Overview of Glider Technology: Current and Near-Term Capabilities

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U.S. IOOS National Glider Strategy Development Workshop

What is a glider

“Underwater gliders are autonomous vehicles that profile vertically by controlling buoyancy and move horizontally on wings.”

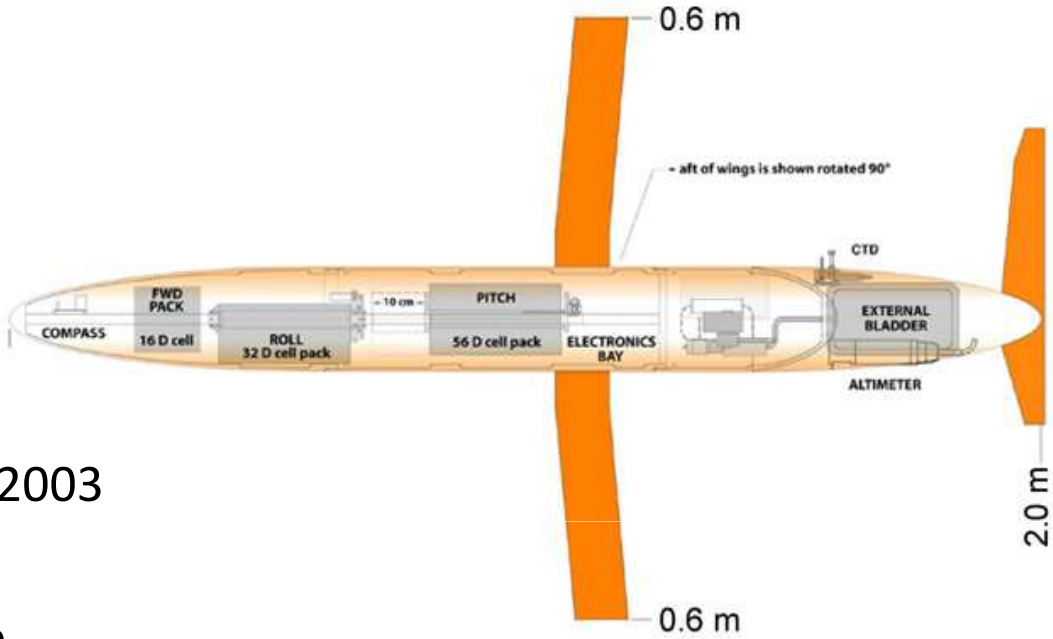
Russ Davis

The Industry Standards

Spray

Developed at Scripps Institution of Oceanography Instrument Development Group

- Buoyancy by hydraulics
- Steering by CG adjustments
- Science in aft compartment
- To date 56 built in house
- Licensed to Bluefin Robotics in 2003
- To date 15 sold by Bluefin
- Currently sold for $125k and up

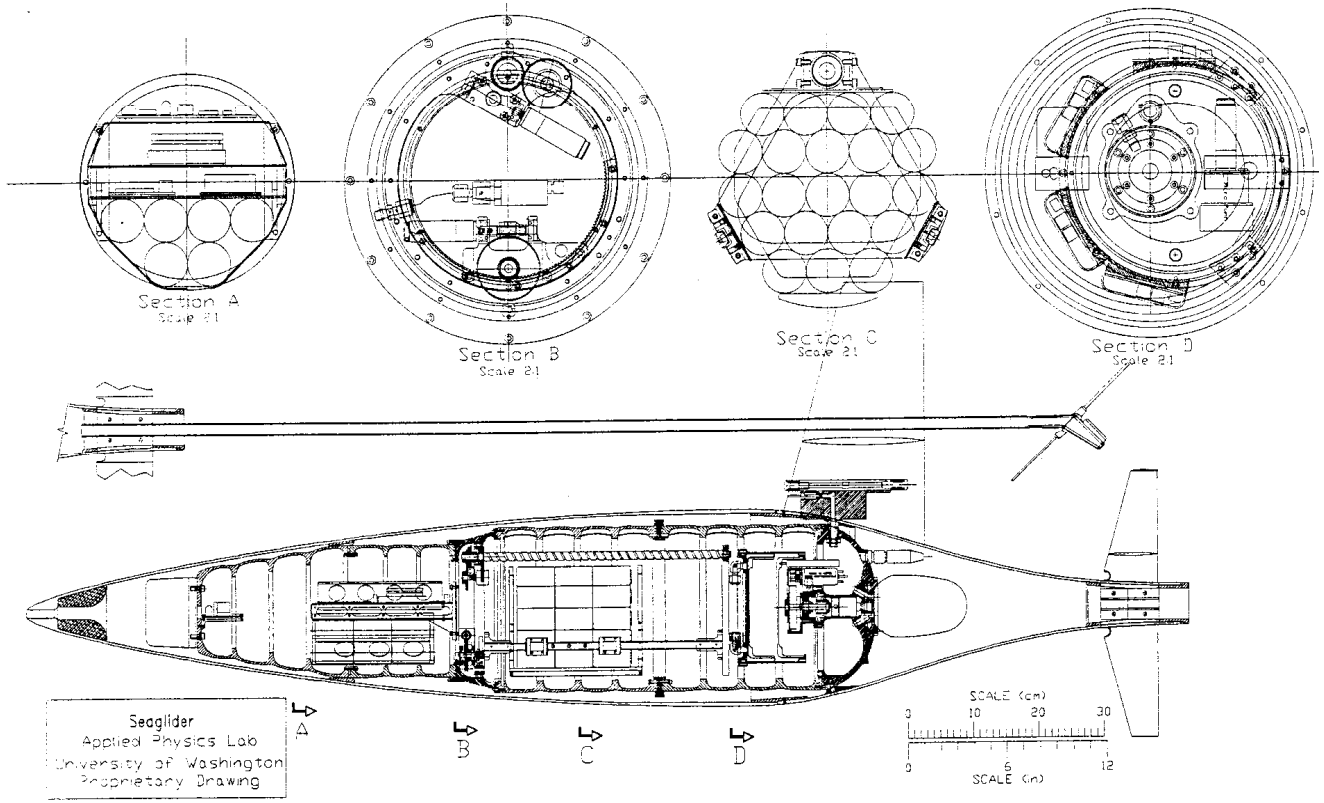


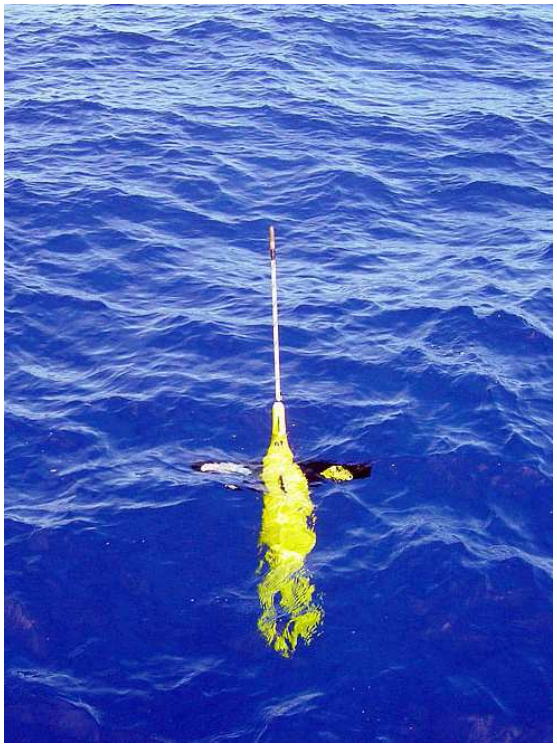
Seaglider

Developed at University of Washington, Applied Physics Lab

- Buoyancy by hydraulics
- Steering by CG adjustments
- Isopycnal pressure hull

- Science in aft flooded compartment
- Several options:
  - Enhanced buoyancy engine for shallower water (to 20 m).
  - Standard or Ogive (10% longer) profile hulls
- Licensed to iRobot in 2009
- To date approximately 170 made by UW-APL and iRobot



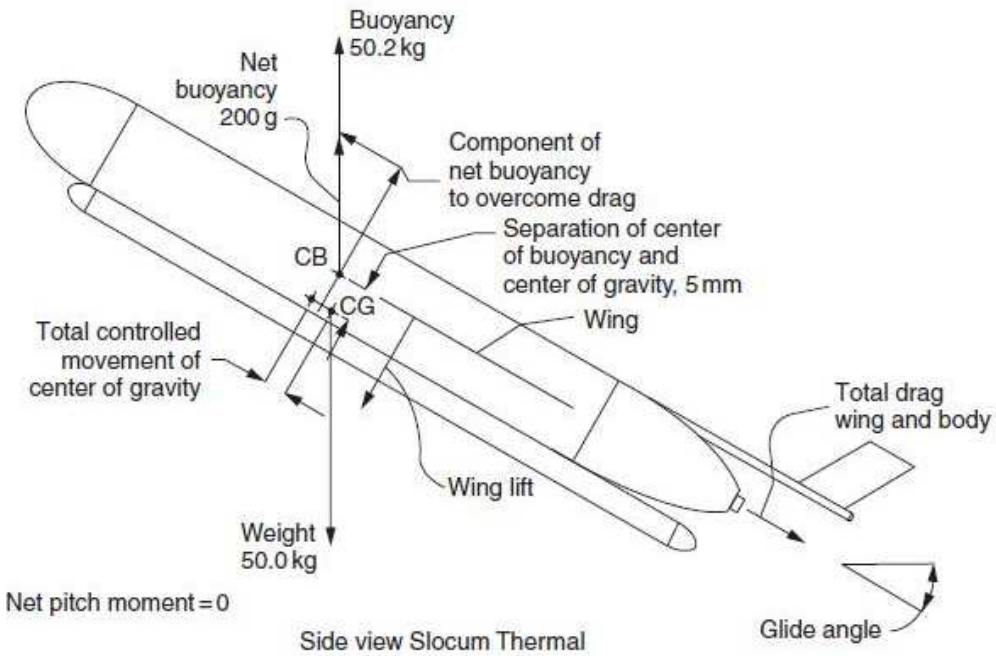


Slocum

Developed at Webb Research Corporation, now Teledyne Webb Research.

To date ~300 built.

- Buoyancy by piston, hydraulics, or thermal
- Heading adjusted by tail rudder
- Pitch adjusted by CG adjustment
- Science mostly in center hull
- Several versions:
  - 200m Electric (reconfigurable for 30 or 100m), 1000m Electric, Thermal
- Currently sold for $125k and up



Others

SIO Liberdade Xwing glider

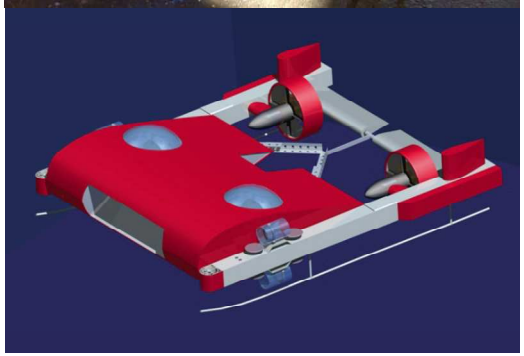
Exocetus Coastal Glider (formerly A.N.T.)
- Larger (109kg), greater buoyancy differential (5l), faster (1.0 m/s).

EvoLogics Subsea Glider – Prototype

Hybrids:

Fogalla AUV - Short deploy, highly manuverable

FIT MAUSS – Concept



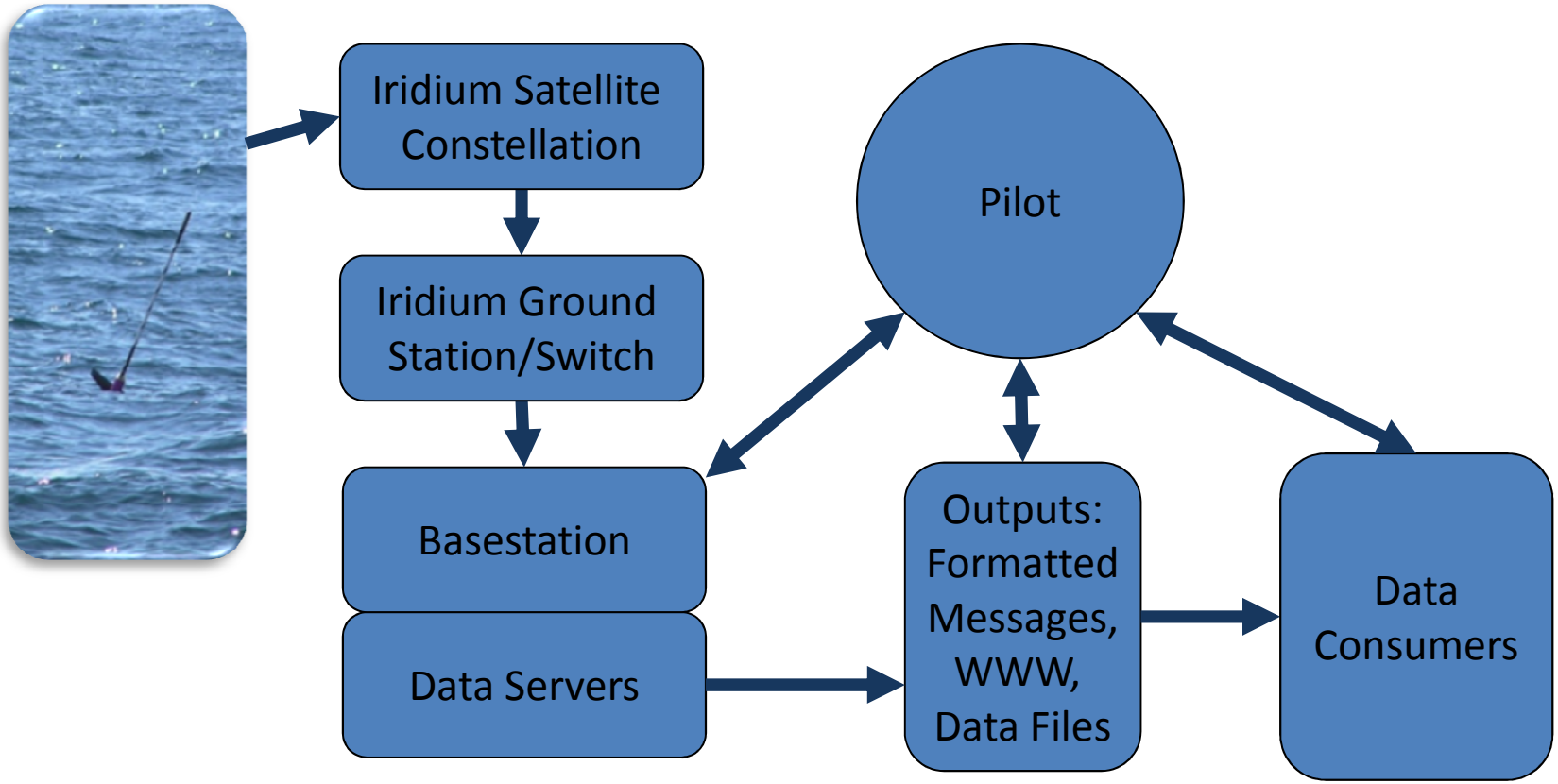
Physical Specifications

	Spray	Seaglider	Slocum
Hull Diameter	0.20 m	0.30 m	0.22 m
Weight	52 kg	52 kg	54 kg (electric) 60 kg (thermal)
Length	2.13 m	1.8 m hull 2.8 m with antenna	1.50 m
Wing Span	1.2 m	1.0 m	1.20 m
Buoyancy Engine	Hydraulic	Hydraulic	Mechanical / Hydraulic / Thermal
Favored Color	Orange	Pink / Yellow	Yellow

All three are customizable with help from the designers or manufacturer for unique sensor packages or specific mission objectives.

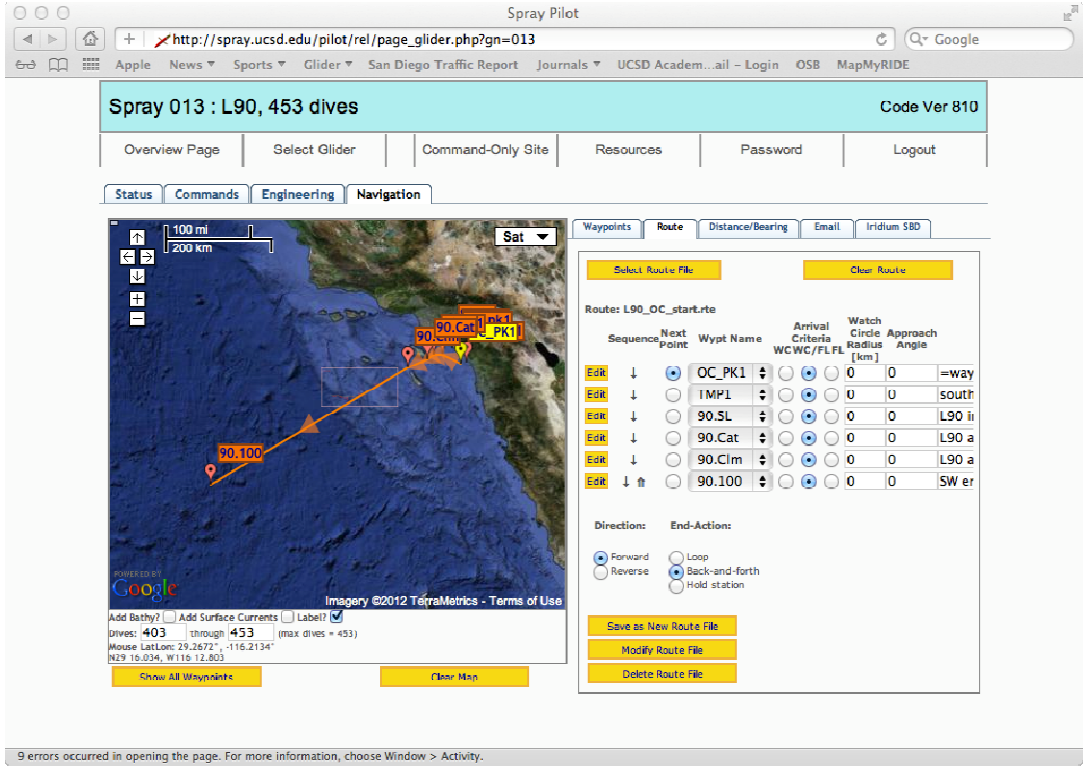
Communications

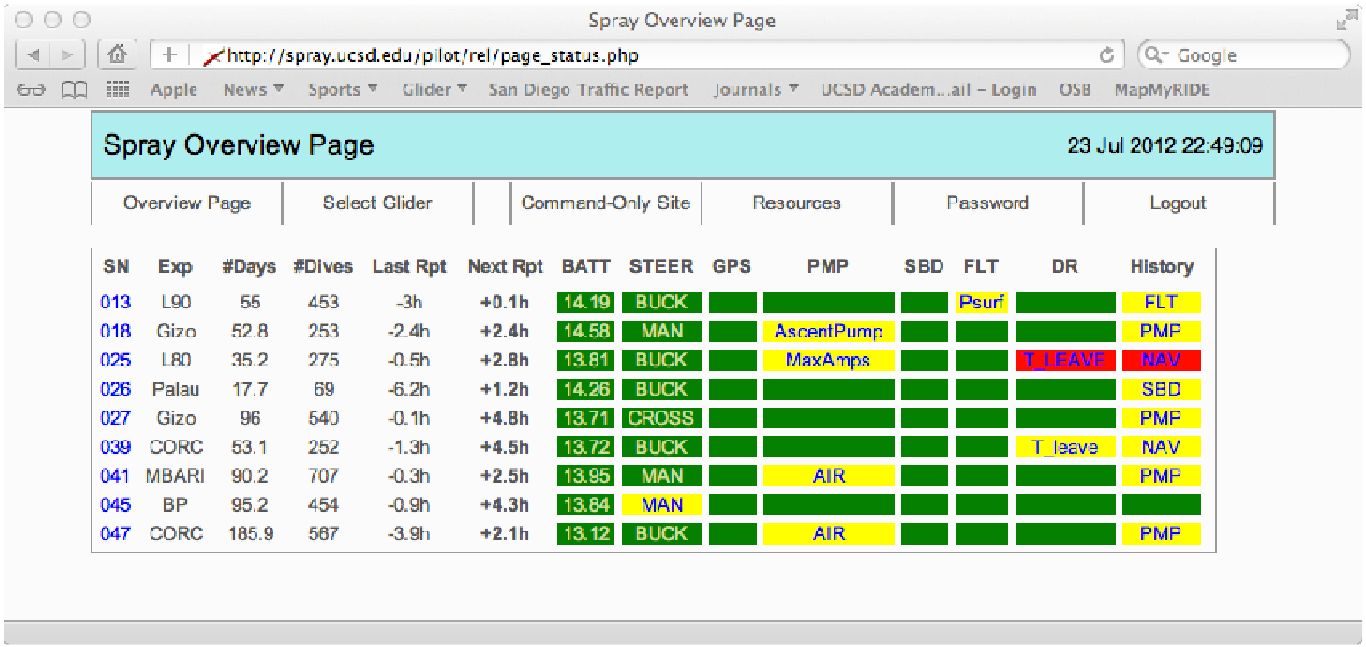
- Short range communication options include RF modem and serial connections.
- All use Iridium modems for bi-directional satellite communications similar to….



User Interfaces

- Multiple custom options.
- All include file transfer protocols, mapping
- All allow for remote operations control for pilots.





SN	Exp	#Days	#Dives	Last Rpt	Next Rpt	BATT	STEER	GPS	PMP	SBD	FLT	DR	History
013	L90	56	453	-3h	+0.1h	14.19	BUCK				Psurf		FLT
018	Gizo	52.8	253	-2.4h	+2.4h	14.58	MAN		AscentPump				PMP
025	L80	35.2	275	-0.5h	+2.8h	13.81	BUCK		MaxAmps			T_LEAVE	NAV
026	Palau	17.7	69	-6.2h	+1.2h	14.26	BUCK						SBD
027	Gizo	96	540	-0.1h	+4.8h	13.71	CROSS						PMP
039	CORC	53.1	252	-1.3h	+4.5h	13.72	BUCK					T_leave	NAV
041	MBARI	90.2	707	-0.3h	+2.5h	13.95	MAN		AIR				PMP
045	BP	95.2	454	-0.9h	+4.3h	13.64	MAN						
047	CORC	185.9	567	-3.9h	+2.1h	13.12	BUCK		AIR				PMP

List of sensors used

- **CTDs: Sea-Bird pumped and free flow**
- **Dissolved Oxygen: Aanderaa Optode, Sea-Bird SBE-43F**
- **Fluorometers: WET Labs (Puck series) and Seapoint**
- PAR: Biospherical QSP-2150
- Doppler Profilers: Nortek, Sontek
- Bioluminescence
- Radiometers: Satlantic
- Nitrate: ISUS, SUNA
- Passive Acoustics
- Microstructure

Mission Planning

Standard maximum mission expectations , platform independent (utilizing standard lithium battery packs)

- Power Supply - 17 MJ
- Mission Duration - up to 6 months
- Mission Range - up to 4500 km
- Depth Range - 5* – 1000m (lower range is platform dependent)
- Forward Speed - 0.2 - 0.3 m/s
- Allowable Environmental Density Variation - 5.0 g/l increasing to up to over 10.0 g/l with recent / upcoming enhancemnts.
- Man deployable utilizing a wide variety of vessels, from RIBs to Fishing Charters to RVs

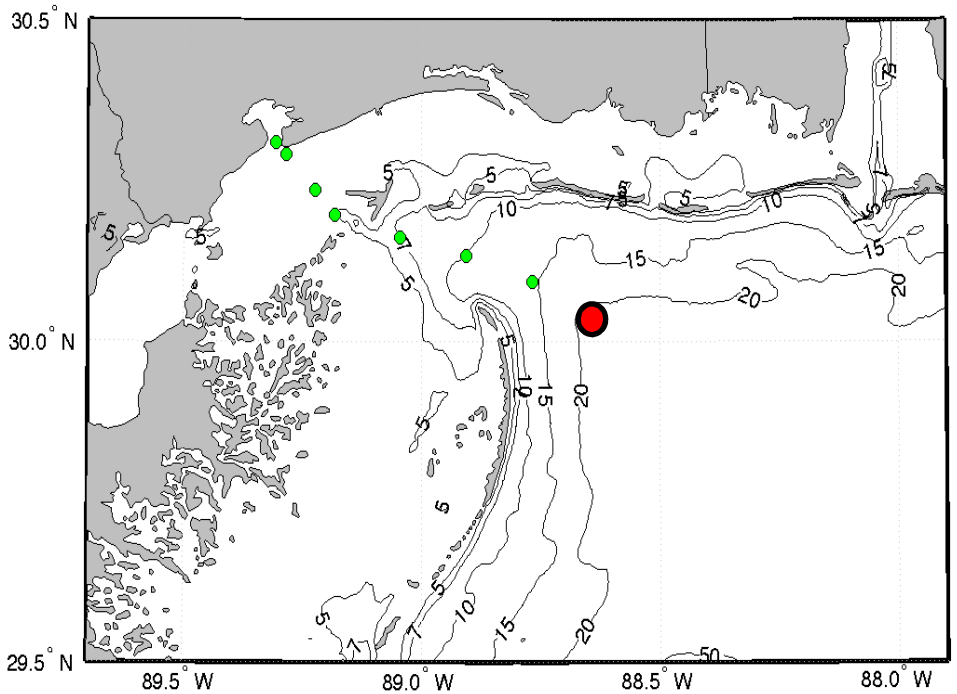
Negative duration and range impacts:

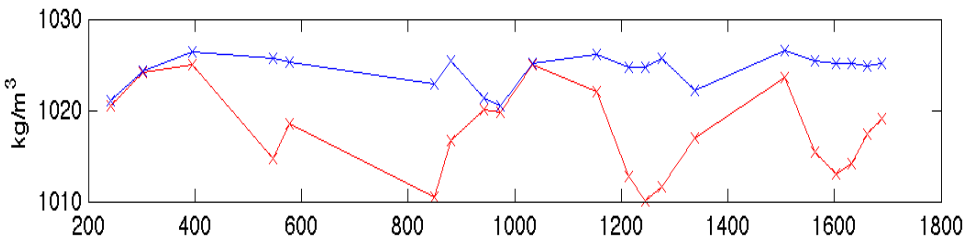
- Water Depth, operating at the shallow end of a glider's capabilities can cut mission length up to 40%.
- Significant stratification requiring greater ballast adjustments.
- Sensor load.
- Drag inducing hull modifications.
- Communications inefficiencies.

Operational Challenges

- Regions of extreme density variation

- Regions with ice cover
- High current environments
- High biofouling environments

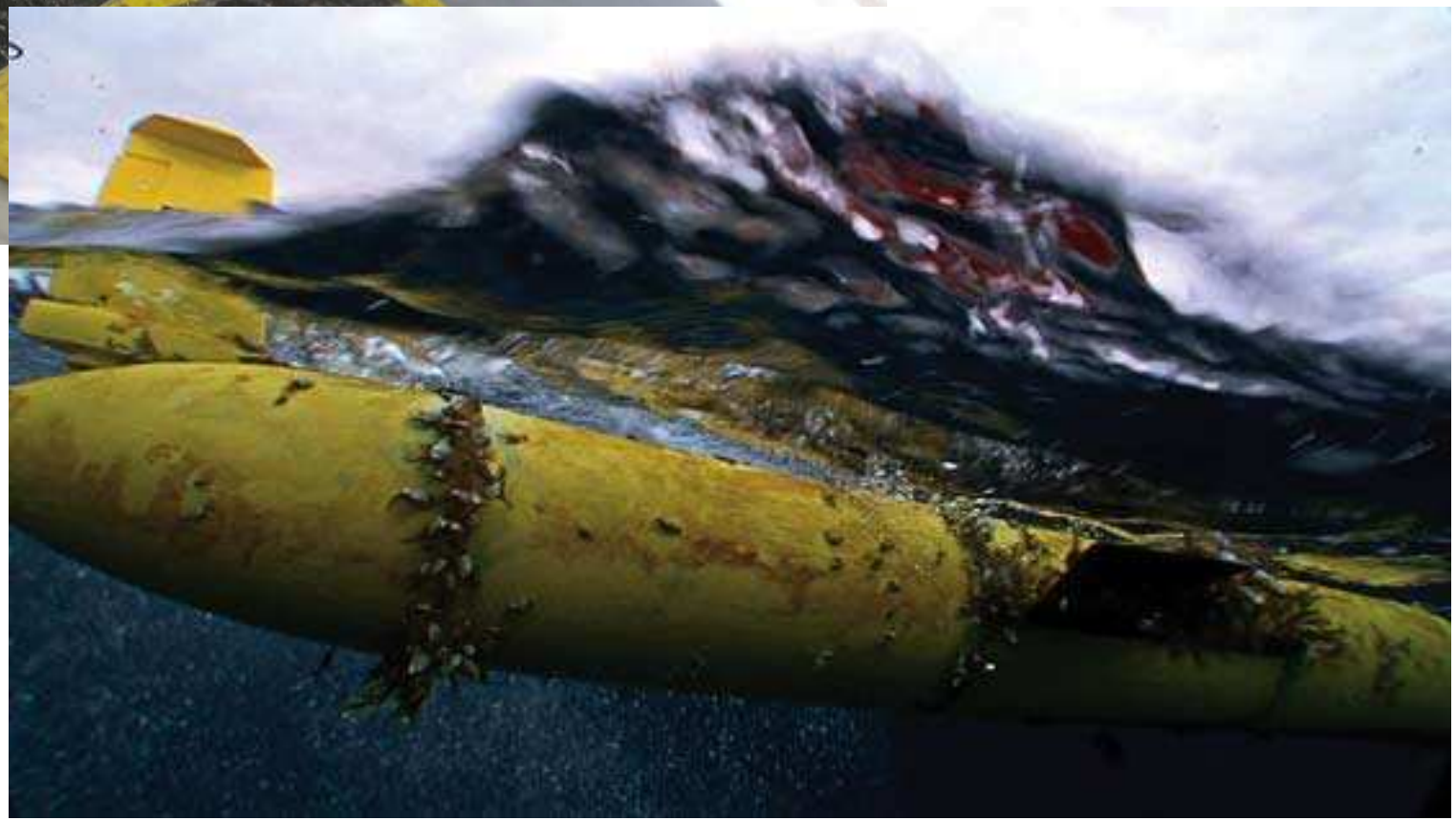




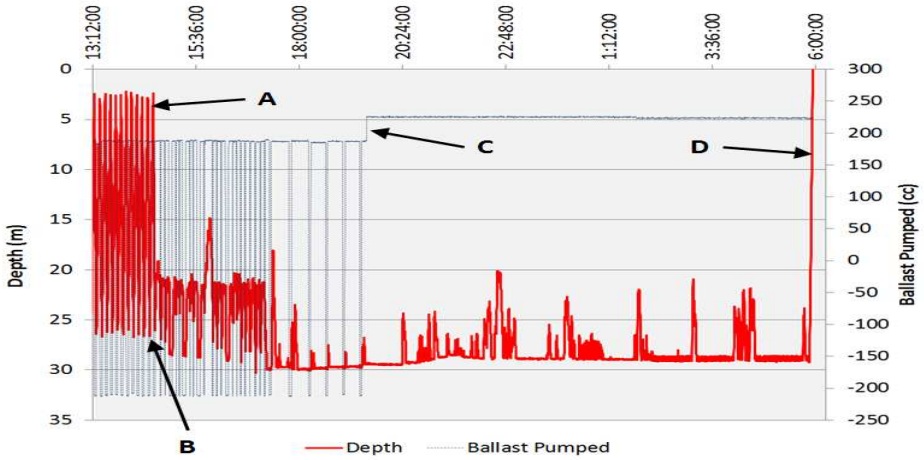
Blue – Bottom Density **Red – Surface Density**

```
sensor:m_present_time(timestamp)=1331210368.00839        1.825 secs ag
sensor:m_water_vx(m/s)=1.70833264681386                 52.88 secs ago
sensor:m_water_vy(m/s)=1.15173575306477                52.937 secs ago
```

Biofouling



Macro-Biofouling

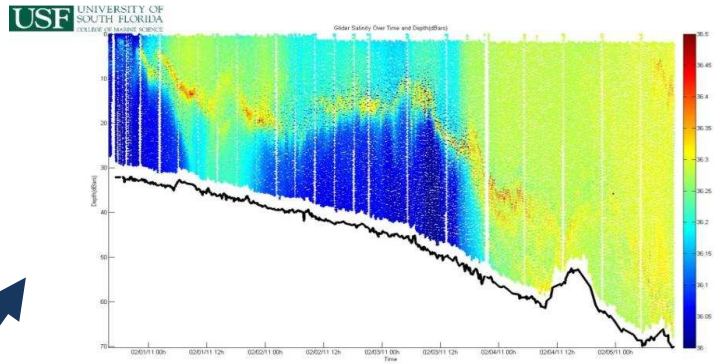


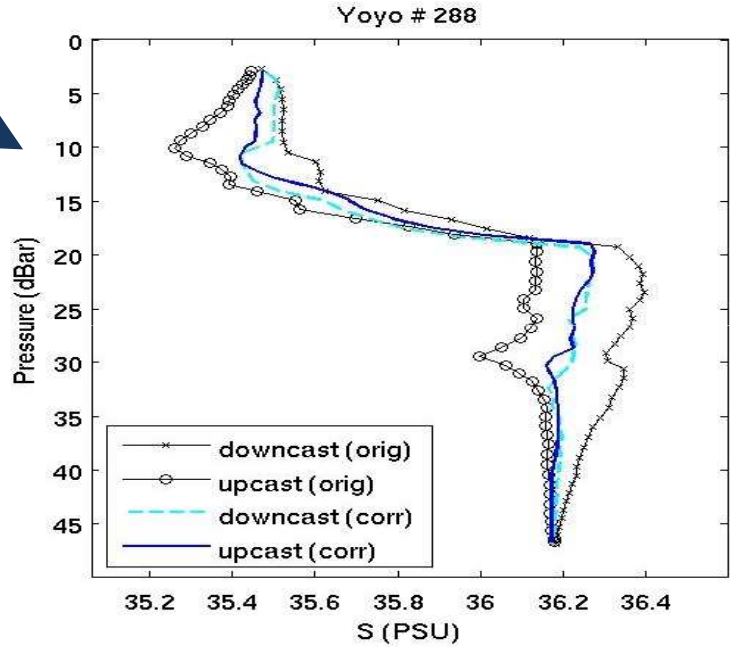
A – Normal Profiling B – Attachment
C – Abort D – Weight Ejection
Red – Glider Depth Trajectory Blue – Ballast Pumped

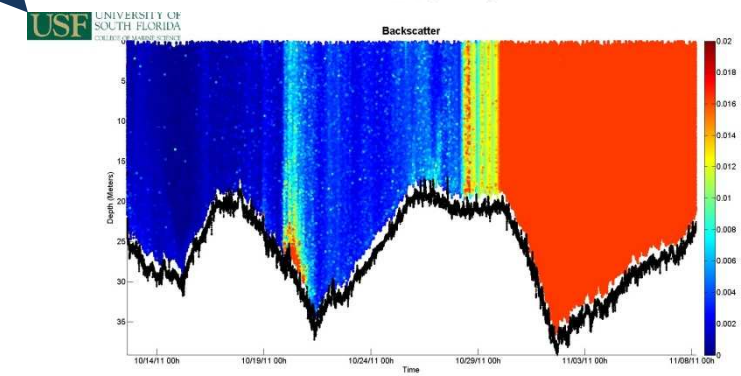
QA / QC

Sensor readings that may need post-processing prior to being usable:

- All CTDs have some issues. i.e. CTD readings in non-pumped versions: temperature lag will cause errors in thermoclines.
- Dissolved Oxygen: response time and similar temperature lag can distort readings.
- Biofouling effects: some optics sensors can foul within days to weeks without preventative measures.
- Glider positioning: without underwater positioning (acoustics), exact position can only be estimated.







Infrastructure needs

Technician Needs (0.5-1.0 man-month / deployment):

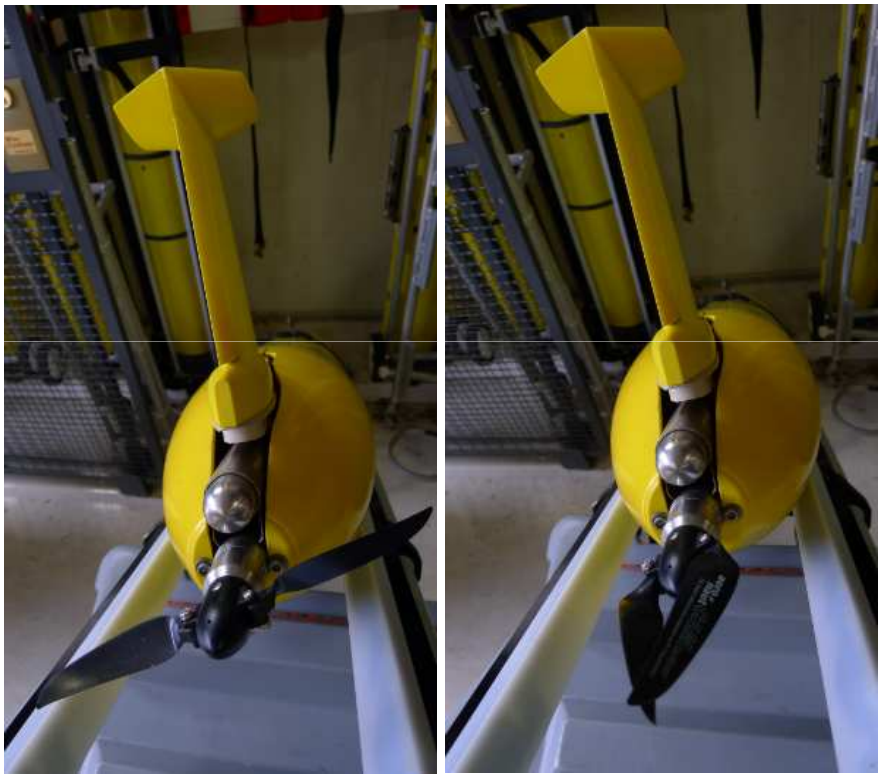
- **Assembly and maintenance**
- **Ballasting**
- **Deployment operations**

Piloting Needs (10-50% commitment during deployment):

- **Mission planning**
- **Mission performance monitoring**
- **Data QA / QC**

IT Needs (varies):

- **Server maintenance / upgrades**
- **Delivery of data / products to customers**

Enhancements Being Developed

- Slocum:
  - Thruster Integration
  - 800 cc Buoyancy Engine
- Seaglider:
  - Deepglider Development and Testing, current success to 5000m, 6000m goal
  - Fully integrated ADCP sending parsed water column velocity data
- Spray:
  - Increased bladder volume
  - Sea-water battery