Final Cruise Report
Marine Field Project 2011

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1.0 Introduction

Florida is one of the most popular destinations in the world for cave divers because of its extensive underground aquifer system. However, cave diving is an extremely dangerous sport, which has claimed the lives of even the most experienced divers. There are several potential
uses for a cave diving ROV: to replace human science divers conducting research in the aquifer, to serve as a “dive-buddy” that would travel ahead of a diver to scout out potential hazards, act as a rescue aid that could locate and bring air supplies to a stranded diver, and assist in recovery operations.

The main goal of FORCE is to create a vehicle that meets the needs of a cave diving ROV. In Fall of 2010, the team was offered the opportunity to upgrade Harbor Branch Oceanographic Institute’s Tomcat ROV. The Tomcat was operational in the late 1980’s to the early 1990’s, when it successfully explored the *Lusitania* shipwreck. All of the components were functional; however, since the electronics were out date, many of those components needed to be replaced and reprogrammed. The body of the vehicle needed to be redesigned due to its large size and inability to effectively move through small cave passages. The topside controls console was also very large and outdated, so the team decided to reduce the size of the rack case and monitor as well.

From June 23rd to June 26th, FORCE took part in a research cruise aboard the *Thunderforce*, which ports in Fort Pierce. For this cruise, FORCE planned to build the ROV, which would be deployed and tested throughout the duration of the cruise. FORCE also planned to obtain meteorological and oceanographic data for the three days at sea. These measurements would be used to plan the deployment of the ROV. The ROV was scheduled to complete a team-made course, explore wrecks on the bottom of the ocean, and observe the Wing Wave II deployment and recovery. The goals for this cruise were to successfully deploy and test the ROV during control conditions and in confined spaces. The team-made course was made to represent the control conditions and wrecks to represent the confined spaces.

Unfortunately, the ROV was not completed in time to test on the cruise. FORCE compensated for this obstacle by deploying the Wing Wave II and BPAUV, as well as other oceanographic instrumentation. Data was collected from each of these deployments and analyzed by all of the team members. The team’s scuba divers assisted in these deployments, and searched for a lost wing from the original Wing Wave.

### 2.0 Activities
2.1 BPAUV Deployment

i. **Introduction:** The Battlespace Preparation Autonomous Underwater Vehicle is the property of the Bluefin Robotics Corporation. This vehicle is autonomous, which means that it is self-propelled and untethered. It is capable of conducting independent search operations in shallow water. Originally, the BPAUV system was used as a mine countermeasure asset of the LCS Mine Warfare mission package that provided mine warfare commander support for mine-hunting reconnaissance operations. Its main function during the cruise is to conduct a mission using sidescan sonar in order to locate both a lost ADCP and the wing to the original Wing Wave.

ii. **Method:** Many requirements must be met in order to deploy the BPAUV. First a crane must be available to load the vehicle on board the boat. The vessel must have a crane or an a-frame on board in order to move the BPAUV in and out of the water. A small boat is required for recovery. A minimum of two personnel is required to effectively operate and maintain the vehicle. The actual number of personnel required depends on the length of the mission and the skill set of the individuals. The method for use is as follows from the BPAUV Operations Manual:

**Pre-Deployment**

- Print all checklists.
- Checkout all BPAUV operations and support equipment for deployment in accordance with Pre-Deployment procedures. Repair or replace any equipment that is not in a ready for issue condition.
- Perform BPAUV mechanical and functional checks in accordance with the Pre-Deployment checkout procedures including a full pre-dive check.
- Replenish all consumables in accordance with the pack-up list.
- Complete the Pre-Deployment checklist.
- Ship the Mission Module to the support ship or installation site.

**Installation**

- Install the Mission Module on the support ship.
- Set up and prepare support equipment.
- Unpack and charge main batteries.
- Complete the installation checklist.

**Pre-Dive**
- Plan the mission(s) using UVMS or Planner when in stand-alone or Exercise Mode.
- Upload the mission to the BPAUV before Pre-Dive checks.
- Record planned launch and recovery time and lat/long position on the Dive Log Sheet.
- Remove the BPAUV from the mission module to the work area in preparation for Pre-Dive checkout.
- Perform all Pre-Dive mechanical, electrical, and functional checks in accordance with Pre-Dive checkout procedures.
- Prepare the small boat equipment (Bluefin Deck Box, Handheld RDF, AMDR200 Deck Box, etc.)
- Transit BPAUV to launch area.

**Launch**
- Prepare BPAUV area for launch.
- Lower BPAUV into water.
- Perform final status check using Deck Box.
- Complete the Pre-Dive checklist.
- Release the SeaCatch and launch.

**Mission**
- BPAUV commences dive.
- Use UVMS and the MM operations station graphic interface to monitor the progress of the BPAUV.
- Update the Dive Log.

**Recovery**
- Deploy small boat for recovery.
- Transit to the recovery location area at the designated time.
- If no visual contact, use available tools to locate the BPAUV.
- When vehicle has been located, use the RECOVER command on the Bluefin Deck Box to stop the Tailcone.
- Recover the BPAUV using the small boat.
- Secure the BPAUV for transit to support ship.
- Recover BPAUV to support ship.
- Recover and unload support equipment from small boat.
- Update the Dive Log.

Post-Dive
- Transit BPAUV to post-dive work area.
- Perform all post-dive mechanical and functional checks in accordance with Post-Dive checkout procedures.
- Download mission data.
- Perform corrective maintenance, as required.
- If the vehicle will be immediately used to perform another mission, perform pre-dive phase operations.
- Return the BPAUV to the mission module.
- Complete Post-Dive checklist.

PMA
- Perform post-mission analysis on the downloaded data using UVMS or appropriate software on the topside computer.

Removal
- Discharge BPAUV main batteries to shipping/storing voltage.
- Pack up main batteries.
- Perform inventory of all BPAUV system equipment.
- Pack up mission module, including HazMat.
- Ship mission module and main batteries.
- Complete Removal checklist.

Post-Deployment
• Unpack and inventory all equipment.
• Unpack and store all batteries.
• Check out all operations and support equipment and prepare it for storage. Perform corrective maintenance or repairs as required.
• Perform BPAUV mechanical and functional checks in accordance with Post-Deployment checkout procedures.
• Repair or replenish all consumables, support equipment, and spares or replacement parts.
• Complete Post-Deployment checklist.

iii. Results: The BPAUV successfully completed its mission and returned sonar images to the Thunderforce. On board the Thunderforce, students studied the data and tagged images that may have been the lost wing. After recovering the BPAUV and looking through all the data, GPS locations were recorded and divers were sent to look for the wing. After attempting the first dive, it was decided that the current was too strong and that the divers should return to the boat.

iv. Implications/Conclusions/Discussion: The AUV was successfully deployed according to the procedures outlined above from the BPAUV manual; however there were some obstacles that were encountered during the recovery. After the BPAUV completed its mission and surfaced, it was spotted much further from the boat than predicted, making remote control of the BPAUV impossible. This was attributed to a strong current, which was experienced by the divers who were investigating the BPAUV’s results. The chase boat was already deployed, assisting the divers, and was able to catch up to the BPAUV floating away. Once a rope was attached to the BPAUV, the team attempted to pin it to one side of the boat for transport as opposed to towing it behind. This method was recommended by the assisting GSA. When everything was secured the team proceeded back towards the ship, only to find that whenever the boat attempted to turn to port, the BPAUV would get pulled under the boat in a position that could have broken off the communications relay. To avoid damage to the vehicle, the team attempted to drive back without turning in that direction. Using a series of right-hand circles, the team was
able to get the BPAUV within range of the vehicle's remote control system, and the vehicle was then able to return to the ship under its own power. Once the vehicle was positioned behind the ship, it was attached to the Thunderforce's crane and hoisted back onboard.

2.2 Scuba Diving

ii. **Introduction:** The purpose of scuba diving was to aid in the ROV deployment and recovery, and to help with underwater monitoring of the vehicle. Scuba diving is beneficial to pre-examine the water conditions and the wrecks that the ROV will be maneuvering. Scuba divers were also expected to deploy the team-made sample course for the ROV as well as the Wing Wave II.

ii. **Method:** The scuba divers must prepare their diving equipment and perform all pre-dive safety checks. All the safety will follow the AAUS standards. The divers will then get into the water and determine the water conditions for the ROV. When the "all clear" has been given the ROV will be deployed. After this the divers will take photos and video of the ROV, as well as take notes on its movements.

iii. **Results:** Since the ROV was not deployed, scuba diving on the cruise was used for two reasons. First, a total of five divers were needed at one time for the deployment of the Wing Wave II energy device. This involved diving to deploy the device, collecting data and making adjustments, and recovering the device. Video, pictures, and angle of wing deflection data were all collected during these dives, which will be used to further aid the Wing Wave II project’s progress. The second diving objective was to explore and search the area for the lost ADCP and original Wing Wave. Using the side-scan sonar tow-fish along with the side-scan sonar capabilities of the BPAUV, images were collected with points of interest that looked like the lost devices. These points of interest were explored to the best of the ability of two divers.

iv. **Implications/Conclusions/Discussion:** All dive gear was transported to Fort Pierce in team members' vehicles. Tanks were borrowed from Tim Fletcher (5) and Steven Jachec (2) to supplement the team's personal tanks (5), and the remaining 9 tanks that were
needed were rented from Sea Level Scuba. Twenty-one tanks total were used during the
cruise. The team had three AAUS divers, all of whom owned all of the required dive
gear. Dr. Wood’s scuba tank benches were used aboard the *Thunderforce*. The boat
loaded the morning of June 23\textsuperscript{rd}, 2011 and unloaded the morning of June 26\textsuperscript{rd}, 2011.
The carpool had a preliminary set up on June 22\textsuperscript{nd}, to make sure all equipment would fit
into the available space. If any accidents occurred they were to be dealt with first
because they could result in fatality. Diving went smoothly and as close to the plan as
could be followed. All AAUS standards were followed and the safety of the divers was
held above all else. There were 5 total divers during the cruise. The deployment of the
Wing Wave II took one dive, data-gathering took two more, then the recovery took
another dive with the exception that one diver went down twice in order to secure the
crane hook. There were then two more dives for the side-scan sonar image data
explorations. All divers used air for the Wing Wave dives. Two FORCE members used
Nitrox 32\% for the other dives. One of the exploration dives involved a very low visibility,
and high speed current. These issues were dealt with by using a reel to keep the divers
attached to the starting point, and the dive was planned to be very short which allowed
the divers to exit the conditions before any great risk was taken.

2.3 Weather

i. **Introduction:** Regular weather observations were important both for research and
hazard avoidance during the cruise. In this section of the cruise proposal, the
climatology of the region will be discussed, describing in detail the various weather
phenomena, which may be encountered during South Florida summers. Then,
recommendations will be made about how to take regular weather observations, as well
as mitigate weather hazards.

ii. **Methods:** When considering the research objectives of the cruise, as well as the need to
take note of potentially hazardous weather conditions – the student observers
recommended making *hourly* weather observations. In addition to the hourly
observations (which will be recorded on paper), all individuals should always keep an
eye on the sky, to make qualitative predictions of how conditions may change over the course of the next 10-15 minutes.

The hourly weather observations should include the following:

- Temperature
- Dewpoint
- Relative Humidity
- Precipitation Type
- Wind Speed and Direction
- Degree of cloud cover
- Cloud types
- Latest Radar and Satellite Trends
- Any special notes or observations

At all times, individuals should take note of the presence of these weather conditions:

- The sound of thunder. If thunder is heard, lightning is close enough to strike.
- The presence of *cumulus congestus* or *cumulonimbus* clouds, which indicate a thunderstorm or developing thunderstorm.
- The apparent speed and direction of any storms on the horizon.

If inclement weather appears imminent when students are planning a dive, the dive should be postponed until the danger has passed. If thunder is audible, all people should take shelter inside the structure of the boat until at least 20 minutes has passed since the last thunder was heard.

In addition to taking hourly weather observations, students will also check the latest National Weather Service forecasts every 6 hours. Some useful weather links that will aid students in judging current and future weather conditions include:

- Miami-South Florida WFO – http://www.srh.noaa.gov/mfl/
iii. Results: Daily weather forecasts were obtained by members of the team as described above. The forecast for day 1 called for isolated morning showers and thunderstorms, with a moderate chop on the intracoastal waters and 2-3 foot seas offshore. This forecast proved accurate; no significant weather hazards interrupted operations that day. The day 2 forecast called for slightly higher probabilities of thunderstorms as well as 2-3 foot waves and a light chop on intracoastal waters. This forecast also verified well, with numerous showers and thunderstorms observed in the vicinity. However, operations by the crew were not interrupted as no storms impacted the ship directly that day. The day 3 forecast called for numerous showers and thunderstorms, 2-3 foot seas, and a light chop on intracoastal waters. Indeed, this day proved to have the most impact on activities by the crew, as dive plans had to be called off early in order to avoid danger presented to team members by a menacing looking storm approaching from the west. Day 4 also called for afternoon showers and thunderstorms, but since operations by this particular team were concluded before noon, weather presented no significant hazards.

iv. Implications/Conclusions/Discussion: South Florida is characterized by two distinct seasons – the wet (summer) and dry (winter) seasons. The dry season is dominated by the regular passage of cold fronts, which bring occasional precipitation and cool, breezy weather to the peninsula. The wet season, however, is dominated by the daily formation of sea breezes, which usually serve as a focus for the development of showers and thunderstorms. The average starting date for the wet season in Miami is May 21st [1], whereas in Orlando it is May 24th [2]. Therefore, it is almost certain that the season will have transitioned fully into the wet regime by the start of
cruise operations in mid-June. The official definition of the “wet season”, as used by meteorologists at the Miami WFO is as follows:

“Daily maxima average in the upper 80s. But more significantly, the daily minima average in the middle 70s. Low temperatures rarely lower below the 70-degree level during the summer months. In addition to warm temperatures, high humidities prevail throughout the summer. The dew-point temperature is the best measure of moisture levels in Florida. During the summer period, the dew-point temperature remains in the lower to middle 70s. In addition, convection in the form of showers and thunderstorms is almost a daily occurrence during the summer.” [1]

Due to the almost daily occurrence of showers and thunderstorms during the summer months, South Florida has one of the highest densities of lightning strikes anywhere in the nation, and even the world. Lighting is the most deadly weather phenomenon in the state of Florida, accounting for 53% of all weather related deaths. Florida also leads the nation in annual lightning-strike deaths, with 2,117 deaths between the years 1959-2004 – more than twice that of the state with the second highest number of fatalities: North Carolina with 818 deaths [3]. Different wind flow regimes tend to push storms to one side of the peninsula or the other, so each day's lighting hazard can be estimated by analyzing upper air charts and numerical models. In southeast Florida, westerly and northwesterly flow regimes are the most hazardous [4].

In addition to lightning strikes, Florida's summer thunderstorms can produce strong winds, small hail, and locally rough seas that can present a serious danger to boaters.

Another significant hazard to mariners during is waterspouts. The Florida Keys experience more waterspouts than any other location in the world, with the coastal waters off of southeast Florida coming in at a close second. “Fair-weather”, or non-tornadic waterspouts typically form beneath the cloud bases of cumulus congestus (towering cumulus) in environments with very light winds, low vertical wind shear, and no strong upper air disturbances – unlike tornadoes which form in areas of strong directional and speed shear. Although most are weak, they can occasionally capsize boats and cause structural damage when moving onshore [5]. Tornadic
waterspouts can also occur in summer, but they are much less common, since the necessary synoptic-scale dynamics do not penetrate far enough south during the summer months. However, a sea-breeze/outflow boundary collision can occasionally enhance helicity enough for a thunderstorm to produce a brief, weak tornado.

Southeast Florida is notorious for its susceptibility to tropical cyclone landfalls, with the highest frequency of major hurricane strikes in the nation. Hurricane season officially begins June 1st, and extends until November 31st. Colorado State University's renowned forecasters Phillip Klotzbach and William Grey have predicted a very active 2011 hurricane season, with 16 named storms, 9 hurricanes, and 5 major hurricanes. Their forecast also calls for heightened landfall probabilities, with a 72% chance of a major hurricane making landfall anywhere in the US (vs. an average of 52%), and a 48% chance of a major hurricane making landfall anywhere on the east coast including Florida (vs. an average of 31%). When breaking down their forecast county by county [7]:

<table>
<thead>
<tr>
<th>County</th>
<th>Probability of 1+ Landfalling Named Storms</th>
<th>Probability of 1+ Landfalling Hurricanes</th>
<th>Probability of 1+ Landfalling Major Hurricanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broward</td>
<td>6.4% (Avg. 3.7%)</td>
<td>4.6% (Avg. 2.7%)</td>
<td>2.1% (Avg. 1.2%)</td>
</tr>
<tr>
<td>Palm Beach</td>
<td>10.1% (Avg. 5.9%)</td>
<td>7.3% (Avg. 4.2%)</td>
<td>3.4% (Avg. 2.0%)</td>
</tr>
<tr>
<td>Martin</td>
<td>3.9% (Avg. 2.2%)</td>
<td>2.8% (Avg. 1.6%)</td>
<td>1.3% (Avg. 0.7%)</td>
</tr>
<tr>
<td>St. Lucie</td>
<td>2.5% (Avg. 1.4%)</td>
<td>1.1% (Avg. 0.6%)</td>
<td>0.3% (Avg. 0.2%)</td>
</tr>
<tr>
<td>Indian River</td>
<td>2.0% (Avg. 1.2%)</td>
<td>0.9% (Avg. 0.5%)</td>
<td>0.2% (Avg. 0.1%)</td>
</tr>
<tr>
<td>Brevard</td>
<td>6.6% (Avg. 3.8%)</td>
<td>2.9% (Avg. 1.7%)</td>
<td>0.8% (Avg. 0.5%)</td>
</tr>
</tbody>
</table>

Fortunately, the majority of hurricane activity occurs in August, September, and October. June is a relatively quiet month [8]. However, the risk of a strong tropical cyclone is not zero, and the
National Hurricane Center's website should be consulted daily in order to get the latest information on any tropical cyclone activity.

2.3 Secchi Disk
i. **Introduction:** A secchi disk is a flat, circular weight that is used to determine water clarity. Some disks are all white, while others are sectioned into four quadrants—two black and two white. Water visibility must be known to determine whether conditions are acceptable for divers to enter the water.

ii. **Methods:** The secchi disk is lowered by hand into the water until the operator can no longer see the white, or distinguish the black and white quadrants. This point is called the Secchi depth, and is measured in feet or meters from the disk to the water surface. The vessel must be stopped to acquire an accurate reading.

iii. **Results:** The secchi disk was not used during the cruise because the ocean floor was visible at a 20 foot depth. Since the secchi disk does not take qualitative measurements, other than than the secchi depth, it would not have produced any useful data.

iv. **Implications/Conclusions/Discussion:** If the secchi disk reads low visibility, the divers may not enter the water.

2.4 Bucket Thermometer
i. **Introduction:** A bucket thermometer is a glass thermometer housed inside tubes with holes or a window to view the instrument. It is used to measure surface temperature.

ii. **Methods:** The bucket thermometer is used by lowering it into the water with a line. After about a minute submerged underwater, it is brought back onboard, and temperature readings are determined in either °F or °C.

iii. **Results:** A bucket thermometer was not available for use during the cruise. Instead, the divers were able to use personal computers and other instruments to determine the water temperature.

iv. **Implications/Conclusions/Discussion:** The water temperature dictates whether the divers can enter the water.
2.5 Sling Psychrometer

i. **Introduction:** A sling psychrometer is used to take readings of relative air humidity. The device uses a wet and dry bulb thermometer, which are slung around at the same time. Both thermometers fit inside a body tube and are attached to a ball-hinge for 180° rotation. The temperature can be read on a side window.

ii. **Methods:** To use the sling psychrometer the wick for the wet bulb thermometer must be wetted. Next, the slinging tube must be pulled from the body and slung around for about 90 seconds at about 2-3 revolutions per second. Then, when back in the body, the temperatures from each thermometer are read and matched up to the “calculator scales” to determine humidity. Temperature is read in °F or °C and humidity is a percentile.

iii. **Results:** A sling psychrometer was not available for use during the cruise. Other instruments were used to determine temperature and humidity.

iv. **Implications/Conclusions/Discussion:** The sling psychrometer is not always accurate and the users must know the scale which is used to determine the humidity.

2.6 Flow Meter

i. **Introduction:** In order to make sure that conditions are acceptable for the use of the ROV and safe for diver entry the current flow must be measured. In order to do this a General Oceanics, Inc. Mechanical Flow meter will be used.

ii. **Methods:** The setup will consist of rope (200 ft) with a weight at an end and the flow meter attached at the depth required to get an accurate measurement where the vehicle and divers will be; surface crew must make sure the line remains tight at all times. In order to ensure that the weight load of the rope is not applied to the flow meter during entry and retrieval, the device must be clipped to loops made in the rope at the depth at which current data needs to be collected.

iii. **Results:** A flow meter was not available for use during the cruise.
iv. **Implications/Conclusions/Discussion:** Since the flow meter calculates from the time it enters the water the time from entry and exit will be recorded, and an average of three deployments will be calculated. If conditions are deemed over 1 knot the dives for that location will be scrubbed and moved to a new location, where the process of deploying the flow meter will be repeated.

2.7 Doppler Velocity Instrument

i. **Introduction:** The Doppler Velocity Instrument is a tool used not only to measure current speed and direction, but water temperature and turbidity as well. It is a useful instrument for making basic oceanographic measurements. Data was desired in the location of the Wing Wave II deployment so that the conditions affecting the operation of the mechanism could be better understood.

ii. **Methods:** The Doppler Velocity Instrument is held over the side of the ship by one student while another records current speed, direction, water temperature, and turbidity. Measurements were taken at the site of the Wing Wave deployment at approximately 5 foot intervals, with the deepest measurement at 25 feet.

iii. **Results:** The results collected were as follows:

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Current Speed (cm/s)</th>
<th>Current Direction (degrees)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>3.91</td>
<td>317.76</td>
<td>26.15</td>
</tr>
<tr>
<td>20</td>
<td>22.00</td>
<td>220.04</td>
<td>25.95</td>
</tr>
<tr>
<td>15</td>
<td>3.42</td>
<td>74.87</td>
<td>26.26</td>
</tr>
<tr>
<td>10</td>
<td>2.93</td>
<td>46.40</td>
<td>26.86</td>
</tr>
<tr>
<td>5</td>
<td>14.18</td>
<td>44.64</td>
<td>27.32</td>
</tr>
<tr>
<td>0 (sfc.)</td>
<td>6.84</td>
<td>34.87</td>
<td>27.42</td>
</tr>
</tbody>
</table>
iv. **Implications/Conclusions/Discussion:** The current speeds which were observed showed
consistency within a 2-6 cm/s range with the exception of two noticeably higher
measurements at 20 feet and 5 feet (22.00 cm/s and 14.18 cm/s, respectively). It is not
known whether these two outlying data points were the result of actual natural
variation in current speed vs. depth, or a malfunction of the instrument. The Wing Wave
deployment site should have been sampled multiple times (instead of just once) to
establish a larger data set in order to make this determination. Current direction
showed distinctive and consistent turning with depth, starting at maximum 317.76
degrees at the bottom and rotating to a minimum of 34.87 degrees at the surface.
Temperature also gradually decreased with increasing depth, with a minimum
temperature of 25.95 degrees observed at 20 feet and a maximum temperature of 27.42
degrees observed at the surface.

2.8 Side-Scan Sonar

i. **Introduction:** Side scan sonar is a device used to create images of the sea-floor using
acoustic transducers and receivers. It was used to search for missing devices and parts
at their last known locations. These include an ADCP and parts of the original Wing
Wave energy system.

ii. **Methods:** The side scan sonar, also known as a ‘fish’, is towed behind the ship while
cruising. First, the cable must be coiled on the deck in a figure-eight shape. Then, the
end not attached to the fish must be plugged into the data-capturing computer. Using
the software, the user must choose the width of the swath of the sonar signal. This
determines how wide the fish can see and the scale of the image on the monitor. When
ready, the fish can be lowered into the water and depending on how much cable is let
out, the depth can be chosen. This is typically about three feet of cable let out drops the
fish one foot of depth. Depth is another factor in the scale of the image on the monitor.
When done, the fish is recovered and washed with clean water. The cable is then
unplugged and coiled neatly into its box. Finally, the fish is placed back in its case.
iii. **Results**: The side scan sonar had many issues that restricted the usage time and area that was covered. All group members got a good amount of experience with setting up and using the device. This experience also includes learning about troubleshooting.

iv. **Implications/Conclusions/Discussion**: There were three main difficulties that occurred while using the tow-fish. The first resulted because the towing was done by people hand-holding the cable. This caused issues with knowing the depth of the fish. In addition, the fish came dangerously close to the ship's propellers whenever the ship needed to slow down and turn to complete the search pattern. The second problem came from the scaling being used to view the swath images. The scale was changed multiple times in order to create the most accurate data. Finally, the general lack of prior experience in resolving the above problems resulted in the tow-fish being used for only a very short time and small search area. The issues that were encountered could have been remedied by better planning; such as towing the fish from the A-frame of the ship instead of by hand, and calculating the best depth and swath width so that the resulting images are accurate while covering a sufficient area.

### 2.9 Wing Wave

i. **Introduction**: The wing wave is an ocean energy device that was developed for the 2010 Marine Field Projects by Mark Christian and his team under the supervision of Dr. Stephen Wood. The first iteration of the device was built in the summer of 2010 and deployed in the fall of 2010. Once retrieved (later than had been planned) all that remained was the base and anchors of the system. Due to the failure of the first system, supporter Lee Marcum constructed a smaller version with a composite wing and steel hinges. The first design used two wings on an aluminum base and had issues with the hinges, whereas the new design sought to reinforce the hinge system so that its failure would be less likely. FORCE Robotics was given the opportunity to deploy and retrieve data on the new system, giving Lee Marcum the data he will need for the next level of testing on this system.
ii. **Methods:** The wing wave system uses the orbital motion of a wave to create a movement forward and back from 90 degrees plus or minus approximately 10 degrees. This motion will eventually use hydraulics or a similar energy harnessing system which will help to accumulate the energy from the wave motion.

iii. **Results:** When deployed, crews made sure to point the Wing Wave in the direction of the oncoming swell. Two dive teams completed the anchoring of the system. Surface support sent four sand anchoring screws to the divers on a line attached to the Wing Wave, as well as rods to turn the screws. Knives and wrenches were brought to remove zip ties and detach c-clamps from the structure. Screws were inserted without any serious problems, and the chains were attached from the Wing Wave to the anchor screws. Movement of the wing appeared to be excellent. Videos of the system were taken by a diver. The next day, the team returned to discover a non-ideal sea-state for the operation of the Wing Wave, with swells approaching perpendicular to the side of the wing. Despite these less-than optimal conditions, the wing was still moving with a significant degree of deflection that could one day be used with the energy capturing system. The dive teams then made two modifications to the Wing Wave, first by removing foam support, then adding a larger top to the wing for better capture of the orbital motion of the waves. Then the results were compiled using the video that divers had captured with a protractor at the base of the wing system to measure angle of deflection.

iv. **Implications/Conclusions/Discussion:** Overall, the results of the deployment of Wing Wave were successful. The acquisition of wing deflection data, along with detailed observations of sea-state is critical to the further development of this system.

2.10 Fishing

i. **Introduction:** Fishing has been around for thousands of years. It is commonly used to catch fish and other sea life which can aide in the research and understanding of the ocean and its ecosystem. There is an old saying, “Give a man a fish; you have fed him for today. Teach a man to fish; and you have fed him for a lifetime.” It was decided as a
team, to fish while on board since one of the teammates had never fished before and it was concluded that fishing is a valuable activity and research technique to have.

ii. **Method:** Common practices of fishing include hand gathering, spearfishing, netting, angling, and trapping. The practice used during the cruise was angling. This was done by using trolling rods and balleyhoo, as well as, cutting bait and preparing artificial lures. The target of angling is big game although the team was also looking to attract small fish.

iii. **Results:** The team caught croakers (Sciaenidae) while using lures at night. Trolling rods were used when a fish was caught; unfortunately, that particular fish was lost. Also caught, were two baby sand sharks (Odontaspididae), also known as sand tiger sharks, using lures at night.

iv. **Implications/Conclusions/Discussion:** Fishing allowed the team to obtain a greater understanding of the biological environment in which the Wing Wave II and BPAUV were deployed. It also served as great way for the team to bond without the stress of many other activities performed on the cruise.

### 3.0 References


4.0 Appendix A: Maps of Coordinates

General Cruise Coordinate Locations
5.0 Appendix B: Cruise Timeline

Use timeline in conjunction with coordinate maps in 4.0 Appendix A.

Day One (6/23/2011):

5:45am Team meets to load tanks and personal gear at Palm Bay house.

-4 Dive Bags- Zach Millers SUV

-22 Tanks- split between Mike Moore and Zach Millers SUV’s

-10 Personal Bags- Holly Ibenez car’s trunk

-3 Cars in total made the trek to Fort Peirce FL

6:45am Team meet other personal at the Link Building

7:57am Team arrived at the M/V Tunderforce which was docked under the Ft. Peirce Causeway

8:50am Team Finished unloading vehicles and organizing gear.
- Cars were left in the causeway parking facility.

9:04am Meeting to discuss diving of Wing Wave II (WWII)

- Release Team
- Screw Team

- May release foam if necessary, will bring camera, and we will do a recovery check.

Meeting ended at 9:12am

9:28am Crew arrived with food and it was loaded onboard.

9:42am Finished loading food

9:46am Captain briefed team and passengers on safety and proper boat operations (PPE).

9:55am Left port to arrive at the WWII drop location 3 miles out of the inlet.

- GPS Location of the WWII Drop Location

  27 26.503 N

  -80 013.586 W

10:00am Weather and ocean conditions were checked.

10:30am Arrived at WWII location and set single anchor point.

11:07am Dive 1: Dive team 1 (Mike Moore and Dr. Stephen Wood) was in the water.

11:13am WWII was in the water

11:20am Dive 2: Dive team 2 (Zach Miller, Cassandra Morecroft King, Sam Rauworth) was in the water.

12:10pm Lunch was served on board.

1:15pm Dive 3: Dive team 2 in the water

1:23pm Doppler Velocity Log was taken at 20, 15, 10 and 5 feet.

2:00pm Left WWII location.

2:57pm Dropped Dr. Wood and Lee Markum off at causeway docking location.

3:10pm Motored out to Wing Wave 1 (WW I) deployment location attempt ADCP recovery.

- GPS Location
3:37pm Began prepping side-scan sonar fish for deployment.

4:26pm Side-scan sonar was put into the water.

4:41pm Side-scan sonar was pulled out of water.

5:30pm Dinner was served.

7:15pm Pulled back into port to dock for the night.

Some of the crew left to spend the night with their families, we stayed on board.

7:30pm Zach did some fishing in the Intracoastal Waterway.

8:00pm Girls sat on the stern and read.

No watches were preformed this night due to the fact we were docked inland.

Cruise Day Two (6/24/2011):

7:25am Wake up!

8:05 Overview of daily activities with Captain

- High tide to bring in the WWII is between 3:30 and 4pm.

9:08am Dr. Wood Arrived with Lee Markum and Morgan Marmitt.

9:16am Departure to the WWII location.

10:00am Arrival at WWII location.

10:59am Divers in the water for Dive 3 to take measurements.

11:32am Last diver out of the water.

12:00pm Lunch served.

1:02pm Divers in the water for Dive 4 and the initial removal prep of the WWII.

1:24pm Divers out of the water.
1:35pm Wing Wave II pulled back on deck.
2:00pm Motored back towards the slip.
2:35pm Dropped Dr. Wood at dock so he could drive to the slip location
2:40pm Boat pulls into slip to unload WWII
3:30pm Left slip to dock at bridge.
3:50pm Attained water and minor stop
4:10pm Headed out to fishing area for the night.
6:30pm Arrived at location
   -GPS Location of Fishing
       27 37.094 N
       -80 019.852 W
Anchor watch all night. Used watch schedule hours.

**Cruise Day Three (6/25/2011):**

Anchor watch continued.
5:20am Anchor was pulled up to being moving out to 150 feet for prime fishing
8:15am Everyone woken up
8:30am We began movement to the WW I location
9:15am AUV meeting to go over everything necessary
9:49am Arrived at WW I past location.
9:58am Began AUV pre dive.
10:30am Began movement of AUV.
   -Into lift area and attached lead lines
10:40am AUV lifted over the side of the vessel and released to small boat control.
10:49am AUV Mission Sent.

11:01am AUV dove for mission.

11:27am Divers in the water for Dive 6 to observe visibility and bottom conditions.

11:51am Divers out of the water.

12:15pm AUV brought back on board.

12:30pm Information download from AUV.

12:45pm Lunch Break.

1:30pm Look at data from AUV side-scan.

- Four Possible items found.

- GPS Locations:

  1) 27 30.023 N
     -80 14.851 W

  2) 27 20.016N
     -80 14.383W

  3) 27 29.792N
     -80 14.862W

  4) 27 29.788N
     -80 14.414W

2:09pm Divers in the Water for Dive 7 to observe side-scan locations.

2:10pm Divers out of the water due to impending storms.

2:30pm Left WW I location to go back to slip for the night.

4:30pm Arrived back at slip.

5:00pm Mike Moore and Dr. Sahoo left to go home.

5:15pm Dinner

The rest of the night was rest and relaxation night.
Cruise Day Four (6/26/2011):

8:00am Everyone wakes up.

9:00am Gecco team arrives with parts.

9:15am Unload AUV.

11:00am Leave to head back to campus with AUV.

6.0 Appendix C: Dive Sites

6.1 Original Dive Sites

United Caribbean
Depth: 70 ft. (21.34 m)
Location: 26.321133° -80.058983°

Palm Beach County

Noula Express
Depth: 71 ft. (21.64 m)
Location: 26.3213° -80.058983°

Broward County
Sea Emperor
Depth: 72ft
26.19460° -80.03689°
Broward County

Ancient Mariner
Depth: 70 ft. (21.34 m)
Location: 26.30195° -80.062417°
Broward County

6.2 New Dive Sites

Dives 1-5
GPS Location
27 26.503 N
-80 013.586 W

Dives 1-5 were performed the Wing Wave II deployment location which was south of the Fort Peirce inlet. The location was found by ROSCo ROV team who had deployed their vehicle a few days earlier and found the conditions to be quite antiquate with all critical conditions for a successful deployment.

Dive 6
GPS Location
27 29.901 N
-80 14.610 W
Dive 6 was at the original Wing Wave location. Divers observed location conditions.

**Dive 7**

GPS Location

27 30.023 N
-80 14.851 W

Dive seven was to attempt to observe possible pieces seen on the Blue Fin AUV side scan sonar location that could be from the wing wave one deployment.

**7.0 Appendix D: Deck Watch Schedule**

<table>
<thead>
<tr>
<th>Time Slot</th>
<th>Watch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1am-5am</td>
<td>Holly and Jaine</td>
</tr>
<tr>
<td>5am-9am</td>
<td>Sam and Zach</td>
</tr>
<tr>
<td>9am-1pm</td>
<td>Cassandra and Mike</td>
</tr>
<tr>
<td>1pm-5pm</td>
<td>Holly and Jaine</td>
</tr>
<tr>
<td>5pm-9pm</td>
<td>Sam and Zach</td>
</tr>
<tr>
<td>9pm-1pm</td>
<td>Cassandra and Mike</td>
</tr>
</tbody>
</table>
8.0 Appendix E: Duties

Deck Watch

- Requires 2 members at 4-hour intervals 24hrs a day. (See 7.0 Appendix D)
  - Keep look-out on deck
  - Assist where needed
  - Keep up ‘Captain’s Log’ including Navigation
  - Post for look-out

Galley Duty

- Requires 4 members who are not on deck watch at that time.

Instrument Use and Deployment

- Requires all hands
- BPAUV, Side-scan Sonar, Doppler Velocity Instrument, etc.
- Use data to decide dive location, time, and final checks

**Scuba Diving**

- Requires AAUS Certified Divers for each ROV or Wing Wave deployment
- 7 Total Dives
  - 2 people minimum for ROV, should use 3
  - Non-members of FORCE to be brought to Wing Wave deployment/recovery

**ROV Deployment and Recovery All Hands**

- 7 Deployments
- 2 ROV Drivers minimum
- Non-divers as deck help
- Divers in water to film and help
9.0 Appendix F: Florida Tech Project Approval Form

(Must be submitted to the Florida Tech DSO at least 2 weeks prior to planned dive activities)

1. Objective of Project (use separate sheet if necessary)
   The objective of this project is to monitor the ROV while it performs its task underwater. The ROV will explore a team made course, consisting of hula-hoops and wrecks. The divers will be taking video and photos of the ROV underwater.

2. Project Director: Dr. Stephen Wood

3. Lead Diver: Zachary Miller

4. Florida Tech and other project equipment to be used (boats, dive gear, transportation, etc.)
   a. Scuba Tanks

5. Special Diving Equipment:
   a. Cameras

Dive Sites (use additional sheets if necessary)

1

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
<th>Day/Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.46662°, -80.2510°</td>
<td>40ft</td>
<td>June 19th, June 20th</td>
</tr>
</tbody>
</table>

6. Date of first dive: June 23rd, 2011
7. Date of last dive: June 25th, 2011
8. Estimated number of dives: 8, sites could be repeated. Sites will be examined for other divers and currents to determine if the wreck is dive able.

Names of All Divers (visiting divers must contact the FL Tech DSO at least 1 month in advance regarding eligibility to dive under the auspices of the FL Tech Dive Program)

<table>
<thead>
<tr>
<th>Name</th>
<th>Depth Rating</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zachary Miller</td>
<td>60ft</td>
<td></td>
</tr>
<tr>
<td>Sam Rauworth</td>
<td>60ft</td>
<td></td>
</tr>
<tr>
<td>Cassandra Morecroft King</td>
<td>60ft</td>
<td></td>
</tr>
</tbody>
</table>

9. Name, location, phone number of nearest recompression chamber.
   Indian River Memorial Hospital
   1000 36th St
10. List all available modes of transportation to be utilized (boats, autos, helicopter, etc) in the event of an emergency involving an injured diver.
Boats, Helicopter, Cars (once on land)

11. Signature of Faculty Coordinator: ________________________________
    Dept. ___________________________ Phone __________________

** Any deviations to this dive plan must be reported to the FL Tech DSO immediately. Divers who fail to do so risk suspension of their Fl Tech Diving privileges.
The Lead Diver is responsible for detailed planning of all underwater activity and to establish and discuss a rescue plan with all divers before any diving takes place. The responsibility of the Lead Diver requires preparation several days before the actual dive takes place. If a large group of divers is involved, a general meeting is recommended to discuss operational procedures at the dive site.

The Lead Diver must be at the dive site during the entire dive operation.

YES Do all divers have their Florida Tech Dive Certification Card?

List the names of the divers at the dive site:

Zachary Miller
Sam Rauworth
Cassandra Morecroft King
Dr. Stephen Wood

**Mandatory on-site emergency equipment:**

YES - First aid kit
YES - Emergency oxygen kit
YES - Dive flag(s)
YES - Emergency information cards
Mandatory personal equipment:

YES - Mask, fins, snorkel
YES - Compressed air cylinder and valve
YES - Regulator (alternate air source is recommended)
YES - Buoyancy control device w/low pressure inflator
YES - Submersible pressure gauge
YES - Depth gauge
YES - Timing device
YES - Compass
YES - Adequate exposure protection
YES - Weight belt/weights w/quick release mechanism
YES - Slate
YES - Knife
_____ - Night diving equipment (if applicable)
YES - Logbook
YES - SSI repetitive dive table

Florida Tech Pre-Dive Checklist – Lead Diver

Review emergency procedures with divers

YES - Lost diver procedures
YES - Emergency numbers
YES - Emergency evacuation procedures
Review dive plan with all divers

YES - Formation of buddy teams

YES - Remind buddy teams that Lead Diver directs all in water-dive activities

YES - Entry and exit areas

YES - Discuss dive objectives

YES - Evaluate water and weather conditions and decide to “go” or “abort dive

YES - Discuss known and potential underwater hazards

YES - Discuss location of emergency oxygen equipment, first aid kit and diving emergency management procedures (appendix 7)

YES - Ensure proper display of dive flag(s)

YES - Roll call

YES - Debriefing after a dive (perform roll call again)

Remind divers

YES - Fill out their Florida Tech Dive Log Sheets
YES - Include Project Approval Number

List the time/depth limitations you imposed for dive(s):

Dive 1- 25 ft, 45 min
Dive 2- 25 ft, 35 min
Dive 3- 25 ft, 25 min
Dive 4- 25 ft, 25 min
Dive 5- 50 ft, 30 min
Dive 6- 50 ft, 20 min

List any problems encountered:
As the Lead Diver for this project, I have discussed all the issues mentioned above and had at the
dive site all the required mandatory equipment. I understand that failure to follow these
guidelines, as well as the rules and regulations in the Florida Tech Dive Manual, may result in loss
of diving privileges and cancelation of the Project Approval.

Signature of Lead Diver: ____________________________________________
Project Approval Number: D011-0114        Date: 6/23/11

Diver: Zachary Miller, Sam Rauworth, Cassandra Morecroft King, Dr. Stephen Wood

Lead Diver: Zachary Miller

Location: Wing Wave Site

Dive Start Time: 11:25        Dive End Time: 11:59        Total Bottom Time: 34 min

Maximum Depth: 22 ft        Visibility: 15 ft

Type or breathing gas: Air

Surface Conditions:
Small

Underwater Conditions:
Fast Current

Purpose of dive:
Deploy Wing Wave

For this dive, a dive computer were utilized (if a computer was utilized, please specify make and model):
Scubapro Gallieo Sol

Comments (be sure to include details regarding any incidents or near incidents):

________________________________________________________

- 39 -
Project Approval Number: D011-0114          Date: 6/23/11

Diver: Zachary Miller, Sam Rauworth, Cassandra Morecroft King,

Lead Diver: Zachary Miller

Location: Wing Wave Site

Dive Start Time: 1:14          Dive End Time: 1:36          Total Bottom Time: 22 min

Maximum Depth: 23 ft          Visibility: 15 ft

Type or breathing gas: Air

Surface Conditions:

Small

Underwater Conditions:

Fast Current

Purpose of dive:

Check Wing Wave

For this dive, a dive computer were utilized (if a computer was utilized, please specify make and model):

Scubapro Gallileo Sol

Comments (be sure to include details regarding any incidents or near incidents):
Diver: Zachary Miller, Sam Rauworth, Cassandra Morecroft King, Dr. Stephen Wood

Lead Diver: Zachary Miller

Location: Wing Wave Site

Dive Start Time: 11:10  Dive End Time: 11:30  Total Bottom Time: 20 min

Maximum Depth: 20 ft  Visibility: 15 ft

Type or breathing gas: Air

Surface Conditions:
Small

Underwater Conditions:
Fast Current

Purpose of dive:
Check Wing Wave

For this dive, a dive computer were utilized (if a computer was utilized, please specify make and model):
Scubapro Gallieo Sol

Comments (be sure to include details regarding any incidents or near incidents):
Project Approval Number: D011-0114        Date: 6/24/11

Diver: Zachary Miller, Sam Rauworth, Cassandra Morecroft King, Dr. Stephen Wood

Lead Diver: Zachary Miller

Location: Wing Wave Site

Dive Start Time: 1:05        Dive End Time: 1:23        Total Bottom Time: 18 min

Maximum Depth: 22 ft        Visibility: 15 ft

Type or breathing gas: Air

Surface Conditions:
Small

Underwater Conditions:
Fast Current

Purpose of dive:
Recovery of Wing Wave

For this dive, a dive computer were utilized (if a computer was utilized, please specify make and model):
Scubapro Gallieo Sol

Comments (be sure to include details regarding any incidents or near incidents):
Project Approval Number: D011-0114          Date: 6/25/11

Diver: Zachary Miller, Sam Rauworth,
Lead Diver: Zachary Miller
Location: Original Wing Wave Site
Dive Start Time: 11:27    Dive End Time: 11:51    Total Bottom Time: 24 min
Maximum Depth: 44 ft    Visibility: 10 ft
Type or breathing gas: Nitrox 32%

Surface Conditions:
Small

Underwater Conditions:
Fast Current

Purpose of dive:
Exploration for Old Wing Wave Parts

For this dive, a dive computer were utilized (if a computer was utilized, please specify make and model):
Scubapro Gallieo Sol

Comments (be sure to include details regarding any incidents or near incidents):
Diver: Zachary Miller, Sam Rauworth, Lead Diver: Zachary Miller
Location: Side Scan Coordinates 1
Dive Start Time: 3:22   Dive End Time: 3:35   Total Bottom Time: 13 min
Maximum Depth: 44 ft  Visibility: 10 ft
Type or breathing gas: Nitrox 32%

Surface Conditions:
Small

Underwater Conditions:
Fast Current

Purpose of dive:
Exploration for Old Wing Wave Parts

For this dive, a dive computer were utilized (if a computer was utilized, please specify make and model):
Scubapro Gallieo Sol

Comments (be sure to include details regarding any incidents or near incidents):
Florida Tech End of Project Report

Project # D011-011  Date of Last Dive: 6/5/11

Total Number of Dives: 8

Names of Divers Participating in Project.

2. Sam Rauworth  7.
3. Cassandra Morecroft King  8.
4. Dr. Stephen Wood  9.
5.  10.

(Use separate sheet for more names if necessary)

Dive logs turned in to Program Manager? Yes

Please note below any problems, complications, aborted dives or deviations from original project. Use second sheet if more room is needed.
## Appendix H: Tidal Information

### Table 3: Tidal Information

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<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Time (LDT)</th>
<th>Height (feet)</th>
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<td>2.34 H</td>
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</table>

**http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8722212**
12.0 Appendix I: List of Equipment

1. 16 Gauge Wire
2. ADCP
3. A Dive Bell
4. AED
5. Aloe
6. Angle Bisectors
7. Assorted Games/Activities
8. Assorted Medicine
9. BCDs
10. Batteries (C, AA, AAA, D)
11. Boat Hook
12. Boots
13. Bucket
   Thermometer
14. Bug Spray
15. Cameras/Cases
16. Chargers for Electric Devices
17. Compass
18. Computer
19. Computers
20. Dikes
21. Dive Flags
22. Dive logs and tables
23. Duct Tape
24. Electrical Tape
25. Extension Cords
26. Extra Clips
27. Extra Thrusters
28. FORCE ROV
29. Fins
30. First Stage setups
31. Fishing Lures
32. Fishing Poles
33. Flow Meter
34. Foul Weather Gear
35. Full Set of Screwdrivers and Wrenches
36. Gauges
37. Gear Bags
38. Gloves
39. Hula Hoops
40. Knives
41. Lighter
42. Lights
43. Masks
44. Measuring Tape
45. Memory Cards (SD, USB)
46. Nautical Divider
47. Nautical Log
48. Nautical Navigation Charts
49. Oxygen 100%
50. Paper
51. Patch Ethernet Cable
52. Pens and Pencils
53. ROV Control Box
54. ROV Power Supply
55. ROV Tether
56. Ratcheting Straps
57. Regulators (primary, backup)
58. Ruler
59. Safety sausages
60. Scuba Benches
61. Secchi Disk
62. Shrink Wrap Tubing
63. Slates
64. Sling Psychrometer
65. Snorkels
66. Soldering Iron, and Solder
67. Spikes
68. Spit (De-fogger)
69. String/Rope/Cord/Cable
70. Sunblock
71. Super Glue
72. Tackle Box
73. Tanks
74. Thermoses
75. Towels
76. Trash Bags
77. Watches
78. Water Bottles
79. Weight pockets
80. Weights
81. Wetsuits
82. Whistles
83. Wire Strippers
84. Zip Ties