# Mojo- Jojo

## Pickens High School
## ROV Team 2008
## Jasper, GA

*Top picture: Mojo-Jojo as it stood 4-26-2008*

*Photo Credit: Megan Higgins*

*Bottom diagram: 3D graphic of Mojo-Jojo 3.0*

*Drawing Credit: Cory Eubanks*

**Team Members:**
**Addie Wofford**
**Scott Wofford**
**Kellie Alexander**
**Kyler Mullins**
**Cory Eubanks**
**Jake Kennedy**
**Daniel Laymon**
**Patricia Deberardinis**

**Team Sponsors:**
**Megan Higgins**
**James Higgins**

# TABLE OF CONTENTS


| Section | Page |
|---|---|
| Abstract | 3 |
| Monterey Bay Aquarium Research Institute | 4 |
| Initial Design Rationale | 5 |
| Design Changes made After Regional Competition | 7 |
| Electrical Schematic | 9 |
| Expense Report | 10 |
| Challenges | 11 |
| Troubleshooting Techniques | 13 |
| Lessons & Skills Gained | 14 |
| Future Improvements | 15 |
| Reflections by Team Members | 16 |
| References | 17 |
| Acknowledgements & Thanks | 19 |

# ABSTRACT

As future science and engineering students, the goals of our project were to become familiar with electrical wiring, motors, pressure systems, all while trying to be as creative as possible. This was accomplished throughout the past 6 months, an ROV was born with a low budget price tag.

Tools of the trade were discussed, learned, and used. Many of the team members had never worked with electrical wiring, power tools, and air compressors. Through theory and planning, trial and error, and “thinking outside the box”, each team member was able to reflect on the many learning experiences.

The research relating the ROV to use in the Deep Sea environments gave a realistic approach to design and rationale. Each component on the ROV has a function and was chosen based on simplicity of its use and operable maneuvering within a Deep Sea environment.

The team members were able to troubleshoot problems, making pool time more productive. Being aware and ready for different problems to arise, proved the team’s planning was in good effort. Little time was spent fixing the different issues that came about during practice sessions.

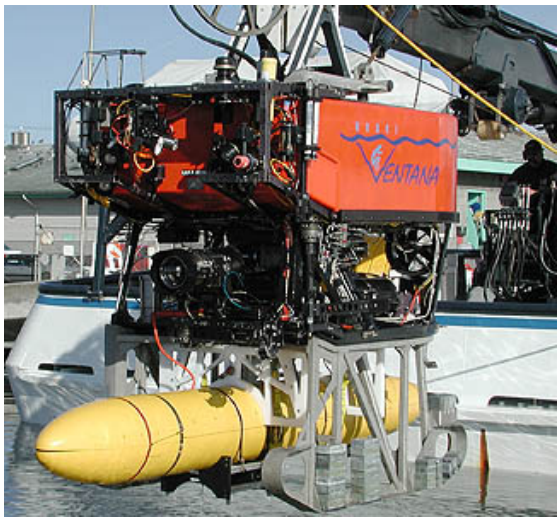
Team communication was another unexpected behavior that had to be learned. Many times, there are different components on the ROV that have to be manned by more than one pilot. Team members learned to be clear, precise, and effective with how they spoke and communicated throughout the entire project.

# MONTEREY BAY AQUARIUM RESEARCH INSTITUTE

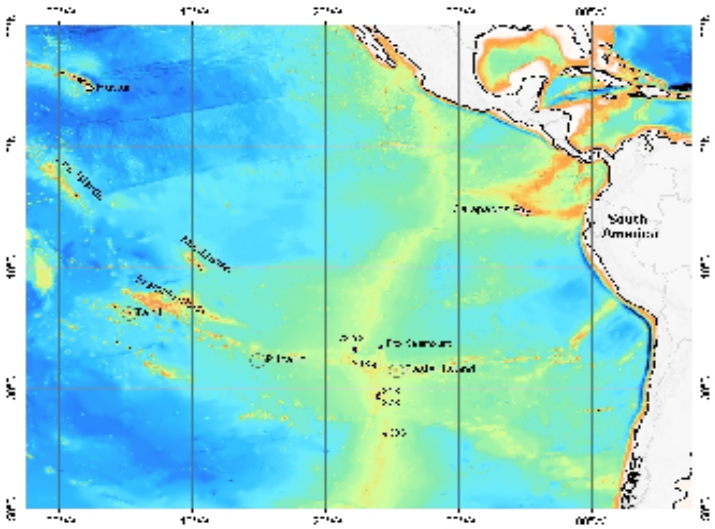
The Monterey Bay Aquarium Research Institute (MBARI) was founded by David Packard in the year 1987. Based in Moss Landing, California, this institute has access to one of the most diverse ecosystems of life, found in Monterey Bay. The facility currently has research being done by eight research teams.

In the first year, the MBARI bought an oil-field supply boat. The changed it for their own research purposes into the R/V *Point Lobos*. On August 25, 1988, the R/V *Point Lobos* and the ROV *Ventana*, which was created by International Submarine Engineering, made their first scientific dive. Ever since then, these two vessels have become more used than any other by the institute. The *Ventana* has recorded the most underwater research time (over 3,000 dives) of any ROV in the world.

At the beginning of the 1990s, scientists fitted the *Ventana* with a special drill in order for it to take rock core samples of rocks that lie beneath Central California. But the first time that this ROV was used to complete long-term projects was in 1993 and 1994, when it was used to study the animals living in the water column and on the seafloor. Once researchers had made several transects for many years, they had obtained an extensive knowledge of the life within the ocean around them.




In 1996, the MBARI had begun field-testing their own custom-built ROV, the *Tiburon*. The *Tiburon* has been used in many of the team's projects and research efforts, because of its ability to dive at a maximum depth of 4,000 meters. It was used to experiment with liquid carbon dioxide at depths over 3,000 meters. The results were uncanny. The $CO_2$ began to combine with the




surrounding water molecules and expanded and was overflowing in the beaker in which it was contained. The prediction was that it would create a stable layer with a solid hydrate skin.

2005 was a great year for the MBARI though. They began research on animal species along hydrothermal vents in the southern Pacific Ocean. The segments of the ridge system near the Easter Microplate exhibit the highest spreading rates (150mm/year) of all the segments of the global mid-ocean ridge system. Also, the transform faults and rifting zones surround the Juan Fernandez and Easter Microplates, which may be slowly rotating in response. Along the East Pacific Rise, hydrothermal venting has been discovered at copious locations. The vents are most active where there are ample amounts of magma.

## INITIAL DESIGN RATIONALE

The ROV was designed with the missions taken into great consideration. As the team pondered the shaped of the ROV frame itself, they chose the octagon. The team was hoping that with a larger size frame, more tasks would be able to be completed in one trip to the "Deep Sea". This would be a time saver and help the team score more points.

By using the front of the octagon, the team members were provided with a front face for which the component to retrieve the crabs in Task #1 to be mounted. A mosquito net was attached to half of the ROV and functioned as a keeping place for the crabs once they were scooped. For the scooper, we attempted to simulate a "Hungry Hippo" device. By using compressed air at the 40 psi limit, a dustpan, and a revised Newton spring scale, the team was able to

get enough force for the scooper to move in a sweeping motion to put the crabs in the net.

For Task #2, the team then devised a scraping device to be placed in the center of the ROV, with the net enclosure spoken about previously completely encasing the front half. This would enable the team to not only contain the crabs but also the black smokers would fall right into the net as they were scraped off. After trying a few options for the scraper, the team decided to recycle a license plate. It was bent around a PVC pipe to the dimensions according to the specifications. In pool trials, the scraper had the desired affect, but prompted the debate about where to place the thrusters in order to optimal force to scrape quickly.

In order to accomplish Task #3, the team realized that they would need a vertically mounted thermometer that could be inserted into the tube at the top of the black smoker. The team was originally hoping to drop a thermometer into the tube and continue to collect the black smokers while the thermometer adjusts. The team found this option harder than it seemed, so they decided to "Keep it simple" and placed the thermometer on the back of the frame. It would still allow the team to collect the smokers, which being near the water tube, would also allow it to adjust to the temperature somewhat and therefore it wouldn't take so long when they come back up with the black smokers to read the temperature.

The ROV contains three cameras, one which overlooks the thermometer, one overlooking the scooper and grabber arm area, and finally the last one allows the team to view the area around the ROV. At first, all three cameras were positioned to view the appendages; however, the team quickly became aware the pilots had no idea where they were flying! These cameras were reconfigured quickly, so that the pilots could view where they were going!

The tether emerges from the rear of the device, in order to balance out the weight that had already been mounted to the front. Also, the team members evenly distributed the thrusters around the ROV in attempt to distribute weight evenly and achieving enough thrust where needed (such as the previously mentioned scraping of the black smokers). It was decided that the ROV would need four thrusters to move the vehicle up and down through the water in order

to do so. The members then utilized the two remaining motors, using them to turn the vehicle left and right and move it forward through the water.

Neutral buoyancy was also one of the goals the team had to achieve. This is attained when the gravitational force on the ROV is equal to the gravitational force of the water displaced by the ROV. Even though calculations could have been completed before the ROV entered the water, it would have been hard to measure the amount of water the ROV would displace due to its larger size. A tub the size of a dog pool would have had to been used. Instead, as many engineers and scuba divers agree, it became a trial and error method once the ROV was in the pool. The team accomplished neutral buoyancy by allowing water to freely flow in and out of the PVC through holes that were drilled onto the bottom frame. For further buoyancy adjustments, pieces of "noodles" that are usually used for child's play in the pool were added and subtracted until the ROV would sink just under the surface and hang out there. Also, the pool that was used for the trials was a chlorinated pool, about 20-22 °C (North Georgia, outdoor pool- Brrr!). The team agreed with that since the missions will be completed under similar conditions, they will just be ready to make minor adjustments on pool deck.

The wiring on the ROV was completed using 2 lengths of 7-stranded sprinkler wire. According to electrical reference books, having approximately 15 meters of tether with a 25 Ampere current would require either a 10 or 12 gauge wire. However, after looking at the 10 and 12 gauge electrical wire, the team considered going to a higher gauge in order to allow for flexibility of the tether. With the lower gauge, and therefore thicker wire, the ROV would be "stiff" in the water. The team agreed to sacrifice some voltage loss for the sake of the tether flexibility. It also allowed them to save a little money, too.

## DESIGN CHANGES MADE AFTER REGIONAL COMPETITION

After a successful competition in Savannah, the team members got back to work. The team knew there had to be many changes if they were to be competitive at the International competition.

The first thing changed was the position of the scraper. The team realized there was a lot of time wasted trying to get the ROV over and around the Vent pipe in order to scrap off the black smokers. The new design has the scraper on the outside edge of the ROV.

The second change was in the type of thermometer being used. Originally, the team used a borrowed thermometer that took to long to adjust to the temperature, therefore providing an inaccurate reading. The team's mentor found an instant reading thermometer that will now be used in place of the original one.

The next change being made to the ROV was thought out by team pilot, Cory Eubanks. After many failed pool attempts to scrape the crabs off the bottom of the pool, the team had added a modified grabber arm to the vehicle. It was this part of the vehicle that saved them during a surprising regional competition. However, it required many trips to the surface in order to deposit the crabs. The team purchased another bilge pump to use as a motor in order to create a movable arm. The team used a plain nail fixed to the new bilge pump in order to create enough torque to move the arm in and out. This will allow the pilots to still grab the crabs, but also to deposit them in the netting on the bottom of the ROV before grabbing another crab. No more multiple trips to the surface!

The last change being made to the ROV will be the newly purchased camera not being placed back into the design. During the trip to the regional competition, the camera somehow shorted out. As team members scramble to contact the manufacture for the warranty, it is not looking promising. The ROV may fly with only 2 cameras.

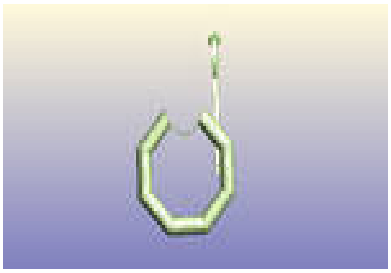


*Figure 2, 3, & 4: 3D images of ROV: top view, bottom view, & side view with planes. Drawn by Cory Eubanks*

# ELECTRICAL SCHEMATIC

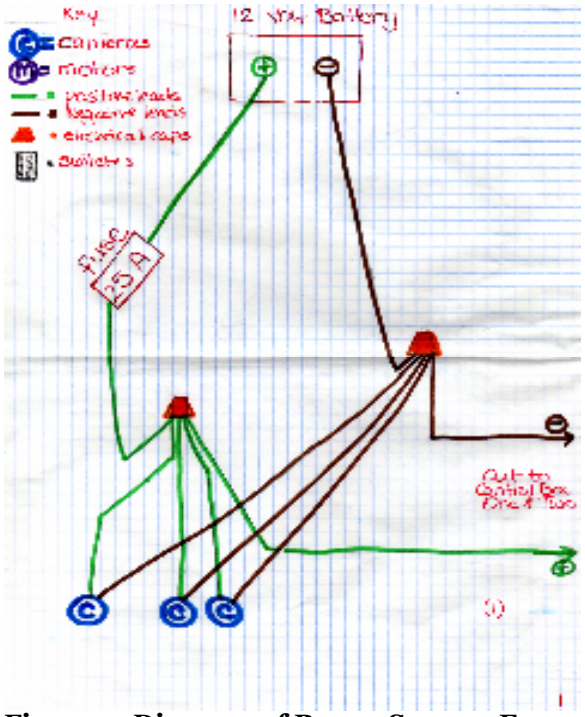



**Figure 5: Diagram of Power Source, Fuse, & Cameras**

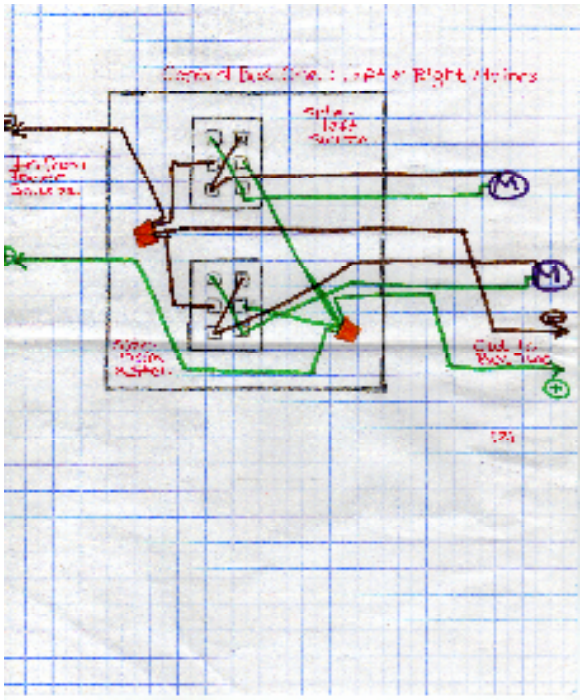


**Figure 6: Diagram of Control Box 1**

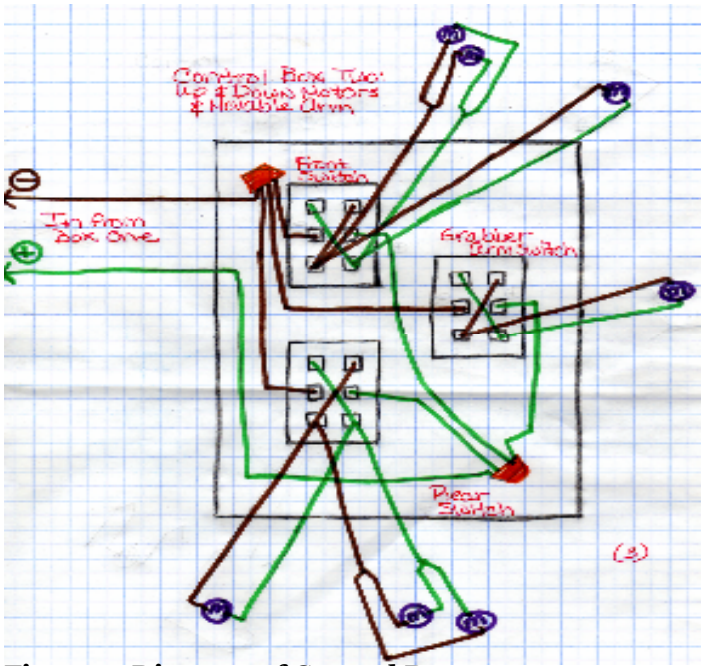



**Figure 7: Diagram of Control Box 2**

*Diagram Credit: Patricia Deberardinis*

# EXPENSE REPORT

Parts that were reused from 2007 ROV Team or donated from team members:

1) 6 Bilge Pump Motors
2) PVC Pipe
3) 2 underwater cameras
4) TV set
5) Noodles
6) Rubber tubing
7) Speaker wire
8) Mini Maglite
9) Air Compressor
10) 2 Recycled License plates
11) 14 gauge wire
12) Cable ties
13) 12 Volt Car battery
14) Outdoor Thermometer

Parts and items bought for current year:

| Store | Part Description | Quantity | Price Each Item | Price Total | Running Expense Total |
|---|---|---|---|---|---|
| Home Depot | Sprinkler wire-100 ft, 7 stranded | 2 | 29.75 | 59.50 | 59.50 |
| | ¾ " PVC 90° connector | 1 | 0.29 | 0.29 | 59.79 |
| | Mosquito screen | 1 | 5.49 | 53.49 | 113.28 |
| | PVC Tee connectors 10 pk | 2 | 2.60 | 5.20 | 118.48 |
| | 3/4" PVC elbow connectors | 12 | 0.64 | 7.68 | 126.16 |
| | Spring set 4 pk | 1 | 5.98 | 5.98 | 132.14 |
| | AAA Maglite | 2 | 4.99 | 9.98 | 142.12 |
| | Solder | 1 | 8.97 | 8.97 | 151.09 |
| | Electrical Tape 10 pk | 2 | 4.95 | 9.90 | 160.99 |
| | ¾" PVC 90° elbow connector | 3 | 0.29 | 0.87 | 161.86 |
| | ¾" PVC cap | 1 | 0.35 | 0.35 | 162.21 |
| | DIY Shims | 1 | 0.99 | 0.99 | 163.20 |
| | Tape | 2 | 3.57 | 7.14 | 170.34 |
| | PVC Cutters | 1 | 12.99 | 12.99 | 183.33 |
| Family Dollar | Dust pan | 1 | 2.29 | 2.29 | 185.62 |
| | Dust pan | 1 | 1.00 | 1.00 | 186.62 |
| Lowes | ½" x ¾" adapters | 18 | 0.67 | 12.06 | 198.68 |
| | ¾" x ½" elbows | 18 | 1.38 | 24.84 | 223.52 |
| Rite Aid | Extension Cord 6ft | 1 | 3.99 | 3.99 | 227.51 |
| | JB Weld | 1 | 4.99 | 4.99 | 232.50 |
| Walgreens | Reaching tool | 2 | 9.99 | 19.98 | 252.48 |
| Overstock.com | Underwater camera & warranty | 1 | 70.93 | 70.93 | 323.41 |

**Total Expenses (as of 4/16/08): $323.41**

Additional Expenses after regional competition:

| *Store* | *Item* | *Quantity* | *Price Each Item* | *Total Price* | *Running Expense Total* |
|---|---|---|---|---|---|
| **Lowes Home Depot** | Thermometer | 1 | 12.97 | 12.97 | **336.38** |
| | 3/4" PVC elbow connectors | 12 | 0.64 | 7.68 | **344.06** |
| | ¾ " PVC 90° connector | 10 | 0.29 | 2.90 | **346.96** |
| | PVC Tee connectors 10 pk | 1 | 2.60 | 2.60 | **349.56** |
| | Electrical Tape 10 pk | 1 | 4.95 | 4.95 | **354.51** |
| | Cable Ties Assorted Sizes 100pk | 1 | 5.99 | 5.99 | **360.50** |
| **Walmart** | 500 gpm Bilge Pump | 1 | 18.98 | 18.98 | **379.48** |

**Total Expenses (as of 6/5/08): $379.48**
*The team did not participate in any fundraising activities to earn money from the building of the ROV.*

# CHALLENGES

Challenge One: The team members are students that are all active members in not only rigorous academic classes, but also in extracurricular activities, and countless school programs. To say the least, members' schedules did not match up. During our first few weeks of meetings, these schedules only allowed one or two of the team members to attend.

Solution to Challenge One: Precise scheduling of meetings was the key to making everything come together. Practically, team members all had to sit down and lay their schedules onto the table and figure out what days were most convenient for all members. In addition to working after school, team members also held numerous meetings on the weekends. Also, an additional solution to

this problem was weighing out each priority of what needed to be done. For example, in the meetings, team members decided what part of the robot needed to be done before progress could proceed, and would work from there. Added to members' priorities was, of course, schoolwork, in which the team took advantage of all spare time and blank moments in the previous days. Although members had to sacrifice some social status, it was definitely worth it to complete this project.

Challenge Two: Although members could tell you a lot about biology, calculus, or even play a mean game of chess, the team was not comprised of carpenters, electricians, or welders. This was a major problem considering those three topics are crucial to this project. Needless to say, team members had a lot of learning to do.

Solution to Challenge Two: Each team member can all honestly say that two major talents that they have acquired are observing and absorbing. By watching members with knowledge of a needed skill, members mirrored, and therein, learned how to do something that had formerly been considered impossible. To give an example, a large worry consisted of soldering. Most of the members were clueless, and since instructions on the back of the soldering gun seemed as foreign as another language, the team was more than happy to learn that a member had experience that stemmed from a dad's business. Not only did this member do some of the soldering himself, but he also taught the rest of the members how to solder, and now some of the first experiences with a soldering gun are showcased on the team's robot.

Challenge Three: As great as it looks in the school's Alma Mater, being "planted in the Blue Ridge Mountains" isn't exactly the best location while working on a ROV. It's difficult to simply get in a car and run down to any old store to shop for parts. Any trip would at least be 45 minutes out of the way to any major shopping vicinity.

Solution to Challenge Three: The internet is truly everyone's friend. The team was able to use stores from all across the nation to order parts. Also, the team was able to recycle and renovate parts from last year's ROV team in order to

cut costs. Although the team had to reconfigure the pieces, members managed to create a rather sensible robot that suits this year's missions.

## TROUBLESHOOTING

Six motors, three cameras, a dust pan, a claw, PVC, and a LOT of electrical tape makes for a pretty good robot; however, the items that make it so unique, can also make the system very difficult to deal with. Especially if something goes wrong. That's why the team had to have a plan B, a back up plan, just in case something goes wrong that shouldn't.

One of the hardest things to get to work, and probably the most important, were the six motors. All six had to be positioned just right and approximately at the right angle. That's why the team decided to have two spare motors just in case one decides to stop working. In such case, the team would pull the machine to the deck, replace the motor, maybe not exactly as the one before, but just enough to get it to moving again.

During practice, the team ran into a problem with a camera wire. All plugs and power were attached, but no video was showing on the monitor. By taking a lucky chance and replacing the wires, then securing with solder and electrical tape, the team managed to divert a situation that would have been arduous to deal with. Although the team has already run into this certain difficulty, they will be prepared to deal with any like it in the future.

The ROV's grabber claw is another key importance to the machine. The ROV has a Newton scale attached to one end of the claw's wire and the other end to an air compressor. The air pushes the spring inside the scale, and pulls on the wire attached to the claw, the spring then rebounds the mechanism inside the scale pulling it back into starting position. Somehow, if the Newton scale breaks or fills up with water, the team will have two other Newton scales ready to be attached and replace the broken one. If this event occurs, the on-deck crew will simply exchange the two and continue with the mission.

In conclusion, whether it be, duplicate motors, a pair of wire cutters, a soldering gun, or just electric tape in general, the team is prepared for the worse, they are expecting the unexpected, but most importantly, they are prepared for just about anything that may get thrown at them during the difficult missions.

## LESSONS & SKILLS LEARNED

Coming into this competition, the team members were faced with learning various electrical techniques, such as wire splicing and soldering. This became increasingly important as some of the newly learned tasks were challenged.

While drilling a hole in the frame of the ROV, team members were dodging already existing wires within the pipe. The drill bit broke through the pipe and sliced one of the video camera's wires in half. They were then faced with the tedious process of reconnecting all of those fine wires that composed that cable.

The team came upon the conclusion that soldering was our best chance for total recovery. Most of the members had not previously used this method before. One the team members had a father teach him this vital method, which was later passed on to the rest of the team.

It has since become a relatively helpful tool as the team worked on other electrical components of their device and they foresee that is will remain useful with other projects later in the future.

Communication was also something the team members had to learn. There were moments during practice sessions when members would get frustrated and agitated by others present and show their feelings. Being able to control these became increasing important when they finally put the ROV in the water.

An example of frustration aroused while trying to configure neutral buoyancy in the pool. There were team members performing several tasks at the same time. Some members where on deck with the ROV, while others where in our make-shift control shack. Many times, either by intention or ignorance, the control shack would practice switching the motors on/off as the group on deck

was pulling the ROV out to add more noodles. This resulted in team members getting soaked, at night, in the cold. Tempers began to flare and things continued to escalate. The team sponsor finally had enough and began lecturing about communication.

Each member on this team has a different personality. Learning to tolerate each other and still present clear and precise instructions was vital to making through the last couple weeks. Frustrations had to be spoken about and discussed, instead of held in until finally shouted at each other.

This skill will also help the team to communicate during the missions. The pilots have to be speaking to each other in order to fly the ROV effectively. They will need to be clear to the pilot in charge of the air compressor when to grab the items. This was a skill to be used throughout life.

## FUTURE IMPROVEMENTS

This year, the ROV team was completely comprised of new members. Last year's team had done well, but since they all graduated, it was hard to get started. In the future, it would be useful to organize and save the files, papers, sketches, etc. from previous years to use in the initial brainstorming and learning sessions.

Commitment will be something to be addressed next year. Each member of the team was involved in many extra-curricular activities and finding a way to work around those busy schedules will be a large obstacle to solve. Some ways to improve this situation could be scheduled meeting times that are set on a calendar ahead of time, team positions that are elected and assigned early on, and better organization of meetings and the notes from those meetings.

Cooperation between team members will also need to be improved. Team building exercises may be incorporated into our meetings early on in the year, that way, we are all on the same level by the end of the year when the final projects come about. All members need to learn to practice self control with their feelings and thoughts, in giving "orders" or directions, and how to handle their frustrations. Also, when brainstorming ideas, everyone's ideas need to be heard

and considered. Team building and better communication will help in every aspect of this team.

The team will also benefit from finding a larger area to work in that can be used at various times. Working in school limited the amount of time, and working at another member's house limited the room we had and our schedule. A centralized location where the team doesn't need to rely on one member to always be available would be ideal.

And lastly, an area of improvement for next year, would be time spent practicing. The ROV should be completed and in the water more than a week before competition. It would help the troubleshooting and the continuous improvement of the vehicle. As the saying goes, "practice makes perfect".

## REFLECTIONS BY TEAM MEMBERS

"This year has been a blast as being part of this team. I made new friends and learned many new things. At times I had bad days or some one would do something and it would upset me. For example, if we were all at the meeting and someone just was sitting in the corner laughing and talking about things that had nothing to do with what were doing. I enjoyed working with a team and being in able to work together to build something like this. Next year I can only hope that it goes as well as it did this year." ~Team Member, Patricia Deberardinis

"Building this robot has been a life changing experience. I've gained two things from this, and one of them is a few new friends. Not only did I get to be with some of my old friends, I also got to know and become fairly good friends with a few new people. The second thing that I gained was the knowledge of a future career. Before I was unsure of what I wanted to study in college, math or engineering, after undergoing this project, I found that building something like this was a lot of fun and that I really could do this for the rest of my life and be happy." ~ Team Member, Scott Wofford

"I have had a great time working on the ROV. Not only was it truly a learning experience, but also, it helped me to get organized with my schedule. Throughout this time, I've also learned to take advantage of any blank moments of my day, so no time is strictly wasted. I enjoyed learning how to think not only creatively, but constructively as well. I can now handle tools whereas before, I couldn't tell a wrench from pliers. Although we were a little unorganized at the beginning, it has all came together and we have created something we are truly proud of. This was a wonderful experience and I'm glad that I have had the chance to work with great people while accomplishing a goal."
~ Team Member, Kellie Alexander

"I have greatly enjoyed working on this project. It was tough trying to organize meetings and work around everyone's schedule. Several of us as well as our mentor have after school activities and jobs. This activity let all of us spend time together and grow closer. We have had a lot of fun and learned a lot of new things. This will be an experience we will never forget." ~ Team Member, Addie Wofford

# REFERENCES


- *Monterey Bay Aquarium Research Institute* Last updated: Mar. 11, 2008
  Apr. 15, 2008 http://www.mbari.org/about/

- *Monterey Bay Aquarium Research Institute* Last updated: Mar. 11, 2008 http://www.mbari.org/about/history.html

- *Internet FAQs Archive* "What size wire should I use?" Last updated: May 13, 2007. http://www.faqs.org/faqs/electrical-wiring/part1/section-20.html

- *The12volt.com* "Recommended Power and Ground Cable Sizes" Last updated: April 18, 2008. http://www.the12volt.com/wiring/recwirsz.asp

- Brewer, P.G., G.E. Friederich, E.T. Peltzer, and F.M. Orr, Jr. Direct Experiments on the Ocean Disposal of Fossil Fuel CO2. *Science*, May 7, 1999, 284: 943-945.

- Tech-archive.net "Re: Upward Force = Downward Force?" Last updated: April 4, 2006. http://sci.tech-archive.net/Archive/sci.physics/2006-04/msg00640.html

- Zitzewitz, Paul W., Ph.D Glencoe Physics- Principles and Problems. Glencoe/McGraw-Hill. New York. Copyright 2002.

- Sager, Robert J. Modern Earth Science. Holt, Rinehart and Winston. New York. Copyright 2002.

- Won, Y., C.R. Young, R.A. Lutz, and R.C. Vrijenhoek (2003) Dispersal barriers and isolation among deep-sea mussel populations (Mytilidae: *Bathymodiolus*) from eastern Pacific hydrothermal vents, *Molecular Ecology*, 12: 169-184.

- Hey, R., E. Baker, D.W. Bohnenstiehl, G. Massoth, M. Kleinrock, F. Martinez, D. Naar, D. Pardee, J. Lupton, R. Feely, J. Gharib, J. Resing, C. Rodrigo, F. Sansone, and S. Walker (2004) Tectonic/volcanic segmentation and controls on hydrothermal venting along the Earth's fastest seafloor spreading system, EPR 27°-32°S, *Geochemistry, Geophysics, Geosystems*, 5(12): 10.1029/2004.


## Bibliographies of Photos


- *Monterey Bay Aquarium Research Institute* Last updated: Mar. 11, 2008
  Apr. 15, 2008 http://www.mbari.org/about/

- *Monterey Bay Aquarium Research Institute* Last updated: Mar. 11, 2008 http://www.mbari.org/news/homepage/2004/auv-rov.html

- *Monterey Bay Aquarium Research Institute* Last updated: Mar. 11, 2008
  http://www.mbari.org/expeditions/EasterMicroplate/index.htm

# ACKNOWLEDGEMENTS & THANKS

*This year's ROV team would like to thank the following people for their time, patience, expertise, and, most importantly, money!*

Our Club Sponsor, "Higgs" & her husband, "Husband Higgins":

Though her schedule was as hectic as ours, her free time was spent with us when she could. Her humor and optimism kept us from pulling our hair out and literally pummeling various objects at times. Through editing this paper, helping organize each move the team made, and brainstorming ideas, she much needed. Her husband's brainstorming and engineering experience was appreciated during the long days at the pool.

Pickens County High School:

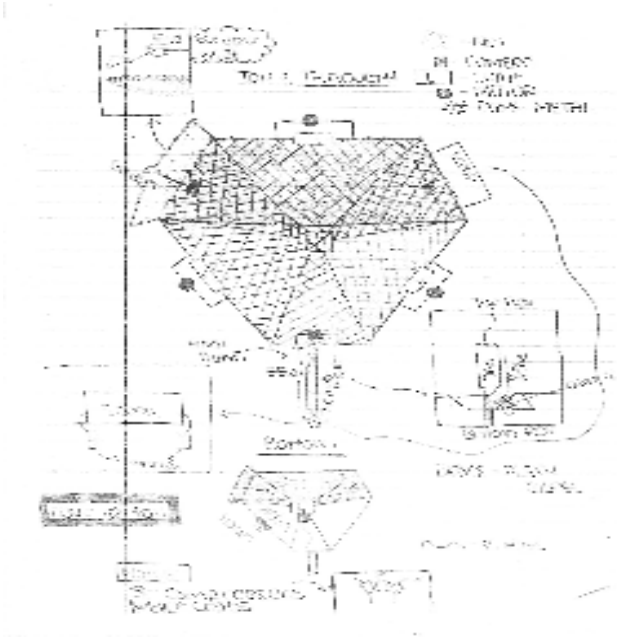
They provided us with this learning opportunity and the financial ability to build the ROV and perform at the Regional competition as well as the International competition. Also, we thank our many teachers and staff that have believed in us and gave us the skills to persevere through the frustrations.

Team Member, Addie's, "Mee-Maw" & "Paw-Paw":

They welcomed us into their home and allowed us to accumulate both lots of teenagers in their living room and lots of messes.

Team Member, Patricia's, Mom & Dad:

Patricia's mom helped the team members earn money by selling snow cones at the local ball park. Patricia's dad, sweet talked his apartment complex into allowing our team to take over the pool decks each night.



*Pictures, clockwise from top left: Team Member, Patricia, checks propellers while another Team Member, Addie, checks the accidentally spliced wire. Top Middle: MoJo-Jojo 1.0 in the water for the first time! Top Right: Team Members, Addie & Kyler fly the ROV for the first time while Team member, Kellie, and sister, look on! Bottom Right: The winning team with Mojo-Jojo 2.0! Bottom Left: Original design of ROV from brainstorming sessions. You've come along way, baby! Photo Credit this page: Megan Higgins. Diagram Credit: Addie Wofford*