Leatherback Turtle Nest Monitoring in Costa Rica

Student Team

Erik Meike and Matthew Mellea, Nueva School, San Mateo, CA, Class of 2017

Funding

Grants awarded to Erik Meike and Matthew Mellea:

Explorers Club Youth Activity Fund Grant "Developing and Testing Nest Temperature Monitors for Pacific Leatherback Sea Turtle Subpopulations", (April 2016, $1500)

Moore Family Foundation "Developing and Testing Nest Temperature Monitors for Pacific Leatherback Sea Turtle Subpopulations", Moore Family Foundation (Jan 2016, $5500)

Sponsorship

Nathan Robinson, PhD, Field Director
Kristin Reed, PhD, Director of Operations
George Shillinger, PhD, Executive Director

Leatherback Turtle Trust - Global HQ
99 Pacific Street, Suite 555-A
Monterey, CA 93940

Installation

Goldring-Gund Marine Biology Station
Playa Grande, Santa Cruz
Guanacaste, Costa Rica

Special thanks for feedback and design review: Nathan Seidle, CEO Sparkfun &, Bob Alkire, Consultant

Project Background

This project began when my 10th grade class visited Costa Rica for a biology immersion program (February, 2015). We worked with the researchers at the Leatherback Trust on Playa Grande for several days to understand their jobs. Our assignment was to use our design thinking knowledge to identify the biologists' needs. From our daily interactions, I could see what they enjoyed and dreaded. As a more personal goal, I tried to come up with ways to increase their efficiency. I noticed the researchers spent hours manually measuring critical turtle nest temperature. After meeting with them, I proposed a custom technological solution. Matthew, one of my friends, was also interested in this project, so we decided to work together to design, manufacture, test, and deploy a monitoring system of 100 sensors to automatically collect data from the nests scattered along the 3 mile beach.

I have been working on this project with my classmate, Matthew. We divided the work such that he is responsible for the waterproof enclosure, while I create the electronic data logging system. We both worked on the grant proposals and communicate with the researchers in Monterey, CA, and Costa Rica.

Scientific Background and Rationale

The Pacific leatherback sea turtle is a critically endangered marine reptile, and yet little is known about the animal's physiology and life cycle. The gender of a sea turtle egg is determined by the temperature of the sand in which it is laid, known as Temperature-Dependent Sex Determination (TSD). As worldwide temperatures rise, more and more females are produced, potentially having widespread impacts on the sustainability of the species. We are building a low cost temperature and humidity sensor that allows sea turtle biologists to better monitor the temperature of sea turtle nests throughout the gestation period of the hatchlings.

The marine biologists we are working with currently use thermocouples that provide little data and are labor intensive to use. The beach that they are located on is three miles long, and to obtain nest temperature data they have to physically walk up and down the beach, sticking their thermocouple reader into each nest. It takes around four hours to complete one cycle, and as a result, biologists choose to record temperatures only once every other day. Thermocouples are additionally prone to breaking, being moved or discarded by tourists, and becoming buried in the sand. Our prototype is roughly egg-sized and shaped and designed to be dropped into the nest when the mother turtle lays her eggs and removed after the researchers excavate the nest to count the number of successful hatchings (after 65 days). It will record temperature and humidity data during this period while not harming the turtle nest.

Prototype Status - as of December, 2016

Our system is currently a 30mm diameter circular PCB that uses an ATmega328pb and Si7021 temperature and humidity sensor to log data. It is powered by a 1Ah non-rechargeable Li 3V CR2477 battery and stores data on a 1Mbit EEPROM.

The case is 3D printed and the form factor is currently a cylindrical design that seals with a 3D printed thread and O-ring. The sensor is intended to be as water-resistant as possible while still being able to measure humidity. We are using a small porous metal breather vent filter to allow humid air in.

We will also conformally coat the PCB to make it more water resistant. Environmental protection is a priority, as the sensor is going to be deployed near water and in sand for about 2 months. We do not expect

it to ever sit directly in water, but we want it to be able to handle being accidentally dropped in a wet environment. Here is an exploded view of our CAD Model.

Our BOM totals $11.64 at qty 100 without assembly. We will order 100 with pick and place from Elecrow for our final production run, which should come to under $17 per sensor, based off of our previous quotes. With the enclosure and all other parts, the sensor will cost less than $22.

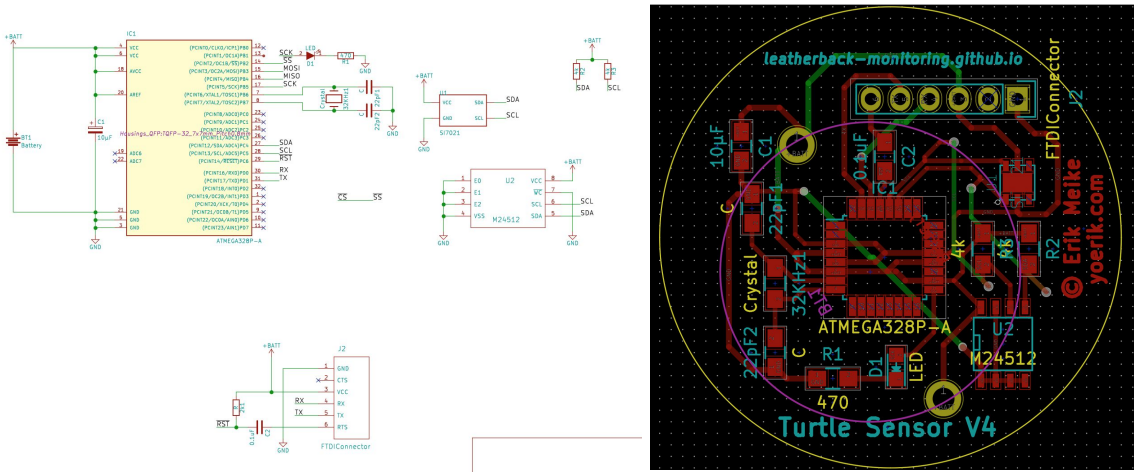
The sensor will be shipped unscrewed to biologists, who will put in the battery and screw the case together. This is not the most user-friendly method of turning the sensor on, but we opted to do this as it saves money and complexity by not using a switch. The biologists will note the time the sensor was turned on with our current setup (We will add a way of doing this automatically soon.) and it will be placed in the nest. Sixty-five days later, the sensors will be recovered and unscrewed. At this point, the data will be downloaded to a computer over a serial connection and visualized.

Project Timeline Overview

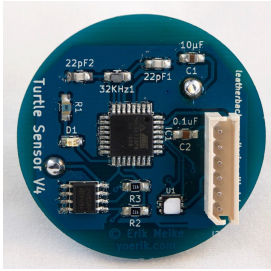
Spring 2015: Nueva Immersive experiential learning trip to Costa Rica, need identified by Erik and Matthew and project scope defined.
Summer/Fall 2015: Project plan and budget detailed. Preparation of grants for funding.
Spring 2016: Two grants awarded, prototyping began.
Summer 2016: Several revisions of prototypes. Identification of manufacturer in China.
Fall 2016: HW design review: Nathan Seidle, Founder of Sparkfun. Further refinement, waterproofing of case, quality testing.
Winter 2016-17: Quantity runs, local and on-site testing in Costa Rica.
Spring 2017: Continuing to debug with researchers and further refinement.
Code and other information

- KiCad PCB layout: https://github.com/leatherback-monitoring/SensorPCB
- Custom code: https://github.com/leatherback-monitoring/sensormonitor
- Enclosure STEP File
- Solidworks Assembly Zip File
- Project Blog

Schematic and PCB Layout

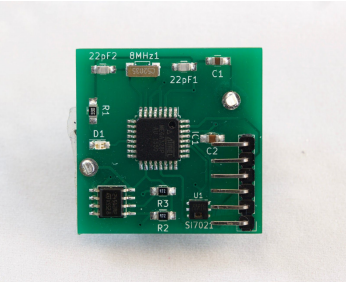


Development Timeline in Photos

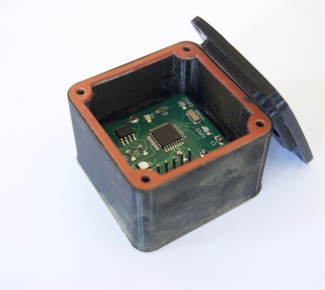


Rev 4 PCB

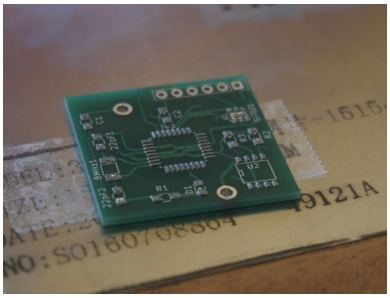
Rev 4 Case



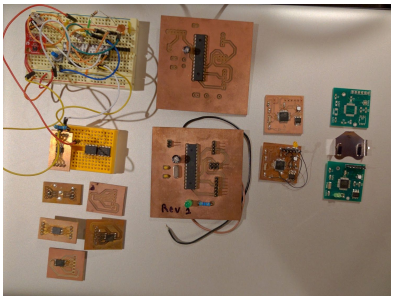
First PCB Prototype from China Fab



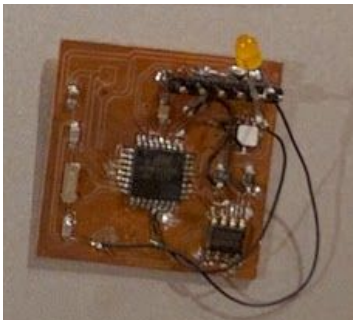
Early Case



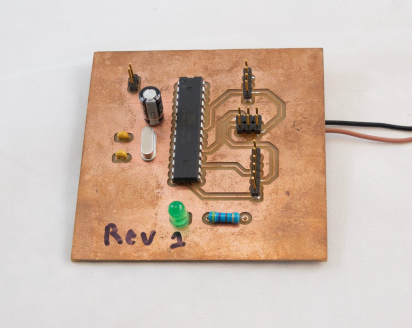
Hand PCB Assembly



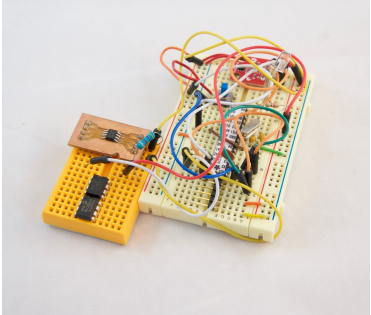
A few of the different prototypes



Rev 2 Surface Mount PCB Prototype



Rev 1 Milled PCB Prototype



First Breadboard Prototype

Waterproofing test in vacuum pump low pressure environment