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# The Living Bridge Project: Measurements of Estuarine Environmental Parameters

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TECH 797

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University of New Hampshire, Durham

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## Introduction

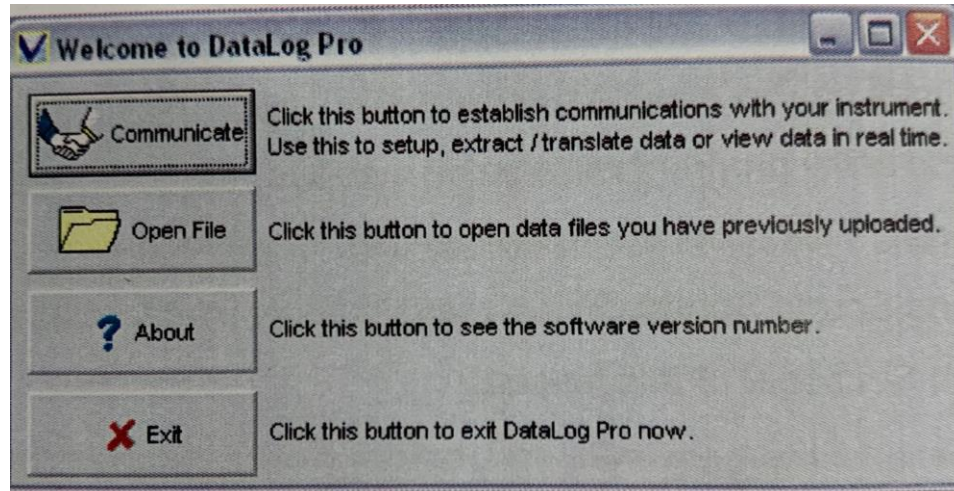
The Living Bridge Project [1] aims to be a self-sustaining experiment of environmental health parameters and renewable energy at the Tidal Turbine Deployment Platform [2] in Portsmouth, New Hampshire. Water quality in this region of the Piscataqua River is of high importance as no consistent environmental data has been collected here. The platform is attached by vertical guide posts on the Portsmouth side of pier #2 of the Memorial Bridge and held afloat by pontoons. The tidal turbine within the moonpool of the platform produces clean carbon free energy to the overall system of instruments attached to the platform. A continuation of years of work provided by a wide group of individuals has put the Living Bridge Turbine Deployment Platform [2] in the position this school year, 2020-2021 to be able to obtain consistent and reliable environmental data. Our goal for this year's continuation of the Living Bridge Project [1] was to calibrate, deploy, and monitor the Valeport Midas CTD+ instrument [3] onto this platform to collect important health parameters in this region in the Piscataqua River. Along with monitoring the Valeport Midas CTD+, planning on performing maintenance for the overall well being of the platform by inspecting old mounts and fabricating new ones, cleaning the pontoons of excess biofouling, and helping run the tidal turbine was necessary.

## **Midas CTD+**

### ***Instrument Interface Introduction***

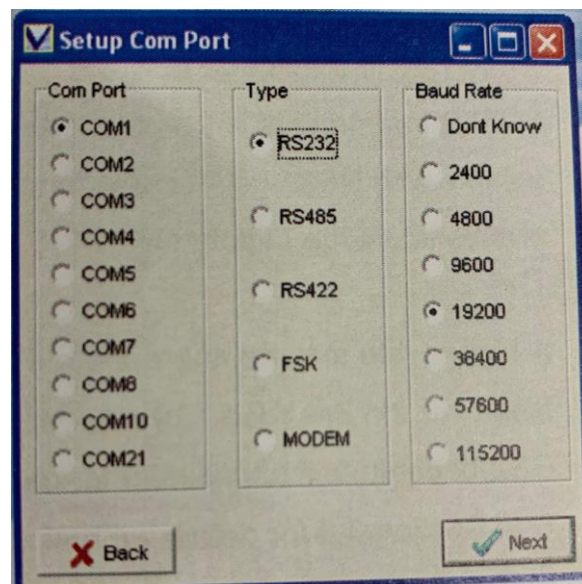
The Valeport Midas CTD+ is an instrument equipped with a sensor for Conductivity, Temperature, and Pressure. The Midas CTD+ can be fitted with additional sensors. Our Midas CTD+ additional sensors are the Seapoint SCF Chlorophyll Fluorometer [4] and the Seapoint STM Turbidity Sensor [5] which are both easily integrated into the overall system and supply important additional data. The Software used to connect to the Midas CTD+ is Valeport Limited Datalog Pro [28]. The type of connection needs to be specified and for this year's purpose the RS232 format is suitable. RS232 is a standard format always available with the Midas and should be used unless a specific adaptor other than the 3m Y lead fitted with a 10 pin Subconn connector supplied is used. The following steps were taken to establish a connection with the Midas.

1. To connect the instrument to a PC for RS232 communications, the 3m Y lead can be plugged into the connector on the top of the Midas Housing. Datalog Pro can be opened on the PC and using the display in figure 1, the 'communicate' command should be chosen to select the Com Port connected to the PC. The purpose of communication to the Midas allows setting it up or collecting recorded data files.



**Figure 1:** Valeport DataLog Pro Display screen to initialize communication with Midas CTD+.

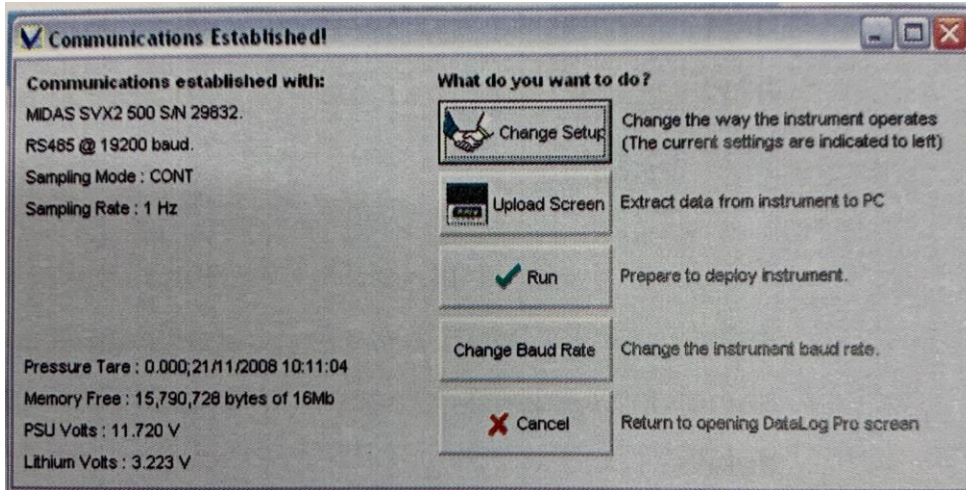
2. Setting up the Com Port as seen in figure 2 includes choosing a Com Port, communication options and Baud Rate. As stated in number 1 of Instrument Interface Introduction RS232 should be chosen for communication options and 19200 is always a suitable baud rate for standard deployments with the Midas using the RS232 cable over lengths up to 50 meters. Choosing next after filling in the parameters on the Com Port setup screen begins the 'Attempting to interrupt instrument' phase and establishes communication among the PC and Midas.



**Figure 2:** Com Port setup display in Datalog Pro.

3. Once the PC is done interrupting with the Midas, Datalog Pro shows the 'Communications Established!' display as seen in figure 3 . Once communications

is established the Midas's setting can be altered with the 'Change Setup' command seen in figure 3.



**Figure 3:** Communications Established display in Datalog Pro.

After communication is established with the PC, deployment settings as seen in the *Pre Deployment Settings* section that need to be altered can be changed within the change setup function seen in figure 3.

### ***Pre- Deployment Sensor Verifications***

#### Conductivity:

Type: Valeport inductive coils  
Range: 0 - 80mS/cm  
Accuracy:  $\pm 0.01$ mS/cm  
Resolution: 0.002mS/cm

#### Pressure:

Type: Temperature Compensated Piezo-Resistive Sensor  
Range: 600Bar absolute (approx 6000m water depth) standard. Others available.  
Precision:  $\pm 0.01\%$  Full scale ( $\pm 0.6$ m with a 600Bar sensor)  
Resolution: 0.001% Full scale (0.06m with a 600 Bar sensor) Temperature  
Type: Fast response PRT Range: -5 to +35°C Accuracy:  $\pm 0.01$ °C Resolution: 0.002°C

#### Temperature:

Type: Fast response PRT  
Range: -5 to +35°C

Accuracy:  $\pm 0.01^{\circ}\text{C}$   
Resolution:  $0.002^{\circ}\text{C}$

#### Turbidity [11]:

Type: Seapoint Turbidity Meter  
Power Requirements: 7-20VDC, 3.5mA avg, 6mA pk  
Output: 0-5.0 VDC  
Output Time Constant: 0.1 sec  
RMS Noise:  $<1\text{ mV}$   
Power-up Transient Period:  $<1\text{ sec}$   
Light Source Wavelength: 880 nm  
Scatterance Angles: 15 - 150 degrees  
Linearity:  $<2\%$  deviation 0-750 FTU  
Sensitivity/Range: 100x gain: 200 mV/FTU 25 FTU  
                  20x gain: 40 mV/FTU 125 FTU  
                  5x gain: 10 mV/FTU 500 FTU  
                  1x gain: 2 mV/FTU ( $<750\text{ FTU}$ )  
Temperature Coefficient:  $<0.05\ \%/^{\circ}\text{C}$   
Operating Temperature:  $0^{\circ}\text{C}$  to  $65^{\circ}\text{C}$   
Depth Capability: 6000 m (19,700 ft)  
Overall Length: 11.2 cm (4.4 in)  
Sensor Weight (dry): 95 g (3.3 oz)  
Body Diameter: 2.5 cm (1.0 in)

#### *Pressure Sensor*

A series of pre deployment sensor verifications were planned to ensure accurate data was being emitted from each individual sensor. The first sensor verification to take place for the Midas was the depth/pressure sensor. Overall goals in this process were to make sure the pressure sensor obtained accurate pressure readings in bars at various depths throughout the 6.096 meter deep Chase Engineering Tank [6] (<https://marine.unh.edu/chase-tank-reservations>) water column. The process of this verification consisted of the following steps to ensure a proper procedure;

1. A rope was secured around the Midas then stretched the rope to full tension to simulate the loading when lowering the instrument in the Chase Engineering Tank.
2. The rope was marked with electrical tape at half meter increments up to five and a half meters which was measured with a tape measure placed at the base of the pressure sensor membrane observed in figure 4.



**Figure 4:** Process of measuring a rope in half meter increments for pressure sensor verification.

3. The instrument was lowered in the Chase Engineering Tank and held still for twenty seconds at each successive marker. Time points were recorded in Eastern Standard Time (EST) to correlate the specified points at each level to the Midas data after the deployment.
4. Calculations of hydrostatics at these measured depths can be obtained and added to the local atmospheric pressure obtained from *weatherwx* (reference) to find the predicted accurate absolute pressure.

### *Salinity and Temperature*

The second verification was a combination of temperature and salinity measured against a newly factory calibrated *Seabird 16* [7] CTD provided by Professor Thomas Lippmann. In the Valeport Midas CTD+ the conductivity is measured as water flows through platinum electrodes in a borosilicate cell. When water contains dissolved natural minerals, these natural minerals contain some conductive ions. These ions will carry charge between the platinum electrodes of the Midas CTD+. The water between the electrodes is a resistance with some voltage drop occurring across the medium. A voltage divider in the instrument determines the voltage drop across the medium of water. This measurement of voltage can be interpreted into Siemens/meter (S/m). Through the Practical Salinity Scale of 1978, conductivity, temperature, and pressure can yield a Practical Salinity Units (PSU), a ratio of grams of solute per kilogram of seawater. “In the Practical Salinity Scale [26] , practical salinity is defined in terms of the ratio K15 of the electrical conductivity of the

seawater sample, at a temperature of 15° C and a pressure of one standard atmosphere, to that of a potassium chloride (KCl) solution, in which the mass fraction of KCl is  $32.4356 \times 10^{-3}$  at the same temperature and pressure” (SalinityRemoteSensing [27] ). Practical Salinity Units is the current professional way of describing parts per thousand in the ocean measurements community. It is important to measure salinity in water because it allows for measuring other parameters of interest such as density and sound velocity. Due to the provided readings from the SeaBird CTD, our team decided to compare salinities and temperature of the instruments. The approach to calibrating these sensors was to place each device in the various solutions containing instant ocean [8] with known salinity contents while collecting timestamps. Both devices needed to be placed on self record during this process with dummy plugs in place. The calibration started by placing each device in succession into the various solutions as seen in the process on figure 5. The time the instruments entered each solution was recorded physically by hand with a world clock.



**Figure 5:** Salinity and Temperature verification with Midas CTD+ [3] and Seabird 16 CTD.

Data sets of both the Midas and Seabird were placed side by side and analyzed for both accuracy in temperature and salinity readings.



Test\Salinity (ppt)	Midas CTD Plus	Seabird 16plus Salinity (ppt)
Test 1	0.1319	0.2726
Test 2	24.5132	25.7514
Test 3	11.3545	13.1097
Test 4	20.6408	21.1412

**Average Difference between instruments: 0.9086 Parts Per Thousand**

Test\Temperature (C)	Midas CTD Plus Temperature (C)	Seabird 16plus Temperature (C)
Test 1	24.2220	24.2406
Test 2	24.4830	24.3448
Test 3	24.3480	24.3629
Test 4	24.3090	24.3222

**Average Difference between instruments: 0.3288 Celcius**

### *Turbidity*

Turbidity is the measurement of clarity within a liquid and is a characteristic of water by analyzing the amount of light scattered by material contained in it [10]. The Seapoint STM Turbidity Sensor measures suspended particles in the water within a 5 cm volume from the sensors window [11]. The STM is set to have a constant response to the Formazin Turbidity Standard in Formazin Turbidity Units (FTU) [11]. FTU is the measurement of scattered light from suspended solids in liquid using infrared light [12].

Last of the in lab sensor verifications was the Seapoint STM turbidity sensor which was done with the help of Valeport [9] and the *VALEPORT LIMITED 400 Series Instruments Additional Sensor Secondary Calibration Procedures* manual [10].

1. Water from the deployment site was sampled via a 5 gallon bucket. The water taken from the site needed to be representative of what the sensor will be measuring when deployed. In our case this was approximately one meter from the free surface of the water at Prescott Park public pier located about 500 feet from the deployment site and was the closest accessible water source at the given time.

2. A thorough cleaning of the sensor's window and the plastic calibration pot making sure any and all residue was removed.
3. Provided with the Midas CTD+ was a black plastic calibration pot fitted with an o-ring and drain hole that fits snug around the Seapoint STM turbidity sensor as seen in figure 6.



**Figure 6:** Start of Seapoint STM turbidity sensor verification with the plastic calibration pot snug around the sensor.

4. When placing the black pot around the turbidity sensor the user had to make sure the window of the sensor faced upwards and the drain hole was blocked.
5. The Midas then was connected to the Valeport Data Logger Pro [11] and data logging could be set up and placed on run then the solutions were added into the black calibration pot
6. The different solutions created from distilled water and site water could be methodically placed in the black pot approximately filling the pot with solution 5 cm above the sensor's lens window. Each solution should be time stamped and monitored until FTU readings are stable. This process took place with concentrations in order as follows while increasing site water level ratios in comparison to distilled water every sample;
  1. Pure distilled water
  2.  $\frac{1}{8}$  dilution
  3.  $\frac{1}{4}$  dilution
  4.  $\frac{1}{2}$  dilution
  5. Original site water sample

7. Now the data all the way through each solution until the last one is reached can be compared along with the turbidity sensor value prior to starting the verification as seen in table 3.

Solution of Increasing Site Water Ratio	Turbidity Sensor Value (FTU)
Prior to Solution	1.75
0	3.35
1/8	3.49
1/4	3.63
1/2	3.74
1	4.401

**Table 3:** Values of Seapoint STM Turbidity sensor in FTU in different solutions by increasing the ratio of site water in distilled water.

#### *Fluorometer*

Fluorometers are devices that measure the fluorescence or light emitted by different fluorescing objects. Fluorometers use a constant running LED diode, usually blue light, to excite electrons in fluorescent material and a spectrometer, a photodiode device, to output a voltage reading that correlates to the amount of fluorescent material in the water. When fluorescent material is considered excited this means photons cause some electrons of the medium to be energized past a ground state. The result of excited electrons causes a light of a different wavelength than the source LED to be emitted from the excited medium. The spectrometer's photodiode converts the emitted light into electrical current. The electrical current gives a voltage output that correlates to the measured wavelength of the emitted light from the fluorescent material. How a fluorometer differs from a spectrophotometer, a light distributing and emitted wavelength measuring device, is that a fluorometer is designed to measure specific parameters of fluorescent material. Fluorescent material consists of: Chlorophyll-a, DOM, Fluorescein, Rhodamine, Phycocyanin, Phycoerythrin. These materials are either pigments, chlorophyll, dyes, or dissolved organic matter. To distinguish one parameter, a fluorometer uses filtering, gain, and backscattering to observe a specific range of wavelengths. The fluorometer used on the MIDAS CTD+ is a Seapoint Chlorophyll Fluorometer [4] which measures Chlorophyll-A.

#### *Pre Deployment Settings*

The Midas CTD+ needed a strategic set of pre deployment settings that corresponded to the local environment it was going to be mounted in for the duration of the data logging. These settings were developed from the pre-deployment verification of the sensors, the

VALEPORT LIMITED *DataLog Express Operation Manual* [12], and our engineering knowledge of the conditions the local ecosystem provides.

Baud Rate: 19,200 (bits-per-second)  
Sampling Mode: Continuous  
Sampling Rate: 1 (Hertz)  
Conditional Sampling: Off  
Logging output: On  
Direct Output: On  
Local density: 1,000 (kg/m<sup>3</sup>)  
Local Gravity: 9.805 (m/s<sup>2</sup>)  
Latitude: 43.139  
Longitude: 70.937  
Site Info: UNH Memorial Bridge Tidal Deployment Platform  
Overall Units: Metric  
Turbidity (FTU): Gain = 1  
Fluorometer Gain (ug/l): Gain = 3  
Outport: No Selection  
Pressure Tare: Zero Pressure Tare

### *Deployment*

On March 16th the Valeport Midas CTD + was deployed on the Living Bridge Tidal Turbine Deployment Platform. The Living Bridge team arrived at Judd Gregg Marine Research Center [13] and began loading the Galen J [14] of all necessary deployment tools and equipment. From the UNH Pier [15], the team traveled aboard the Galen J to the Memorial Bridge and boarded the Tidal Turbine Deployment Platform.



**Figure 7:** The Galen J is seen on the left and on the other, the platform

Work flow generally consists of checking the platform for any oddities, unloading tool boxes, cleaning the platform, deploying the turbine, monitoring power output, checking server status, and performing specific trip tasks. On 3/16, we were able to access the servers aboard the platform and run live feed footage of cameras on the platform. Some of the original bolt fittings that secured the CTD to the 2 inch diameter galvanized pipe failed and were replaced. Installation required multiple hands and guidance to secure the mount attachment. Using the 2016-2017 Living Bridge mounts, the Midas CTD + was installed. Starting 3/19/2021, measurements from the CTD were recorded every 5 minutes on the GE Cimplicity SCADA Data Acquisition System [16].



**Figure 8:** The Midas CTD Plus Deployed 3/16/2021

## **Data Collection**

### *SCADA System*

The data acquisition system for the Living Bridge platform was designed to provide a continuous data stream for the environmental instrumentation for the project. The Midas CTD+, ADCP's, and Luxus Underwater cameras [17] all provide data to the MacArtney Multiplexer [18] which then gives each instrument a 'virtual com port'. All of these instruments are integrated by the GE Cimplicity SCADA System and the data is then sent into a database where the data can be accessed by tapping into the database's BIN.

### *Water Samples*

Water samples from the Living Bridge Deployment Platform at the Memorial Bridge in Portsmouth, NH were collected over a series of weeks as a part of the calibration with the Harvey Laboratory [19]. These water samples were processed for Chlorophyll-a levels to help our team calibrate the Seapoint SCF Fluorometer. Three water samples were taken throughout the duration of the Midas deployment at different periods in the tidal cycle to obtain a range of Chlorophyll values. The range associated with these samples over the changing tides helped correlate our hypothesis of Phytoplankton blooms in the Great Bay Estuary being flushed out through the Piscataqua during Ebb tides. When taking these water samples there was a methodical process to maintain accuracy of the Chlorophyll

contained in them provided by both Dr. Elizabeth Harvey and our boat Captain of the Galen Jay, Jonathan Hunt. The procedure to obtain these samples was the following;

1. Obtain clean 300 milliliter amber water samples collection bottles from the Harvey Laboratory
2. Once at the platform and ready to take a sample, the amber bottle must be rinsed with site water to ensure all contents inside the bottle resemble what will be collected
3. After the bottles were rinsed the actual sample must be taken relative to where the Midas was deployed which was approximately one meter below the surface
4. A total of four samples were to be collected every time and at the start of the collection important details must be recorded as in; the date, location of the sample, depth of the sample, stage of the tidal cycle, weather conditions, and the time window from the beginning of sample collection to the end.
5. The cap of the amber bottle can then be removed and to collect every sample each bottle was secured using electrical tape to the end of a two meter wooden shaft that could be lowered into the water column depth to one meter, without risking safety of the team members.
6. Once the bottle was firmly attached to the shaft it is vital to lower the bottle opening vertically facing downwards to hold in the trapped air until one meter was reached. At the desired depth then the bottle opening could be flipped vertically to release the air bubbles and fill the container with water that accurately depicts what the Midas would be reading at that time. The individual taking the sample must make sure the water forms a meniscus at the top of the bottle opening to ensure no air is trapped inside reducing the ability of the water to move inside the bottle and harm the microorganisms contained
7. A second member is needed to immediately cap the bottle once the shaft setup is lifted out of the water
8. For our duration during the months of March and April the ocean water is cold compared to air temperature. After all four samples are taken they need to be put in a cooler on blue ice to maintain the cool Piscataqua River Temperatures
9. Lastly the site water samples must be brought back to the Harvey Laboratory on the UNH Durham campus within three hours of collection time to reduce temperature rise and minimize the death of the microorganisms inside

This process is detailed and must be followed to maintain a quality data result when being processed in the Harvey Laboratory. Once at the Harvey Laboratory the site water samples are then processed and put through an acetone filtering procedure that accurately extracts all Chlorophyll-a from the 300 milliliter amber bottle as seen in figure 9.



**Figure 9.** Processing of water samples collected from the Memorial Bridge platform in Portsmouth, New Hampshire. The Acetone filtration process is being performed in the Harvey Laboratory to extract Chlorophyll-a.

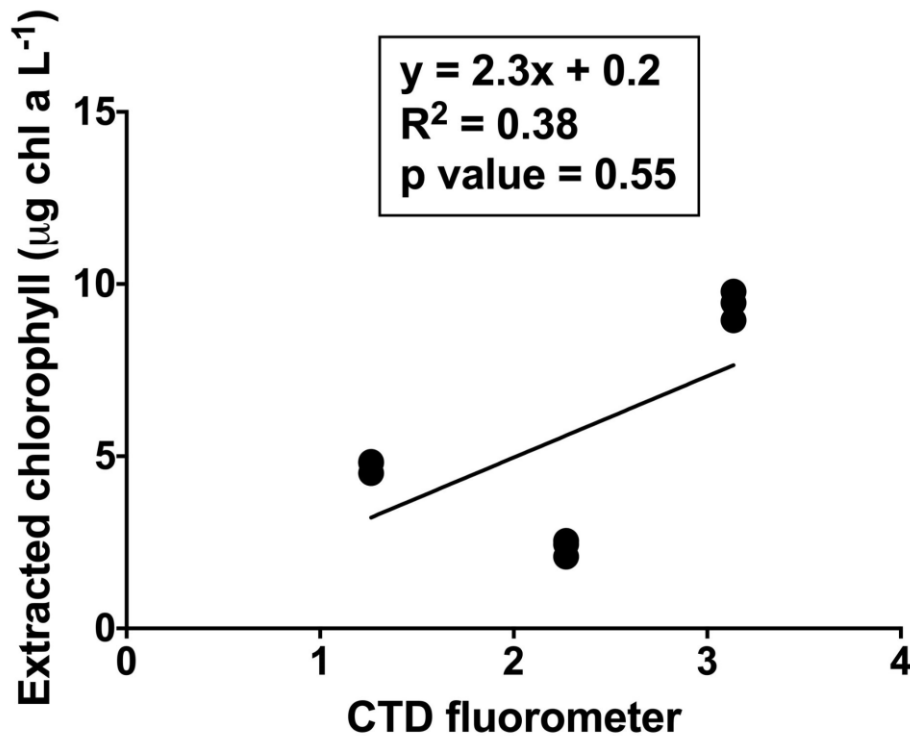
## **Collaboration with Harvey Laboratory**

### *Fluorometer Calibration*

Pre-deployment verification processes took place for all sensors contained on the Midas CTD+ but under certain circumstances this year the requirements were not present for any pre-deployment verifications for the Seapoint SCF Fluorometer. Right before the deployment of the Midas we found a calibration with Dr. Elizabeth Harvey and the Harvey Laboratory to help us calibrate the Midas's fluorometer. A plan was made to take water samples from our platform site to validate our fluorometer data and generate a calibration curve specific to the Chlorophyll-a local to the Piscataqua River ecosystem as seen in section *Data Collection, Water Samples*. The second part of the Midas fluorometer calibration that couldn't occur in this year's time frame would be to buy live algae that has a local habitat in the Piscataqua River. The goal is to view the fluorescent values through



the Seapoint SCF Fluorometer to gain additional verifications for this sensor's accuracy. Chlorophyll values found from the collected site samples as seen in the *Water Samples* section compared to the Midas CTD+ are viewed in figure 10.



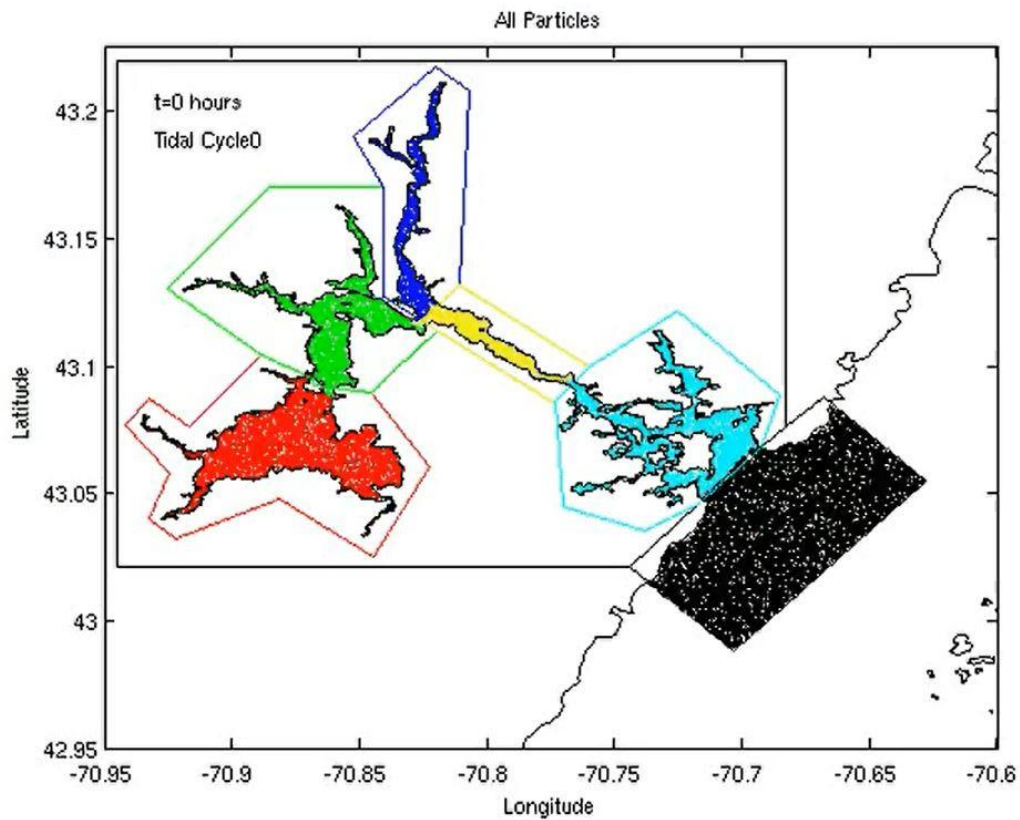
**Figure 10:** Chlorophyll value comparison from Tidal Turbine platform water samples vs. Midas Seapoint Fluorometer [22].

Another factor could be due to the fact that the Piscataqua River has high riverine inputs to its system and thus larger levels of colored dissolved organic matter (cDOM). This is an important factor because sometimes cDOM has similar fluorescence values to chlorophyll depending on the composition of it. While some potential relationship is starting to emerge seen in figure 10, more water samples from the tidal turbine platform need to be collected and analyzed to obtain a more accurate trend.

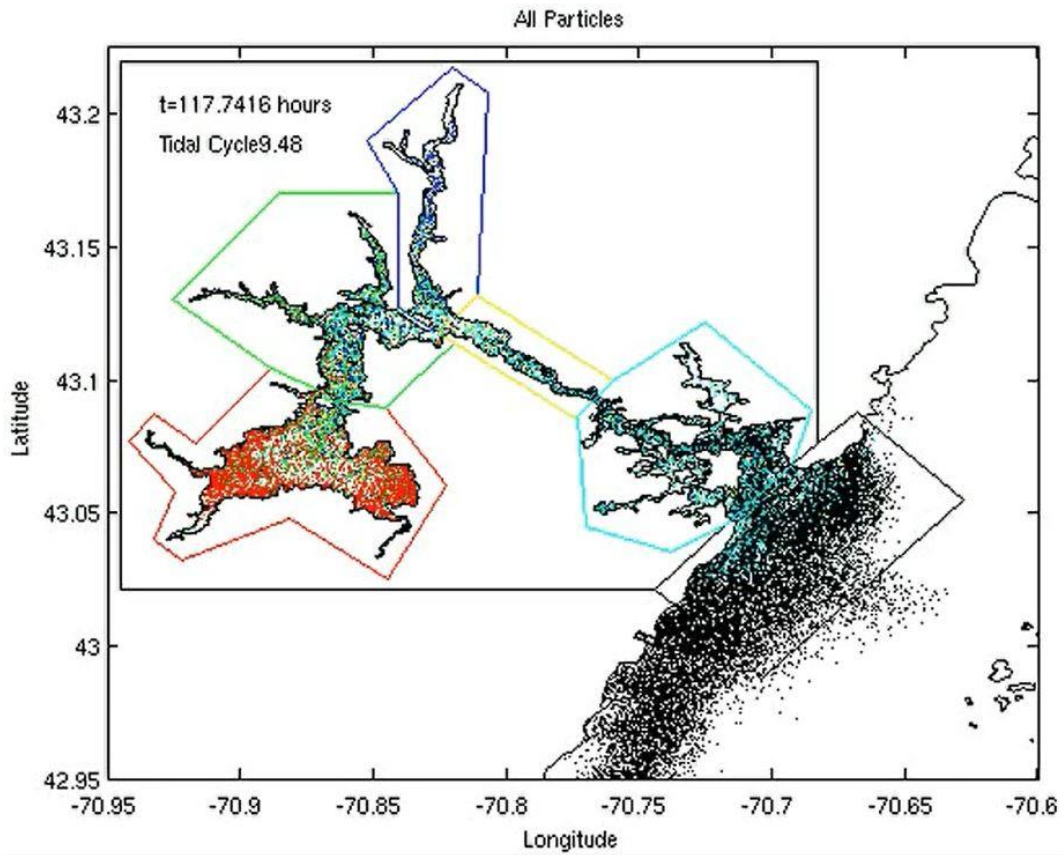
### *Hypothesis Generation*

Dealing with a copious amount of data from the Midas CTD+ a hypothesis relative to the local environment our instrument was deployed in was needed. The physical characteristics of estuaries like Great Bay allow more stagnant water conditions and less vertical mixing in the water column than areas of the outflow passage to the ocean like the Piscataqua River. Also within the Great Bay the estimated residence times are short compared to other large estuaries in New England and can be seen in table 5 and different

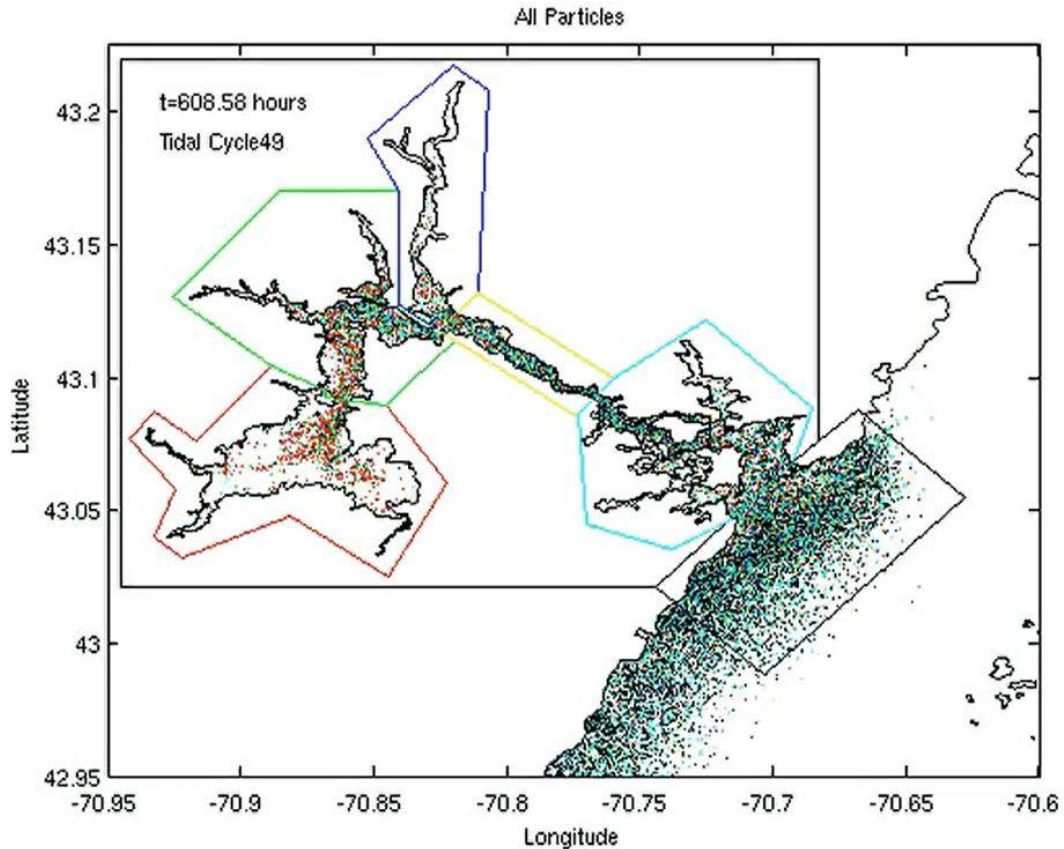
captured periods of simulated residence times using tracers over the timespan of a month in figures 11, 12, and 13.



**Figure 11:** The beginning of the residence simulation at t=0 days , 0 hours using modeled tracers in the Great Bay over a month [23].



**Figure 12:**  $t=4$  days , 6 hours into the residence simulation using modeled tracers in the Great Bay over a month [23].



**Figure 13:** t=25 days , 8.6 hours into the residence simulation using modeled tracers in the Great Bay over a month [23].

Region	Avg. Residence Time (days)
Great Bay	~ 3
Great Bay – Little Bay	~ 8
Upper Piscataqua R.	< 1

**Table 5:** HDR | HydroQual Hydrodynamic Model Average Residence Times in the Great Bay region [21]

Along with the data from figures 11, 12, 13 and table 5, Chlorophyll-a values processed from water samples collected at the Jackson Estuarine Laboratory that aligned with the Midas’s deployment period were provided by the Harvey Laboratory. These Chlorophyll-a values along with the averaged Seapoint SCF fluorometer data from the given days can be seen in table 6.

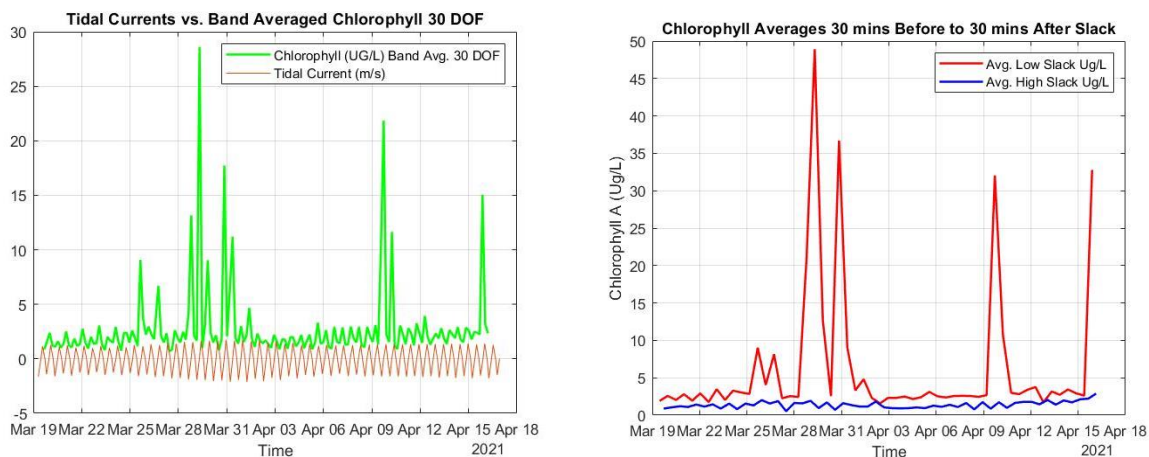
Date	JEL Chlorophyll-a average (ug/l)	Midas CTD+ average (ug/l)
3/24	21.7929	1.9274
3/31	23.3541	4.3619
4/7	23.4347	2.0009
4/14	16.4988	2.2360

**Table 6:** Comparison of Chlorophyll-a data from Jackson Estuarine Laboratory and Midas CTD+ stationed at the Memorial Bridge platform.

Our Midas data compared to the values found at Jackson Estuarine Laboratory along with what is depicted in table 6 and figures 11, 12, and 13 lead us to believe that phytoplankton blooms in the Great Bay system develop in the Little Bay region. From the Little Bay region of the Great Bay phytoplankton and thus Chlorophyll-a concentrations dissipate as current velocity and vertical mixing increase towards the Memorial Bridge and on an outward flow towards the ocean. Through these conclusions we predict that Chlorophyll-a peaks at the Midas CTD+ deployment location will be after EBB tide when the water and biological contents from the Little Bay area are flushed out towards the ocean during 'slack low' as seen in the *Time Series Analysis* section.

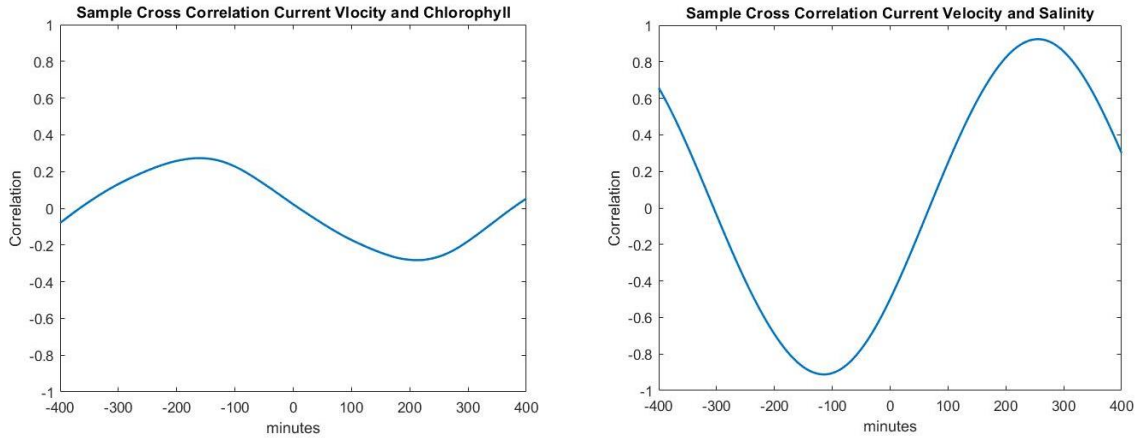
### Time Series Analysis

Some of our measurements contained a lot of noise and required smoothing via band averaging methods. Correlations between accessible data such as CTD measurements, tidal currents were made to determine trends. Through time series analysis, the Living Bridge team was able to plot evidence supporting a hypothesis made about low slack corresponding to peaks in Chlorophyll-A readings.



**Figure 14:** The left graph plots Chlorophyll A measurements and peak tidal currents in time. The right graph plots the average measured chlorophyll around high slack and low slack.

Figure 14 demonstrates that the fluorometer measurements have maximum and minimum values at a period similar to the tidal cycle. There is some phase between the tidal cycle and the chlorophyll cycle. Figure 14 also demonstrates that low slack tide has far greater averages of Chlorophyll A measurements than high slack tide.



**Figure 15:** The correlation plots use CTD measurements against tidal current predictions. Left plot depicts chlorophyll measurements correlated with peak tidal currents. Right plot depicts salinity measurements correlated with peak tidal currents. Current Velocity is from NOAA Predicted Data. Flood Tide is considered a positive current value and Ebb tide is considered a negative value in NOAA’s current predictions.

Correlation does not mean causation for hypothesis in this experiment. The lag seen in the left plot of figure 15 identifies that maximum correlation between tidal currents and chlorophyll measurements occur at a lag at approximately 180 minutes. The Pisataqua experiences a diurnal tidal cycle where tides change every 6 hours. Because the correlation is a negative value at 3 hours, this means chlorophyll is lowest at high slack tide and highest at low slack tide. Figure 15 also provides the correlation between current velocity and salinity in the right hand plot. This plot is used to confirm the principle and reliability of the chlorophyll correlation. The results of the salinity correlation are as expected, to see high salinity concentrations at high slack tide and low salinity concentrations at low slack tide.

Tidal currents have an effect on Chlorophyll-a measurements and concentrations in the piscataqua and the Tidal Deployment Platform experiences maximum values at high slack tide and minimum values at slack tides.

## Conclusion and Future Work

## *Post-Deployment*

The 2020-2021 Living Bridge team has recorded calibration techniques, performed platform operations, launched the Midas CTD +, and performed data analysis of measurements provided from the SCADA data acquisition system. Sensors of the Midas CTD + can be reevaluated by the same process performed in this paper and it is suggested. Biofouling and obstacle collision might cause the sensor reading to become skewed, this is especially a potential threat to the optical sensors. It is important to note that the CTD is also recording memory internally and will be available if the platform servers shutdown. As of late April, the team feels it is important to perform another deployment with different deployment settings to compare values at the testing site. Another abnormality we encountered were the values of the pressure sensor through the deployment period have low values of absolute pressure compared to the Airmar Weather station which is also located at the Memorial Bridge platform. The two ADCP's that are located on the Memorial bridge platform were deployed later than expected and in future work their data can be used to correlate tidal current values alongside the Midas CTD+ data. To date (4/30/2021) the Midas CTD+ is still deployed on the Living Bridge platform and when it is removed should be immediately cleansed of any and all biofoul that has accumulated on its sensors. A post-deployment sensor verification process should also be gone through to make sure each sensor can still accurately record data.

## **Appendix**

### ***Acoustic Sensor Mount***

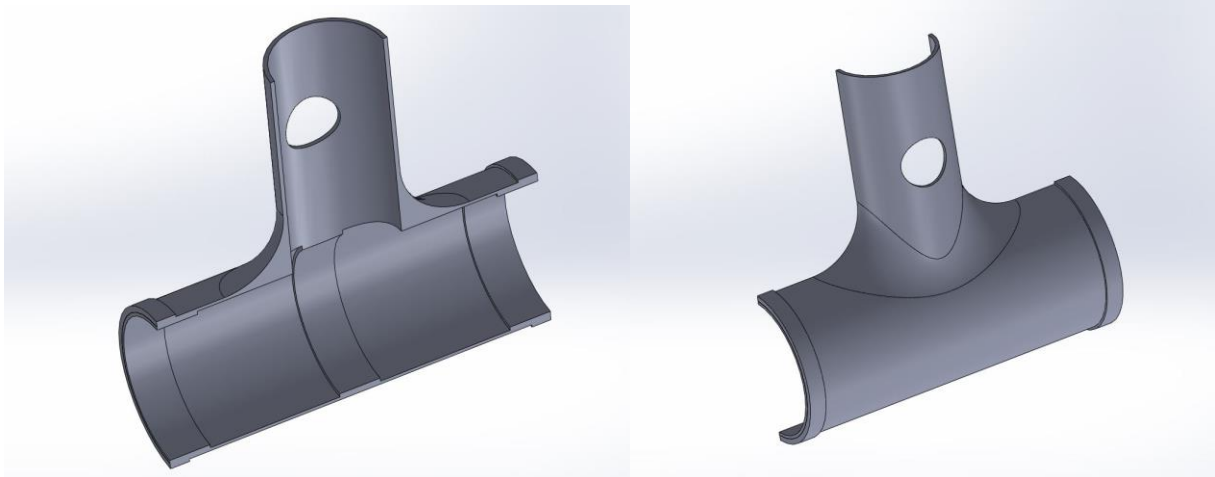
#### *Motivation for Design*

In cooperation with Professor Nathan Furey in the Department of Biological Sciences, the Living Bridge undergraduates designed a mount for an acoustic fish finder. "Estuaries are presumed to serve as important ecosystems for rainbow smelt because smelt travel between fresh and saltwater habitats, but the role of estuaries play in smelt populations is not well understood. Through experimental larval release, acoustic telemetry, and otolith microchemistry, a team of researchers led by Nathan Furey at the University of New Hampshire will explore how rainbow smelt use estuaries throughout their life cycle" [\*\*\*]. The fish finder given to the Living Bridge team is used to identify tagged Rainbow Smelt, a declining fish species in NH. The fish finder mounted to the Living Bridge tidal turbine platform will help provide info to understand Smelt migration of the Great Bay, Piscataqua River, and Atlantic. The Great Bay is a major tidal estuary located in Strafford and Rockingham counties in eastern New Hampshire, United States. By studying

migration of rainbow smelt in and out of Great Bay, inferences of smelt action in estuaries can be made with more supporting evidence.

### *Solid Model*

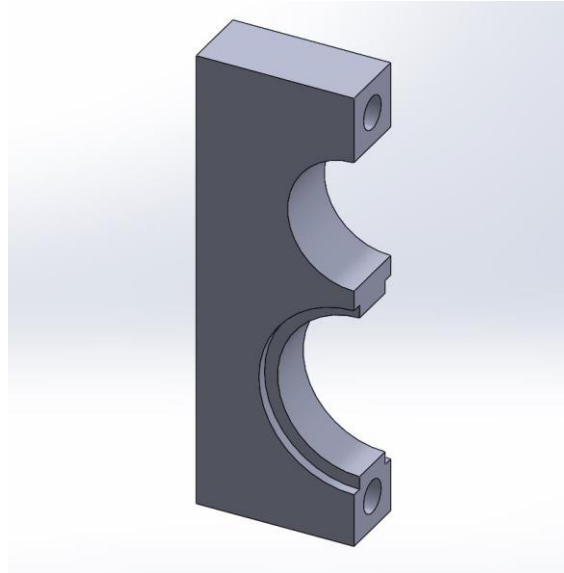
Using solid works and the knowledge of available pipe fixtures, solid model ideas for the fish finder mount were produced. Originally, a smooth interface was designed to completely encompass the fish finder and sit at the end of a 2 inch diameter galvanized pipe. This 2 in diameter galvanized pipe will hold the fish finder and be attached to the platform via a 2016-2017 Living Bridge mount. The 2016-2017 Living Bridge mounts hold 69.5 inch long 2 inch diameter galvanized pipes in the water. The mounts dampen expected oscillations the pipe might experience from currents and waves.



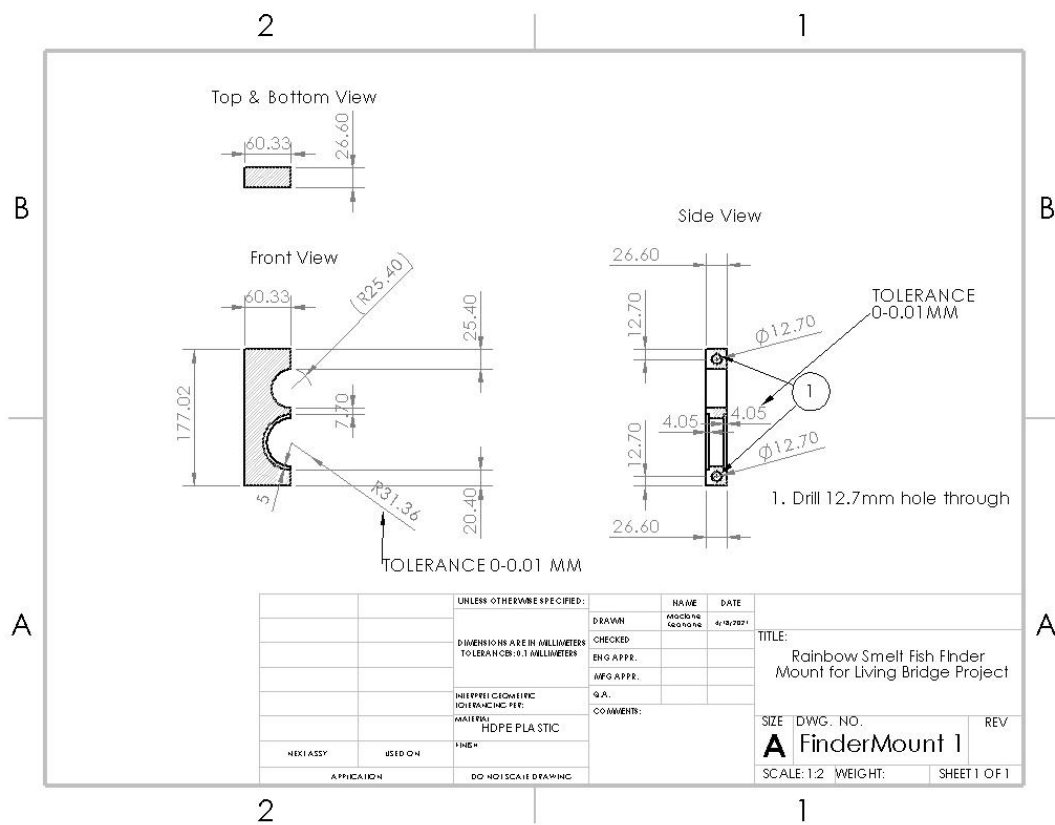
**Figure 16:** Two piece mount system shut by clamps around exterior and 1 inch nut and bolt through pipe.

The solid model idea seen in figure() above was exchanged for a method similar to how the Midas CTD + and ADCP are mounted to their 2 inch galvanized pipes. The design consists of a rectangular mount with fewer cuts and an overall simpler part. By utilizing the projects' extra pipe fixtures and high-density polyethylene plastic, the team developed this new model to save expenses and time that would go into manufacturing of a T-type connection mount.





**Figure 17:** Two of these rectangular mounts clamp the fish finder by two half inch bolts and nuts.



**Figure 18:** This is a drawing of the latest fish finder mount design.

The latest mount design clamps the fish finder and a cross sectional pipe that feeds through a standard 2 inch galvanized T-coupling which connects the cross sectional pipe

to the vertical platform mounted 2 inch galvanized pipe. The cross sectional pipe is parallel with the piscataqua river. 8 of these mounts can be produced to clamp a fish finder facing upstream on one side of the T-coupling and a fish finder facing downstream on the other side of the T-coupling. The only drawback to this design, not being parts or manufacturing, is that the shape might not coincide with the dampening solution mounts created by the 2016-2017 Living Bridge team.

*Bill of Materials: Acoustic Fish Sensor Mount*

(Onlinemetals, Shape Plastics, Boltdepot are online suppliers referenced in Bill of Materials)

Part	Quantity	Cost	Own or Purchase	Does Item Need Machining?
2 in diameter galvanized pipe (69.5 inches or longer)	1	\$58.33 Unit %58.33	Owned	Yes (drilled)
½ in Gal - bolt (8 inches or longer)	8	\$33.39 / 25 Unit \$1.68	Owned	No
½ in Gal - flat washer	16	\$16.43 / 100 Unit \$0.20	Owned	No
½ in Gal - nut	8	\$6.17 / 50 Unit \$0.19	Owned	No
HDPE (1.05 inches is SolidWorks Drawing thickness, 1 inch suffices)	1	\$66.40 / 4 sq. ft. \$14.60 / sq. ft.	Owned (some volume might need purchased for 8 fish finding mounts)	Yes (drilled and cut)

## Budget

Throughout the data collection process multiple trips to the Tidal Deployment Platform by the Galen Jay boat from the pier in New Castle, New Hampshire. Each trip consisted of payments to Sheri Millette for boat usage time which came from the undergraduates of the Tech 797 Living Bridge Team. An outline of our budget and the dates these payments can be outlined in table 8.

Date	Description	Payment (\$)	Current Balance
3/24/21	Water sample and Cleaning of Platform 1pm-4pm	83	917
4/14/21	Water sample and ADCP Deployment 9am-4pm	155	762
4/22/21	Water sample and Turbine Test 9am-2pm	155	607

**Table 8:** Living Bridge 2020-2021 Budget.

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