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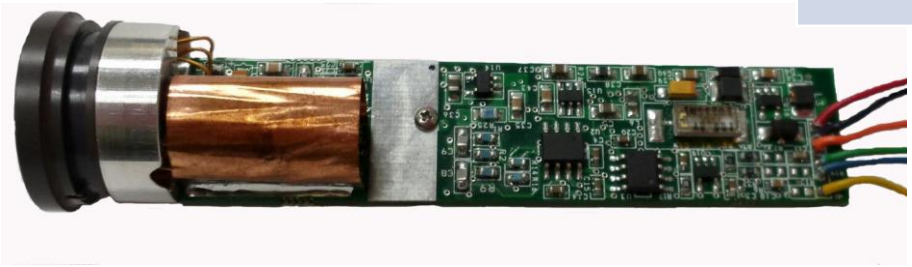
Fluorometers: Integration Experiences with Unmanned Vehicles

Pam Mayerfeld
VP of Marketing & Sales, Turner Designs
September 19, 2017

Fluorometers for Integration

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	20 mA

Apium – Data Diver

- Small prototype swarm vehicle
  - 29.5” X 2.25”; 3.7lb
- Operates at surface
  - Max dive depth 100m
- Profiling capability enables measurement of water column

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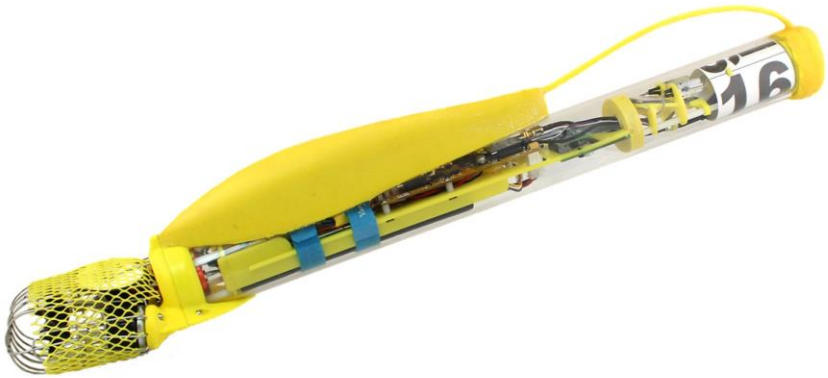
Apium - Integrated No Housing Cyclops

- Key reasons
  - Small size
  - Low cost
  - Multiple sensing options with same form factor
- Targeting diverse markets
  - Physical Oceanography
  - Aquaculture
  - Hydrographic Survey
  - Defense



APIUM SWARM ROBOTICS

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Ocean Aero – Submaran™ S10

- Self-powered, hybrid surface and sub-surface vehicle
  - Wind and solar powered
- Previously integrated ADCPs, CTDs, cameras, multi-beam sonars, acoustic modems, high bandwidth radios, passive acoustic receivers

Ocean Aero - Integrated Cyclops Integrator

- 3 sensors: Chlorophyll, Turbidity, Crude Oil
- Key reasons
  - Dimensions
  - Weight
  - Power requirements
- Hull fully floodable
  - Sealed housing on CI

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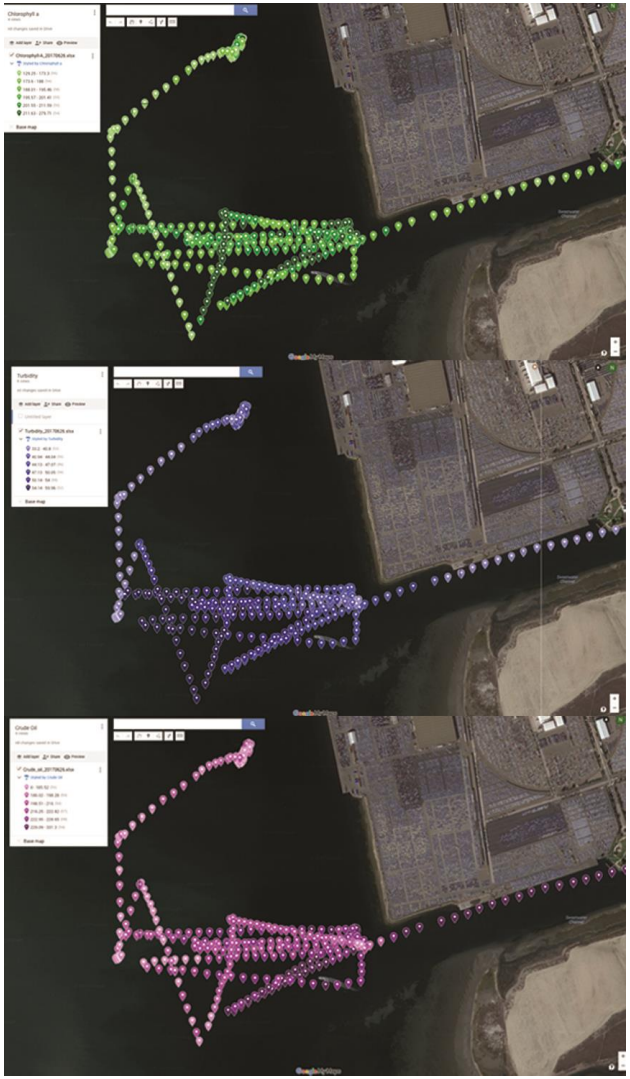
Ocean Aero data - San Diego Bay

- Targeting Oil & Gas and Environmental Monitoring



Chlorophyll

Turbidity

Crude Oil

OCEAN AERO

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Navocean - Nav2 ASV

- Sail and Solar ASV
  - Average speeds of 2+ knots
  - Continuous communications
- Previously integrated CT sensors as well as hydrophone receivers

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Navocean - Integrated Cyclops Integrator

- 3 sensors: Chlorophyll, CDOM, Turbidity
- Key reasons
  - Size
  - Power requirements
- Sealed Hull (unsealed housing on CI)

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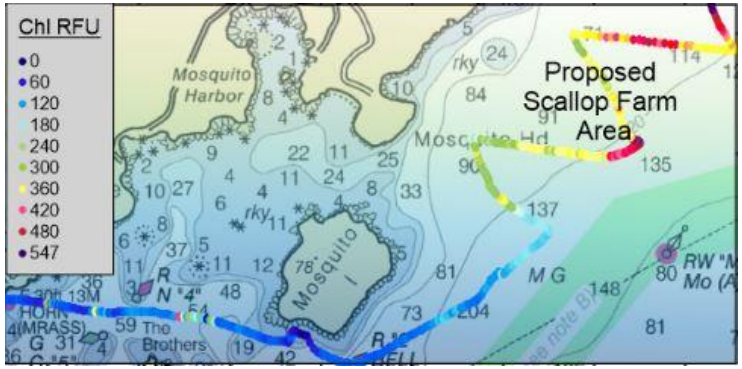
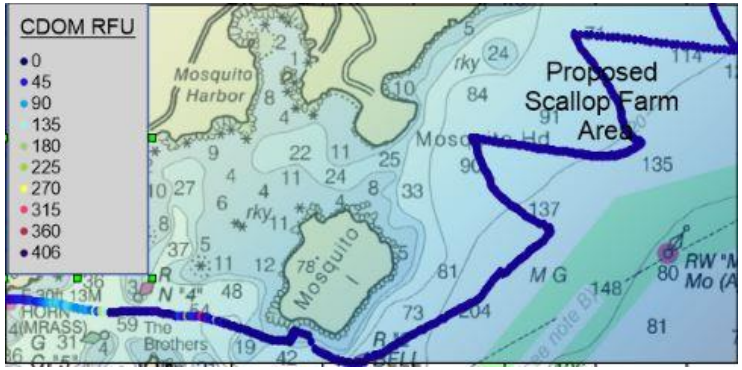
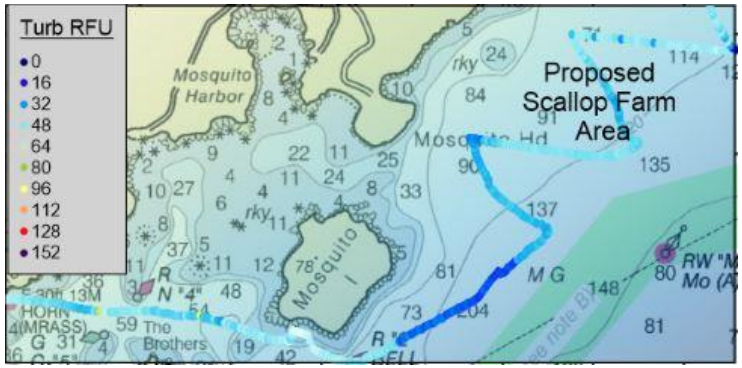
Navocean - Test run near proposed scallop farms in Maine



Chlorophyll



CDOM



Turbidity

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Navocean – Target Markets

- Conducting HAB and Productivity Surveys
  - Fisheries
  - Marine mammal researchers
- Adding Mote Marine Labs OPD (Optical Plankton Discriminator)
  - Map the extent of surface algal blooms and determine the presence or absence of toxic algal species.
- Ultimate goal is to be able to deliver HABs forecast for a region, much like a weather forecast

navocean
Sail and Solar Drone for Ocean Data Collection

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Liquid Robotics - Wave Glider[R]

- Wave and solar powered surface vehicle
- Initial integration 2010 Deepwater Horizon Oil Spill
  - C3s on base of the float & on the sub
- Improved design; now integrate over 60 sensors
  - CTDs, CTDOs, Ocean Current Monitors, Acoustic Modems, Hydrophones, Acoustic Monitoring Receivers, Fluorometers
- Target markets
  - Defense
  - Maritime Surveillance
  - Environmental Assessment
  - Oil and Gas

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Liquid Robotics - PacX Mission

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!

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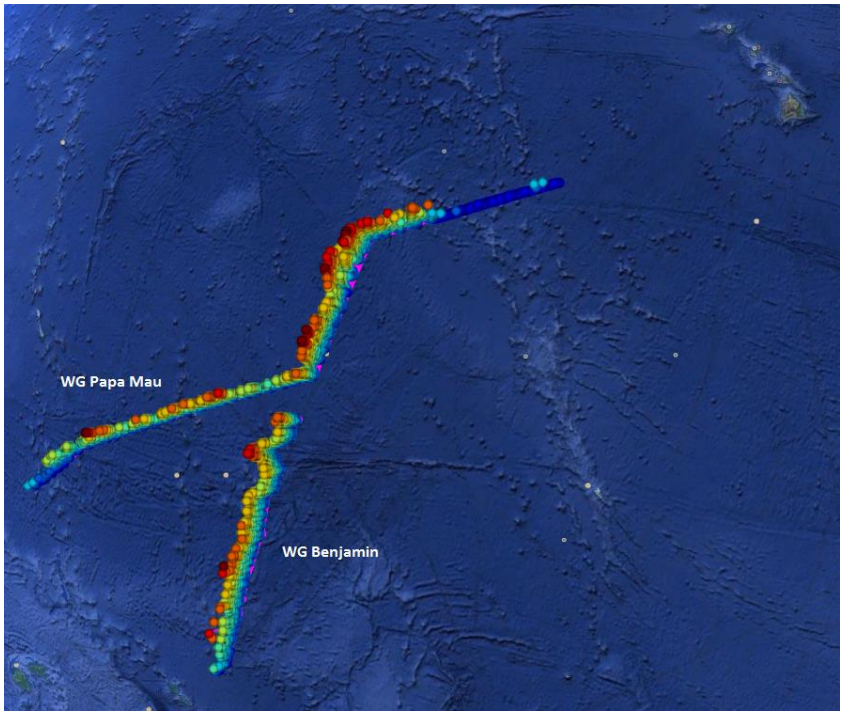
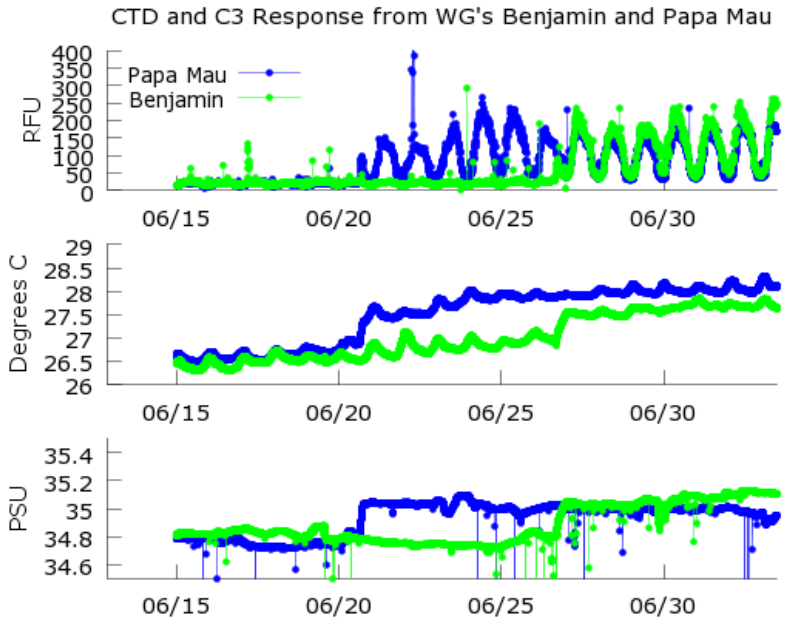
PacX: Open Ocean Phytoplankton Bloom

- 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





LIQUID ROBOTICS
A Boeing Company
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Teledyne Webb Research – Slocum Glider

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

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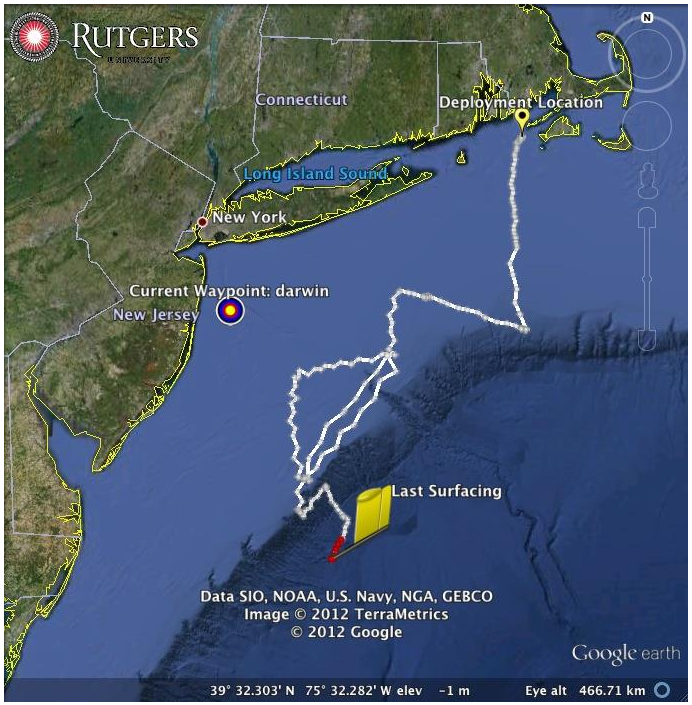
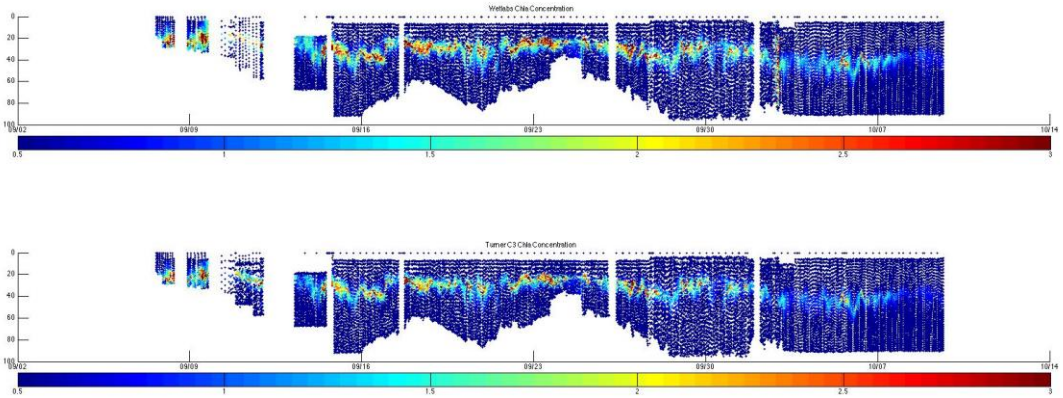
Teledyne Slocum Glider - Fluorometer Intercomparison

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.

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TELEDYNE MARINE
Everywhereyoulook™

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BRIDGES
BRINGING TOGETHER RESEARCH AND INDUSTRY FOR THE DEVELOPMENT OF GLIDER ENVIRONMENTAL SERVICES

19 project partners from 9 countries, including 6 European SMEs (*Cyprus Subsea is one*)

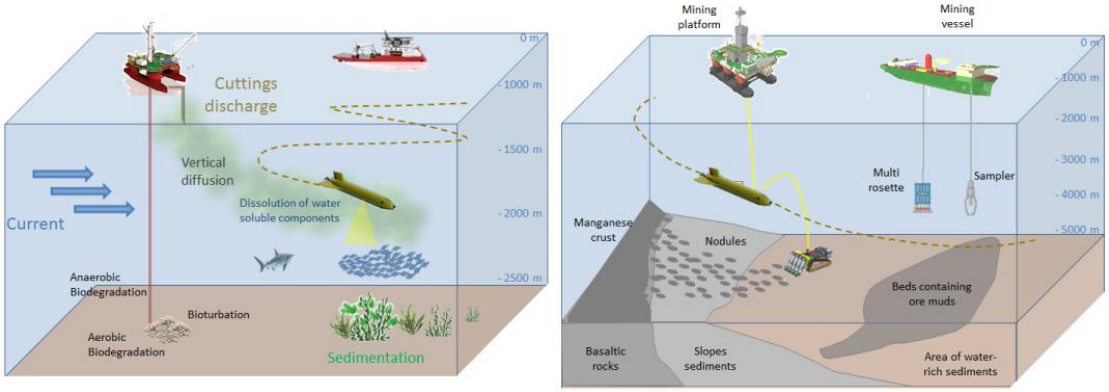
4 year project (2015–2019)

Coordinated by Laurent Mortier of ARMINES, France

Development and at-sea qualification of two deep-sea autonomous gliders (to 5000m depth)

Multi-mission vehicles providing services for:

- Fundamental research
- Long-term environmental monitoring (Copernicus, MSFD)
- Offshore industry (Oil and Gas, Sea Mining)



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HORIZON 2020

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BRIDGES
BRINGING TOGETHER RESEARCH AND INDUSTRY FOR THE DEVELOPMENT OF GLIDER ENVIRONMENTAL SERVICES

- A pair of deep (2400m) and ultra-deep (5000m) gliders
- Extended payloads targeting several markets
- Several Sensors developed under the project
  - Successful sensor demonstrations in June 2017
  - Developed smart sensor interface for easy integration
- Cyclops-6K are extensively used in most payloads
  - They will be mounted vertically in the payload bay
- Vehicle Demonstrations are due Spring 2019
- Commercial vehicles will be sold by ALSEAMAR, France

Payload	Sensors
General Purpose	• CTD • O2 • CYCLOPS-CRUDE • CYCLOPS-REFINED
Water Column Habitats	• CTD • O2 • Phosphate • CYCLOPS-TURB • CYCLOPS-CDOM • Octopus Camera • Water Sampler
Hydrographics	• CTD • O2 • Sub Bottom Profiler • CYCLOPS-TURB • Octopus Camera
Oil & Gas	• CTD • O2 • CYCLOPS-CDOM • CYCLOPS-CRUDE • CYCLOPS-REFINED • Octopus Camera
Climate Change	• CTD • O2 • Octopus Camera

For more information on payloads: Dan Hayes hayesdan@cyprus-subsea.com

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Thank you

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