe Intermediate ROV team researched ROV websites, examined past Kealakehe Intermediate School ROV frames and interviewed members from the 2007 team. The team lengthened the 2008 ROV frame so the ROV had more stability. This year's frame is made out of PVC piping. PVC is easy to work with. You can cut it down to the size you need and connect it with elbows and T's. We designed a stream-lined PVC frame around the 2008 MATE competition mission tasks and the tools we designed to accomplish them. Frame dimensions are: 97 cm long, 52 cm wide and 46.5 cm high.

Propulsion:

We decided to use Johnson Pump 4732 LPH (1,250 GPH) marine bilge pump cartridge motors, outfitted with 5 cm. tri-blade model boat propellers as thrusters. These motors are reliable and waterproofed with a depth rating of 15 meters.

Thruster, propeller and safety housing

The ROV has six thrusters altogether, configured as follows: four center-mounted thrusters, which serve as ascent and descent power, and two motors which are side-mounted for forward, reverse, left and right propulsion. All thrusters are surrounded by custom built, 7.62 cm (3”) diameter ABS plastic safety housings which direct propulsion in a steady stream. Each thruster is also outfitted with a stainless steel drive dog with a model boat propeller. Each motor draws 3 amps under a full load and spins at a rate of 4,732 LPH [liters per hour] or 1,250 GPH [Gallons per hour]. The thrust of each motor is 1.15 ± 0.05 kg.

Thrust:

We measured the thrust by constructing a tester out of a notched length of 60 cm of 7.62 cm (3”) diameter ABS pipe, a 22 kg. fish scale, a 4,732 LPH bilge pump motor, and a speaker wire harness. The notches held the motor’s tabs for stability. We submersed the tester in 20 liters of water, turned the motor on and measured the force in kilograms.

Electrical Control System:

Our control system utilizes 2 gray control boxes.

Soldering the control box

Box # 1 controls the ROV's propulsion with 4 switches
Box # 2 controls the crab collector tool with 1 switch.

We used heavy-duty double pole, double throw toggle switches to simplify our controls.

Switches #1 and #2 on box #1 control the left & right thrusters. If you flip switches #1 and #2 forward together, the ROV propels forward. Switching switches #1 and #2 backwards propels the ROV backwards; Switch #3 controls 2 primary and 2 secondary ascent/descent motors. This switch is moved forward to ascend and backwards to descend. Switch 4 turns power on or off for the two secondary ascent/descent motors. This switch is used when the ROV needs extra ascent thrust. Control Box 2 operates the crab claw. Our team carefully soldered the 2 control boxes and waterproofed our electrical system with shrink wraps and electrical tape to ensure safe and reliable electrical controls. 28 conductors are in our 15 meter tether. Total motor amperage is 21 amps for the 6 propulsion thrusters and 1 crab collector tool motor. For safety, we installed a 25 amp fuse and 2 heavy-duty banana plugs in a power box connecting to 2 heavy duty battery clamps to contact the 12 volt marine battery.

Ballast System

'Io o Hohonu Kai's ballast system consists of two capped PVC pipe pontoon floats, two lead fishing weights and foam pipe insulation. We adjusted the insulation to help our tether achieve neutral buoyancy. We drilled holes in our PVC frame to help the ROV sink evenly. We also added lead fishing weights inside of the ROV's frame to stabilize the buoyancy.

Payload Tools:

The team was creative in designing four simple, effective and low maintenance tools to compete our missions. Our tools are made of readily available parts to keep our cost down.

Tool 1: Lava Sample Scraper:

This is a front-mounted tool made of PVC and high test nylon line. The nylon line wedges between the rock and the black smoker and scrapes the sample into the sample net.

Tool 2: Sample Net: This is a nylon net mounted just below the scraper tool to catch & hold rock samples. We threaded elastic through the front, so it bends around the Black Smoker.

Lava sample scraper and net

Tool 3: Crab Collection Tool: A rear mounted tool that consists of a modified set of stainless steel kitchen tongs, PVC, springs, a plexi-glass lever. The crab tool is powered by a 1,893 LPH Mayfair Marine bilge pump cartridge motor. We placed heat shrink on the tong ends for better grip. Control box #2 operates tool 3. Flipping the switch forward opens the tongs and flipping the switch backwards closes them.

Bottom view of Crab collection

Tool 4: Crab Collection Basket: A mesh basket with a string harness and floats. The basket is carried down to the bottom by the crab tool. The crabs are placed in the basket and carried up on final ascent.

Crab collection basket

Tool 5: Temperature Probe Docking System:

Made of 1.27 cm. PVC pipe and a 10.16 cm. diameter rubber coupler. A hole drilled in the PVC holds the submersible Vernier stainless steel temperature probe.

The coupler assists in guiding the probe into the hydrothermal vent top.

Top view of temperature docking system

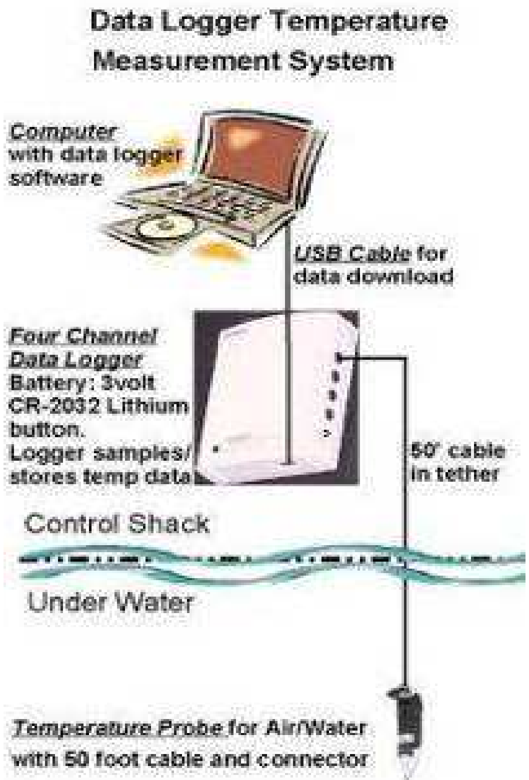
Sensors:

Temperature Probe and Data-Logger system:

A 15 meter waterproof cable connects the stainless steel probe to a Data-Logger on the surface.

The Data-Logger sends an electrical current down the cable and receives the signal from the probe. We programmed the Data-Logger to record temperature at one second intervals in degrees Celsius.

We use a notebook computer to display the data and to obtain accurate readings of the hydrothermal vent fluid, via Hoboware software.



Camera & Video System:

Our team chose to use 3 Harbor Freight underwater cameras and 2 monitors, since we have experienced multi-year success due to the cameras' durability and economy. The cameras are depth rated to 18 meters.

Cameras & monitors are powered by the main 12 volt battery using 2 banana plugs. There are 2 connections-one for each camera with its own separate 2 amp fuse.

Camera 1 provides a bird's eye view of the lava scraper and net.

Camera 2 focuses on the Temperature probe.

Camera 3 supplies a wide angle view of the crab tool.

Cameras 1 & 2 are also used for wide angle front and rear views.

Bird's eye view camera 1

Challenges:

Time management was difficult as a middle school team. We had trouble organizing our schedule due to school work and extra-curricular activities, such as science fair, sports, plays, band and hula. We compromised and adjusted individual schedules so we could all work together as a team.

Agreeing on tool designs for the mission tasks was another challenge. The team came up with a lot of interesting designs that looked like they would work. We used a step by step process to decide what tools we would use. First, we looked over the designs and picked out the best ideas. Then, we tested prototype tools on our ROV. Finally, through direct observation and timed trials, we determined which tools were more efficient and decided on our final design. When things went wrong it was sometimes hard not to blame each other, but we pulled together and became stronger as a team.

Troubleshooting:

Troubleshooting involved the process of elimination, direct observation as well as collecting time and efficiency data. When our monitors malfunctioned, we had to troubleshoot the camera system, by changing connections and cameras to get them working again. Camera angles had to be re-adjusted to obtain a wider view for mission tasks.

After the regional competition, we wanted to test the speed difference two extra ascent thrusters made. We tested this by flipping our side thrusters to a vertical position. We timed the ascent & descent with a stop watch, comparing the difference between two or four vertical thrusters. Adding 2 additional thrusters, we cut fourteen seconds off our mission time.

Troubleshooting continued

The crab tool tongs malfunctioned and locked in a closed position. The control box switch could not open them. We examined the drive shaft, checked if the motor was still operating and found that zip ties holding the nut to the drive shaft, caused binding and prevented the motor from rotating. We went back to our workshop to stabilize the crab claw with a metal rod; however this was not the solution. We discovered the crab tool motor had excessive torque and high RPM's. The combination of high torque and high RPM's caused the motor to bind and jam the drive shaft into the lever guide. We added springs on both sides of the drive shaft to relieve the pressure and stop the binding. Re-design caused time setbacks, but it was critical.

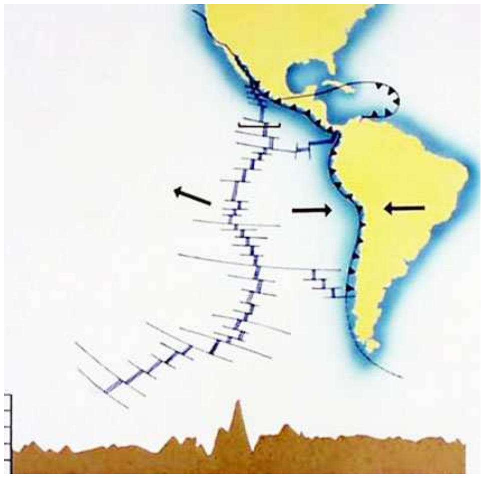
Future Improvements:

Next year, we would like to try water-proof brushless motors. Brushless motors make speed control more efficient. There are no brushes that wear out, and electromagnets provide precise control. The main disadvantage is the high cost; however we may save money in the long run if we can re-use the motors year after year. We also would like to try using joy-sticks to simplify the controls. The team thought of using a joy stick for forward and reverse movement, another for ascent and descent and a third joystick for the mission tools. More team fundraising will be required to try these new systems.

Lessons learned:

Communicating clearly and working as an efficient team is a work in progress, as we are middle school kids. Learning to use tools and equipment safely was important. The major lessons we learned were the importance of discipline, time management, teamwork and safety. Without these important principles, an ROV such as ours would not be possible. Learning these principles will help us in the future and through out our lives.

ROV Research at the East Pacific Rise:



www.dkimages.com/.../Plate-Boundaries-09.html

The East Pacific Rise is an undersea, volcanic range stretching 65,000 km from the Gulf of California to Antarctica. It is a divergent or spreading, tectonic plate boundary along the eastern edge of the Pacific Ocean Basin. Here, the Pacific Plate is separated (north to south) from the North American, Cocos, Nazca and Antarctic Plates. Hydrothermal vents were first discovered and studied at the East Pacific Rise.

A robotic arm takes samples from a Black Smoker
science.nasa.gov/headlines/images/vents/intro.jpg

Tube Worms, vent crabs and deep sea fish live at Hydrothermal vents.
www.science.psu.edu

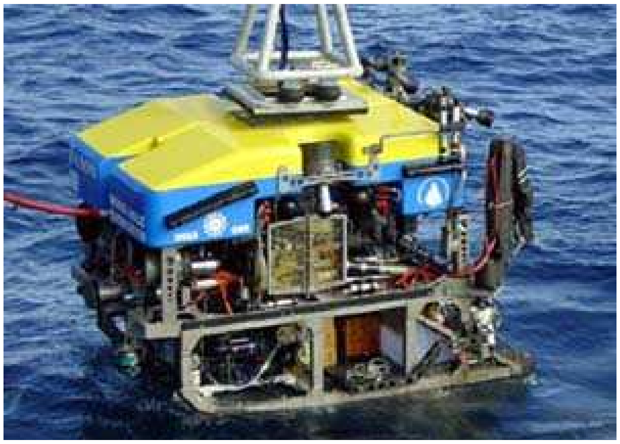
Tiburon awaits its deep sea mission

Tiburon is an ROV built by MBARI (Monterey Bay Aquarium Research Institute). Tiburon dives to 4000 meters and explores oceans worldwide. Tiburon has been used to explore Mid-Pacific undersea volcanoes, the Juan de Fuca Ridge, the Sea of Cortez' Guaymas Basin, and deep-sea hydrothermal vents along the East Pacific Rise. Tiburon uses electrical thrusters and manipulators which allows it to move silently through the water without disturbing the ecosystem. Tiburon also has the ability to change from one tool-sled to the next for different missions. Tiburon is used to collect lava samples and to see how the eruptions at the ridges shaped the region.

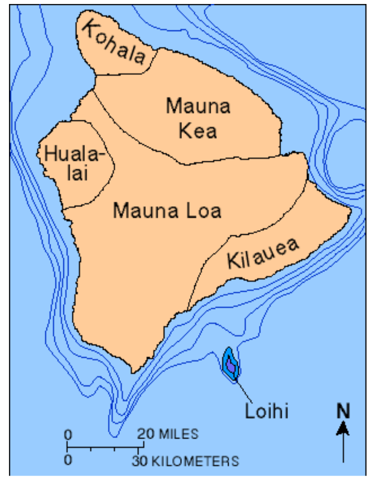
David Clague, PhD.

David A. Clague, PhD, is a Marine Geologist from MBARI who uses Tiburon to gather data at the East Pacific Rise (EPR) and oceanic volcanoes across the Pacific. His main research interests are oceanic volcanoes (mainly Hawaiian volcanoes), mid-ocean ridges, and isolated sea mounts (extinct volcanoes). He jumpstarted his career by participating in advanced math, chemistry, physics, and geology classes in high school. He has participated in several research expeditions in Hawaii. David worked on MBARI's 2003 R/V *Western Flyer*/ROV *Tiburon* expedition to the Gulf of California and East Pacific Rise, where he searched for lava sediment particles, to compare to samples found at the northeast Pacific Gorda Ridge to find out if explosive eruptions occurred at the faster-spreading East Pacific Rise. Tiburon was equipped with a specialized u/w vacuum cleaner and custom core-catchers to perform this delicate mission. With Tiburon, he found that explosive eruptions due occur at the EPR.

Photo Source: MBARI



Jason II Photo from Woods Hole Institute



Hawaii Volcano Observatory
Map of Hawaii island and Loihi

ROV Research at Loihi Undersea Volcano, Hawaii

Loihi is a submarine volcano found 32 km off the southeast shore of Hawaii Island. Although Loihi is technically not part of a mid-ocean ridge, we wanted to include it in our report, since we live close by, and ROV's are used to explore Hawaii's newest undersea volcano. Loihi is more than 3000 meters tall. Pele's pit, a caldera on Loihi where frequent hydrothermal vent activity is found, is 600 meters in diameter. Loihi is monitored by Hawaiian Undersea Research Laboratory (HURL) and the Fe-Oxidizing Microbial Observatory (FeMO). Jason II was used in 2002 at Loihi to recover HUGO (Hawaii Undersea Geological Observatory) and most recently in 2007 to collect hydrothermal vent temperatures and chemical analysis of the vent fluid at Pele's Pit by FeMO in conjunction with HURL.

The ROV Jason-II is a 2 bodied ROV, operating with the mini ROV Medea. Jason II weighs 3529 kg. and can dive down to 6500 meters. Jason-II has 2 hydraulic manipulators and a payload capacity of 143 kg, plus sonar, video cameras, electrochemistry probes, water samplers and temperature gradient recorders. This system also collects bathymetry information to profile the ocean floor. Jason II is owned by the NSF and operated by Woods Hole Institute.

Terry Kerby is HURL's Chief ROV and Submarine Pilot. The main reason why he uses

ROV's and submarines to explore Loihi is to learn more about Hawaii's newest volcano so that he can teach others about what is happening in the abyss. Terry is an artist and paints pictures of submarine journeys to Loihi to show what it's really like and the exotic details missing in standard photos.

Photo & watercolor painting from:
http://www.soest.hawaii.edu/HURL/gallery/Kerby/Terry_Kerby.html

A submarine explores Loihi.
Watercolor by Terry Kirby

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http://www.whoi.edu/page.do?pid=8423 http://en.wikipedia.org/wiki/East_Pacific_Rise

Reflections & Teamwork:

Our ROV team

Participating in the MATE competition helped us achieve many goals. We gained public speaking, team work, mechanical, research and real world problem solving skills. We learned about how scientists use ROV's to explore the oceans and make new discoveries. We also began thinking about future career paths, related to ocean technology. We used our past mistakes and accomplishments to improve our 2008 ROV. Time management was one of our biggest challenges. The team learned the importance of compromise and perseverance in working together.

Through teamwork, we were able to create a functional and efficient ROV. Three returning members from 2007 had to patiently teach 7 new team mates who were unfamiliar with ROV construction and electronics. Our new team mates were younger and had less experience with time management. Building an ROV can be unpredictable. Sometimes parts mysteriously stopped working. This forced us to re-group and stay late until we could resolve the problem and be prepared for the competition. We had to encourage each other not to give up, and to overcome our challenges.

Designing and building ***'Io o Hohonu Kai's*** electrical system was challenging for us as middle school students. Our team leaders and mentors held basic electronic and mechanical skill classes to learn the skills we needed to be able to design and build the ROV and its electrical system independently. When we needed help, our mentors guided us to evaluate several options so we could make our own decisions and move forward. We learned to respectfully listen to each other's ideas and agree on solutions, as a team.

Acknowledgements:

Thank you to Our Mentors: Mike Hauck, Rondee Miller, Andrew & Terry Argyris, Jeannie Kutsunai, and Ed Harrs. We greatly appreciate guidance from our teachers Lisa Diaz and Brenda Overcast.

We Thank Our Sponsors: NOAA B-Wet, Jack's Diving Locker, HELCO, Ferguson Plumbing Supply, Kealakehe School PTO & Faculty, Buccaneer Plumbing, Wal-Mart, Hawaii Dredging Company, Hawaiian Seafood Producers, Coldwell Banker Realty, Windmere Properties, Hawaii Community Federal Credit Union, Marjorie & Dewayne Erway, Doug Perrine and Rep. Josh Green, for their support.

Special Thanks to: the MATE Center, Jill Zande, Deidre Sullivan, and Lani Clough as well as the MATE International ROV judges and volunteers, the RIDGE 2000 Foundation, the Marine Technology Society, NOAA, Scripps Institute, the Birch Aquarium and U.C. San Diego for organizing, sponsoring and hosting the 2008 International competition.

Mahalo Nui Loa to: Cynthia Fong, BIRR Director, the BIRR regional judges and volunteers. KECK Observatory, Stephanie Stanley, Garrett Frost, Andrew Pope of Hot-Stuff Engineering, Larry Rice, Cindi Punihaole of Kohala Center, Sarah Peck of UH Sea Grant, Carolyn Stewart of Malama Kai Foundation, Don Merwin , our parents, teachers and classmates on the Big Island of Hawaii.

Beach clean up at Kahalu'u

Kealakehe Intermediate ROV Team Community Service Projects:

The Big Island Regional ROV Competition required all teams to complete community service.

Our team completed a total of 98 hours of community service.

We had fun working at Kahalu'u Beach Park to give back to our community by devoting time to help cleanup a popular snorkeling beach park in Kona. Kahalu'u is a basking area for endangered green sea turtles and home to many species of coral and reef fish. Hundreds of people visit Kahalu'u daily, and the turtles, coral, and reef fishes are affected by human impacts. Team members also volunteered for the March of Dimes and Lavaman and gave a ROV presentation to middle school 4-H students. Doing these service projects was fun and makes us feel that we are contributing as members of our community.

▪ **4 Kahalu'u Beach Park clean ups: March 2008**. **64 hours total.** We picked up 10 kilos of trash including 3 kilos of cigarette butts. Cigarette butts are especially dangerous to marine life. Our work at Kahalu'u has helped to minimize some of the human impacts on marine life here.

▪ **Coral Reef Awareness Day: 20 hours**. **April 19.** 10 team mates: 2 hours each. This public event is sponsored by UH Sea Grant, International Year of the Reef, & Kohala Center, and offers a variety of fun kids' activities. We displayed our ROV & taught other kids about ROV's, and the importance of taking care of our coral reefs and oceans.

▪ **4-H Science Engineering Tech Camp: 1 hour ROV Presentation. March 20, 2008** Team Leader, Jonathan Kutsunai, spoke to a group of middle school students about ROV's and their importance in ocean research and careers.

▪ **March of Dimes Walk: April 5, 2008. 6 hours.** 2 team mates (3 hrs. each) entered this walk to assist the March of Dimes earn funds to help children with birth defects.

▪ **Lavaman Triathlon Volunteers: April 6, 2008. 8 hours.** 2 team mates devoted 4 hours each by volunteering at an aide station to help the athletes