Final Report: PWSRCAC Contract #6531.16.01, “Weather Buoy Demonstration Project”

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Introduction

The Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) has long had an interest in the successful operation and maintenance of weather buoys installed in Prince William Sound (PWS). There have been multiple instances where weather buoys have failed and they have not been serviced in a timely manner. Committee members and PWS mariners have questioned the location of the West Orca Bay buoy and many believe the buoy should have been installed in a location closer to Naked Island. There was also a desire to transmit near real-time weather data via Automated Identification System (AIS) so it would be immediately available to vessels in the area.

The goal of the project was for PWSRCAC to work with the Prince William Sound Science Center (PWSSC) and Micro Specialties Inc. to develop and install a weather buoy at 60.667469N 147.186615W near Naked Island. Data would be disseminated in near real-time via the internet (and if possible, by AIS).

Narrative of project activities

The project was initially conceived in early 2015, presented to the Board in mid-2015, and approved in September 2015. Because commercial weather buoys are extremely expensive ($250K - $350K), it was proposed to develop a small weather buoy using local expertise, and deploy the buoy on the western side of PWS, to better capture northerly winds and waves. The original plan for the project was for set up of the data logging and telemetry to be done by Richard Brown of Micro Specialties, Inc., given his experience with constructing and deploying weather stations in remote locations. The design of the buoy was essentially a floating weather station, and it used the same instruments and logger as Micro Specialties weather stations statewide. The mounting of the instruments to the buoy, development of the mooring system, and deployment of the buoy would be done by Rob Campbell, in consultation with Richard Brown. Alan Sorum was the project manager, and also did much of the purchasing, to avoid overhead charges levied by PWSSC.

The buoy hull was ordered in October 2015, and arrived in Cordova in April 2016. The buoy hull chosen was a NexSens technologies CB1450 data buoy, which is the largest buoy they manufacture and is "designed for deployment in lakes, rivers, coastal waters, harbors, estuaries and other freshwater or marine environments". A copy of the buoy datasheet is included in Appendix A. After unpacking, the hull was cleaned, primed and painted with antifoul paint. Although specifically formulated for plastics, the first primer system did not adhere well to the hull. The primer and paint were manually removed and the buoy painted with a different antifoul paint, which had better adhesion (the polyurea skin of the buoy is flexible, which causes paints to crack). All of the weather instruments were purchased in August 2016, and were installed on the buoy that autumn. Given the conditions expected in mid-PWS, the through-bulkhead fittings that came with the buoy were not used for the weather instruments: all the wiring for the instruments were soldered to Subconn wet-pluggable connectors and sealed to withstand submersion; compatible bulkhead fittings were installed on the buoy hull.

The weather instruments were installed on the buoy tower as soon as they arrived, as Brown is very familiar with them and did not need them to develop the data logger program. There were however some instruments that were new to him, an ADCP (Acoustic Doppler Current Profiler) and a wave sensor. Those instruments, the data logger (a PWSSC unit left over from another project), and cell modem were shipped to Micro Specialties in July 2016 (see table 1 for a listing of the equipment mounted to the buoy).

While preparing the buoy hull and mounting the instruments, Campbell would check in with Brown from time to time on how the logger programming was coming. Brown was/is extremely busy and was having trouble finding time to spend on this project. By late February, he asked if Campbell would be willing to take on programming the logger. The electronics and instruments were shipped to Campbell in March 2017, and Campbell purchased a license for the Campbell Scientific software development environment to begin developing the logger control program.

Control of the instruments and data telemetry by the buoy was done with a Campbell Scientific CR1000 data logger. The CR1000 is a small, low-power computer with a number of analog and digital inputs that can control instruments, process measurements, and transmit data. It is controlled by a proprietary software called CRBasic, which is a proprietary programming language developed for controlling Campbell Scientific loggers. It is a language like any other and learning to speak or program in one takes some time. Being new to CRBasic, and not originally having time budgeted for development, it took several months to get up to speed on the language and figure out its various quirks. The weather instruments were all analog and were easy to configure, but the more complicated instruments (the ADCP and wave sensor) are digital and took over a month to get working with the logger. The wave sensor was particularly difficult to configure, because it uses a binary protocol (MODBUS, which could be queried with a CR1000 via an RS232 adapter), and is a new instrument to the market with fairly minimal documentation. There was several weeks of back-and-forth with the instrument support team and Campbell Scientific support to get the CR1000 and wave sensor communicating properly. An addition CR1000 program was written to calibrate the wave sensor and return the calibration parameters. The weather sensors were wired and working by June 2017, and the digital sensors were wired and working with the logger by July 2017. The final version of the logger program was about 700 lines of code, tracked several dozen variables, controlled power to the instruments, and sent out the data via ethernet and a cellular data connection (Appendix B). The buoy was deployed in Cordova harbor in July 2017, for *in situ* testing of the instruments and power system.

While the buoy was being developed, a 360 degree webcam was also developed to install on the buoy because no off-the-shelf solutions could be found. The camera system was developed by Paul Roberts (an engineer at the Scripps Institution of Oceanography in San Diego) and consisted of eight small cameras arranged in a circle. It used off the shelf equipment (Raspberry Pi cameras controlled by PiZero controllers, all being controlled by an Odroid computer), a custom power board, and was extremely flexible in terms of imagery collected (stills or video, the size/resolution of the images could be adjusted) and scheduling (it could take pictures at a set interval, or be set

Table 1: Major components of the weather buoy.

Component	Make/Model	Link
Hull	NexSens CB1450	http://www.nexsens.com/pdf/CB1450_datasheet.pdf
Solar panels	Ameresco BSP30-12-LSS	http://www.amerescosolar.com/bsp30-12-lss
Charge controller	Morningstar SunKeeper-12	https://www.morningstarcorp.com/products/sunkeeper/
Batteries	Optima 34M	https://www.optimabatteries.com/en-us/bluetop-dual-purpose-deep-cycle-and-starting/34m
Cellular Modem	Sierra Wireless RV50	https://source.sierrawireless.com/devices/rv-series/rv50/
Data logger	Campbell Scientific CR1000	https://www.campbellsci.com/cr1000
Anemometer	R.M. Young 05106	https://www.campbellsci.com/05106-l
Temp/rh sensor	Rotronic HC2S3	https://www.campbellsci.com/hc2s3
Barometer	Met One 092-L	https://www.campbellsci.com/p092
Solar radiation sensor	Hukseflux LP02	https://www.campbellsci.com/lp02-l
Wave sensor	Nexsens S500	http://www.nexsens.com/knowledge-base/nexsens-sensors/s500-wave-sensor/s500-inertial-wave-sensor.htm
Acoustic current meter	Nortek Aquadopp 600 kHz	https://www.nortekgroup.com/products/aquadopp-profiler-600-khz
Web camera	Paul Roberts (custom)	n/a

to take a series of pictures when power is applied). The camera system was ordered in March, but being a new design, took some figuring and testing; it arrived in Cordova in June 2017 and was tested on the bench into September. In our trials we found that the camera produced rather large images at full resolution, which necessitated changing cell data providers from Cordova Wireless to Verizon (Verizon has an "unlimited" data plan). It took until October for the new SIM card from Verizon to be activated. Integrating the camera to work with the buoy electronics took some modifications, the data logger was not able to supply enough current for the camera to boot. The electronics were removed from the buoy hull in October 2017, and the power system reconfigured: several relays were added to control power to the camera, wave sensor, and ADCP. The new Verizon SIM card was installed at the same time. The buoy was returned to the harbor for more testing in late October.

During in-harbor testing in early November, the wave sensor stopped reporting. Upon inspection, water was found inside the housing, due to a crack in the lid. The electronics were not damaged, but the sensor needed to be sent back to the manufacturer to have the fuses reset. The manufacturer reset the fuses and installed a new lid (at no charge). The source of the crack is not known, it was small and not easily seen and was likely present for some time. The sensor had been shipped between PWSSC, the manufacturer, and Micro Specialties several times and may have been damaged in transit. Although it added a further delay, discovering this issue in the harbor likely saved the wave sensor, because it was infiltrated only by rain water. Had seawater entered the housing the electronics would have been destroyed. The sensor was reinstalled on the buoy in the harbor in late November.

During continued in-harbor testing in December, the webcam stopped sending out images. In looking more closely at power use by the instruments, it was noted that power consumption was much higher than expected, and that the battery voltage was being drawn down during the boot up phase of the instruments. The camera was not sending out images because the power system was not able to provide enough current for the camera system to boot. This was puzzling, because the camera did not draw a tremendous amount of power (less than two amps for a fraction of a second) and the battery bank is quite large (four 55 amp-hour batteries in parallel). A high frequency test program was developed in CRBasic to better monitor power use during the measurement cycle, and Richard Brown consulted on power draw by the instruments and logger. Larger power supply wiring was installed and several more tests were done in December into January 2018. The buoy was removed from the harbor in early January to pull out the battery bank for closer inspection.

After charging and testing the batteries, all four batteries were judged defective, both by scalar resistance tester and full discharge curves determined with a battery analyzer; all were operating well below their expected capacities. The cause of the loss of capacity is unclear, the batteries may have been from a bad lot, frozen in transit, or may have sulfated in storage. The batteries were charged occasionally while in storage, but a bad cell in one battery could have prevented the other batteries from achieving a full charge, which would have led to sulfation of the battery plates and reduced capacity. The batteries used in the buoy (absorbed glass mat sealed batteries) are not easily rehabilitated once sulfated. Four replacement batteries were not available in Cordova, two were purchased in Cordova and two in Anchorage in mid January. Charging and testing the new batteries showed the ones purchased in Cordova to be in good shape, but the two batteries purchased in Anchorage were also found to be defective. Those batteries were eventually replaced by the supplier, after Campbell was able to get the original two batteries brought back to Anchorage.

While the development and testing of the buoy was ongoing, another parallel effort was led by Sorum to obtain a permit from the U.S. Coast Guard (USCG) to operate a synthetic aid to navigation. This would allow broadcasting of the buoy observations by AIS used by large commercial vessels (and visible on most newer GPS chartplotters). As far as we are able to ascertain, that was the first permit of its type and navigating the USCG bureaucracy was an extremely slow process. There had been some progress by January 2017, but if/when that permit was issued, a second permit would be required with the FCC. The integration of the AIS transmitter with the logger electronics could only begin after the issuance of those permits, and the integration itself would likely have been a nontrivial programming exercise. It was decided to deploy the buoy without the AIS system on board until permits and testing could be done.

Following more in-harbor testing with the new batteries, the buoy was deployed at the Naked Island site on April 6, 2018. The buoy data was transmitted hourly via FTP (File Transfer Protocol) over the cellular data connection and served on a data server as plain text files (one per hour). Initially the data was only available as text files and Campbell developed a simple web page to

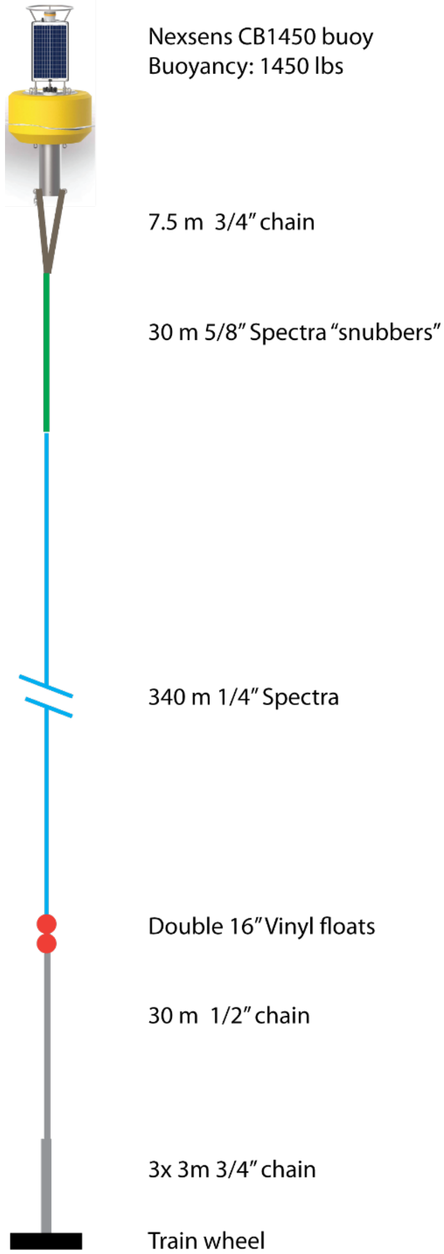


Figure 1: A simplified schematic of the buoy mooring system. The water depth at the site was 250 meter.

display the most current data that went live on April 16. The web page was static HTML that was generated hourly by a scheduled MATLAB program. At five minutes past the hour, the MATLAB program would take in the most recent data, create an HTML web page, and upload it to the buoy website. The process to serve the data to the Alaska Ocean Observing System (AOOS) also began with AOOS and Axiom Data Science staff in Anchorage at the same time.

The mooring system chosen for the buoy was of a "float inverse catenary" design, with buoyancy added to chain above the anchor, which is the design favored by the National Data Buoy Center for the deep ocean and the Great Lakes (Fig. 1; Taft et al. 2009). The mooring used a train wheel and 3/4 inch chain as the primary anchor, with a 30 meter section of 1/2 inch chain above buoyed by two 16 inch vinyl trawl floats. The primary mooring line was 1/4 inch UHMW spectra (Samson AmSteel Blue), which has been used by PWSSC for many years for subsurface moorings and has been found to be strong and durable.

Immediately above the mooring line were two "snubbers", which were lengths of 5/8 inch Samson AmSteel Blue line through which 5/8 inch bungee cord was fed through the middle and secured with clamps. The snubbers will extend to approximately twice their length under load and were added to further decouple the buoy from surface motions (to obtain better wave measurements). Snubbers of this type have been used by Campbell since 2012, on a profiling mooring that is deployed near the buoy site.

After installing the weather instruments on the buoy, it was found to be slightly top-heavy, and a length of 3/4 inch chain was hung immediately below it to stabilize it. The chain added a buoyancy penalty but stabilized the buoy and produced a strong righting moment.

The performance of the mooring system was assessed with the Mooring Design and Dynamics toolbox (Fig. 2; Dewey, 1999). A worst case scenario of 2 m/s surface currents (0-10m), 1 meters per second subsurface currents (10 meter-bottom), and 80-knot winds was assessed. Calculations for that scenario indicated that 69 percent of the surface buoyancy would be used, and there would be -400 kilogram weight under the anchor. Those results, combined with a generous scope (float inverse catenary designs used by the National Data Buoy Center (NDBC) have a scope of 1 to 1.5, the mooring had a scope of approximately 1.63) appeared to be an adequate margin for deployment (almost 500 pounds reserve buoyancy, around 850 pounds excess anchor weight).

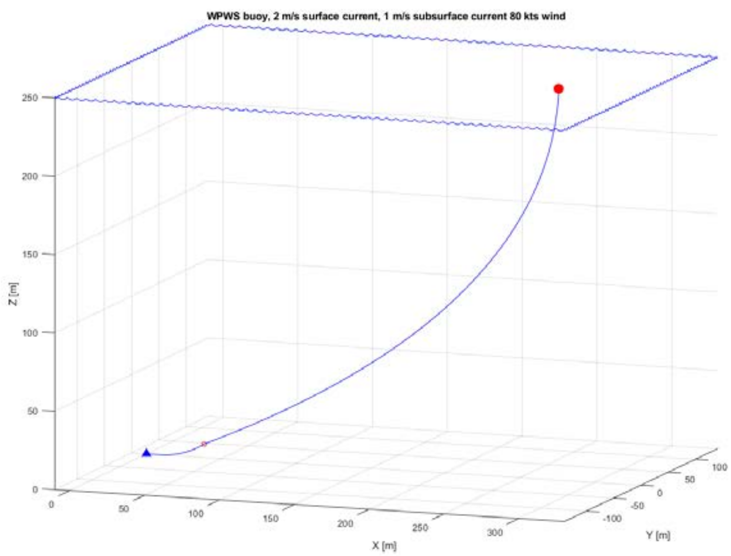


Figure 2: Diagram of the resulting catenary calculated by the Mooring Design & Dynamics toolbox run with 2 meters per second surface currents, 1 meters per second subsurface currents, and 80-knot winds.

The buoy transmitted data hourly via internet without any major interruptions and took a panoramic picture every day at noon. The buoy was working as expected until 16:00 on April 23, when communications were disrupted. Attempts were made to connect to the data logger on April 24, but were unsuccessful. The cellular modem powered on at the top of every hour on schedule and could be communicated with, but the data logger would not connect. The power relay to the cellular modem was controlled by the data logger, which powered the modem on from two minutes before the hour to four minutes after, indicating that the data logger was functioning at the time. It was initially thought that some settings on the modem had changed, and the modem was logged into several times that day when it powered up at the top of the hour in an attempt to diagnose what was wrong.

The webcam had transmitted images on April 22, but not on April 23. The April 24 photograph showed underwater and sky images, indicating that the tower on the top of the buoy had bent over or broken. Communications were permanently lost the afternoon of April 24, as wind and waves increased as a storm passed through. The buoy was visited following the storm on the morning of April 26, and only the hull remained (Fig. 3). The hull and mooring were recovered and brought back to Cordova. Upon inspection it was found that the wave sensor housing was broken open and the bulkhead for the wave sensor data cable had broken, allowing seawater to enter the buoy hull. Most of the electronics were exposed to salt water while powered and were damaged beyond repair.

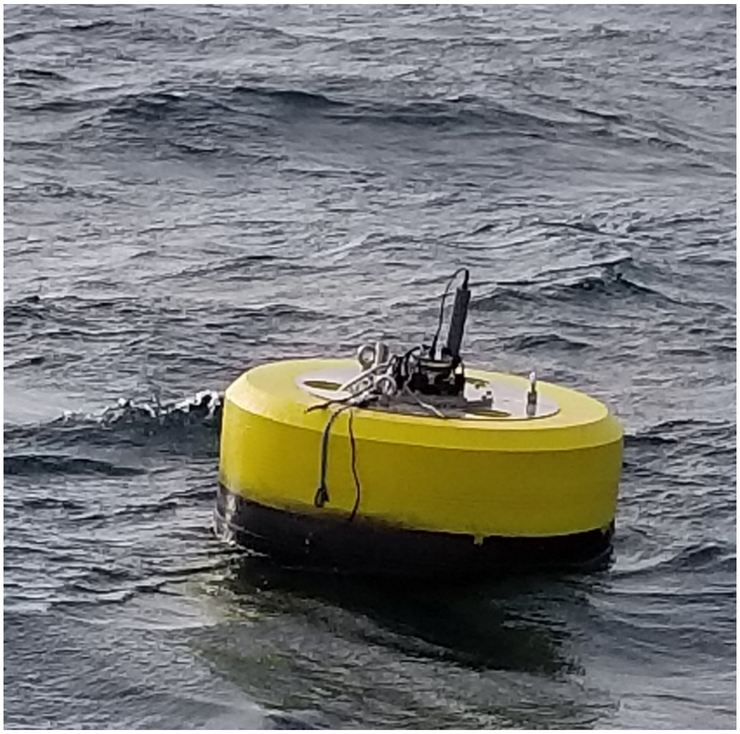


Figure 3: The buoy hull on site, April 26.

Conditions at the site leading up to the failure

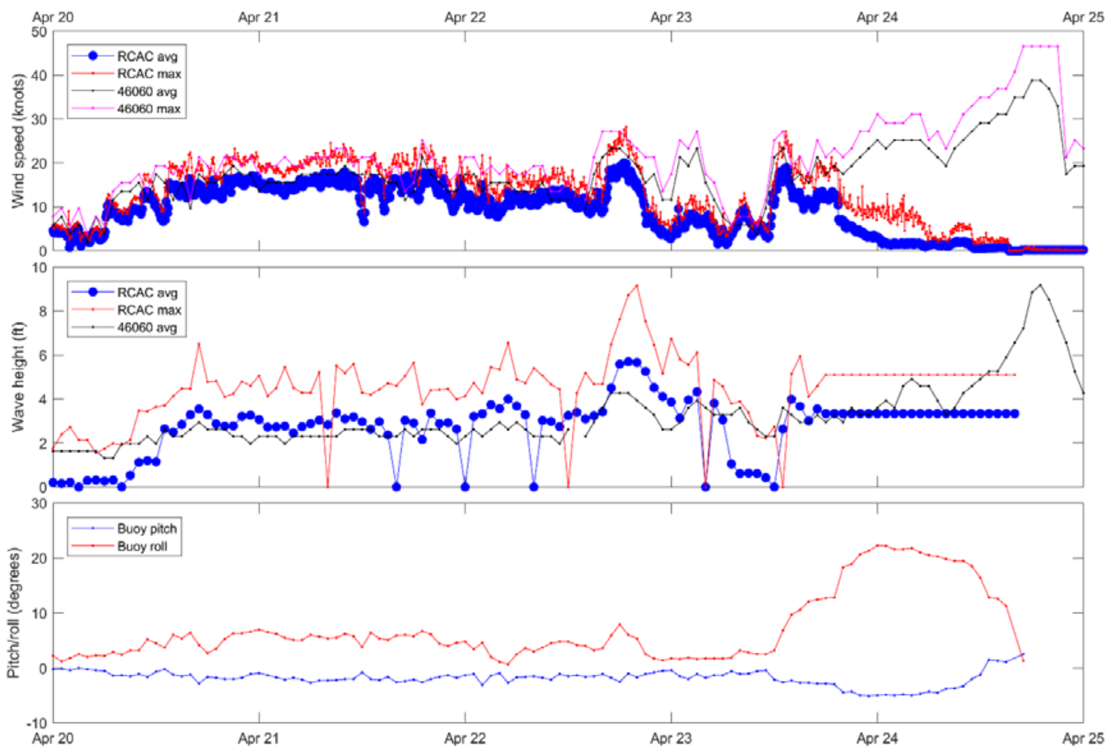


Figure 4: Conditions at the Western PWS buoy site and at NDBC buoy 46060 (Eastern PWS) in the days leading up to the failure, including average and gust wind speeds (top panel), wave heights (middle panel), and tilt and roll from the ACDP on the buoy.

The buoy appears to have been working as expected until at least April 22, and recorded similar wind speeds and wave heights to buoy 46060 in eastern PWS (Fig. 4). There was a difference in wind speeds early on April 23, which appears to have been due to wind shifts (the buoys measured winds from different directions). Wave heights were similar to buoy 46060 (if slightly higher, which would be expected from easterly winds). Wave heights dropped towards midday on April 23, then increased before settling at a constant 1 meter average height for the rest of the record. Those measurements are no doubt spurious. The tilt and roll recorded by the ADCP showed nothing abnormal until midday on April 23, when both departed from their regular values. That time (1300-1400) is likely when the tower began to fail, tilting the buoy over. As the tower tilted over, it probably hit the wave sensor, cracking open the housing and causing the spurious constant values.

What caused the failure? A hypothesis

The buoy tower is in a tripod configuration, with the legs of the tripod fitting into mounts and held in place by clevis pins (Fig. 5).

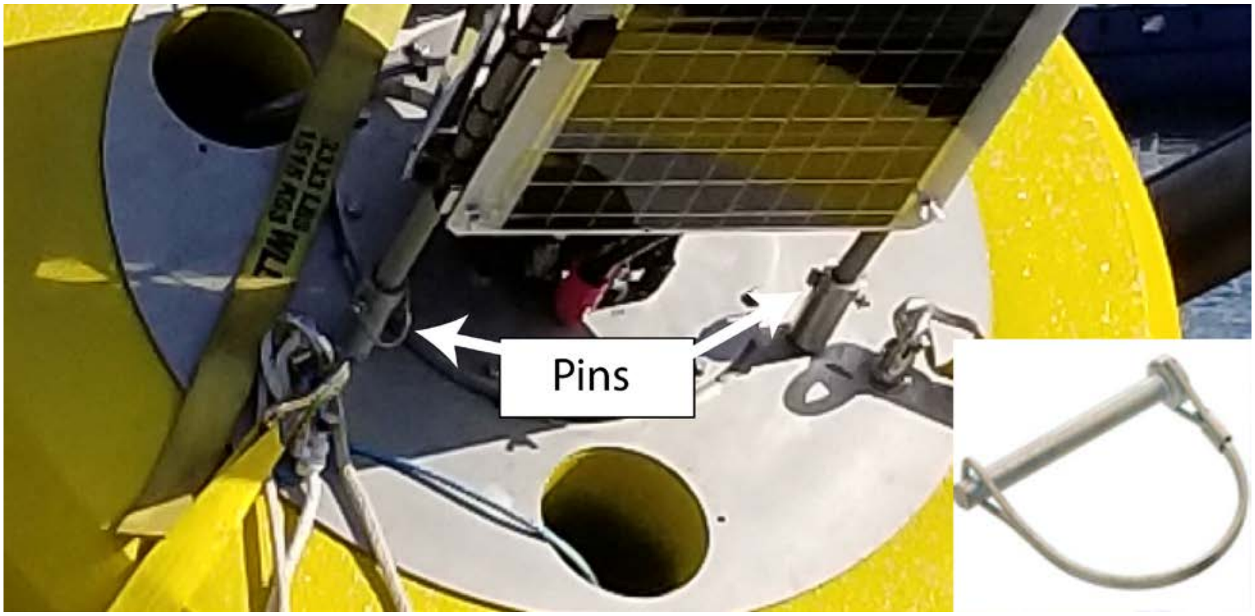


Figure 5: Close up of the tower fastening arrangement on deck prior to deployment. Inset: A clevis pin of the type used to secure the tower.

The pins were installed on the buoy as instructed in the buoy manual, although they were installed from inside-out, because the arrangement of the lifting eyes on the buoy were so close that the pins could not be inserted from the outside (Fig. 5, 6).

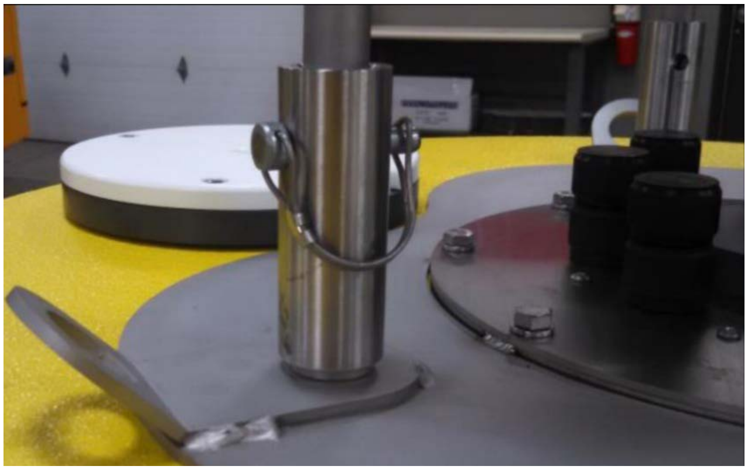


Figure 6: An image from the buoy quickstart manual showing the insertion of the clevis pins. Note that the lifting eye arrangement is different from the PWS buoy.

Following recovery two of the mounts affixing the tower to the hull were found to be missing (Fig. 7).

Figure 7: The top of the buoy hull post-failure.

The mounts were secured to the buoy by long sections of 5/8 inch stainless steel threaded rod that pass through stainless steel plates on top and below the foam of the floatation section. The remaining threaded rod was removed and inspected, it had some minor surface corrosion but did not appear to be compromised (Fig. 8). Having noted some corrosion on the stainless portion of the buoy hull, all three rods had had sacrificial anodes affixed to ring on the submerged end prior to deployment.

Figure 8: The threaded rod to which the remaining mount was attached. Inset: a close-up of the section that was threaded into the tower mount. No major corrosion is evident.

The most parsimonious explanation for the failure of the buoy tower is that one of the clevis pins failed or fell off, which allowed the buoy tower to bend the remaining threaded rods under wind and wave action. The buoy floatation is closed cell foam and would deflect as the threaded rods bent, failing to provide any structural buttressing to the tower. By April 24, the tower had fallen into the water and it broke off during the April 24-25 storm. An illustration of the mode of failure is shown in Figures 9 and 10.

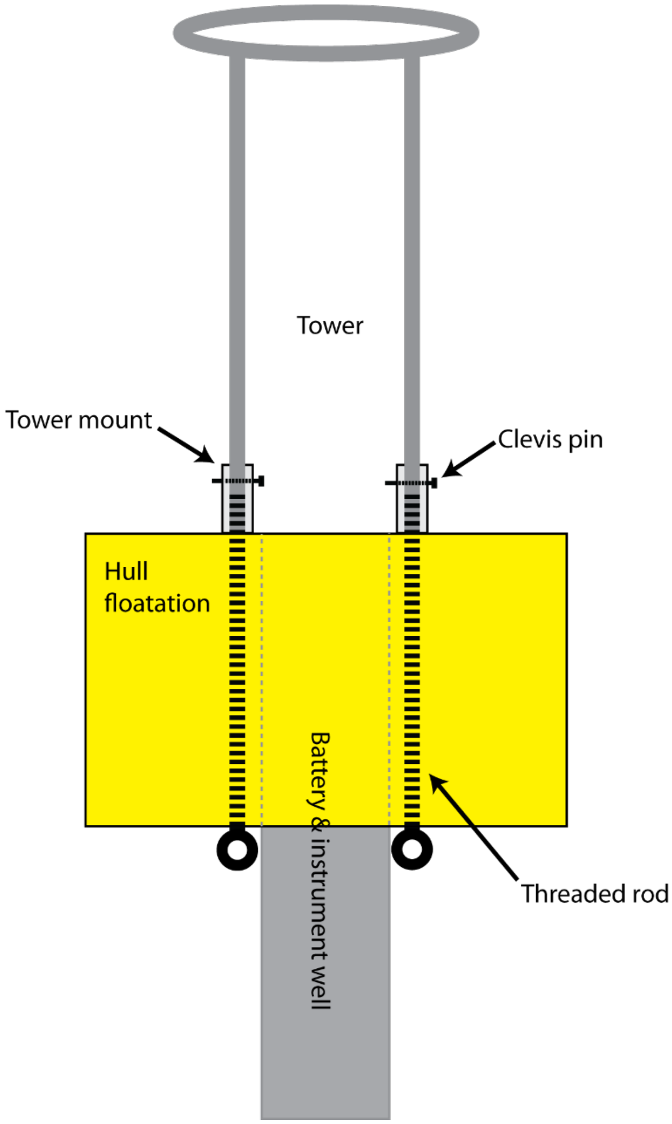


Figure 9: A schematic of the buoy prior to the failure. Only two of the three tripod legs are shown for simplicity.

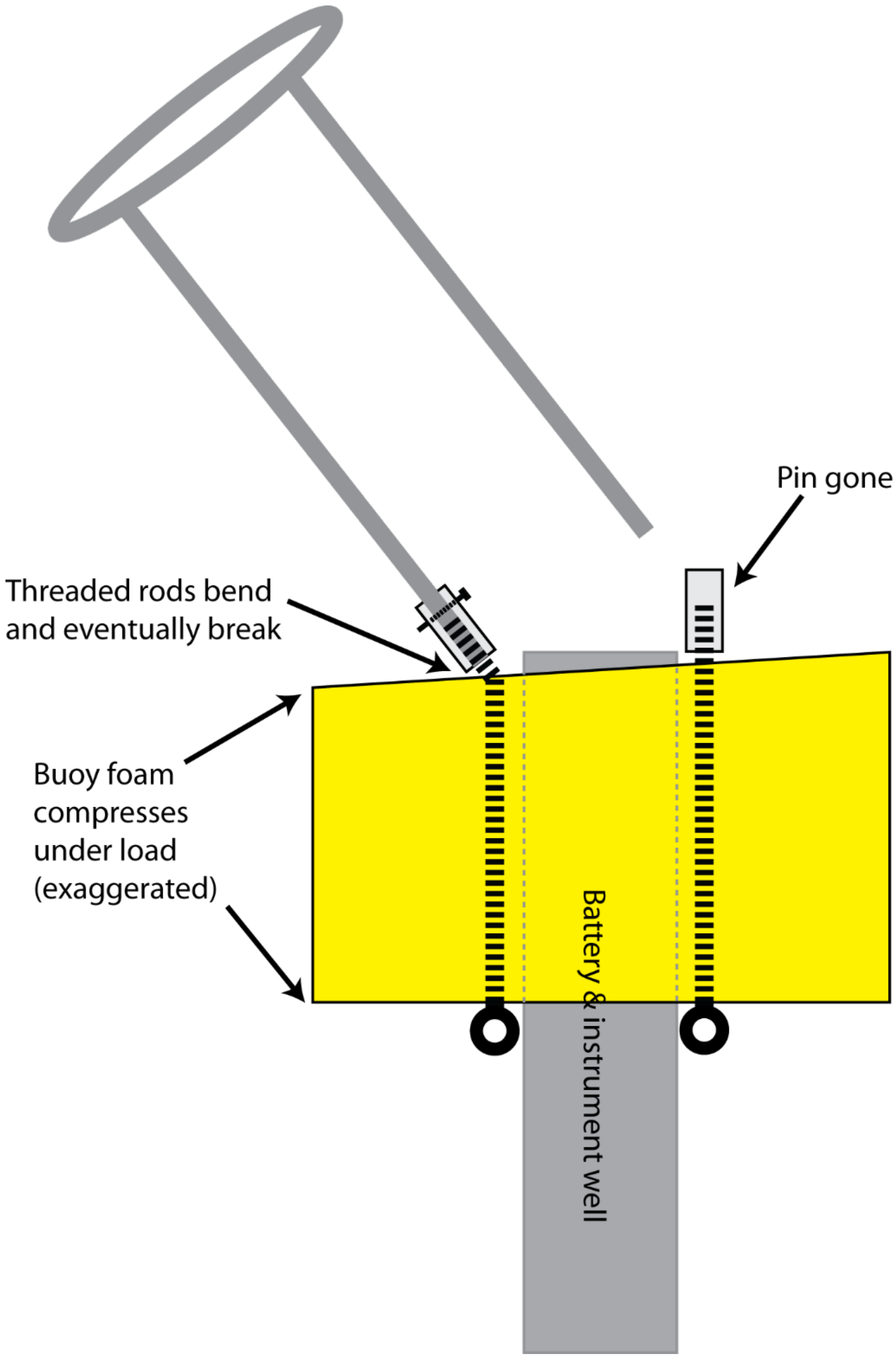


Figure 10: Failure of the buoy tower by loss of one of the clevis pins.

Why did the project get so far behind schedule?

To be clear, the purpose of this report is not to assign blame. Every participant entered into the project with the best of intentions and have done their best to move it forward. There are several issues that lead to the long delays by this project.

Overcommitted participants

There is something of a gap between proposing a project and having it approved, and other projects may come online in the meantime. We were somewhat optimistic in the proposal process about the time commitment for some of the development activities and Brown found himself overcommitted with other projects during the early part of this project. Campbell agreed to take on that portion of the project to move it forward, but had several other projects also requiring time and attention. This project consumed a great deal of unbudgeted time. That lead to a lot of juggling of tasks and a number of setbacks. Dealing with those setbacks then took longer than if there was dedicated time set aside for them. This is something of a structural feature of the way contract driven projects done by private nonprofits happen and something to watch for in future.

Ambitious timeline

On paper this was a fairly simple project, using mostly off the shelf components. The reality was that it has been a rather complex development project and should have had much more time allocated to the testing of the various components. The wave sensor delivered with the buoy was a very new instrument (single digit serial number) and the webcam developed was completely novel.

Bad luck

Every project has its setbacks, but this project had a truly impressive list of misfortunes. Some were perhaps foreseeable in hindsight, but most were not. The author has reflected on this a great deal and is of the opinion that there was very little that could have been done better, beyond building in more time for testing for such a development-heavy project.

Why did the buoy fail so quickly and so catastrophically?

The manufacturer makes and sells the CB1450 buoy for great lakes and coastal deployments, and it was purchased with the understanding that it was appropriate for Prince William Sound (which is smaller than most of the Great Lakes). Campbell followed up with the manufacturer post-failure (a copy of the correspondence is included in Appendix C) about the likelihood of a clevis pin failure and the manufacturer responded that the clevis pins are used in several of their buoy models and have been deployed in several open water locations without any issues to date. Although the conditions experienced by the buoy prior to the failure were not calm (Fig. 4: 10-20-knot winds, 4-6-foot seas), they were by no means extreme or of a level that would be expected to damage an uncompromised buoy.

The loss of the tower caused a breach to the buoy hull because it impacted a PVC pipe used to support an RS232 adapter that was required to allow the CR1000 data logger to communicate with the wave sensor. The adapter is quite large (about 8 inches long) and was built in such a way that it could not be placed inside the buoy hull. Instead, it came with a specific through-hull connector that mated with the bulkhead fittings that came with the buoy which required it to be externally mounted. A length of PVC pipe was used to secure the adapter from buoy motion and was affixed to the through-hull bulkhead connector, which was made of plastic. It is likely that when the tower tipped over it contacted the PVC pipe and cracked the bulkhead fitting which allowed seawater to drip into the buoy hull. The total amount of water allowed in was small (less than a gallon), but the compromised bulkhead happened to be directly over most of the electronics inside the buoy (the cellular modem and data logger) and both were exposed to seawater while powered which destroyed the circuit boards. Although in hindsight this was not the best arrangement, the loss of the tower obviously did not figure into the design considerations. All of the instruments and cabling were well secured to the tower in the expectation that it would hold up to the deployment conditions.

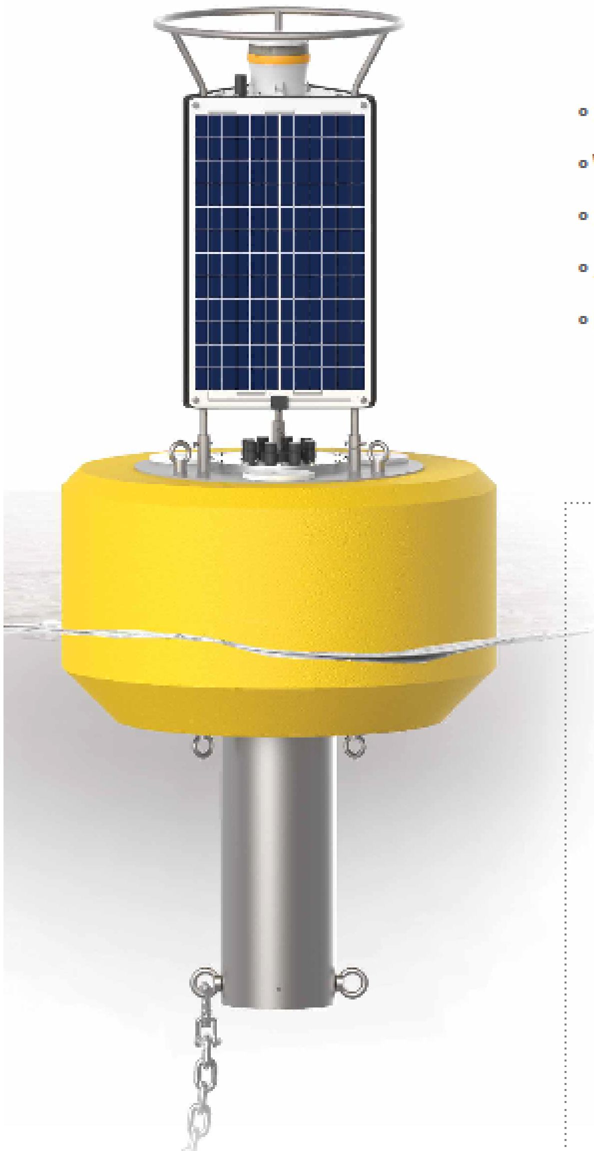
Remaining equipment

The hull was brought back to the PWSSC in Cordova and the salt water in the hull cleaned out. It is undamaged and has been stored for the time being. The bulkhead is also in storage, it can be made watertight again by replacing the broken fitting. All of the batteries are in good condition and are currently stored on a battery maintenance system in the PWSSC warehouse. The ADCP current meter, which is a submersible instrument and fully operational, is still mounted on the hull. The wave sensor control board is not operational, but the accelerometer is sealed and likely salvageable. The manufacturer has indicated that they will offer a discount if there is interest in making the buoy operational again (see Appendix C). If there are concerns about the durability of the system it could be deployed in a more sheltered location, such as monitoring weather and current conditions adjacent to the Alyeska Marine Terminal Security Zone in Port Valdez.

Literature cited

Dewey, R.K. 1999. Mooring Design & Dynamics—a Matlab package for designing and analyzing oceanographic moorings. Marine Models. 1:103-157.

Taft, B., Teng, C. and T. Rutledge. 2009. Low load compliant mooring history and status update. OCEANS 2009, MTS/IEEE Biloxi. DOI: 10.23919/OCEANS.2009.5422447



CB-1450

DATA BUOY

- Self-powered data logging buoy
- Wi-Fi, radio, cellular or satellite telemetry
- Supports a variety of environmental sensors
- Accommodates most environmental data loggers
- Rugged polymer-coated foam hull

The NexSens CB-1450 Data Buoy is designed for deployment in lakes, rivers, coastal waters, harbors, estuaries and other freshwater or marine environments. The floating platform supports both topside and subsurface environmental monitoring sensors including weather stations, wave sensors, thermistor strings, multi-parameter sondes, Doppler current profilers and other monitoring instruments.

The buoy is constructed of an inner core of cross-linked polyethylene foam with a tough polyurea skin. A topside 50" tall stainless steel tower includes three 55-watt 12VDC solar panels, and a center 12" ID x 55" tall data well accommodates batteries, data loggers, sensors, and more. Three 4" pass-through holes with female NPT bottom threads allow for quick connection of instrument deployment pipes and custom sensor mounts. The stainless steel frame supports both single point and multi-point moorings.

The CB-1450 Data Buoy is optimized for use with NexSens data loggers. Wireless telemetry options include Wi-Fi, spread spectrum radio, cellular and Iridium satellite. Compatible digital and analog sensor interfaces include RS-232, RS-485, SDI-12, VDC, mA, and pulse count. The top of the instrument well includes 8 pass-through ports for power and sensor interface. Each port offers a UW receptacle with double O-ring seal for a reliable waterproof connection.

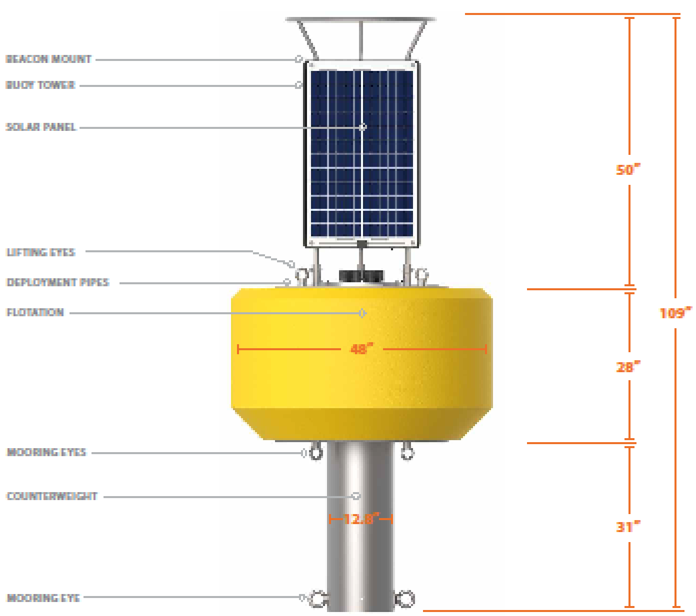
NEXSENS technology

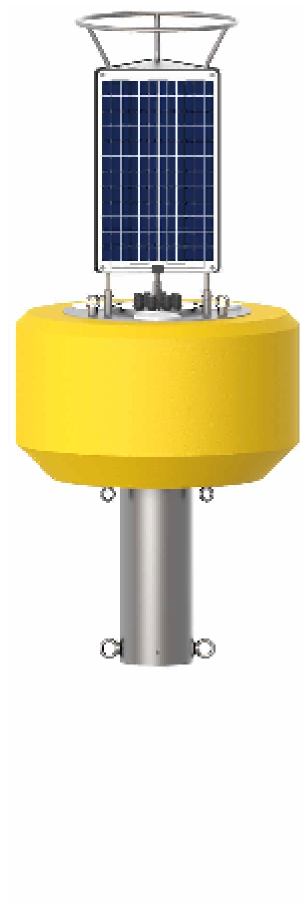
CB-1450

DATA BUOY

specifications

Hull Dimensions	48" (121.92 cm) outside diameter; 28" (71.12 cm) tall
Tower Dimensions	50" (127.00 cm) tall, 7/8 tubular
Data Well Dimensions	12.25" (31.12 cm) inside diameter; 55" (139.70 cm) tall
Weight	500 lbs. (226.80 kg)
Buoyancy	1450 lbs. (657.71 kg)
Hull Material	Cross-linked polyethylene foam with polyurea coating & stainless steel deck
Hardware Material	304 Stainless steel
Mooring Attachments	1 or 2 point, ⅝" eyenut
Solar Power	(3) 55-watt 12 VDC solar panels





parts list

Part #	Description
CB-1450	Data buoy with polymer-coated foam hull & (3) 55-watt solar panels, 1450 lb. buoyancy
CB-A09-3	Battery harness with integrated solar regulator & (3) 55 A-Hr batteries
CB-A09-4	Battery harness with integrated solar regulator & (4) 55 A-Hr batteries
ISIC-CB	ISIC data logger housed in CB-Series buoy lid enclosure
RTU-R-SS	Radio modem & antenna kit, 900 MHz
RTU-C	Cellular modem & antenna kit, multi-carrier
RTU-I	Satellite modem & antenna kit, Iridium
M650H-Y	Solar marine light with 4 nautical mile range, 15 flashes per minute, yellow
914M	Deployment pipe assembly with stop bolt & threaded male adapter, 4" schedule 80 PVC, 32" length
CB-WS-M	Lufft WS-Series weather sensor mount for CB-Series data buoys
CB-WX-M	Airmar WX-Series weather sensor mount for CB-Series data buoys

NEXSENS technology

tel: 937.426.2703
8am to 7pm EST, Monday-Friday

fax: 937.426.1125

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nexsens.com

```
'PWSwx_v4.cr1
'Program to sample wx instruments, Nortek Aquadpp and S500 wave sensor
'Reduced power version - 1 sec scan rate
'RV50 power off with relay C5 from 00:58 to 00:05
'Waves sampling done once per hour, off otherwise powered off with
relay C6
'Camera sampling done once per hour, off otherwise powered off with
rely C7
'ADCP sampling done every 20 minutes

SequentialMode

'$$$$ VARIABLES AND UNITS %%%%

'CR1000 variables
Public BattV
Public PTemp_C
Dim IntRHmv As Float
Public IntRH As Float
Dim FloatSwitchmv
Public FloatSwitchStatus As String * 7
Units IntRH=%
Units BattV=Volts
Units PTemp_C=Deg C

'FTP variables
Dim RT(9)
Dim fnames As String * 256
Dim YYYY As String, MO As String, DD As String, HH As String, MM As
String, SS As String
Public ADCPname As String *256
Public FTPResult, FTPResult_ADCP

'Weather instrument variables
Public AirTC
Public RH
Public DewPt
Public BP_mbar
Public WS_ms
Public WindDir
Public Wgust
Public SlrW
Public SlrkJ

Units AirTC=Deg C
Units RH=%
Units DewPt=Deg C
Units BP_mbar=mbar
Units WS_ms=m/s
Units WindDir=degrees
Units Wgust=m/s
Units SlrW=W/m^2
```

```
Units SlrkJ=kJ/m^2

'ADCP variables
Dim RawString As String * 1000, SplitStrings(137) As String * 70,
Public ADCP_month As Long
Public ADCP_day As Long
Public ADCP_year As Long
Public ADCP_hour As Long
Public ADCP_minute As Long
Public ADCP_second As Long
Public ADCP_error_code As Long
Public ADCP_status_code As Long
Public ADCP_batt_volt As Float
Public ADCP_soundspeed As Float
Public ADCP_heading As Float
Public ADCP_pitch As Float
Public ADCP_roll As Float
Public ADCP_pressure As Float
Public ADCP_tempurature As Float
Public ADCP_analog1 As Float
Public ADCP_analog2 As Float

Public Bin0_spd As Long
Public Bin1_spd As Long
Public Bin2_spd As Long
Public Bin3_spd As Long
Public Bin4_spd As Long
Public Bin5_spd As Long
Public Bin6_spd As Long
Public Bin7_spd As Long
Public Bin8_spd As Long
Public Bin9_spd As Long
Public Bin10_spd As Long
Public Bin11_spd As Long
Public Bin12_spd As Long
Public Bin13_spd As Long
Public Bin14_spd As Long
Public Bin15_spd As Long
Public Bin16_spd As Long
Public Bin17_spd As Long
Public Bin18_spd As Long
Public Bin19_spd As Long
Public Bin20_spd As Long
Public Bin21_spd As Long
Public Bin22_spd As Long
Public Bin23_spd As Long
Public Bin24_spd As Long
Public Bin25_spd As Long
Public Bin26_spd As Long
Public Bin27_spd As Long
Public Bin28_spd As Long
Public Bin29_spd As Long
```

```
Public Bin30_spd As Long
Public Bin31_spd As Long
Public Bin32_spd As Long
Public Bin33_spd As Long
Public Bin34_spd As Long
Public Bin35_spd As Long
Public Bin36_spd As Long
Public Bin37_spd As Long
Public Bin38_spd As Long
Public Bin39_spd As Long
Public Bin0_dir As Long
Public Bin1_dir As Long
Public Bin2_dir As Long
Public Bin3_dir As Long
Public Bin4_dir As Long
Public Bin5_dir As Long
Public Bin6_dir As Long
Public Bin7_dir As Long
Public Bin8_dir As Long
Public Bin9_dir As Long
Public Bin10_dir As Long
Public Bin11_dir As Long
Public Bin12_dir As Long
Public Bin13_dir As Long
Public Bin14_dir As Long
Public Bin15_dir As Long
Public Bin16_dir As Long
Public Bin17_dir As Long
Public Bin18_dir As Long
Public Bin19_dir As Long
Public Bin20_dir As Long
Public Bin21_dir As Long
Public Bin22_dir As Long
Public Bin23_dir As Long
Public Bin24_dir As Long
Public Bin25_dir As Long
Public Bin26_dir As Long
Public Bin27_dir As Long
Public Bin28_dir As Long
Public Bin29_dir As Long
Public Bin30_dir As Long
Public Bin31_dir As Long
Public Bin32_dir As Long
Public Bin33_dir As Long
Public Bin34_dir As Long
Public Bin35_dir As Long
Public Bin36_dir As Long
Public Bin37_dir As Long
Public Bin38_dir As Long
Public Bin39_dir As Long

Units ADCP_month = month
```

```
Units ADCP_day = day
Units ADCP_year = year
Units ADCP_hour = hour
Units ADCP_minute = minute
Units ADCP_second = second
Units ADCP_error_code = unitless
Units ADCP_status_code = unitless
Units ADCP_batt_volt = VDC
Units ADCP_soundspeed = m/s
Units ADCP_heading = degrees
Units ADCP_pitch = degrees
Units ADCP_roll = degrees
Units ADCP_pressure = dbar
Units ADCP_tempurature = degrees C
Units ADCP_analog1 = counts
Units ADCP_analog2 = counts
Units Bin0_spd = MM/s
Units Bin1_spd = MM/s
Units Bin2_spd = MM/s
Units Bin3_spd = MM/s
Units Bin4_spd = MM/s
Units Bin5_spd = MM/s
Units Bin6_spd = MM/s
Units Bin7_spd = MM/s
Units Bin8_spd = MM/s
Units Bin9_spd = MM/s
Units Bin10_spd = MM/s
Units Bin11_spd = MM/s
Units Bin12_spd = MM/s
Units Bin13_spd = MM/s
Units Bin14_spd = MM/s
Units Bin15_spd = MM/s
Units Bin16_spd = MM/s
Units Bin17_spd = MM/s
Units Bin18_spd = MM/s
Units Bin19_spd = MM/s
Units Bin20_spd = MM/s
Units Bin21_spd = MM/s
Units Bin22_spd = MM/s
Units Bin23_spd = MM/s
Units Bin24_spd = MM/s
Units Bin25_spd = MM/s
Units Bin26_spd = MM/s
Units Bin27_spd = MM/s
Units Bin28_spd = MM/s
Units Bin29_spd = MM/s
Units Bin30_spd = MM/s
Units Bin31_spd = MM/s
Units Bin32_spd = MM/s
Units Bin33_spd = MM/s
Units Bin34_spd = MM/s
Units Bin35_spd = MM/s
```

```
Units Bin36_spd = MM/s
Units Bin37_spd = MM/s
Units Bin38_spd = MM/s
Units Bin39_spd = MM/s
Units Bin0_dir = 0.1 degrees
Units Bin1_dir = 0.1 degrees
Units Bin2_dir = 0.1 degrees
Units Bin3_dir = 0.1 degrees
Units Bin4_dir = 0.1 degrees
Units Bin5_dir = 0.1 degrees
Units Bin6_dir = 0.1 degrees
Units Bin7_dir = 0.1 degrees
Units Bin8_dir = 0.1 degrees
Units Bin9_dir = 0.1 degrees
Units Bin10_dir = 0.1 degrees
Units Bin11_dir = 0.1 degrees
Units Bin12_dir = 0.1 degrees
Units Bin13_dir = 0.1 degrees
Units Bin14_dir = 0.1 degrees
Units Bin15_dir = 0.1 degrees
Units Bin16_dir = 0.1 degrees
Units Bin17_dir = 0.1 degrees
Units Bin18_dir = 0.1 degrees
Units Bin19_dir = 0.1 degrees
Units Bin20_dir = 0.1 degrees
Units Bin21_dir = 0.1 degrees
Units Bin22_dir = 0.1 degrees
Units Bin23_dir = 0.1 degrees
Units Bin24_dir = 0.1 degrees
Units Bin25_dir = 0.1 degrees
Units Bin26_dir = 0.1 degrees
Units Bin27_dir = 0.1 degrees
Units Bin28_dir = 0.1 degrees
Units Bin29_dir = 0.1 degrees
Units Bin30_dir = 0.1 degrees
Units Bin31_dir = 0.1 degrees
Units Bin32_dir = 0.1 degrees
Units Bin33_dir = 0.1 degrees
Units Bin34_dir = 0.1 degrees
Units Bin35_dir = 0.1 degrees
Units Bin36_dir = 0.1 degrees
Units Bin37_dir = 0.1 degrees
Units Bin38_dir = 0.1 degrees
Units Bin39_dir = 0.1 degrees

'S500 Wave Sensor
Public ModbusResult
Public ModbusResults
Public ModbusResultSF
Public SampFreq As Long
Dim WaveParam(30) As Long
```

```
Public
WVHT,DPD,APD,Dir,Hs,H10,Havg,Hmax,Ts,T10,Tavg,Tp5,NumZero,Steep,Spread
Public Wavestart As String
Public Waveresult As String
Units WVHT = m
Units DPD = s
Units APD = s
Units Dir = degrees
Units Hs = m
Units H10 = m
Units Havg = m
Units Hmax = m
Units Ts = s
Units T10 = s
Units Tavg = s
Units Tp5 = s


'%%%% DATA TABLES %%%%

DataTable(Wx,True,-1)
 DataInterval(0,5,Min,0)
 Minimum(1,BattV,FP2,False,True)
 Sample(1,PTemp_C,FP2)
 Sample(1,IntRH,FP2)
 Sample(1,FloatSwitchStatus,String)
 Average(1,AirTC,FP2,0)
 Average(1,RH,FP2,0)
 Average(1,DewPt,FP2,0)
 Average(1,BP_mbar,FP2,0)
 Maximum (1,WS_ms,FP2,False,False)
 Minimum (1,WS_ms,FP2,False,False)
 WindVector (1,WS_ms,WindDir,FP2,False,0,0,0)
 FieldNames("WS_ms_avg,WindDir_deg,WS_ms_stdev")
 Maximum(1,Wgust,FP2,False,False)
 Average(1,SlrW,FP2,0)
 Totalize(1,SlrkJ,IEEE4,False)
EndTable

'ADCP
DataTable (ADCP,True,-1)
 DataInterval (0,20,Min,0)
 'Sample (1,SplitStrings(137),String)
 Sample (1,ADCP_month,Long)
 Sample (1,ADCP_day,Long)
 Sample (1,ADCP_year,Long)
 Sample (1,ADCP_hour,Long)
 Sample (1,ADCP_minute,Long)
 Sample (1,ADCP_second,Long)
 Sample (1,ADCP_error_code,Long)
 Sample (1,ADCP_status_code,Long)
 Sample (1,ADCP_batt_volt,FP2)
```

```
Sample (1,ADCP_soundspeed,FP2)
Sample (1,ADCP_heading,FP2)
Sample (1,ADCP_pitch,FP2)
Sample (1,ADCP_roll,FP2)
Sample (1,ADCP_pressure,FP2)
Sample (1,ADCP_tempurature,FP2)

Sample (1,Bin0_spd,Long)
Sample (1,Bin0_dir,Long)
Sample (1,Bin1_spd,Long)
Sample (1,Bin1_dir,Long)
Sample (1,Bin2_spd,Long)
Sample (1,Bin2_dir,Long)
Sample (1,Bin3_spd,Long)
Sample (1,Bin3_dir,Long)
Sample (1,Bin4_spd,Long)
Sample (1,Bin4_dir,Long)
Sample (1,Bin5_spd,Long)
Sample (1,Bin5_dir,Long)
Sample (1,Bin6_spd,Long)
Sample (1,Bin6_dir,Long)
Sample (1,Bin7_spd,Long)
Sample (1,Bin7_dir,Long)
Sample (1,Bin8_spd,Long)
Sample (1,Bin8_dir,Long)
Sample (1,Bin9_spd,Long)
Sample (1,Bin9_dir,Long)
Sample (1,Bin10_spd,Long)
Sample (1,Bin10_dir,Long)
Sample (1,Bin11_spd,Long)
Sample (1,Bin11_dir,Long)
Sample (1,Bin12_spd,Long)
Sample (1,Bin12_dir,Long)
Sample (1,Bin13_spd,Long)
Sample (1,Bin13_dir,Long)
Sample (1,Bin14_spd,Long)
Sample (1,Bin14_dir,Long)
Sample (1,Bin15_spd,Long)
Sample (1,Bin15_dir,Long)
Sample (1,Bin16_spd,Long)
Sample (1,Bin16_dir,Long)
Sample (1,Bin17_spd,Long)
Sample (1,Bin17_dir,Long)
Sample (1,Bin18_spd,Long)
Sample (1,Bin18_dir,Long)
Sample (1,Bin19_spd,Long)
Sample (1,Bin19_dir,Long)
Sample (1,Bin20_spd,Long)
Sample (1,Bin20_dir,Long)
Sample (1,Bin21_spd,Long)
Sample (1,Bin21_dir,Long)
Sample (1,Bin22_spd,Long)
```

```
 Sample (1,Bin22_dir,Long)
 Sample (1,Bin23_spd,Long)
 Sample (1,Bin23_dir,Long)
 Sample (1,Bin24_spd,Long)
 Sample (1,Bin24_dir,Long)
 Sample (1,Bin25_spd,Long)
 Sample (1,Bin25_dir,Long)
 Sample (1,Bin26_spd,Long)
 Sample (1,Bin26_dir,Long)
 Sample (1,Bin27_spd,Long)
 Sample (1,Bin27_dir,Long)
 Sample (1,Bin28_spd,Long)
 Sample (1,Bin28_dir,Long)
 Sample (1,Bin29_spd,Long)
 Sample (1,Bin29_dir,Long)
 Sample (1,Bin30_spd,Long)
 Sample (1,Bin30_dir,Long)
 Sample (1,Bin31_spd,Long)
 Sample (1,Bin31_dir,Long)
 Sample (1,Bin32_spd,Long)
 Sample (1,Bin32_dir,Long)
 Sample (1,Bin33_spd,Long)
 Sample (1,Bin33_dir,Long)
 Sample (1,Bin34_spd,Long)
 Sample (1,Bin34_dir,Long)
 Sample (1,Bin35_spd,Long)
 Sample (1,Bin35_dir,Long)
 Sample (1,Bin36_spd,Long)
 Sample (1,Bin36_dir,Long)
 Sample (1,Bin37_spd,Long)
 Sample (1,Bin37_dir,Long)
 Sample (1,Bin38_spd,Long)
 Sample (1,Bin38_dir,Long)
 Sample (1,Bin39_spd,Long)
 Sample (1,Bin39_dir,Long)
EndTable

'Wave Sensor
DataTable(Waves,True,-1)
 DataInterval(0,1,hr,0) 'Read at top of hour
 Sample(1,SampFreq,Long)
 Sample(1,WVHT,IEEE4)
 Sample(1,DPD,IEEE4)
 Sample(1,APD,IEEE4)
 Sample(1,Dir,IEEE4)
 Sample(1,Hs,IEEE4)
 Sample(1,H10,IEEE4)
 Sample(1,Havg,IEEE4)
 Sample(1,Hmax,IEEE4)
 Sample(1,Ts,IEEE4)
 Sample(1,T10,IEEE4)
 Sample(1,Tavg,IEEE4)
```

```
 Sample(1,Tp5,IEEE4)
 Sample(1,NumZero,IEEE4)
 Sample(1,Steep,IEEE4)
 Sample(1,Spread,IEEE4)
EndTable


'Main Program
BeginProg

 'Main Scan
 Scan(1,sec,2,0) 'DO NOT SET COUNT TO 1

  'RV50 power
  If TimeIsBetween (58,5,60,min)
   PortSet(5,1)
  Else
   PortSet(5,0)
  EndIf

  'Webcam power - only if enough light (SlrW>5)
 '  If TimeIsBetween (0,15,60,min) 'AND SlrW > 5
 '  PortSet(7,1)
  ' Else
  ' PortSet(7,0)
  'EndIf

  'Wave sensor relay
  If TimeIsBetween (39,01,60,min)
   PortSet(6,1) 'Toggle power
  Else
   PortSet(6,0)
  EndIf

  'Start Wave sensor
  If TimeIntoInterval (40,60,Min)
   'Wave sensor obs
   ModbusMaster(ModbusResult,COM2,9600,1,6,1,12299,1,1,50,3) 'Start
sampling waves
   If ModbusResult = 0
    Wavestart = "Waves started"
   Else
    Wavestart = "Waves start failed"
   EndIf
  EndIf

  'Default CR1000 Datalogger Battery Voltage measurement 'BattV'
  Battery(BattV)
  'Default CR1000 Datalogger Wiring Panel Temperature measurement
'PTemp_C'
  PanelTemp(PTemp_C,_60Hz)
  'Internal Humidity
```

```
  VoltSe(IntRHmv,1,mV5000,12,True,0,_60Hz,1,0)
  IntRH=((IntRHmv/1000)-0.816)/0.030154812
  'Float Switch
  VoltSe(FloatSwitchmv,1,mV5000,11,True,0,_60Hz,1,0)
  If FloatSwitchmv > 1000 Then
   FloatSwitchStatus = "Flooded!"
  Else
   FloatSwitchStatus = "OK"
  EndIf

  'Wx instruments
  'HC2S3 (constant power) Temperature & Relative Humidity Sensor
measurements 'AirTC' and 'RH'
  VoltSe(AirTC,1,mV2500,1,0,0,_60Hz,0.1,-40)
  VoltSe(RH,1,mV2500,2,0,0,_60Hz,0.1,0)
  If RH>100 AND RH<103 Then RH=100
  DewPoint(DewPt,AirTC,RH)
  '092 Barometric Pressure Sensor measurement 'BP_mbar'
  VoltSe(BP_mbar,1,mV5000,9,1,0,_60Hz,0.1,600)
  '05106 Wind Speed & Direction Sensor measurements 'WS_ms' and
'WindDir'
  PulseCount(WS_ms,1,1,1,1,0.098,0)
  BrHalf(WindDir,1,mV2500,8,1,1,2500,True,20000,_60Hz,355,0)
  If WindDir>=360 OR WindDir<0 Then WindDir=0
  AvgRun (Wgust,1,WS_ms,5)
  'LP02 Pyranometer measurements 'SlrkJ' and 'SlrW'
  VoltDiff(SlrW,1,mV25,3,True,0,_60Hz,1,0)
  If SlrW<0 Then SlrW=0
  SlrkJ=SlrW*0.8156607
  SlrW=SlrW*81.56607

  CallTable Wx

NextScan

  'Read Wave sensor output at top of hour
  SlowSequence
  Scan(1,Hr,0,0)
   'Get Sampling Frequency
   ModbusMaster(ModbusResultSF,COM2,9600,1,4,SampFreq,12289,1,1,50,3)

   'Get and parse results
   ModbusMaster(ModbusResults,COM2,9600,1,4,WaveParam,12325,30,1,50,3)
   If ModbusResults = 0
    Waveresult = "Wave results read"
   Else
    Waveresult = "Waves results failed"
   EndIf

   MoveBytes(WVHT,0,HexToDec(Hex(WaveParam(1)) +
Hex(WaveParam(2))),0,4)
```

```
   MoveBytes(DPD,0,HexToDec(Hex(WaveParam(3)) +
Hex(WaveParam(4))),0,4)
   MoveBytes(APD,0,HexToDec(Hex(WaveParam(5)) +
Hex(WaveParam(6))),0,4)
   MoveBytes(Dir,0,HexToDec(Hex(WaveParam(7)) +
Hex(WaveParam(8))),0,4)
   MoveBytes(Hs,0,HexToDec(Hex(WaveParam(9)) +
Hex(WaveParam(10))),0,4)
   MoveBytes(H10,0,HexToDec(Hex(WaveParam(11)) +
Hex(WaveParam(12))),0,4)
   MoveBytes(Havg,0,HexToDec(Hex(WaveParam(13)) +
Hex(WaveParam(14))),0,4)
   MoveBytes(Hmax,0,HexToDec(Hex(WaveParam(15)) +
Hex(WaveParam(16))),0,4)
   MoveBytes(Ts,0,HexToDec(Hex(WaveParam(17)) +
Hex(WaveParam(18))),0,4)
   MoveBytes(T10,0,HexToDec(Hex(WaveParam(19)) +
Hex(WaveParam(20))),0,4)
   MoveBytes(Tavg,0,HexToDec(Hex(WaveParam(21)) +
Hex(WaveParam(22))),0,4)
   MoveBytes(Tp5,0,HexToDec(Hex(WaveParam(23)) +
Hex(WaveParam(24))),0,4)
   MoveBytes(NumZero,0,HexToDec(Hex(WaveParam(25)) +
Hex(WaveParam(26))),0,4)
   MoveBytes(Steep,0,HexToDec(Hex(WaveParam(27)) +
Hex(WaveParam(28))),0,4)
   MoveBytes(Spread,0,HexToDec(Hex(WaveParam(29)) +
Hex(WaveParam(30))),0,4)
   CallTable Waves

 NextScan

 'ADCP
 SlowSequence
 Scan(20,min,0,0)
  SerialOpen (Com1,9600,3,0,1000)
  SerialOut (Com1,"@@@@@@","",0,0)
  Delay(0,100,msec) 'Wait 100 msec for 2nd string
  SerialOut (Com1,"K1W%!Q",CHR(06)+CHR(06),0,0)
  Delay(0,10,Sec) 'Wait 2 sec for ADCP to boot
  SerialOut (Com1,"MA",CHR(06)+CHR(06),1,10) 'Take sample
  SerialFlush(Com1)
  SerialIn (RawString,com1,18000,-1,1000) 'Wait and collect data
  SplitStr (SplitStrings,RawString," ",137,0) ' Split out lines

  'ADCP header data
  Dim ADCP_hdr(17);
  SplitStr(ADCP_hdr,SplitStrings(1)," ",17,0)
  ADCP_month = ADCP_hdr(1)
  ADCP_day = ADCP_hdr(2)
  ADCP_year = ADCP_hdr(3)
  ADCP_hour = ADCP_hdr(4)
```

```
ADCP_minute = ADCP_hdr(5)
ADCP_second = ADCP_hdr(6)
ADCP_error_code = ADCP_hdr(7)
ADCP_status_code = ADCP_hdr(8)
ADCP_batt_volt = ADCP_hdr(9)
ADCP_soundspeed = ADCP_hdr(10)
ADCP_heading = ADCP_hdr(11)
ADCP_pitch = ADCP_hdr(12)
ADCP_roll = ADCP_hdr(13)
ADCP_pressure = ADCP_hdr(14)
ADCP_tempurature = ADCP_hdr(15)
ADCP_analog1 = ADCP_hdr(16)
ADCP_analog2 = ADCP_hdr(17)

'Pull out values from data lines
ADCP_month =SplitStrings(1)
ADCP_day=SplitStrings(2)
ADCP_year=SplitStrings(3)
ADCP_hour=SplitStrings(4)
ADCP_minute=SplitStrings(5)
ADCP_second=SplitStrings(6)
ADCP_error_code=SplitStrings(7)
ADCP_status_code=SplitStrings(8)
ADCP_batt_volt=SplitStrings(9)
ADCP_soundspeed=SplitStrings(10)
ADCP_heading=SplitStrings(11)
ADCP_pitch=SplitStrings(12)
ADCP_roll=SplitStrings(13)
ADCP_pressure=SplitStrings(14)
ADCP_tempurature=SplitStrings(15)
ADCP_analog1=SplitStrings(16)
ADCP_analog2=SplitStrings(17)
Bin0_spd=SplitStrings(19)
Bin1_spd=SplitStrings(22)
Bin2_spd=SplitStrings(25)
Bin3_spd=SplitStrings(28)
Bin4_spd=SplitStrings(31)
Bin5_spd=SplitStrings(34)
Bin6_spd=SplitStrings(37)
Bin7_spd=SplitStrings(40)
Bin8_spd=SplitStrings(43)
Bin9_spd=SplitStrings(46)
Bin10_spd=SplitStrings(49)
Bin11_spd=SplitStrings(52)
Bin12_spd=SplitStrings(55)
Bin13_spd=SplitStrings(58)
Bin14_spd=SplitStrings(61)
Bin15_spd=SplitStrings(64)
Bin16_spd=SplitStrings(67)
Bin17_spd=SplitStrings(70)
Bin18_spd=SplitStrings(73)
Bin19_spd=SplitStrings(76)
```

```
Bin20_spd=SplitStrings(79)
Bin21_spd=SplitStrings(82)
Bin22_spd=SplitStrings(85)
Bin23_spd=SplitStrings(88)
Bin24_spd=SplitStrings(91)
Bin25_spd=SplitStrings(94)
Bin26_spd=SplitStrings(97)
Bin27_spd=SplitStrings(100)
Bin28_spd=SplitStrings(103)
Bin29_spd=SplitStrings(106)
Bin30_spd=SplitStrings(109)
Bin31_spd=SplitStrings(112)
Bin32_spd=SplitStrings(115)
Bin33_spd=SplitStrings(118)
Bin34_spd=SplitStrings(121)
Bin35_spd=SplitStrings(124)
Bin36_spd=SplitStrings(127)
Bin37_spd=SplitStrings(130)
Bin38_spd=SplitStrings(133)
Bin39_spd=SplitStrings(136)
Bin0_dir=SplitStrings(20)
Bin1_dir=SplitStrings(23)
Bin2_dir=SplitStrings(26)
Bin3_dir=SplitStrings(29)
Bin4_dir=SplitStrings(32)
Bin5_dir=SplitStrings(35)
Bin6_dir=SplitStrings(38)
Bin7_dir=SplitStrings(41)
Bin8_dir=SplitStrings(44)
Bin9_dir=SplitStrings(47)
Bin10_dir=SplitStrings(50)
Bin11_dir=SplitStrings(53)
Bin12_dir=SplitStrings(56)
Bin13_dir=SplitStrings(59)
Bin14_dir=SplitStrings(62)
Bin15_dir=SplitStrings(65)
Bin16_dir=SplitStrings(68)
Bin17_dir=SplitStrings(71)
Bin18_dir=SplitStrings(74)
Bin19_dir=SplitStrings(77)
Bin20_dir=SplitStrings(80)
Bin21_dir=SplitStrings(83)
Bin22_dir=SplitStrings(86)
Bin23_dir=SplitStrings(89)
Bin24_dir=SplitStrings(92)
Bin25_dir=SplitStrings(95)
Bin26_dir=SplitStrings(98)
Bin27_dir=SplitStrings(101)
Bin28_dir=SplitStrings(104)
Bin29_dir=SplitStrings(107)
Bin30_dir=SplitStrings(110)
Bin31_dir=SplitStrings(113)
```

```
  Bin32_dir=SplitStrings(116)
  Bin33_dir=SplitStrings(119)
  Bin34_dir=SplitStrings(122)
  Bin35_dir=SplitStrings(125)
  Bin36_dir=SplitStrings(128)
  Bin37_dir=SplitStrings(131)
  Bin38_dir=SplitStrings(134)
  Bin39_dir=SplitStrings(137)

  CallTable ADCP
 NextScan

 'FTP
 SlowSequence
 Do
  Delay(1,1,Min)
  RealTime(RT)
  Sprintf(YYYY,"%4.0f",RT(1))
  Sprintf(MO,"%02.0f",RT(2))
  Sprintf(DD,"%02.0f",RT(3))
  Sprintf(HH,"%02.0f",RT(4))
  Sprintf(MM,"%02.0f",RT(5))
  Sprintf(SS,"%02.0f",0)

  'Do ADCP separately
  ADCPname="/pwswx.pwssc.org/buoydata/ADCP/PWSwx_ADCP_"&YYYY & "-" &
MO & "-" & DD & "T" & HH & MM & SS & ".txt"
  FTPResult_ADCP =
FTPClient("ftp.pwswx.pwssc.org","pwswxbuoy","c84buge9","ADCP",ADCPname
,2,0,1,Hr,1008,7500)

  '  fnames="/pwswx.pwssc.org/buoydata/WX/PWSwx_WX_"&YYYY & "-" & MO &
"-" & DD & "T" & HH & MM & SS &
".txt,/pwswx.pwssc.org/buoydata/ADCP/PWSwx_ADCP_"&YYYY & "-" & MO & "-
" & DD & "T" & HH & MM & SS &
".txt,/pwswx.pwssc.org/buoydata/Waves/PWSwx_Waves_"&YYYY & "-" & MO &
"-" & DD & "T" & HH & MM & SS & ".txt"
  fnames="/pwswx.pwssc.org/buoydata/WX/PWSwx_WX_"&YYYY & "-" & MO & "-
" & DD & "T" & HH & MM & SS &
".txt,/pwswx.pwssc.org/buoydata/Waves/PWSwx_Waves_"&YYYY & "-" & MO &
"-" & DD & "T" & HH & MM & SS & ".txt"
  FTPResult =
FTPClient("ftp.pwswx.pwssc.org","pwswxbuoy","c84buge9","WX,Waves",fnam
es,2,0,1,Hr,1008,7500)
 Loop

EndProg
```

To: Paul Nieberding <paul@fondriest.com>
Cc: info@nexsens.com
From: Rob Campbell <rcampbell@pwssc.org>
Subject: CB1450 in Prince William Sound
Date: Mon, 21 May 2018 10:32:30 -0800

Hello:

Myself and the PWS Regional Citizens' Advisory Council bought a CB1450 from Fondriest in 2015. Our electronics partner dropped out partway through the project, which delayed us a bit while I did the electronics integration. After a long testing process in the Cordova harbor we deployed it in western PWS this April. It was out for all of three weeks before being losing the tower and having the hull breached - I've attached a preliminary report I prepared for the RCAC (Murphy's law being what it is, the buoy failed the week before their board meeting).

I'm curious to know if you've had any other failures like this. You might want to recommend to other end users replace their clevis pins with something less likely to come off - bolts with nylock nuts perhaps? If you have any other thoughts about the mooring system or other recommendations I'd appreciate hearing them.

Regards, Rob

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From: <Paul.Nieberding@fondriest.com>
To: 'Rob Campbell' <rcampbell@pwssc.org>
Subject: RE: CB1450 in Prince William Sound
Date: Tue, 22 May 2018 10:38:36 -0400

Hi Rob,

Thanks for making us aware of this. I shared your email and report with the Fondriest/NexSens engineering and management team, and we met this morning to discuss the information. To date, we have not seen any clevis pin failures on our buoy platforms, and we use this design on the CB-650, CB-950, CB-1250, and CB-1450 models. They are used by several NOAA offices and deployed in the Great Lakes, Chesapeake Bay, and throughout the Caribbean to name a few. While we can appreciate that Alaska deployments are exceptionally hard on equipment, we would not have thought of the clevis pin to be a weak point of the design. There were a couple of questions that came out of the meeting that we were hoping you could comment on:

1. You mention in your email that the hull was breached. Do you just mean that water had entered the data well through the wave sensor port? Or was there physical damage to the coated foam? If the foam was damaged, can you send a photo of this?
2. Do you have any photos of the overall solar tower before it was deployed so that we can see how the components were mounted?
3. Can you send a photo of the wave sensor housing damage?
4. Can you envision a scenario where the buoy could have been vandalized and had the clevis pins pulled in the process?

The price of a replacement tower with 3x 55-watt solar panels is $5950 if this is something you wanted to replace at some point. We can certainly work with you on this pricing and offer it at a discounted rate given the circumstances.

I look forward to hearing from you.

Best regards,

Paul

--
Paul Nieberding
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2091 Exchange Court
Fairborn, OH 45324
Phone: 937-426-2151
Fax: 937-426-1125
www.Fondriest.com

Subject: Re: CB1450 in Prince William SoundDate: Tue, 22 May 2018 09:19:42 -0800
From: Rob Campbell <rcampbell@pwssc.org>
To: Paul.Nieberding@fondriest.com

Hi Paul:

Thanks for the quick reply. Comments in context below.

Regards, Rob

>
> 1. You mention in your email that the hull was breached. Do you just
> mean that water had entered the data well through the wave sensor
> port? Or was there physical damage to the coated foam? If the foam
> was damaged, can you send a photo of this?

We had the RS485-RS232 converter on the wave sensor so to be able to have our Campbell Scientific logger talk to it. Given the size of the converter and my worry that it would flop around and get damaged, I had mounted it within a piece of PVC pipe that was secured to the bulkhead fitting and the side of the wave sensor - I made a 3D printed spacer between the two of them that matched the diameter of the wave sensor and the PVC pipe and held it all together with stainless hose clamps. When the tower tilted over, it hit the PVC pipe, which simultaneously broke the plastic bulkhead fitting and pulled the wave sensor off its base. That exposed the wave sensor electronics, and the broken bulkhead fitting let water into the hull. It didn't let in a lot of water (there was less than a gallon in the hull when I recovered it), but it dripped right onto the electronics and killed most of it. I don't have a super great picture of that arrangement, I've attached what I have.

> 2. Do you have any photos of the overall solar tower before it was
> deployed so that we can see how the components were mounted?

I've attached a photo of the buoy just prior to deployment. As well as the radar reflector and light that came with it, the tower had a Young anemometer, the Temp/rh sensor, a panoramic webcam, and a SPOT trace satellite tracker. There was also GPS and cellular antennas on.

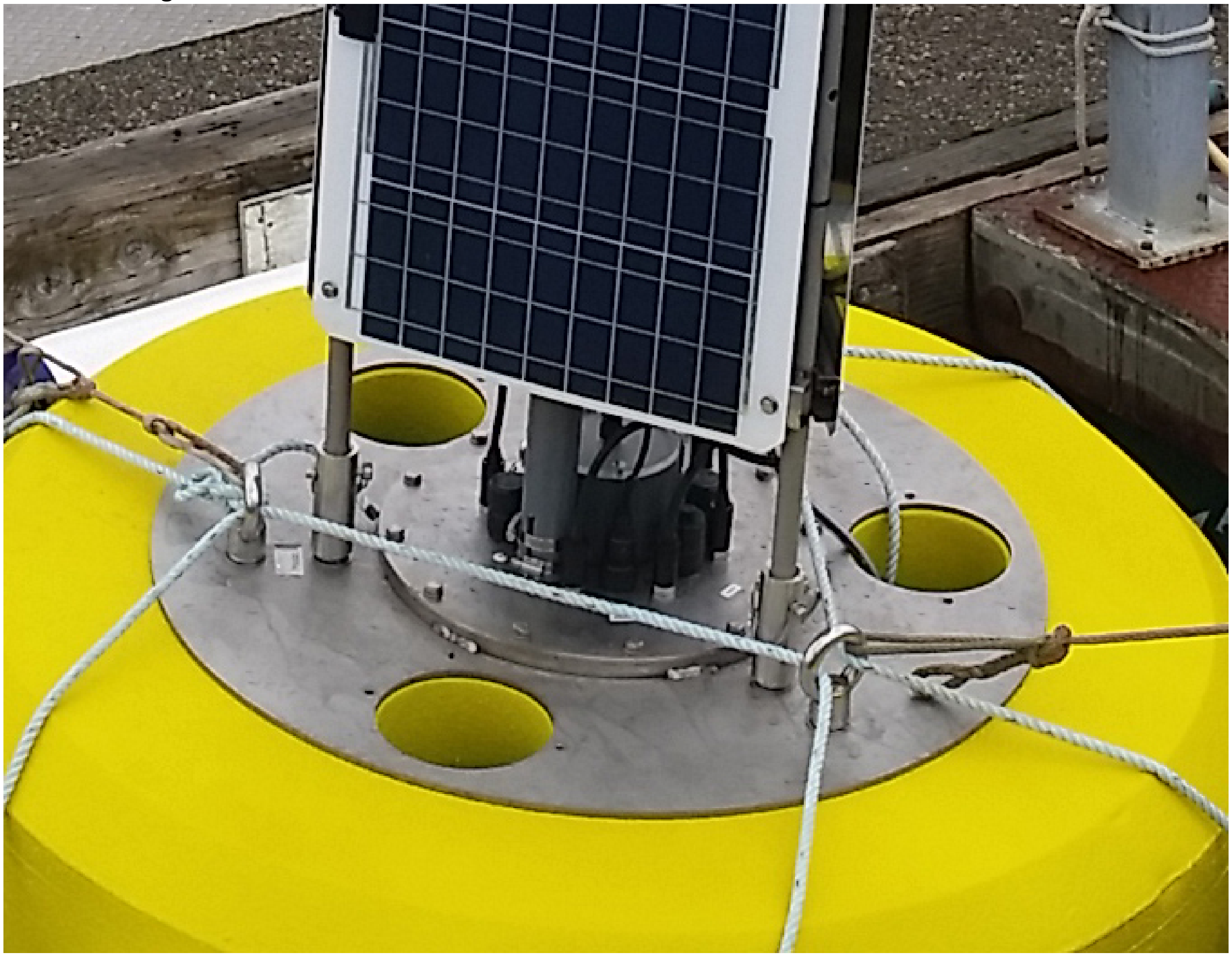
> 3. Can you send a photo of the wave sensor housing damage?

I've attached an annotated version - the one bolt still has the threaded insert still on it. In hindsight probably not the best way to mount it, but having the tower bending over didn't really enter into my design considerations.

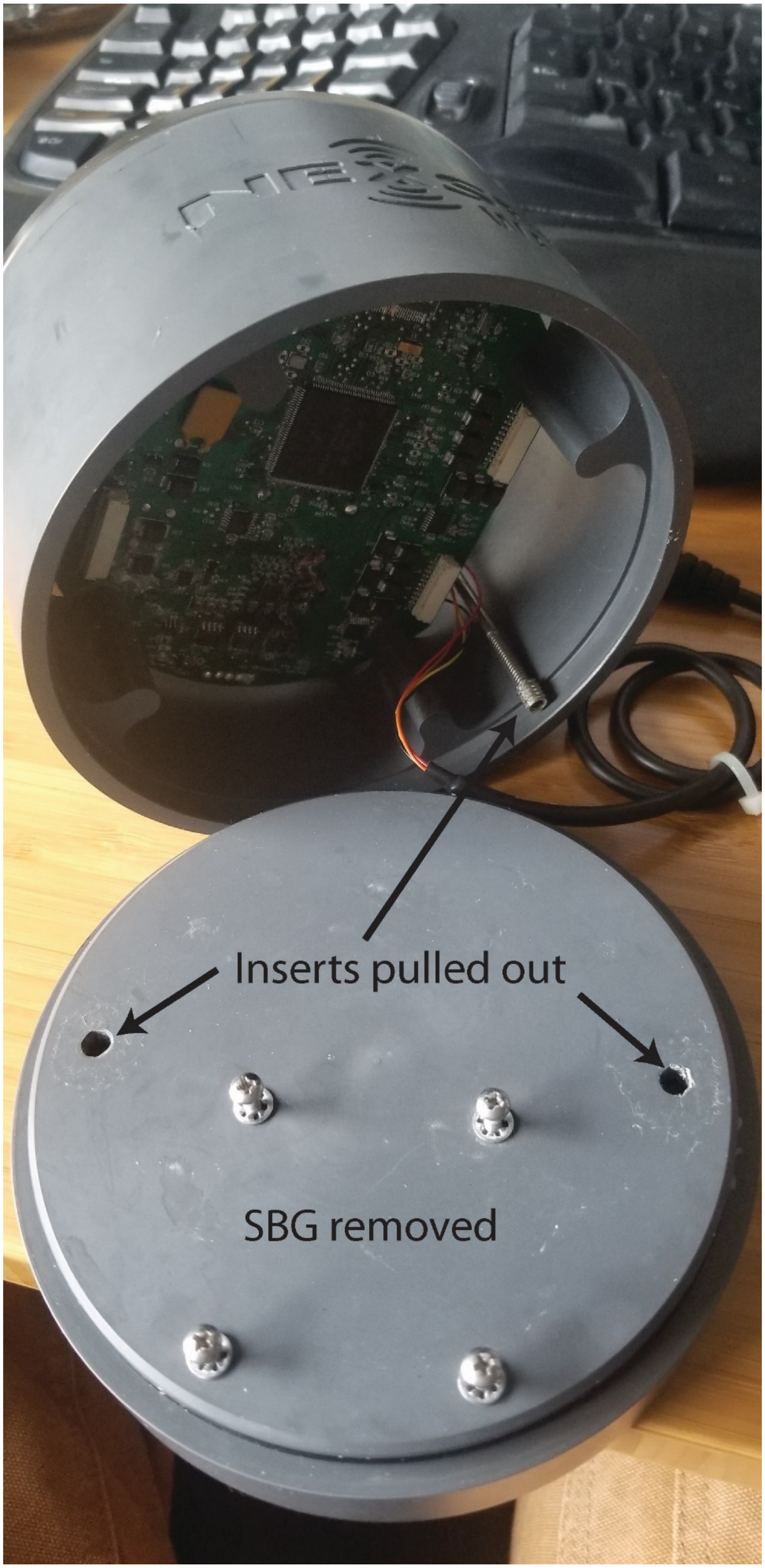
> 4. Can you envision a scenario where the buoy could have been
> vandalized and had the clevis pins pulled in the process?
>

I'm fairly doubtful it was vandalism, there was not a lot of people out in the sound around then - this was well before salmon fishing or much in the way of sport fishing, and the buoy was about as far away from settlements as one could be. The weather prior to the failure wasn't super great either, not a lot of boats out. The hull is fine, it doesn't appear to have been run into or anything.

Attached images:




CORDOVA, AK


Inserts pulled out
SBG removed

Subject: RE: CB1450 in Prince William Sound
Date: Wed, 23 May 2018 15:32:08 -0400
From: Paul.Nieberding@fondriest.com
To: 'Rob Campbell' <rcampbell@pwssc.org>

Hi Rob,

Thanks for the additional information - I passed this along to our team for further review and analysis. Certainly let me know if you want to rehab the wave sensor and/or replace the solar tower at some point in the future.

Best regards,

Paul

--
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