TideRiders: Toward a Citizen-Scientist-Enabled and Institution-Supported Distributed Sensor Network for Water Quality Monitoring

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Abstract

The advocacy activities necessary to sustain healthy watersheds and improve impaired ones ultimately rely on the democratic process, and therefore depend on a public that values our coastal resources and understands the role that water quality plays in maintaining that value. We contend that an opportunity exists to improve the temporal and spatial density of monitoring by reducing the cost of collecting measurements, while simultaneously fostering an informed and invested public. We envision a distributed water quality monitoring sensor network, composed of low-cost ($1000-$2000) profiling devices we call TideRiders, built and operated by private citizens and local educational organizations and supported by an institution-hosted centralized data and control portal. The TideRider concept engages the public not just in the collection of data but also in the building, deployment, operation, and recovery of these robot sensors. TideRiders will carry a suite of basic water quality instrumentation (temperature, conductivity, and dissolved oxygen), transmit data and accept commands over the cellular network, and can sample surface and bottom waters by surfacing and submerging on a programmable schedule. Operators will harness tidal currents to move their TideRiders deliberately around an embayment, essentially by surfacing in a favorable tide and anchoring on the bottom in an adverse tide. A network of TideRiders deployed in tidally-dominated estuaries like Buzzards Bay and Narragansett Bay could provide basic water quality data at several-hour intervals for weeks at a time by "virtually mooring" in center-bay locations that are otherwise only accessible by boat and therefore typically sampled less frequently than shore stations. We present preliminary field results from a series of prototypes designed and built by students. The prototype devices utilize a novel low-cost semi-passive shallow-water buoyancy engine and were constructed for less than $1000 in parts.

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PRESENTER:
Mike Jakuba

MOTIVATION: We are developing low cost ($1000-$2000) coastal profiling devices we call TideRiders that can be built and operated by students and private citizens. Our intention is to aid the public's understanding of their local coastal ocean and foster a sense of stewardship via accessible and inexpensive observing technology. Low cost ($100-$200) off-the-shelf water quality monitoring sensors may ultimately allow TideRiders to augment existing professional water quality monitoring programs.

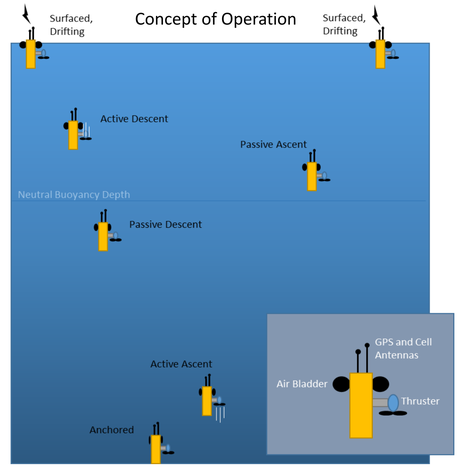
CONCEPT OF OPERATION: TideRiders use pump-less semi-passive buoyancy control to transition between drifting at the surface and anchoring on the seafloor. TideRiders are not actuated in the horizontal direction. Instead, they will navigate coastal embayments by deliberately timing profiles to coincide with favorable tidal currents. TideRiders avoid the need for an expensive pump by using a thruster (<$200 from Blue Robotics) to transition between passively floating at the surface and sinking to the seafloor. TideRiders use the cellular network to communicate and take commands.

OPERATIONAL STATUS: The first prototype TideRider, designed and built by co-author Zhang as an undergraduate, proved the buoyancy control concept. The second generation prototype, built by co-author McGuire as a high school student, demonstrated control and data acquisition over the cellular network and demonstrated free-swimming operation including "virtual mooring" in a salt pond. High school engineering students at Tabor Academy are currently refining the design.

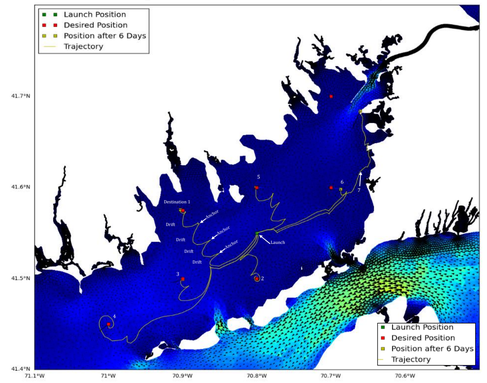
Student-built **coastal profiling floats** for **$1000**?

Come talk to us about integrating a TideRider into your education or monitoring program - or building one yourself!

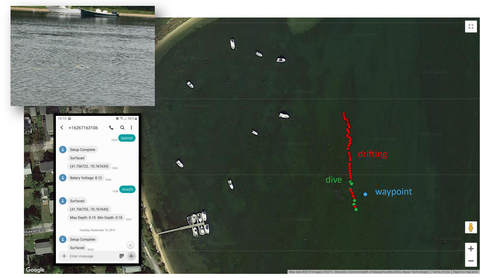
Take a picture to see a **video** of a prototype working in a tank.



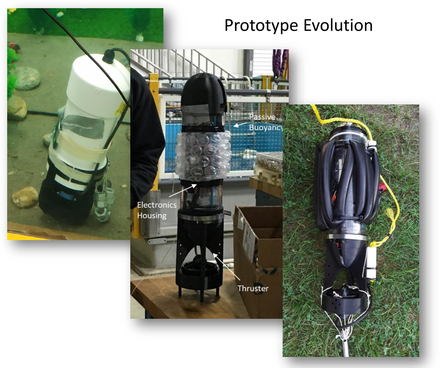
Riding the Tides (NECOFS Simulation)



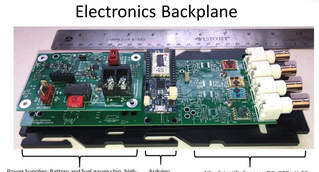
Riding a Real Tide (1st Attempt at Virtual Mooring)



Prototype Evolution



Electronics Backplane



Power Supplies: Battery and fuel gauge chip, high-current thruster connections, low-power sleep state. Underneath: off-the-shelf GPS, 9-axis motion sensor, connections for water pressure/temperature.

Arduino Microcontroller

Atlas Scientific Sensors: DO, ORP, pH, EC, with power-supply isolation and connectors.

Price List

Component	Cost ($)
Electronics	
Blue Robotics(BR) T100 Thruster	$ 119.00
Blue Robotics Basic ESC	$ 25.00
Arduino MKR GSM 1400	$ 69.00
Blue Robotics Depth Sensor	$ 68.00
SD Card + Adapter	$ 10.00
MicroSD Card Breakout Board	$ 9.00
Electronics Backplane (WHOI designed)	$ 160.00
Battery pack, OVONIC 7.4V 5200mAh hardcase LiPo	$ 35.00
SparkFun ambient RGB light sensor	$ 6.00
SparkFun 9-Axis IMU	$ 15.00
SparkFun Ambient Pressure/Temp/RelHum sensor	$ 20.00
GPS Module	$ 5.00
GPS antenna	$ 25.00
Cellular Antenna and connector	$ 55.00
Cellular Data SIM Card (T-Mobile prepaid IoT)	$ 17.00
Mechanical	
Blue Robotics Acrylic Housing, 4"	$ 65.00
Blue Robotics O-Ring Flange, 4" (q. 2)	$ 58.00
Blue Robotics Electronics Tray, 4"	$ 49.00
Blue Robotics Enclosure Vent Plug	$ 8.00
Blue Robotics Aluminum End Cap (10 holes)	$ 24.00
Blue Robotics Blank Aluminum End Cap, 4"	$ 16.00
Blue Robotics M10 Penetrator Blank (q. 3)	$ 12.00
Blue Robotics M10 cable Penetrator (q. 7)	$ 28.00
Air bladder	$ 10.00
Brackets (3D printed)	$ 150.00
Miscellaneous	
Weld.ink Potting Compound	$ 19.00
Nofuss	$ 20.00
Fasteners	$ 25.00
Baseline Device	$ 1,122.00
Payload Sensors	
Atlas Scientific Dissolved Oxygen kit	$ 283.00
Atlas Scientific Conductivity kit	$ 215.00
Atlas Scientific PT-1000 Temperature kit	$ 94.00
Atlas Scientific ORP Kit	$ 192.00
Atlas Scientific pH kit	$ 164.00
Whitebox Lab Tentacle Shield Mini	$ 94.00
Grand Total	$ 2,164.00

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