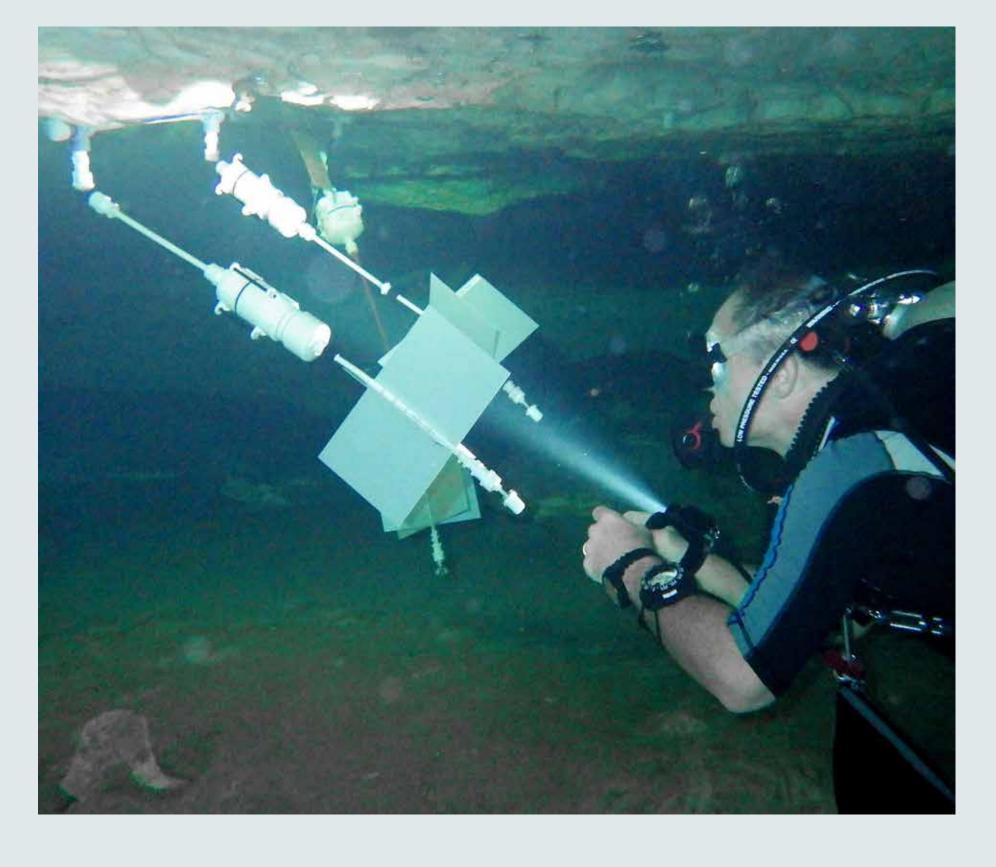# the Cave Pearl Project

A LOW-COST OPEN-SOURCE DATA LOGGER FOR ENVIRONMENTAL MONITORING

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Introduction

We present a low cost DIY data logger and environmental housing system developed for long term monitoring projects that require operation in remote locales under humidity saturation and/or sub-aquatic environments, with a number of different sensor configurations. The project ethos focuses on accessibility for non-experts, by using a limited number of inexpensive parts assembled with common tools. The Cave Pearl Project has demonstrated the capability of generic Arduino microcontrollers as data loggers that are inexpensive enough to bring large monitoring projects within the range of modest budgets.
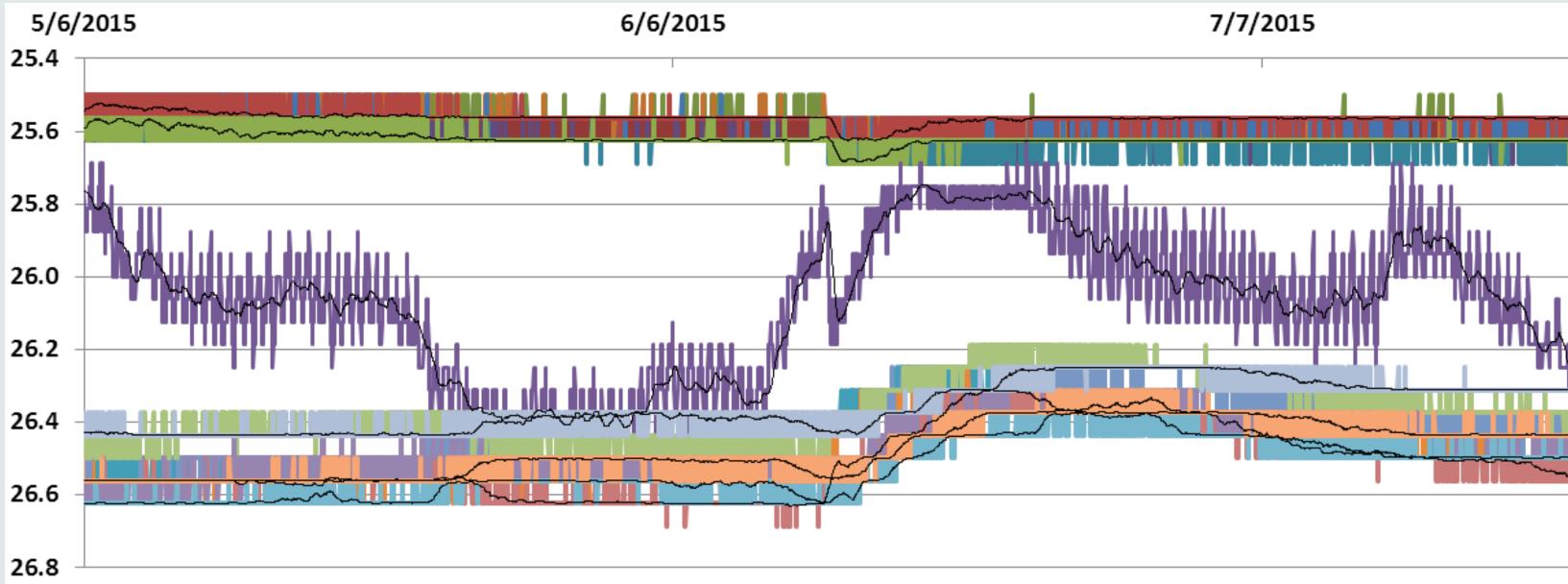
One Build for Below the Water...

Several generations of pendulum style flow meters have now been tested at depths from 5 to 25m. With each build there have been a variety of challenges to overcome ranging from simple physical failures (epoxy, pivot joints, etc) to more subtle issues (eg: how MEMs sensors are affected by pressure at depth). Instrument response has been boosted by a factor of four in low flow (<1cm/s) systems by the attachment of 'drag enhancing' flags. The underwater housings have evolved away from the original 3" end cap design to a more compact 2" cylinder made from Formufit table leg supports.

The drag-tilt sensors continue to deliver excellent long term records in co-deployments with underwater pressure and temperature sensors. Since the Arduino is based on the Atmel family of processors, it supports a variety of sensor BUS technologies. Groups of 1-Wire DS18B20 temperature sensors have been assembled into segmented, multi-probe strings using a DIY underwater connection system based on plumbing parts. By simply lengthening the body to accommodate more batteries, these loggers power a 20 node chain for a four month deployment at 15m, after which they were redeployed at 25m. The unit pictured here (with accompanying data) had a material cost of approximately $150.00

The heart of the system

2 RTC Module
DS3231 powered by pin during bus coms. or coincell

3 EEprom Module
32k buffers up to five days of data before SD writes

1 MCU Module
Mini form factor with MCP1700 voltage Regluator

4 SD Module
SD cards tested & selected based on low current sleep
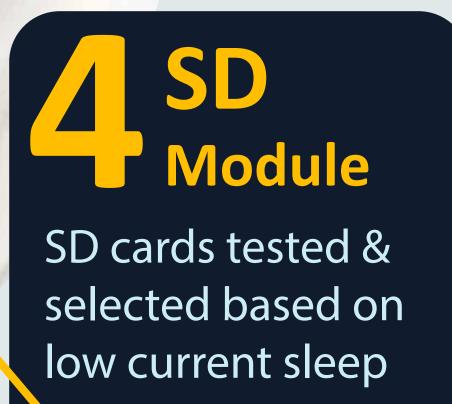
Component	Cost
Rocket Ultra 8mHz Arduino	$14.00
Ds3231 RTC & Eeprom	$3.00
MicroSD card & Adapter	$3.00
Resistors, Wire, Connectors etc.	$3.00
Battery Holders	$7.00
Total	**$30.00**

...and One for Monitoring Above Water

The same electronic components are arranged on a platform housed inside of a 4" pvc end cap. This provides more surface area for sensors opening up other monitoring options. Temperature, pressure and relative humidity sensors are commonly available as I2C sensors and there are Arduino compatible breakout boards for most other atmospheric monitoring, including gas sensing.

Impact sensing accelerometers work well for monitoring in-cave drip rates and this design was repurposed as an accurate surface rain gauge with a simple funnel to control the catchment area and standardize the drip volume.   This style of logger can be assembled in approximately 4 hours at a material cost between $25-$50.
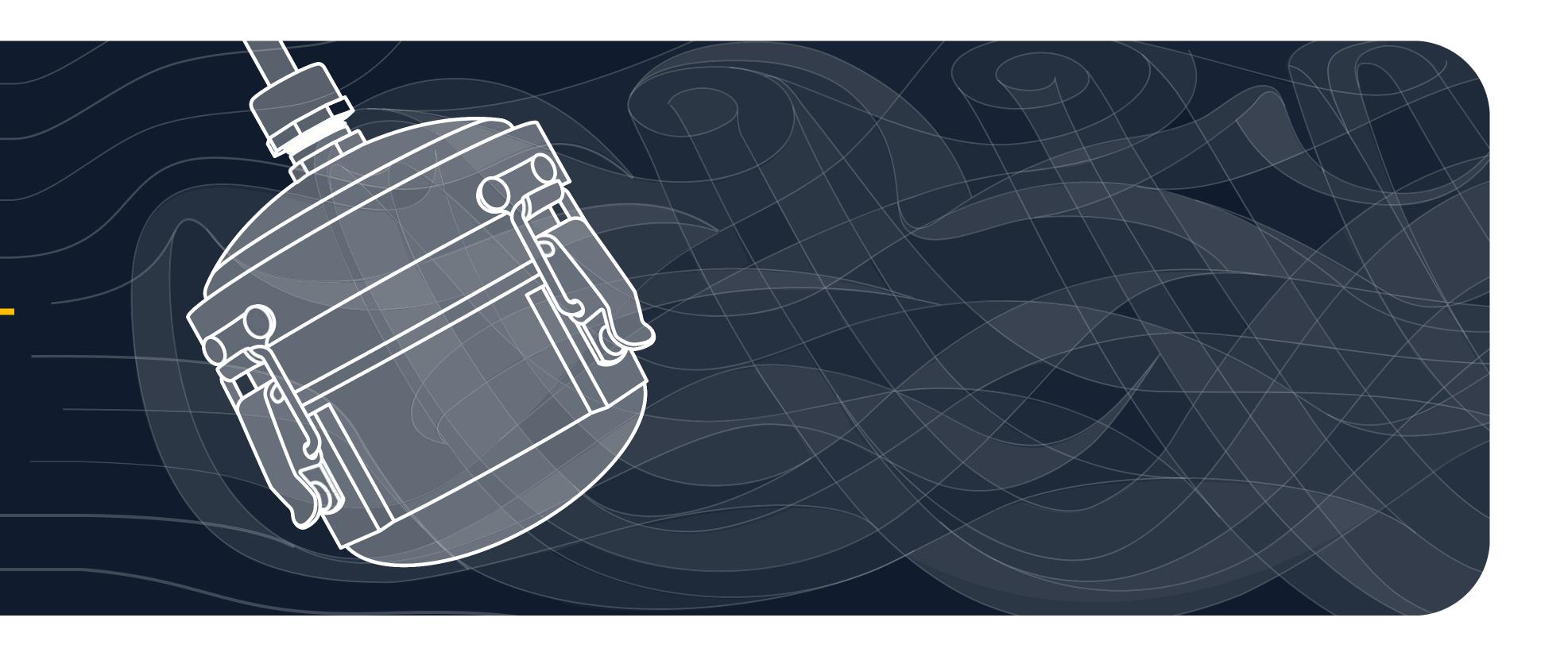
In Summary

Field tests of more than sixty Cave Pearl loggers over the last year have produced simple but robust housing designs and advanced the basic 'jumper wires & modules' build. Optimizations to data handling, pin powering the RTC, and sleeping the processor, allow current builds to exceed the original design goal of one year of operation on 3xAA batteries. The Arduino IDE makes it easy to modify the open source code directly and add new analog or digital sensors that address a specific research question, without requiring major changes to the basic design.

Cave Pearl Project blog
http://edwardmallon.wordpress.com/