Wave Gliders Instrumented for Air-Sea Interaction Research

by the Air-Sea Interaction Laboratory at Scripps Institution of Oceanography

The Liquid Robotics Wave Glider is an ocean-wave-propelled autonomous surface vehicle with a two-body design. The lower portion, called the sub, is tethered to the surface float portion of the vehicle by an umbilical cable. The fins on the sub convert the orbital motion of ocean waves into a horizontal force that tows the instrumented surface float forward.

Solar panels are mounted on the float to supply power for the navigation and communication systems as well as any onboard instrumentation. Sealed payload bays beneath the solar panels house data acquisition systems and supporting electronics for sensors that can be installed above or below the ocean surface on the float, along the umbilical, or on the sub. The updated SV3 model is larger with additional solar charging potential and also includes an electric thruster for supplementary propulsion as well as an optional electric winch that is mounted to the sub for sensor profiling below the surface.

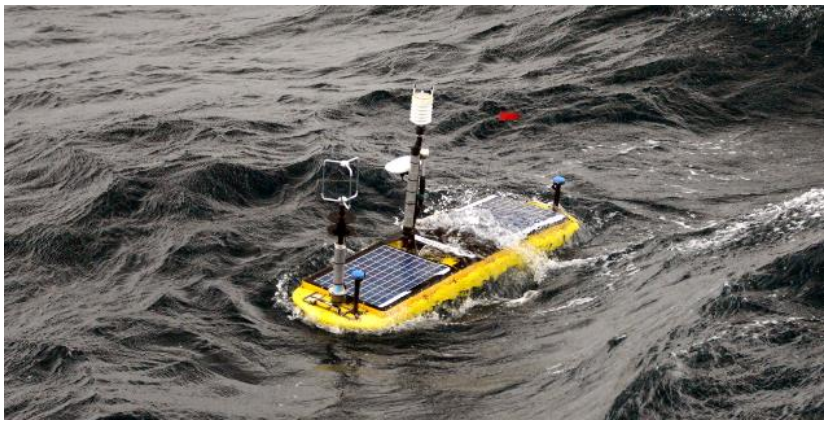
Control and navigation of the vehicles is handled from shore through an Iridium satellite link. Navigational waypoints and system commands can be sent to the vehicle while telemetry packets that have vehicle and payload data can be transmitted back to shore for real-time monitoring.

The Air-Sea Interaction Lab currently operates a fleet of four Wave Gliders with two SV3 and two SV2 models instrumented for air-sea interaction research. The instrument suites include meteorological sensors, CTDs, thermistor chains, ADCPs, and GPS/IMUs for navigation and surface wave measurements with an additional winch-profiled CTD/fluorometer/dissolved oxygen sensor on the SV3.

The minimal supervision that this unique platform requires offers an alternative to operationally demanding and costly research vessels. The sustainable electrical power source allows for prolonged time series measurements while the continuous source of propulsion and optional winch allows for flexible horizontal and vertical sampling strategies not available to moored options. Also, the unobtrusive design of the vessel minimizes its own physical imprint on the complex environment of the lower atmospheric and upper marine boundary layers where these vessels' measurements are focused.

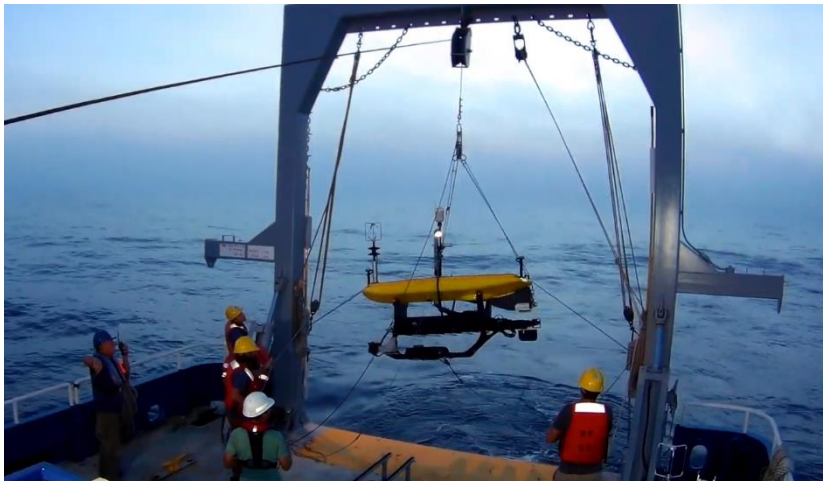
Previous Wave Glider Fieldwork Campaigns:

- NSF Pioneer Array Experiment, 2018, mid-Atlantic coast south of New England near the Coastal Pioneer Array
- ONR Langmuir Cell Department Research Initiative, 2017, near the Channel Islands, CA
- Consortium for Advanced Research on Transport of Hydrocarbon in the Environment, 2016, Gulf of Mexico
- ONR SOCAL experiment, 2013, near Channel Islands, CA



An instrumented Wave Glider during the NSF Pioneer Array experiment in October 2018 prior to recovery after 4 weeks at sea.

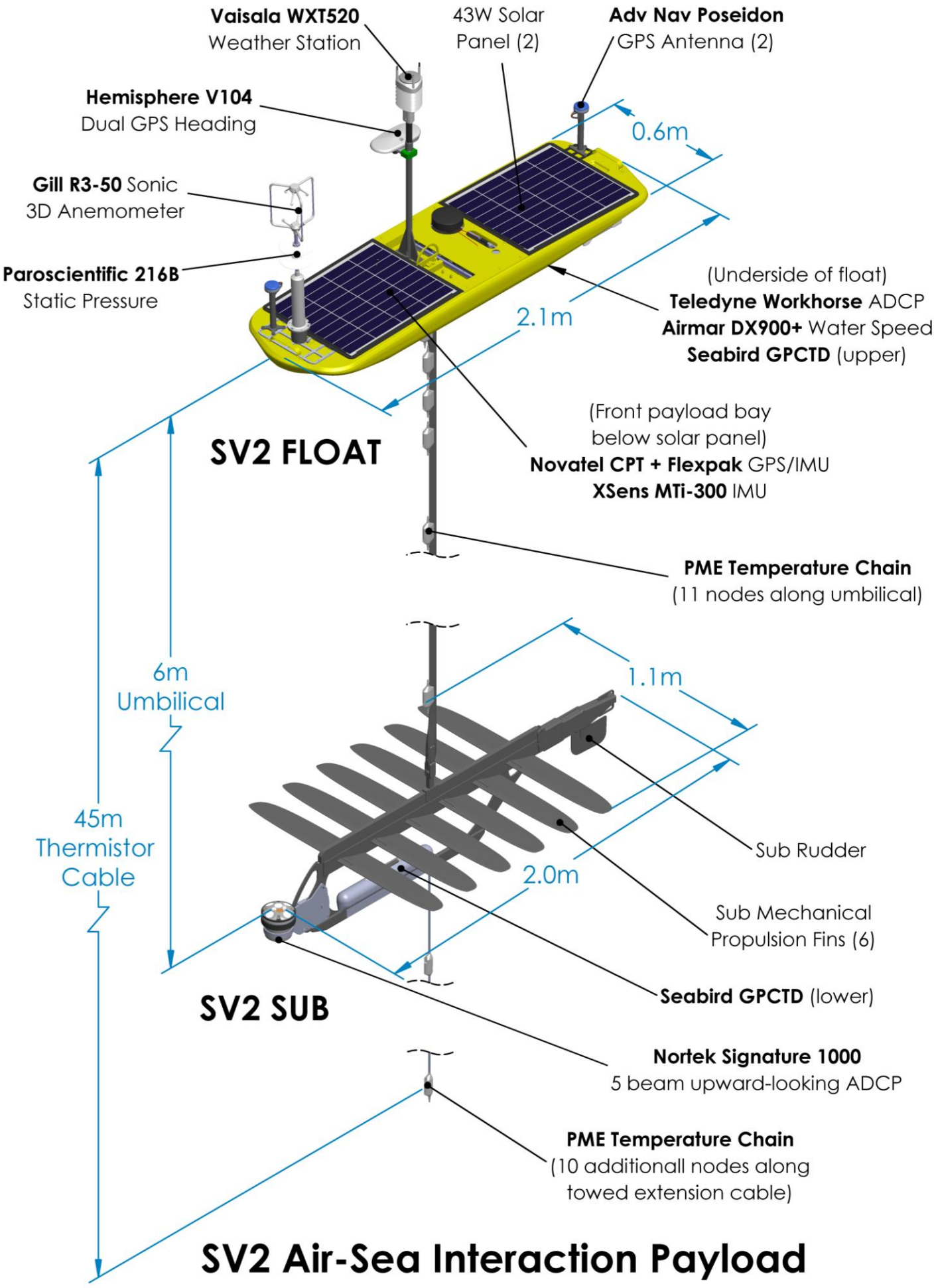
Photo from R/P FLIP of a Wave Glider in large seas during the ONR Langmuir Cell DRI off the coast of Southern California in March 2017.



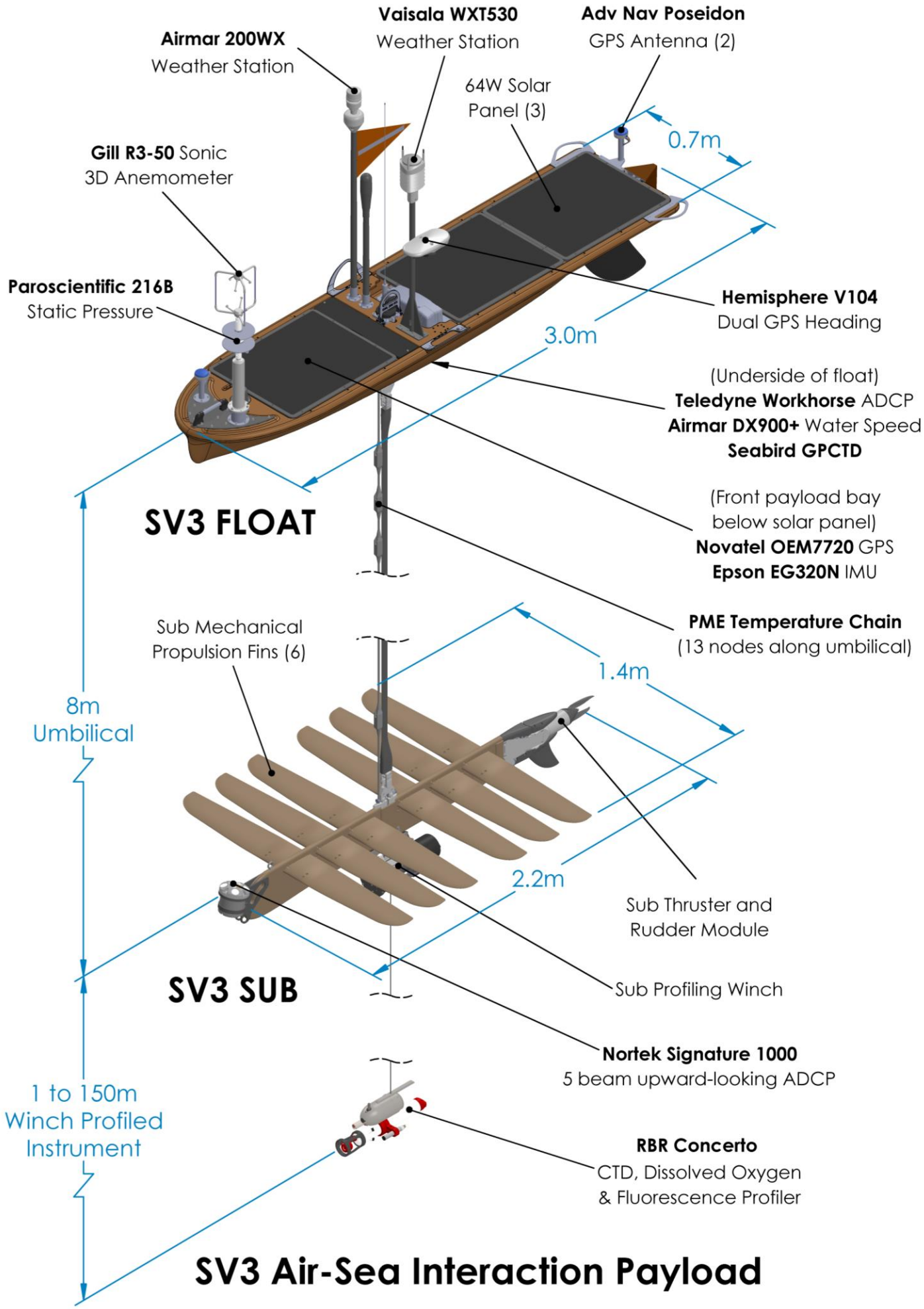
Deployment of a Wave Glider near the Pioneer Buoy Array from the a-frame of the R/V Connecticut in September 2018.

Wave Glider Specs	SV2 and SV3 Vehicle Specifications
Vehicle Weight	90kg (SV2) and 155kg (SV3) including float, umbilical and sub without payloads
Vehicle Dimensions	2.1m x 0.6m float footprint, 6.3m umbilical length, 2.0m sub length, 1.1m wing width (SV2) 3.0m x 0.7m float footprint, 8.0m umbilical length, 2.2m sub length, 1.4m wing width (SV3)
Vehicle and Air-Sea Payload Power	665Wh (SV2) and 2700Wh (SV3) battery capacity, 86W (SV2) and 192W (SV3) max solar input, 30W max (12W SPAN off) payload power SV2, xxW max 12.5W payload power SV3
Water Speed	0-1kn sea state dependent (SV2), 1.3kn typical (SV3)
Communications	Iridium/Xbee (SV2) and Iridium/Cell/WiFi (SV3) with web-based command & control interface
Vehicle Winch*	15-25lb payload with 10W power & 10MB/s data to 150m depth. *Installed on SV3 sub only.

Payload Instruments*	Air-Sea Payload Instrument Descriptions and Specifications
Novatel SPAN* GPS / IMU	GPS receiver and tightly coupled 100hz (SV2) or 125hz (SV3) IMU data post-processed with PPP corrections to calculate cm-level accurate vehicle trajectories. *SV2 uses Flexpak GPS receiver with SPAN-CPT IMU. SV3 uses OEM7720 GPS receiver with Epson EG320N IMU.
Adv Nav Poseidon GPS Antenna	Low profile subsea antenna rated to depths of up to 3000m. GPS, GLONASS, Galileo, and BeiDou constellations enabled.
Hemisphere V104 Dual Antenna GPS	GPS receiver integrated with two antennas in a single housing for 10hz heading data. Internal gyro and tilt sensors allow for quick start-up and reacquisition in poor GPS environments.
Xsens MTi-300 * AHRS IMU	Low power IMU with roll, pitch and true North referenced yaw outputs at 20hz used when high power SPAN system is off to conserve power. *Only installed on SV2 vehicles.
Gill R3-50 Sonic Anemometer	3D sonic anemometer with 50hz wind speed, wind direction, and sonic temperature outputs with 0 to 45 m/s range, 0.01 m/s resolution, and <1% RMS error accuracy.
Paroscientific 216B* Static Pressure	High precision absolute static pressure gauge with 80-110kPa range, 1mPa resolution, and 20hz output. *Substitute for Paroscientific 202BG gauge pressure version on one SV2 vehicle.
Vaisala WXT530* Weather Station	2D sonic wind speed and direction, pressure, temperature, humidity, and rainfall data 1hz. *Substitute for similar Vaisala WXT520 on both SV2 vehicles.
Airmar 200WX* Weather Station	2D sonic wind speed and direction, pressure, temperature, humidity, GPS receiver and three axis compass/gyro/accelerometer at 1hz. *Only installed on SV3 vehicles.
PME T-Chain* Thermistor Chain	Underwater thermistor node chain with 1hz output. *21 nodes from 0.5m to 45m depth on SV2 vehicles, 13 nodes from 0.5m to 8m node depths on SV3 vehicles.
Seabird GPCTD* Glider CTD	Low profile conductivity, temperature, and depth data at 1hz. *Two installed on each SV2 (25cm and 7m depth) and one installed on each SV3 (25cm depth).
RBR Concerto* CTD, DO, Fluorometer	Conductivity, temperature, depth, dissolved oxygen, and fluorometer data at 1hz. Sensor profiled from 8m to 150m from subsurface winch. *Only installed on SV3 vehicles.
Teledyne Workhorse* ADCP	Downward-looking 300khz acoustic doppler current profiler for SV3 and one SV2. 35x 3m-depth bins to 107m at xxhz. *600khz with 35x 2m bins to 73m depth for other SV2.
Nortek Sig 1000 ADCP	Upward-looking 1MHz 5-beam acoustic doppler current profiler mounted to the sub (6.3m depth SV2, 8m depth SV3) sampled at 8hz with 20cm resolution (50 bins SV3, 40 bins SV2).
Airmar DX900+* Water Speed	Low profile sensor with no moving parts that outputs dual axis speed, depth, and water temperature at 10hz. *Substitute for Airmar CS4500 at 1hz on one SV3 vehicle.



SV2 Air-Sea Interaction Payload


Airmar 200WX
Weather Station
Vaisala WXT530
Weather Station
Adv Nav Poseidon
GPS Antenna (2)
64W Solar
Panel (3)
0.7m
Gill R3-50 Sonic
3D Anemometer
Paroscientific 216B
Static Pressure
Hemisphere V104
Dual GPS Heading
3.0m
(Underside of float)
Teledyne Workhorse ADCP
Airmar DX900+ Water Speed
Seabird GPCTD
SV3 FLOAT
(Front payload bay
below solar panel)
Novatel OEM7720 GPS
Epson EG320N IMU
PME Temperature Chain
(13 nodes along umbilical)
Sub Mechanical
Propulsion Fins (6)
1.4m
8m
Umbilical
2.2m
Sub Thruster and
Rudder Module
SV3 SUB
Sub Profiling Winch
Nortek Signature 1000
5 beam upward-looking ADCP
1 to 150m
Winch Profiled
Instrument
RBR Concerto
CTD, Dissolved Oxygen
& Fluorescence Profiler
SV3 Air-Sea Interaction Payload