

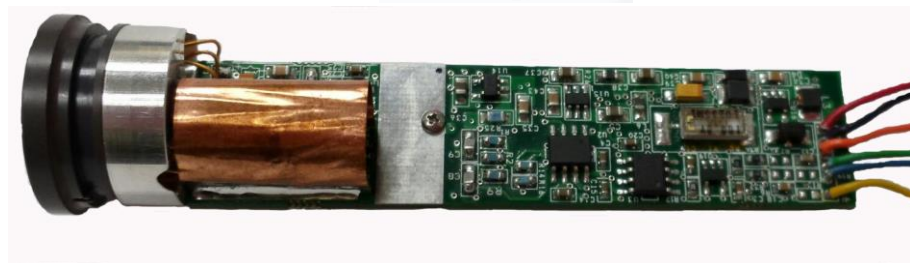
Environmental Monitoring using Fluorescence: Successful Vehicle Integrations



Desirable characteristics of a fluorometer intended for system level integration:

- Low Power
- Small & lightweight
- Configurable (form factor and optics)
- Easy data integration

Manufacturer	Model	Typical Current Draw
Turner Designs	Cyclops Integrator	80 mA (3 sensors)
WET Labs	ECO Puck	80 mA (3 sensors)
Turner Designs	Cyclops No Housing	20 mA
Turner Designs	C-FLUOR	10-12 mA



- Sail and Solar ASV
 - Weight: 85 pounds (plus payloads)
 - Length: 6 feet, 6 inches
 - Power system: 12V batteries w/ solar recharge
 - Speed: 1 to 3 knots
 - Mission duration: Up to 6 months
 - Continuous communications



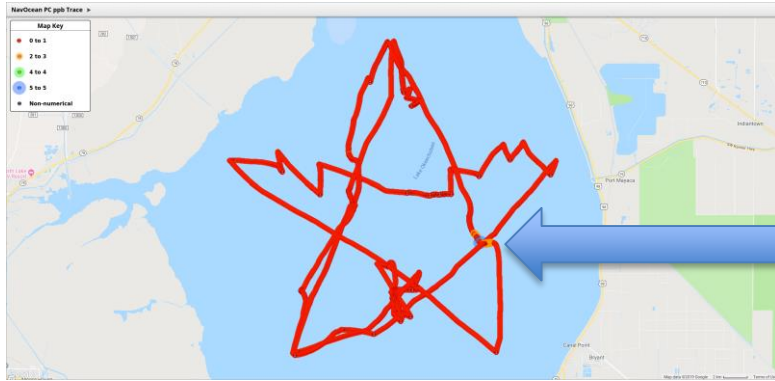
- 3 sensors: Chlorophyll, CDOM, Phycocyanin
- Key reasons
 - Power requirements
 - Size



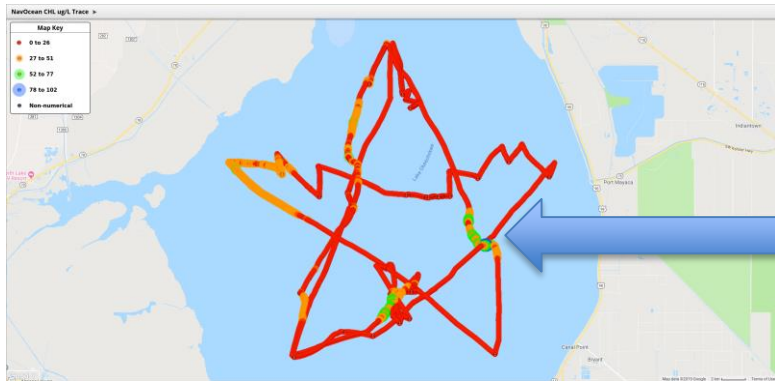
- Harbor Branch Oceanographic Institute launches
 - Studying Algae Blooms
 - Why they form
 - Where they exist
- Banana River Lagoon near Cape Canaveral
 - Winds in excess of 30 mph, 54 mph peak
 - Data indicates Brown Tide bloom
- Lake Okeechobee in Florida
 - 8 day duration



Navocean – Lake Okeechobee

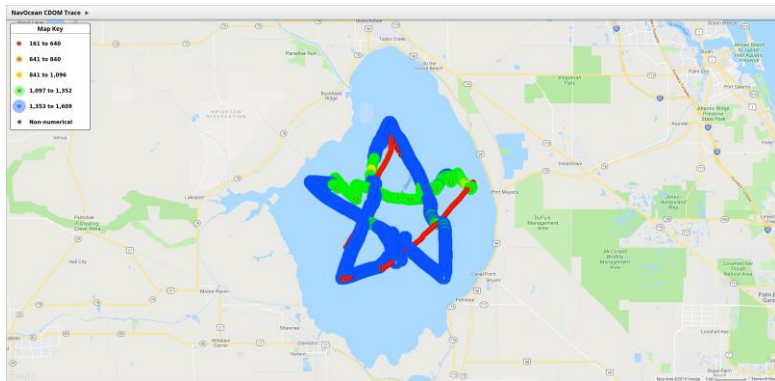


PC



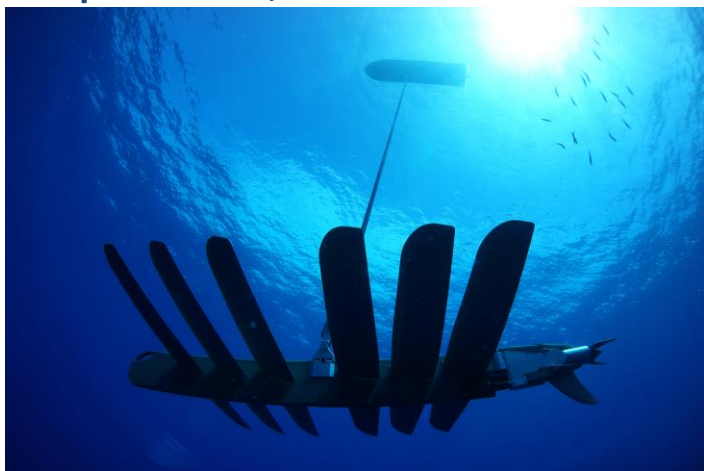
Chlorophyll

Hot spot for Algae



CDOM

- Wave and solar powered surface vehicle
- Initial integration 2010 Deepwater Horizon Oil Spill
 - C3s on base of the float & on the sub
 - Low power, small, reliable, numerous sensing options
- Improved design; now integrate over 60 sensors
 - CTDs, CTDOs, Ocean Current Monitors, Acoustic Modems, Hydrophones, Acoustic Monitoring Receivers, Fluorometers



On November 17th 2011, Liquid Robotics launched 4 Wave Gliders from San Francisco with the goal of being the first to cross the Pacific Ocean

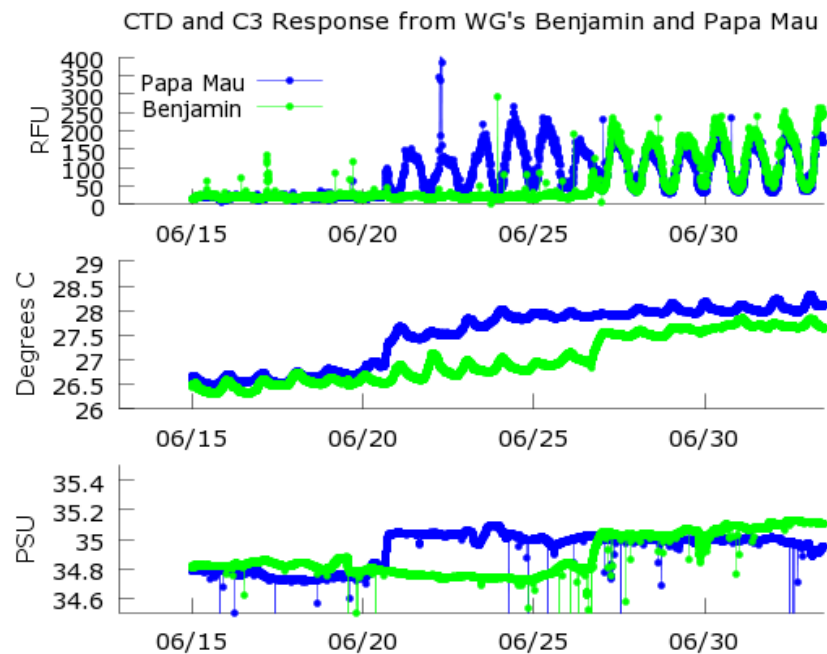
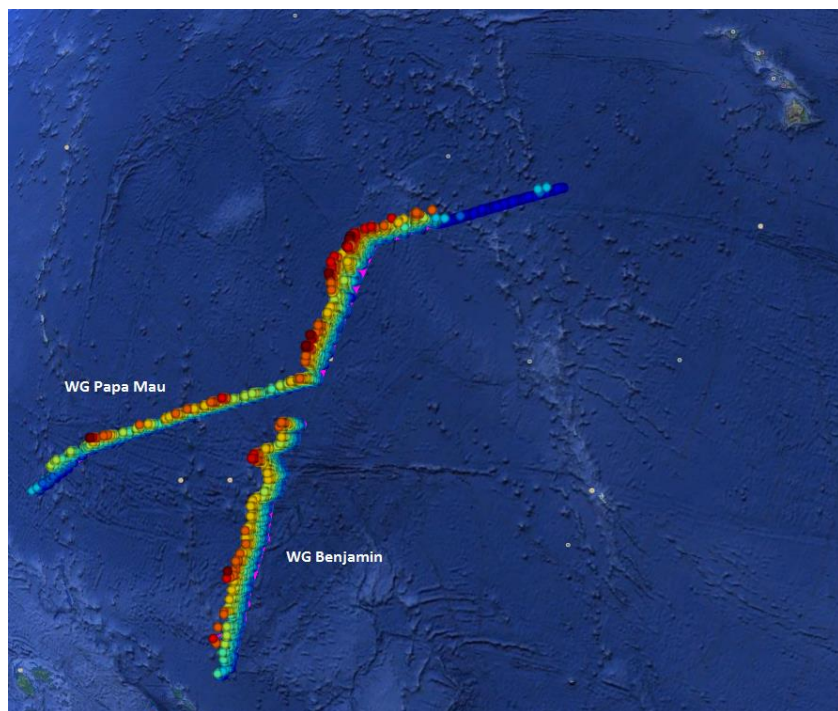


Each vehicle carried identical scientific payloads including a CTD, weather station, wave sensor, and Turner Designs C3 Fluorometer configured with Chlorophyll, Turbidity, and Crude Oil sensors

13 months later the first Wave Glider arrived in Australia and two months later the second arrived!

PacX: Open Ocean Phytoplankton Bloom

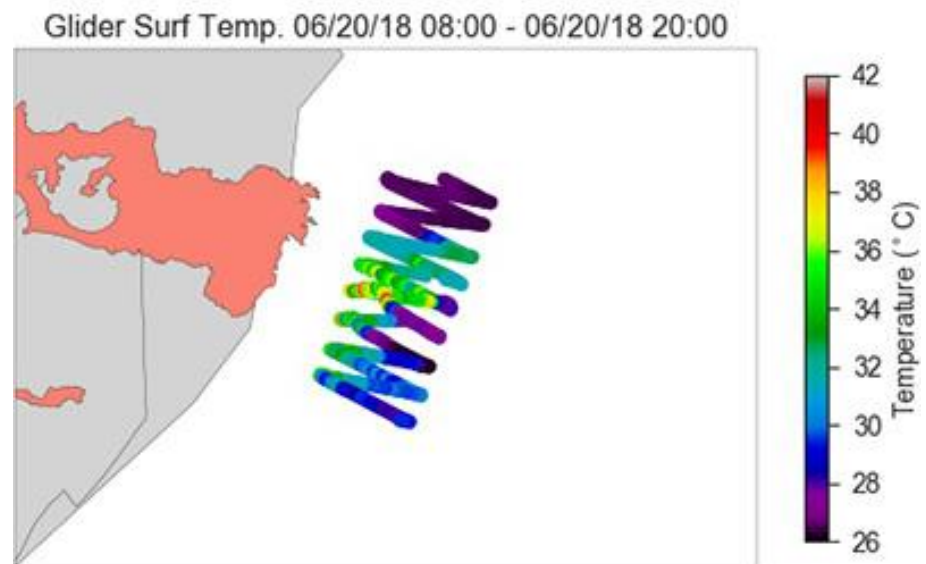
- Collected over 5.5M data from the surface of the ocean in places rarely sampled, if at all!
- Bloom was spotted by 1st Wave Glider & validated 6 days later by 2nd
- Coincidental changes in the physical and biological sensors from the vehicles



- Deployed 2 vehicles to understand the impact of lava on the ocean and marine life, ~1 month duration
 - SeaBird CTDs (float & sub)
 - Turner Designs C3s with Chlorophyll, Turbidity, Crude Oil (float)
 - GPS Waves (float)
 - Cameras, Hydrophones, ADCP, Weather Station, and more



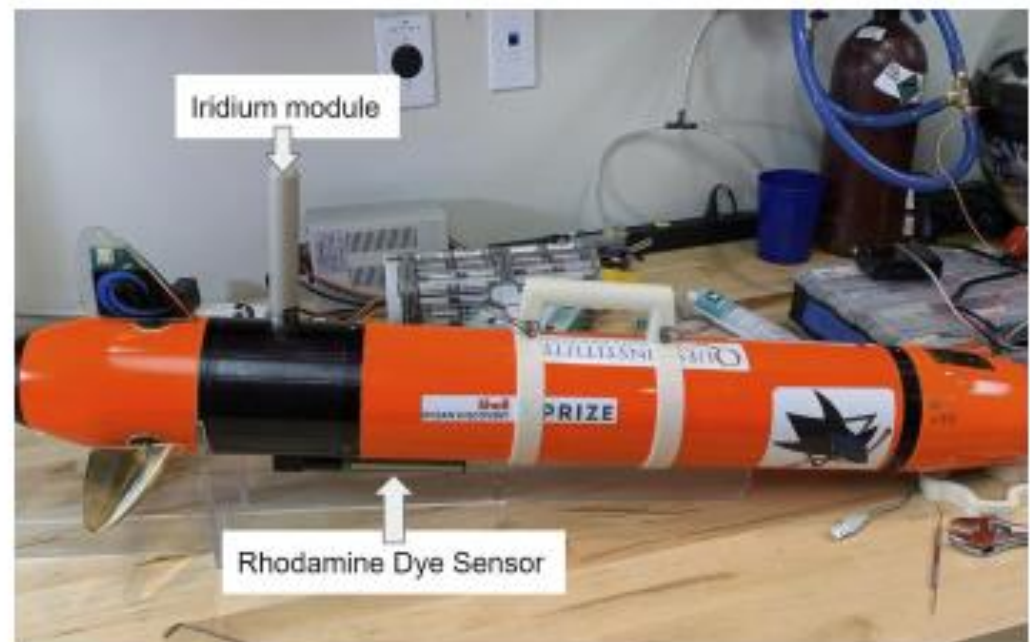
- Applied autonomous front-tracking method (MBARI)
- Zig zag path
 - Calculates horizontal gradient of temp
 - When threshold exceeded, vehicle reports & zigs
 - Switches northward & southward
 - Avoids red-flag temps



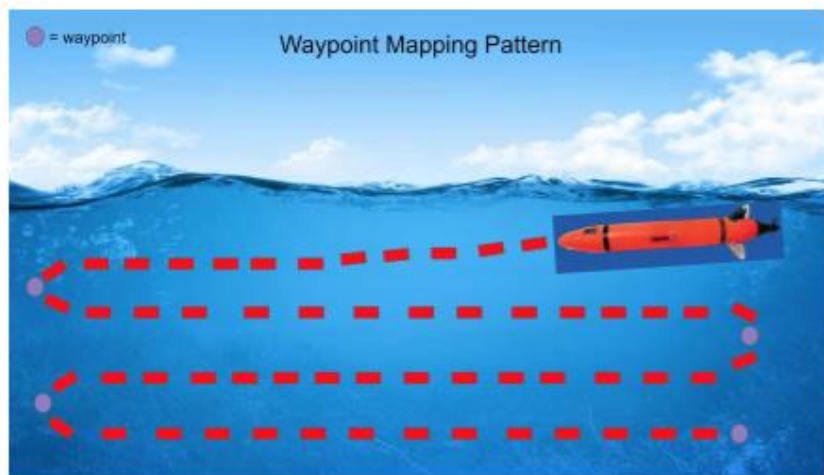
- Junior High & High School Students!
- Integrated Cyclops Sensor into Riptide AUV
- Challenge was to autonomously track chemical plume back to source
- Came closer than any other entrants
 - Nobody won
 - Detected chemical
 - But below threshold



- Riptide AUV
 - Weight: 65 pounds (29.5 kg)
 - Including 180 AA cell batteries
 - 50 inches (1270 mm) L x 7.5 inches (190.5 mm) D
 - Communication: Iridium Sensor
 - Depth rating: 300 m
- Cyclops-7F Fluorometer
 - Small Size
 - Low Price
 - 600m depth
 - Rhodamine Dye
 - MDL 0.01ppb



- Begins moving horizontally
 - Descends and turns around
 - Repeats until depth threshold met
- Moves upstream and repeats starting at depth
- If Rhodamine detected above threshold
 - Search area constrained



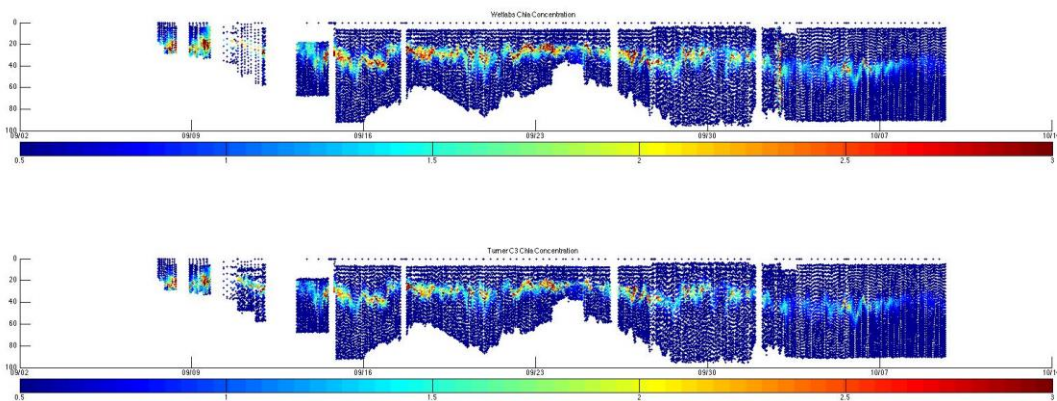
Ran for 3 hours

- Buoyancy driven AUV
- Over 40 sensors available for integration into payload bay
 - Integrate both ECO Puck & Cyclops Integrator



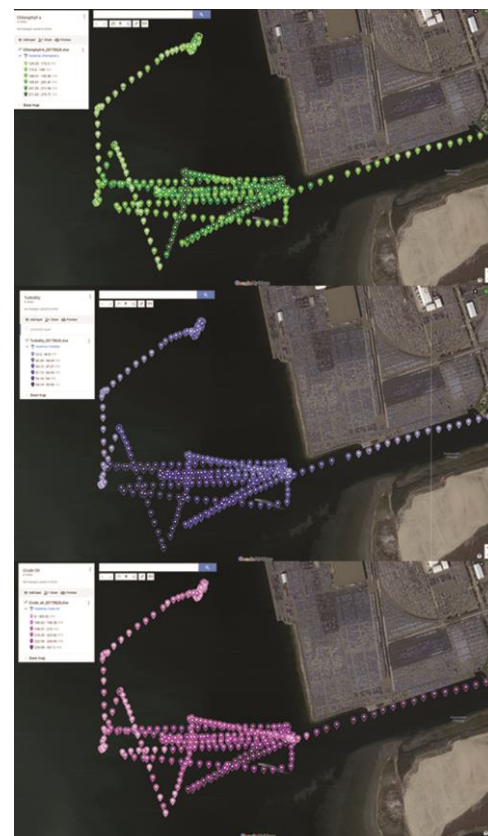
Teledyne Slocum Glider - Fluorometer Intercomparison

Rutgers I-COOL program and Teledyne Webb Research deployed a Slocum Glider to evaluate the C3 No Housing Fluorometer vs ECO Puck. The deployment lasted 45 days starting September 7th, 2012.

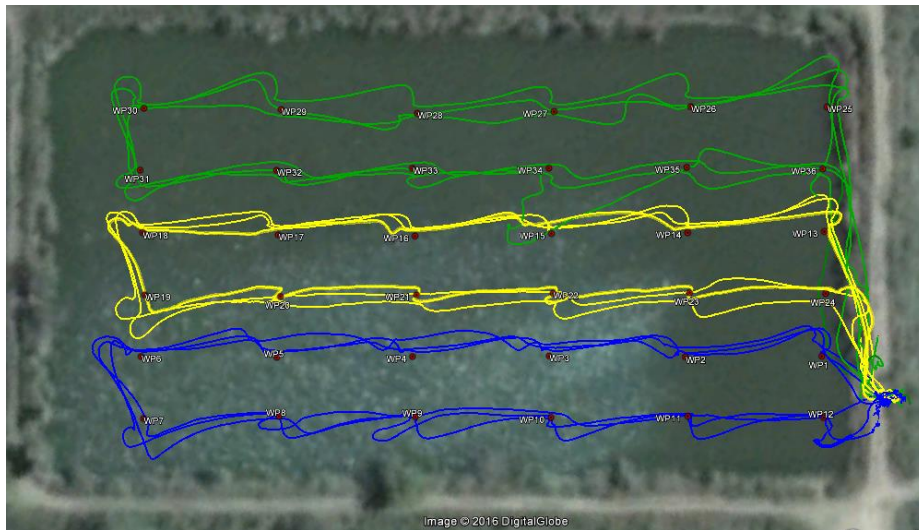


Each instrument had two channels that were directly comparable; Chlorophyll and CDOM. The spatial time series of chlorophyll shows similar response to significant structure in the water column.

- Self-powered, hybrid surface/sub-surface vehicle
 - Wind and solar powered
- Cyclops Integrator: Chlorophyll, Turbidity, Crude Oil
 - Dimensions
 - Weight
 - Power requirements



- Rhodamine tracing at Waste Stabilization Ponds
 - 36 preprogrammed measurement points
 - 2 different depths
- Costs as low as possible



Thank you



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