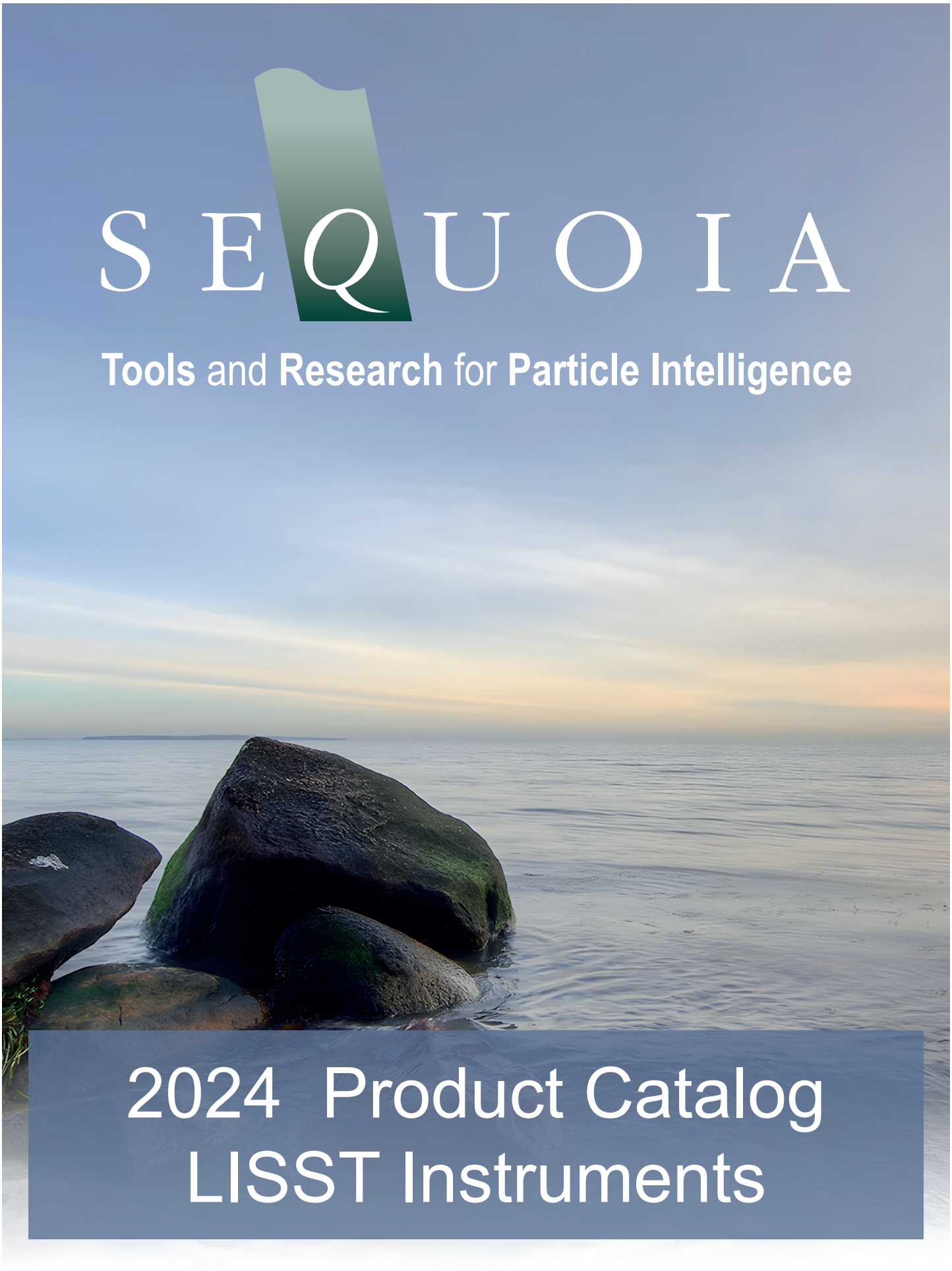
SEQUOIA
Tools and Research for Particle Intelligence
2024 Product Catalog
LISST Instruments

About Sequoia Scientific, Inc.

Sequoia was founded in 1995 by Dr. Yogesh (Yogi) Agrawal and Chuck Pottsmith. Yogi received his Ph.D. from University of California, Berkeley in 1975, and was a scientist at Woods Hole Oceanographic Institution (WHOI) from 1978-1988 when he relocated to Seattle. At WHOI, Yogi had developed interests in optical and acoustic instrumentation development, marine boundary layers and sediment transport.

In Seattle, he started working at a company where he met Chuck, who studied mechanical engineering. Chuck quickly became Yogi's right-hand man. In 1988 they got involved in an US Office of Naval Research (ONR) program studying shelf sediment transport on the California Shelf. At the time, the navy was just recognizing that acoustics and optical transmission or optical backscatter could not measure size distribution or obtain correct concentration if sediment size was unknown. ONR issued a call for proposals for instrumentation that could measure sediment size and concentration, and Yogi submitted a proposal based on laser diffraction technology. Laser diffraction was well-known and widely used in industrial process control applications. But not for in-situ equipment that was intended to be lowered into the ocean. Yogi's proposal won and Sequoia was born with three years of funding!

Over the years almost fifty different LISST models have been developed. A few never made it past the prototype or single-customer stage, but the majority went into production at some point. Today, more than a dozen instruments derived from the original LISST-100, all manufactured and sold by Sequoia, are available from Sequoia and its distributor network covering 60+ countries. Thousands of instruments have been sold worldwide since 1995. The LISSTs are now used in scientific applications as diverse as dynamic sedimentology, bottom boundary layer, sediment transport, aquatic optics, remote sensing, plankton, harmful algae bloom, fishery, soil, terrestrial ecology, public health and drinking water studies.

The LISSTs are also used in a range of industrial and environmental environments such as aquaculture food pellet production, oil spill response, stormwater response, hydropower turbine monitoring, wastewater, mining, dredging and oil drilling operations, general environmental monitoring, and for industrial process control applications. Almost regardless of your sediment or particle application, there is a LISST for you!

#LISST

#ParticleIntelligence

How To Choose a LISST

		200X	Black	HAB	XR	Tau	ABS	AOBS	Holo2	SL2	Deep	Glider	Horizon	Hyper-a	Hyper-bb	VSF
Parameter	Particle size	X	X	X	X				X	X	X	X				
	Particle images								X							
	Concentration	X	X	X	X		X	X	X	X	X	X				
	Volume Scattering Function												X			X
	Absorption													X		
	Beam attenuation	X	X	X	(X)	X				X	X	X	X			X
	Backscattering												X		X	X
	Depth	X	X	X					X	X	X			X	X	X
	Temperature	X	X	X					X	X	X			X	X	X
	Velocity									X						
	Fluorescence		X	X												
	Turbidity							X								
Power, logging, operation options	Externally powered	X	X	X		X	X	X	(X)	X	X	X	X	X	X	X
	Internal battery				X				X							
	External battery pack(s) available	X	X	X					X	X	X			X	X	X
	External battery pack(s) included	X	X	X						X						X
	Integrates with 3rd party dataloggers					X	X	X								
	Datalogger available					X	X	X								
	Logs internally	X	X	X	X				X		X	X	X	X	X	X
	Real-time option via PC/tablet	X	X	X		X	X	X		X	X					
	Autonomous operation	X	X	X		(X)	(X)	(X)	X		X	X	(X)	X	X	X
	Profiling/Moored/Towed operation[1]	PMT	PMT	PMT	N/A	PT(M)	MT	MT	P(M)	P	P(M)	GLIDER ONLY	N/A	M(P)	M(P)	P(M)
Featured specs	Depth rating (m)	600	600	600	NOT SUBMER-SIBLE	2,000	100	100	300	30	3,000	600	NOT SUBMER-SIBLE	600	600	50[2]
	Size range (µm)	1-500	1-500	1-500	0.34-500	N/A	30-400	1-400	25-2,500	1-500	2.5-500	1-500	0.2-500	N/A	N/A	N/A
	Concentration range for 7 µm particles ($\mu L \cdot L^{-1}$)[3]	1-105	1-105	1-105	4-525	N/A	1-30,000 $mg \cdot L^{-1}$	1-30,000 $mg \cdot L^{-1}$	<50 $mg \cdot L^{-1}$	5-875	0.5-50	1-105	0.3-40	N/A	N/A	0.15-18
	Concentration range for 200 µm particles ($\mu L \cdot L^{-1}$)	25-3,000	25-3,000	25-3,000	125-15,000	N/A	<20,000 $mg \cdot L^{-1}$	<20,000 $mg \cdot L^{-1}$	<50 $mg \cdot L^{-1}$	200-25,000	15-1,500	25-3,000	10-1,050	N/A	N/A	5-500
Application area	Energy	*			***		***	***								
	Environmental	***	***	***	*	**	***	***				**		*	*	
	Freshwater	***	***	***	*	***	***	***	**	***		**		***	***	***
	Industry				***		*	**								
	Marine	***	***	***	*	***	*	*	***		***	***	***	***	***	***

1. For extended deployments, the BioBlock (available for the LISST-200X, LISST-Black and LISST-HAB) must be used.
2. 50 m operational. Will survive to 300 m.
3. Concentration range for the LISST-200X, LISST-Black, LISST-HAB, and LISST-Holo2 can be increased using optical path reduction modules (PRM's).

SEQUOIA
Tools and Research for Particle Intelligence

LISST-200X

Submersible Particle Size Analyzer

Particle Size Distribution • Volume Concentration
Beam Attenuation • VSF

The LISST-200X is Sequoia's workhorse. It is a self-contained submersible laser-diffraction based particle size analyzer, designed for measuring suspended particle size and concentration in the aquatic environment - oceans, rivers, lakes, streams. A fast response temperature sensor and a high-resolution depth sensor makes it suitable for profiling or towing. With Sequoia's optional BioBlock accessory it can be deployed for months on moorings or landers for long-term studies. For the system integrator, the LISST-200X can power and accept inputs from up to three external analog sensors. The LISST-200X is typically used for sediment, (harmful) algae, oil-spill, ocean optics, visibility, dredging, aquaculture, environmental and laboratory applications.

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Tools and Research for Particle Intelligence

FEATURES

- Small angle forward scattering laser diffraction technology
- Measures particle size, concentration, beam attenuation, VSF, depth, temperature
- Self-contained with internal programmable datalogger for autonomous data collection
- Externally powered; short- and long-term deployment battery packs included
- USB connection to PC for programming, offloading and real-time size distribution displays
- Integrated depth and fast response temperature sensors
- Power and integrate up to three external analog sensors
- Analog output of mean particle size and total volume concentration for CTD integration
- Real-time output of complete Particle Size Distribution (s/n 2131 and higher)
- Wide range of accessories available

SPECIFICATIONS subject to change without ntoice

Parameters Measured

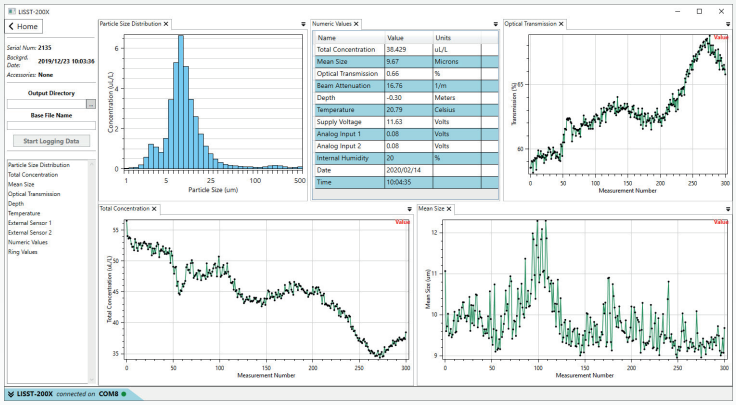
- Particle Size Distribution (1 µm to 500 µm in 36 size ranges)
- Depth (600 m max depth @ 0.01 m resolution)
- Temperature (- 5 °C to 45 °C @ 0.01 °C resolution; response time 2.5 s)
- Optical transmission (0.3 to 0.99 [30 % to 99 % @ 0.1 % resolution])
- Volume Concentration @ 0.1 µL·L^{-1} resolution; range strongly particle-size dependent
- Volume Scattering Function (0.039° to 13.8° in water at 36 angles)

Technology

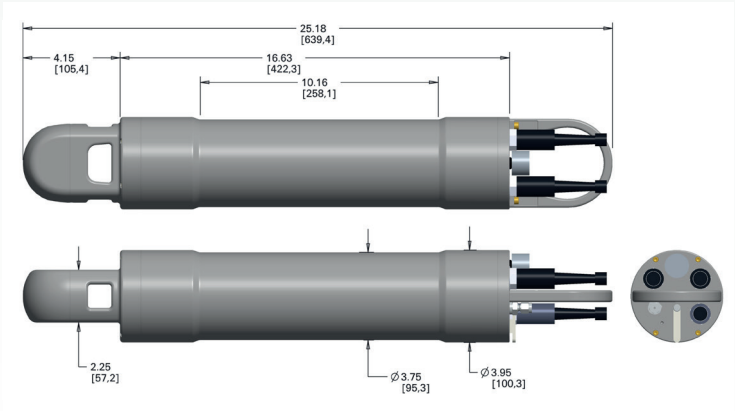
- Small-angle forward laser scattering
- 32-ring custom photodiode Ring Detector + 4 large angle detectors
- 25 mm optical path
- 670 nm laser diode

Mechanical and Electrical

- Dimensions [Ø × L]: 10.03 cm × 63.9 cm (3.95” × 25.2”)
- Weight [air / water]: 5.4 kg / 1.7 kg (11.8 lbs / 3.8 lbs)
- Depth rating: 600 m
- External power input: 12 VDC nominal, 9 VDC to 24 VDC
- Current drain at 12 V: 75 mA Sampling
- Sampling rate: Up to 1 Hz
- Data storage: 1 GB (~12,000,000 measurements; ~140 days @ 1 Hz)
- SubConn MCBH3M, MCBH5M and MCBH6M connectors



LISST-200X software screenshot



LISST-200X dimensions

LISST-200X connector endcap

LISST-200X with BioBlock antifouling accessory installed

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SEQUOIA
Tools and Research for Particle Intelligence

LISST-Black

Oil-Spill Response Instrument

- **Particle Size Distribution**
- **Volume Concentration**
- **Refined Fuels**
- **Crude Oil**
- **Chlorophyll**
- **Beam Attenuation**

The LISST-Black is a self-contained stand-alone instrument for use on profiling packages, towed and remote vehicle applications, for deployment during and after an oil spill event. The system will continuously measure particle size distribution and concentration, along with the fluorescence of refined fuels, crude oil and chlorophyll, as well as beam attenuation.

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Tools and Research for Particle Intelligence

FEATURES

- Complete package based on LISST-200X integrated with Turner Designs Cyclops-7F fluorometers
- Small angle forward scattering laser diffraction technology
- Measures refined fuels, crude oil, chlorophyll, particle size, concentration, beam attenuation, VSF, depth, temperature
- Self-contained with internal programmable datalogger for autonomous data collection
- Externally powered; short- and long-term deployment battery packs included
- USB connection to PC for programming, offloading and real-time size distribution displays
- Integrated depth and fast response temperature sensors
- Real-time output (s/n 2131 and higher)
- Wide range of accessories available

Fluorometer Performance

The Turner Designs submersible instrumentation modules used in the LISST-Black includes single-channel fluorometers for detection of refined fuels, crude oil, and chlorophyll. Together with particle information from the LISST-200X, this package solution provides a comprehensive picture of potential contamination.

SPECIFICATIONS (subject to change without notice)

Parameters Measured

- Particle size distribution from 1 µm to 500 µm in 36 size ranges
- Depth @ 0.01 m resolution
- Temperature @ 0.01 °C resolution; response time 2.5 s
- Optical transmission @ 0.1 % resolution
- Volume Concentration @ 0.1 $\mu L \cdot L^{-1}$ resolution
- Beam attenuation
- Refined Fuels fluorescence
- Crude Oil fluorescence
- Chlorophyll fluorescence

Operating Concentration Range

- Optical transmission from 0.3 to 0.99 (30 % to 99 %) Concentration from ~ 0.5 $mg \cdot L^{-1}$ to 700 $mg \cdot L^{-1}$ (particle-size dependent)

	Minimum Detection	Linear Range
Oil - Fine	0.4 ppm	0-20 ppm
Oil - Crude	1.5 ppm	0-275 ppm
Chlorophyll	0.03 $\mu g \cdot L^{-1}$	0-50 $\mu g \cdot L^{-1}$

Fluorometer outputs reported in Volts. Absolute calibration, if any, must be executed by users according to their own requirements.

Technology (laser diffraction)

- Small-angle forward laser light scattering
- 670 nm laser diode
- 32-ring custom photodiode Ring detector + 4 large angle detectors
- 25 mm optical path

Mechanical and Electrical

- Dimensions [W×H×L]: 10.03 cm × 13.21 cm × 63.9 cm (3.95” × 5.2” × 25.2”)
- Weight: [air / water]: 6 kg / 2.5 kg (13.2 lbs / 5.5 lbs)
- Depth rating: 600 m
- External power input: 12 VDC nominal, 9 VDC to 24 VDC
- Current drain at 12 V: 205 mA Sampling
- Sampling rate: Up to 1 Hz
- Data storage: 1 GB (~12,000,000 measurements; ~140 days @ 1 Hz)
- SubConn MCBH3M, MCBH5M and MCBH6M connectors
- Refined fuels – EX 290, EM 350
- Crude oil – EX 325 nm, EM 410-600 nm
- Chlorophyll – optical filters: EX 465, EM 496

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Tools and Research for Particle Intelligence

LISST-HAB

Harmful Algae Bloom (HAB) Instrument

- **Particle Size Distribution**
- **Volume Concentration**
- **Phycocyanin**
- **Phycoerythrin**
- **Chlorophyll**
- **Beam Attenuation**

The LISST-HAB is a self-contained, stand-alone instrument system for use on profiling packages, towed and remote vehicle applications, for deployment during a HAB event. The system will continuously measure particle size distribution and concentration, along with the fluorescence of Phycocyanin, Phycoerythrin, Chlorophyll, and Beam Attenuation.

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Tools and Research for Particle Intelligence

FEATURES

- Complete package based on LISST-200X integrated with Turner Designs Cyclops-7F fluorometers
- Small angle forward scattering laser diffraction technology
- Measures Phycocyanin, Phycoerythrin, chlorophyll, particle size, concentration, beam attenuation, VSF, depth, temperature
- Self-contained with internal programmable datalogger for autonomous data collection
- Externally powered; short- and long-term deployment battery packs included
- USB connection to PC for programming, offloading and real-time size distribution displays
- Integrated depth and fast response temperature sensors
- Real-time output (s/n 2131 and higher)
- Wide range of accessories available

Fluorometer Performance

The Turner Designs submersible instrumentation modules used in the LISST-Black includes single-channel fluorometers for detection of Phycocyanin, Phycoerythrin, and Chlorophyll. Together with particle information from the LISST-200X, this package solution provides a comprehensive picture of HAB development.

SPECIFICATIONS (subject to change without notice)

Parameters Measured

- Particle size distribution from 1 µm to 500 µm in 36 size ranges
- Depth @ 0.01 m resolution
- Temperature @ 0.01 °C resolution; response time 2.5 s
- Optical transmission @ 0.1 % resolution
- Volume Concentration @ 0.1 $\mu L \cdot L^{-1}$ resolution
- Beam attenuation
- Phycocyanin fluorescence
- Phycoerythrin fluorescence
- Chlorophyll fluorescence

Operating Concentration Range

- Optical transmission from 0.3 to 0.99 (30 % to 99 %)
  Concentration from ~ 0.5 $mg \cdot L^{-1}$ to 700 $mg \cdot L^{-1}$ (particle-size dependent)

	Minimum Detection	Linear Range
Phycocyanin	2 ppb^{PC}	0-450 ppb^{PC}
Phycoerythrin	0.1 ppb^{PE}	0-75 ppb^{PE}
Chlorophyll	0.03 $\mu g \cdot L^{-1}$	0-50 $\mu g \cdot L^{-1}$

Fluorometer outputs reported in Volts. Absolute calibration, if any, must be executed by users according to their own requirements.

Technology (laser diffraction)

- Small-angle forward laser light scattering
- 670 nm laser diode
- 32-ring custom photodiode Ring detector + 4 large angle detectors
- 25 mm optical path

Mechanical and Electrical

- Dimensions [W×H×L]: 10.03 cm × 13.21 cm × 63.9 cm (3.95” × 5.2” × 25.2”)
- Weight: [air / water]: 6 kg / 2.5 kg (13.2 lbs / 5.5 lbs)
- Depth rating: 600 m
- External power input: 12 VDC nominal, 9 VDC to 24 VDC
- Current drain at 12 V: 160 mA Sampling
- Sampling rate: Up to 1 Hz
- Data storage: 1 GB (~12,000,000 measurements; ~140 days @ 1 Hz)
- SubConn MCBH3M, MCBH5M and MCBH6M connectors
- Phycocyanin – optical filters: EX 590, EM ≥ 645
- Phycoerythrin – optical filters: EX 531, EM ≥ 590
- Chlorophyll – optical filters: EX 465, EM 496

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LISST-Portable|XR

Low-Cost Particle Size Analyzer

Particle Size Distribution • Particle Volume Concentration

The LISST-Portable|XR is the worlds' only portable, battery-powered laser diffraction based particle size analyzer. Designed for use in the field and the laboratory, it analyzes the sample in a wet state to obtain particle size distribution and particle volume concentration. To ensure maximum portability and complete freedom from a laboratory environment, it features an integrated mixing chamber, touch panel display, rechargeable battery, shock mounted optics, built-in ultrasonic probe and onboard data processing and storage.

SEQUOIA
Tools and Research for Particle Intelligence

FEATURES

- Truly portable: Completely self-contained with built-in data logger, processor, rechargeable battery, ultrasonic probe and 7” touch panel color display
- No PC needed: Touch panel color display allows for easy programming, sample analysis and data display
- Rugged design: Sealed enclosure and shock mounted optics block
- Simplicity: On-screen step-by-step instructions walks the operator through a measurement
- Versatility: Multiple Mie models as well as Fraunhofer model available for inversion, selectable from the touch panel
- All data-processing performed on board and stored in ASCII format. No post-processing
- Outputs: Total volume concentration, mean size, standard deviation, optical transmission, D5, D10, D16, D25, D50 (median grain size), D60, D75, D84, D90, D95, D60/D10 (Hazen uniformity coefficient), particle surface area, silt fraction, silt volume, size distribution, battery voltage, sample notes, operator name and instrument configuration

SPECIFICATIONS subject to change without ntoice

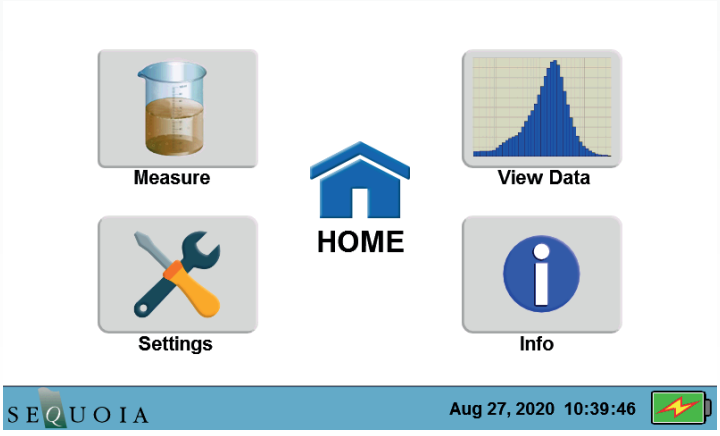
Operating Concentration Range

- Size range 0.34 µm to 500 µm in 44 log-spaced size classes
- Concentration range 30 mg·L^{-1} to 1,900 mg·L^{-1}. Note: Dependent on particle size (see table)

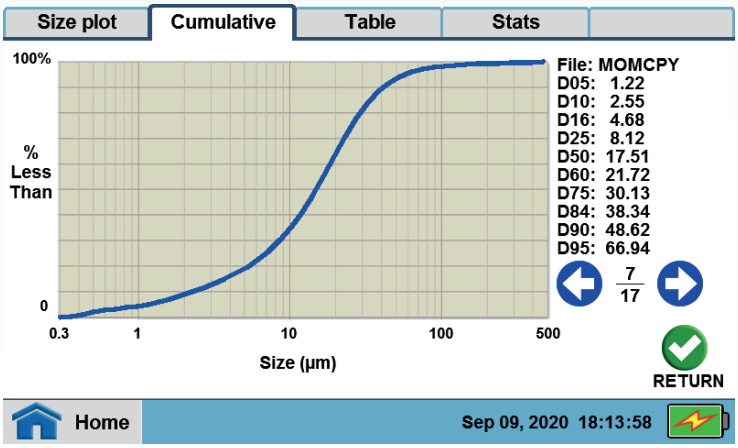
Material	Concentration [mg/l] @ 95% transmision	Concentration [mg/l] @ 75% transmision	D10 [µm]	D50 [µm]	D90 [µm]	SMD [µm]
ISO Fine	30	170	1.5	7	41	3
ISO Coarse	95	395	4	38	99	10
20-30 µm glass beads	195	1,075	19	24	34	24
Sieved sand 75-125 µm	345	1,925	85	122	175	112

Mechanical and Electrical

- Dimensions: [H × D × W] 17.7 cm × 29 cm × 44.3 cm (7” × 11.5” × 17.5”)
- Weight: 7.5 kg (17 lbs)
- Shipping box dimensions: [H × D × W] 78 cm × 53 cm × 28 cm (31” × 21” × 11”)
- Gross weight: 22 kg (49 lbs)
- Data storage: 1 GB (~100,000 size distributions and associated sample information)
- Rechargeable Lithium-ion batteries provide six hours of sample processing. Batteries classified as non-hazardous for air shipment
- 25 W, 40 kHz ultrasonic probe with controller electronics, managed from the touch panel display



Touch panel Screenshot of Main Menu



Touch panel Screenshot of Size Distribution

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LISST-Tau

High-Precision Transmissometer

Optical Transmisson • Beam Attenuation

LISST-Tau is a high-precision transmissometer for underwater vehicles, profiling packages, CTDs, and other systems. With high-quality optics and a carefully selected LED source, it transmits a collimated beam through the water, and precisely measures the light transmitted through its 15 cm path. Light modulation with synchronous detection rejects ambient light, while oversampling and averaging yield better than 16-bit resolution. LISST-Tau's digital controller applies calibration coefficients, corrects for temperature effects, and transmits data from both digital and analog outputs. Included software provides real-time display of data, and functions for checking and updating pure-water calibrations. LISST-Tau advances the state of the art for in-situ transmissometers.

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Tools and Research for Particle Intelligence

FEATURES

- Measures optical transmission and beam attenuation
- Externally powered
- RS-232 and analog real-time outputs
- Ambient light rejection
- Onboard temperature compensation
- Available with green or red LED source (specify upon ordering)

SPECIFICATIONS (subject to change without notice)

Parameters Measured

- Optical transmission
- Beam attenuation

Operating Ranges and Stability

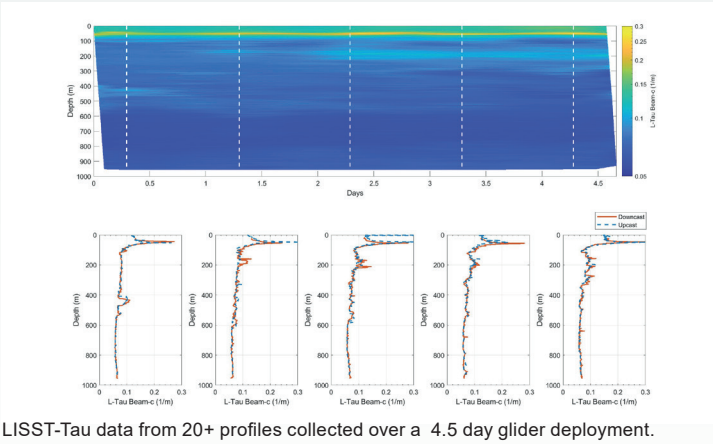
- Operational temperature range: -3 °C to 40 °C
- Storage temperature range: 20 °C to 60 °C
- Beam attenuation range: ~0 m^{-1} to 30 m^{-1}
- Linearity (concentration): >99 %
  - Short-term stability (1 min standard deviation, typical) Transmission: 0.003 %FS (Green) / 0.005% (Red)
  - Beam attenuation: 0.0002 m^{-1} (Green) / 0.0004 m^{-1} (Red)
- Long-term stability (6 hr test)
  - Transmission: ~0.003 %FS·hr^{-1}
  - Beam attenuation: ~0.0002 m^{-1}·hr^{-1}

Technology

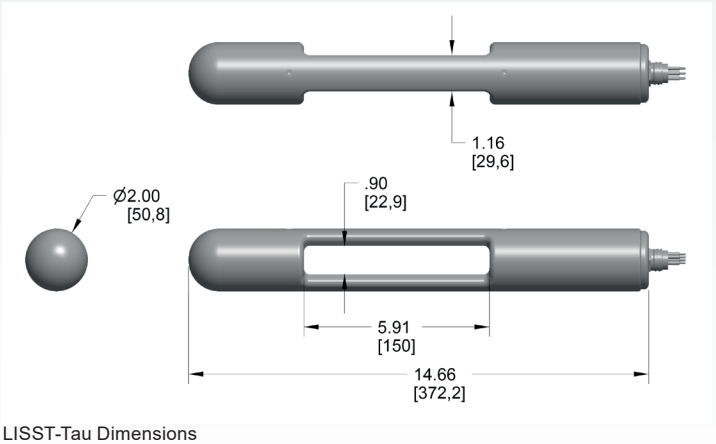
- Optical path length: 15 cm
- Source wavelength: ~532 nm (green) or ~650 nm (red) LED
- Source spectral bandwidth: <10 nm FWHM
- Acceptance angle (half angle, in water): 1.0°
- Optical transmission @ 16-bit resolution

Mechanical and Electrical

- Dimensions [Ø x L]: 5.1 cm x 40.6 cm (2.00" x 16")
- Weight [air / seawater]: 1.140 kg / 0.585 kg (2.5 lbs / 1.3 lbs)
- Depth rating: 2,000 m
- Sampling rate: 1 Hz
- External power input: 7 VDC to 25 VDC
- Current drain @ 12V: 42 mA average during sampling
- Connector: SubConn MCBH6M

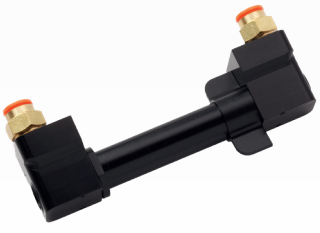


LISST-Tau data from 20+ profiles collected over a 4.5 day glider deployment. Dashed lines indicate timing of the five individual profiles. Note chlorophyll maximum, small-scale structure and stability over time and pressure.



LISST-Tau Dimensions

LISST-Tau with inserted Flow-Through chamber.



LISST-Tau Flow-Through chamber accessory.

LISST-Tau stainless steel frame

Submersible X3 battery

Nexsens X3 logger

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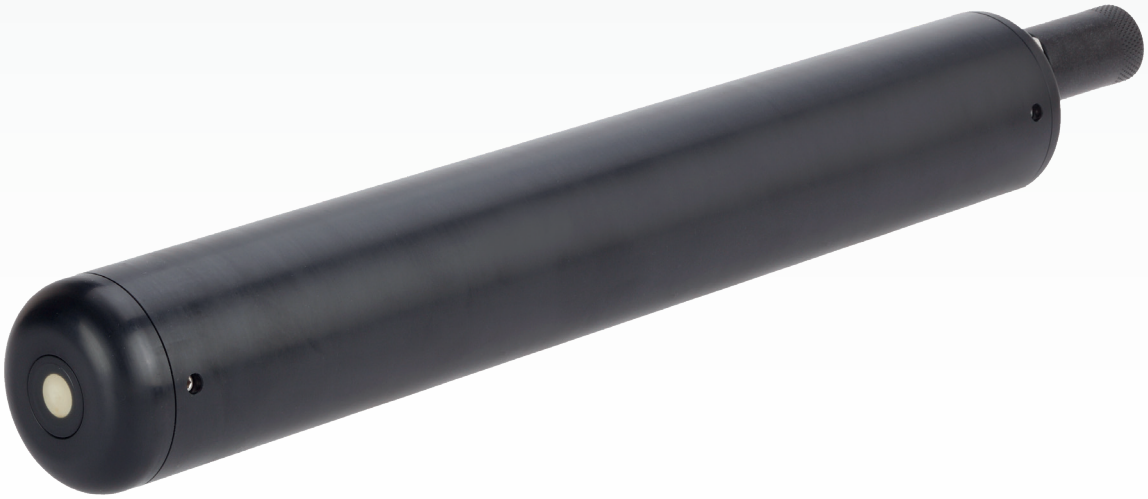
Tools and Research for Particle Intelligence

LISST-ABS

Submersible Acoustic Backscatter Sensor

- **Suspended Sediment Concentration**
- **Total Suspended Solids**
- **Fouling Tolerant**
- **Low-Cost**

The LISST-ABS is a low-cost acoustic backscatter sensor designed specifically for measuring suspended sediment concentration. It is designed for fixed-point measurements and operates at 8 MHz. At this frequency, acoustic has a nearly flat response to particles in the size range 30 µm to ~400 µm. As a result, the LISST-ABS maintains calibration within ± 30 %. This compares with optical turbidity sensors that maintains calibration within ± 400 % over the same size range.



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Tools and Research for Particle Intelligence

FEATURES

- Outputs concentration in analog, SDI-12 and RS232 formats on the underwater connector
- Integrates with any datalogger that can provide power and accept analog, SDI-12 or RS232 signals
- Installs on fixed structures, profiling packages and underwater vehicles or tow bodies (minimum 15 cm from solid boundaries)
- Wide range of accessories
- Factory calibrated concentration performed with 75 µm to 90 µm glass beads.

SPECIFICATIONS subject to change without ntoice

Technical

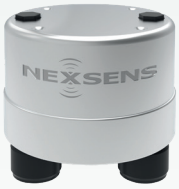
- Sensing frequency: 8 MHz
- Sample Volume: [Ø × L] 10 mm × 15 mm, located ~55 mm in front of sensor
- Resolution: 0.5 % of reading
- Outputs:
  - 0-4 V analog (logarithmic, 0.5 V/decade covering 100 g/L)
  - SDI-12
  - RS-232
- Range: 1 mg·L^{-1} to 30 g·L^{-1} (7 µm silt) or < 20 g·L^{-1} (200 µm sand) (Note: there is no equivalent to NTU or turbidity units for LISST-ABS.)
- Sample rate 1 Hz (average of 1000 measurements)
- Suspended sediment concentration accuracy: +/-30 % for particles 30 µm to 400 µm

Mechanical and Electrical

- Dimensions: [Ø × L] 5.08 cm × 33.65 cm (2” × 13.25”)
- Weight (air / water): 0.5 kg (1 lbs) / 0.22 kg (0.5 lbs) - buoyant in water
- Power supply: 9 VDC to 18 VDC
- Current draw: 50 mA max (for s/n 6232 and lower, current is 110 mA max)
- Depth rating: 100 m
- Transducer: 10 mm Ø ceramic
- ABS Plastic Housing
- Temperature Range: 0 °C to 30 °C – not recommended for use in water bodies that freeze
- Connector: Subconn MCBH8M (s/n 6233 and lower Impulse MCBH-8-MP)

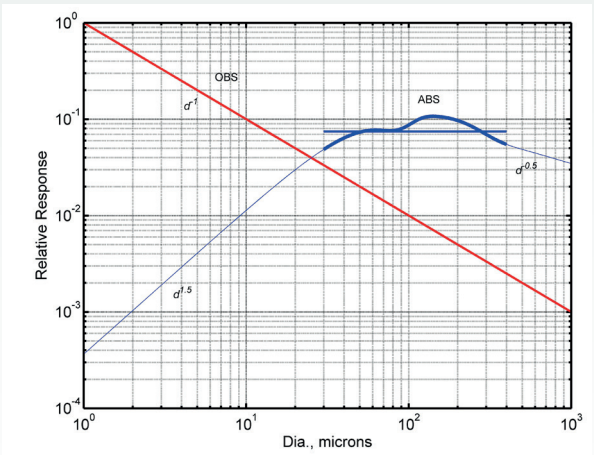
Submersible X3 battery

Solar Power Panel



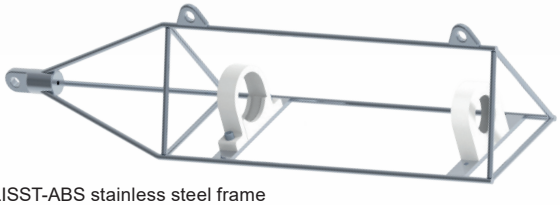
Nexsens X3 logger

Power & Data Cable



LISST-ABS and turbidity sensor response to particle size variation for constant concentration

LISST-ABS dimensions



LISST-ABS stainless steel frame

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Tools and Research for Particle Intelligence

LISST-AOBS

Super-Turbidity Sensor

- **Suspended Sediment Concentration**
- **Total Suspended Solids**
- **Turbidity**

The LISST-AOBS is a simple, low-cost Super-Turbidity sensor to measure suspended sediment concentration (SSC). Super-Turbidity is a new technology developed by Sequoia Scientific, Inc. It involves pairing a LISST-ABS with a turbidity sensor using a weight factor, which results in a single, combined output from the two sensors. Once paired, the LISST-AOBS retains near-constant calibration for SSC over a wide grain-size range. The LISST-AOBS Super-Turbidity sensor is supplied by Sequoia as an integrated and paired turbidity and acoustic sensor with a variety of cabling and data logger options.

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FEATURES

- Paired acoustic and optical technologies
- Near-constant calibration within a factor of two for grain-sizes from 1 µm – 500 µm
- Complete, integrated package pairing a LISST-ABS and a Turner Designs Turbidity Plus™
- NOTE: Turbidity Plus™ sensors are NOT factory-calibrated
- Included Y-cable integrates SDI-12 and RS-232 communication and power for both sensors
- Tolerant to biofouling (LISST-ABS); integrated wiper (Turbidity Plus™)

SPECIFICATIONS (subject to change without notice)

Technical

- Combined 850 nm optical turbidity sensor and 8 MHz acoustic backscatter sensor
- Sample Volume: [Ø × L] 10 mm × 15 mm, located ~55 mm in front of sensor
- Optics per ISO 7027 turbidity technique
- Mechanical wiper for turbidity sensor
- Outputs:
  - SDI-12
  - RS-232
- Range:
  - Suspended Sediment Concentration (1 mg·L^{-1} to 30,000 mg·L) for LISST-ABS
  - Turbidity (V) [0 NTU to 3,000 NTU for Turbidity Plus™ upon calibration]

Mechanical and Electrical

- Dimensions [H × W × L]: 5.72 cm × 10.16 cm × 33.65 cm (2.25” × 4” × 13.25”)
- Weight (air): 0.7 kg (1.54 lbs)
- Power supply: 9 VDC to 15 VDC (12 VDC nominal)
- Current drain: 75 mA @ 12V
- Depth rating: 100 m
- Transducer: 10 mm Ø ceramic
- Temperature Range: 0 °C to 30 °C – not recommended for use in water bodies that freeze
- Connector: Subconn MCBH8M (LISST-ABS s/n 6233 and lower Impulse MCBH-8-MP)

Submersible X3 battery

LISST-AOBS stainless steel frame

Power & Data Cable

Solar Power Panel

Nexsens X3 logger

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LISST-Holo2

Submersible Digital Holographic Camera

- **Particle Images**
- **Particle Size Distrubtion**
- **Particle Volume Concentration**

The LISST-Holo2 is a submersible digital holographic camera. It is designed for capturing holograms of suspended particles (algae, plankton, sediment, oil droplets, flocs etc.). The internal rechargeable battery and memory allow for collection of up to 100,000 holograms. To facilitate data processing, the included software ranks the holograms by image content richness, then automatically extracts particle information and images from the holograms. The resulting data output is a composite image where all particles are in focus, as well as the particle size distribution and volume concentration.

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FEATURES

- In-situ digital in-line holographic technology
- Self-contained with internal data memory and rechargeable battery
- Ethernet connection to PC for programmable data collection—no software needed for programming or offloading data
- Power via internal rechargeable battery pack or external power source
- Programmable data collection including burst and fixed Rate modes and programmable start and stop conditions
- Automated firmware updates possible when instrument is connected to the Internet
- Automated ranking of collected images based on richness of data, permitting a user to view the most interesting holograms first
- Data processing yields in-focus particle images and particle volume distribution
- Optical Path Reduction Modules available for higher concentration ranges
- Towable up to 4 knots (2.05 m/s).

SPECIFICATIONS subject to change without ntoice

Parameters Measured

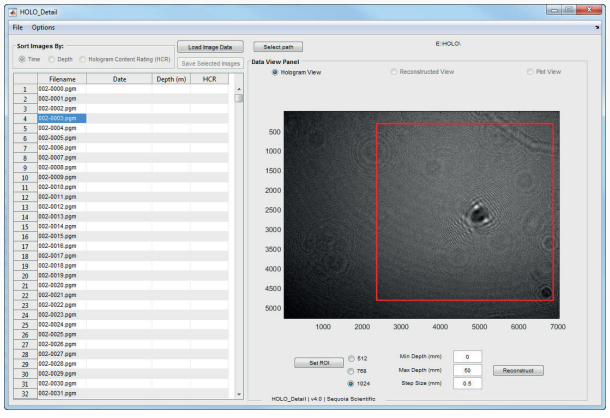
- 2MB time-stamped Hologram containing the interference pattern of all particles in the laser beam
- Depth
- Temperature

Parameters Derived upon hologram processing

- Reconstructed in-focus particle images
- Particle Size Distribution (25 µm to 2500 µm equivalent spherical diameter, features down to 4 µm), Particle Area Concentration, Mean and Median particle size and other particle parameters based on image analysis
- 5 seconds processing time per cm^3 volume in MATLAB (typical, @ 2.2 GHz PC)

Technology

- Digital inline holography
- Solid state 8 mW laser diode @ 658 nm
- 4.4 µm pixel size digital camera @ 1600 × 1200 pixels
- 50 mm optical path



Detail of hologram reconstruction.

Mechanical and Electrical

- Dimensions: 13.3 cm × 76.7 cm (5.25″ × 30.21″) [Ø × L]
- Weight [air / water]: 7.2 kg / 1.0 kg (15.8 lbs / 2.2 lbs)
- 600 m depth rating
- 237 GB internal solid state drive
- Sampling rate up to 25 Hz; sampling volume 1.5 cm^3
- Power:
  - Internal Battery for at least 12 hours of continuous use or
  - External power 12 VDC to 24 VDC (18 VDC nominal)
- Power drain @ 12 VDC: 200 µA / 700 mA / 800 mA / 800 mA (sleeping / idling / laser on / laser + camera on)
  - Max current spike @ 1.7 A for up to 40 s upon power up
- Connectors: SubConn MCBH5M, MCBH6M, DBH8M

The open LISST-Holo2 optics design permits measurement of undisturbed fragile particles.

LISST-Holo2 Path Reduction Module accessory.

LISST-Holo2 Full Path Flow Through Chamber accessory.

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LISST-SL2

StreamLined Isokinetic Sediment Sensor

- **Particle Size Distribution**
- **Sediment Concentration**
- **Current Velocity**
- **Sediment Flux**
- **Depth**
- **Temperature**

The LISST-SL2 is designed exclusively for river sediment monitoring. The sensor is deployed from a bridge or boat with a small winch. A topside controller box with rechargeable batteries provides power to the sensor. The LISST-SL then returns real-time data of all parameters. Data are transmitted from the topside box to a PC or tablet via Bluetooth for immediate processing and display.

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Tools and Research for Particle Intelligence

FEATURES

- Small angle forward scattering laser diffraction technology
- Measures particle size distribution, sediment concentration, current velocity, depth, temperature
- Iso-kinetic sampling using feedback-controlled pump operation
- 2-wire communication protocol consistent with USGS B-reel use
- Topside box with rechargeable batteries for LISST-SL2 power and Bluetooth for real-time data transfer to PC / tablet
- Data processed and displayed in real-time on PC / tablet
- Software delivers point-integrated and depth-integrated sediment data
- Choice of units: m and m/s, or ft and ft/s

SPECIFICATIONS subject to change without ntoice

Parameters Measured

- Particle size and concentration in 36 size ranges from 1 µm to 500 µm
  - Sediment concentration from ~10 mg·L^{-1} to 44,000 mg·L^{-1} for 120 µm particles.
  - NOTE: Actual concentration limits are HIGHLY grain-size dependent
- Depth from 0.15 m to 30 m @ 0.02 m resolution
- Velocity from 0 m/s to 3.5 m·s^{-1} @ 0.03 m·s^{-1} resolution
  - Iso-kinetic control from 0.5 m·s^{-1} to 3.5 m·s^{-1}
- Water temperature from 0 °C to 25 °C @ 0.1 °C resolution

Mechanical and Electrical

- Dimensions
  - LISST-SL2 [Ø × L]: 17 cm × 87 cm (6.7” × 34.2”)
  - Topside box [H × L × W]: 41.7 cm × 33.4 cm × 22.1 cm (16.4” × 13.2” × 8.7”)
- Weight
  - LISST-SL2 [air / submerged]: 19.5 kg / 8.2 kg (43 lbs / 18 lbs)
  - Topside box: 8.6 kg (19 lbs)
- Rechargeable battery life: 6 hours continuous sampling

LISST-SL2 with Topside Control Box and USGS B-reel
(computer & reel not inclued)

LISST-SL2 Topside Box

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LISST-Deep

Deep Submersible Particle Size Analyzer

Particle Size Distribution • Volume Concentration
Beam Attenuation • VSF

The LISST-Deep, updated in 2023, is a deep-sea version of Sequoia's workhorse LISST-200X. It is a self-contained submersible laser-diffraction particle size analyzer for ocean depths up to 4000 meters. Like the LISST-200X, it measures the concentration of suspended particles in 36 size bins from 1 µm to 500 µm. With an optional battery pack, it can be deployed independently, storing all its data internally. It can also be deployed as part of a CTD package, receiving power from the CTD while producing real-time analog outputs for mean particle size and total concentration. In either configuration it always stores comprehensive particle size data in its own non-volatile memory, for later downloading and analysis. For system integrators, the LISST-Deep can power and accept inputs from up to three external analog sensors, such as fluorometers.

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Tools and Research for Particle Intelligence

FEATURES

- Small angle forward scattering laser diffraction technology
- Measures particle size, concentration, beam attenuation, VSF, depth, temperature
- Self-contained with internal programmable datalogger for autonomous data collection
- Externally powered; 4000 meter battery housing available
- USB connection to PC for programming, offloading and real-time size distribution displays
- Integrated depth and temperature sensors
- Power and integrate up to three external analog sensors
- Analog output of mean particle size and total volume concentration for CTD integration
- Real-time output of complete Particle Size Distribution

SPECIFICATIONS (subject to change without notice)

Note: Specifications were different for serial numbers 4055 and lower

Parameters Measured

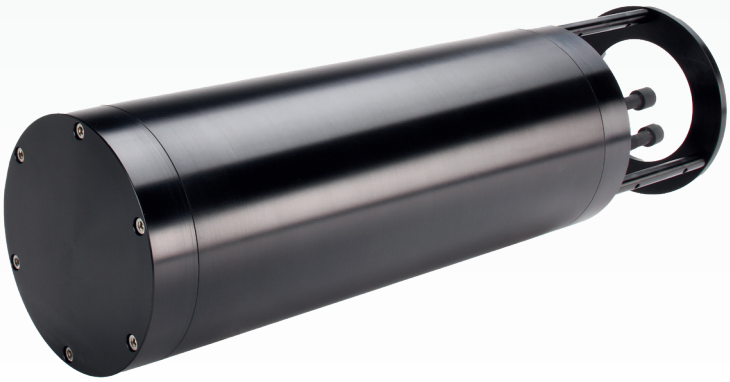
- Particle Size Distribution (1 µm to 500 µm in 36 size ranges)
- Depth (4000 m max depth @ 0.1 m resolution)
- Temperature (- 5 °C to 45 °C @ 0.01 °C resolution
- Optical transmission (0.3 to 0.99 [30 % to 99 % @ 0.1 % resolution])
- Volume Concentration @ 0.1 $\mu L \cdot L^{-1}$ resolution; range strongly particle-size dependent
- Volume Scattering Function (0.039° to 13.8° in water at 36 angles)

Technology

- Small-angle forward laser scattering
- 32-ring custom photodiode Ring Detector + 4 large angle detectors
- 50 mm optical path
- 670 nm laser diode

Mechanical and Electrical

- Dimensions [Ø × L]: 12.57 cm × 80.3 cm (4.95” × 31.5”)
- Weight [air / water]: 17 kg / 8 kg (38 lbs / 18 lbs)
- Depth rating: 4000 m
- External power input: 12 VDC nominal, 9 VDC to 24 VDC
- Current drain at 12 V: 75 mA Sampling
- Sampling rate: Up to 1 Hz
- Data storage: 1 GB (~12,000,000 measurements; ~140 days @ 1 Hz)
- SubConn MCBH3M, MCBH5M and MCBH6M connectors



Left: Detail of LISST-Deep optical path and laser cable

Right: LISST-Deep external battery case (optional accessory)

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LISST-GLIDER

PARTICLE SIZE ANALYZER FOR GLIDERS

- **Particle Size Distribution**
- **Volume Concentration**
- **Beam Attenuation**
- **VSF**

The LISST-Glider is a version of the LISST-200X designed for glider integration on Teledyne Webb Research's SLOCUM G2 and G3 gliders. The LISST-Glider must be purchased from Teledyne Webb Research.

SEQUOIA

Tools and Research for Particle Intelligence

FEATURES

- Small angle forward scattering laser diffraction technology
- Measures particle size, concentration, beam attenuation, volume scattering function (VSF)
- Self-contained with internal programmable datalogger for autonomous data collection
- Output of mean particle size and volume concentration to internal glider control system

SPECIFICATIONS (subject to change without notice)

Parameters Measured

- Particle Size Distribution (1 µm to 500 µm in 36 size ranges)
- Depth (600 m max depth @ 0.01 m resolution)
- Temperature (- 5 °C to 45 °C @ 0.01 °C resolution; response time 2.5 s)
- Optical transmission (0.3 to 0.99 [30 % to 99 % @ 0.1 % resolution])
- Volume Concentration @ 0.1 µl·L^{-1} resolution; range strongly particle-size dependent
- Volume Scattering Function (0.039 ° to 13.8 ° in water at 36 angles)

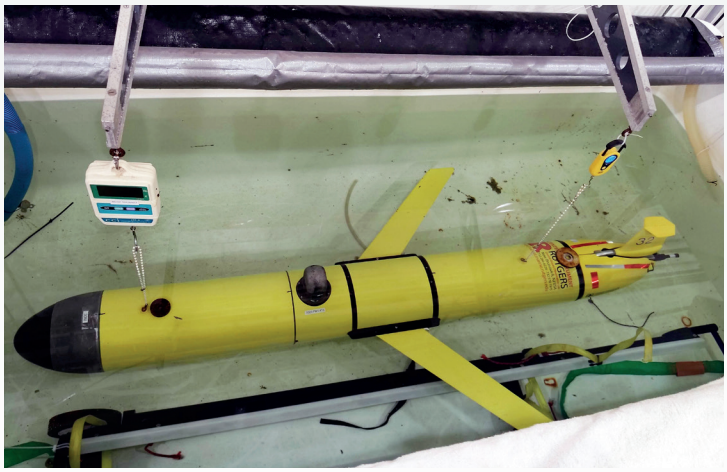
Technology

- Small-angle forward laser light scattering
- 670 nm laser diode
- 32-ring custom photodiode Ring detector + 4 large angle detectors
- 25 mm optical path

Mechanical and Electrical

- Dimensions, Weight: Depending on glider
- Depth rating: 600 m
- External power input: 12 VDC nominal, 8 VDC to 24 VDC
- Current drain @ 12 V: 100 mA sampling, 8 mA between samples
- Sampling rate: Up to 1 Hz
- Data storage: 1 GB (~12,000,000 measurements; ~140 days @ 1 Hz)

Glider with LISST-Glider module in operation.
Courtesy of Travis Miles, Rutgers University.



Glider with LISST-Glider module installed.
Courtesy of Travis Miles, Rutgers University.

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LISST-Horizon

Flow-Through Automated Optical Scattering Measurement

Beam Transmission • Optical Scattering

The LISST-Horizon is a self-contained instrument for bench-top deployment in a research vessel laboratory. Plumbed to continuous underway uncontaminated seawater, it continuously measures light scattering at 60 different angles.

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Tools and Research for Particle Intelligence

FEATURES

- Optical scattering from near-forward and side-scattering detectors using a 520 nm laser source
- Beam attenuation and particle size from proven LISST-200X optics, with extended pathlength for application to offshore waters
- Automated deployment in flow-through seawater systems, including clean water backgrounds, cleaning, and scattering standard measurement
- Mixers in the sample chamber to keep particles suspended during measurement
- Automated filtered sample background using attached external particle filter (0.2 µm). Raw data stored internally and offloaded via ethernet for processing with provided MATLAB software (MATLAB software license NOT included).

SPECIFICATIONS subject to change without ntoice

Parameters Measured

- Optical scattering at 60 angles
- Beam transmission
- Sample temperature and fluidics parameters such as pressures and flow rate

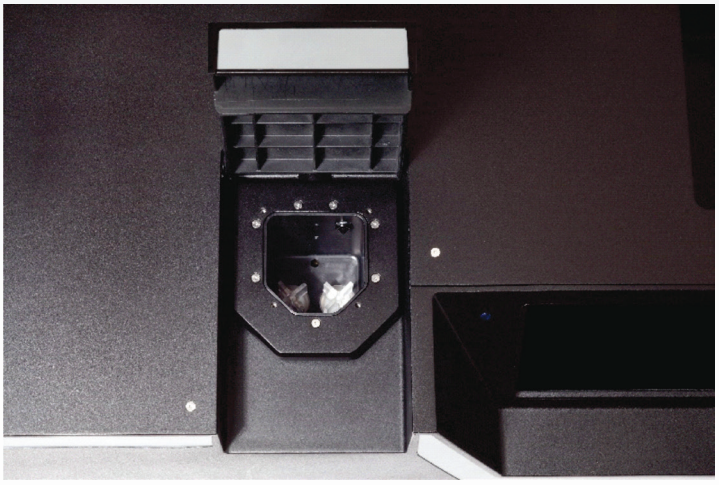
Measurement Ranges

- Optical scattering from 0.1 ° to 150 ° in water; near-forward
- 0.1 ° to 15 ° on 36 log-spaced detectors and side-scattering 35 ° to 150 ° on 24 detectors
- Beam transmission from 0.3 m^{-1} to 15 m^{-1} (30 % to 98 %)

Mechanical and Electrical

- Dimensions [L × W × H]: 674 mm × 375 mm × 293 mm
- Weight: 19 kg
- Laser: 520 nm solid state diode laser
- External power input: 110/220 VAC converted to 24 VDC using provided power brick
- Plumbing connections using 3/8” OD (½" OD for drain) tubing and push-to-connect fittings
- External tanks for holding clean water background

Front view: sample cover open & touch panel



Top view: open chamber with mixers

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LISST-VSF

Multi-Angle Polarized Light Scattering Measurements

VSF • DoLP • Beam Transmission • Depth • Temperature

On the market since 2012, Sequoia's LISST-VSF is a submersible instrument for measuring the volume scattering function (VSF) insitu with some polarization discrimination capability. The instrument covers the angular range from 0.1° to 150° in water by combining a standard LISST ring detector with a rotating 'eyeball' optic. Polarization of the incident laser beam is alternated between horizontal and vertical, the received scattered light is split into its two linear polarization components and sensed by separate photomultiplier tubes permitting calculation of the particulate VSF and degree of linear polarization (DoLP). The LISST-VSF is programmable and externally-powered.

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Tools and Research for Particle Intelligence

FEATURES

- In-situ measurements of P11 (VSF) and P12 (DoLP) elements of the scattering Mueller matrix from 15-150° in water
- VSF (P11) at small angles, 0.1 to 15° in 32 logarithmic angle steps
- Integration of 0.1-150° VSF provides a good estimate of total particle scattering coefficient *bp*
- Beam attenuation *cp*. measured with LISST-100X optics
- Roving Eyeball optics permit 1° resolution in angles between 15° to 150°
- Approximately two seconds per measurement set (two polarizations of incident laser beam)
- Daylight rejection by laser modulation
- Extension of dynamic range in VSF measurements using control of laser power and photomultiplier gain
- Data from small and large angles in a single data stream, including depth and temperature
- External, submersible battery pack included.

SPECIFICATIONS subject to change without ntoice

Parameters Measured

- Small-angle VSF in 32 log-spaced angles, from 0.1° to 15°
- VSF and P12 (DoLP) from 15° to 150° in 1° steps
- *bp* estimate from VSF integration over 0.1° to 150°
- Temperature from –5 °C to 50 °C @ 0.01 °C resolution
- Depth
  - 0 m to 50 m @ 0.08 m resolution for all parameters
  - 50 m to 300 m (max depth) @ 0.08 m resolution for small-angle VSF and beam attenuation only
- Beam attenuation > 0.1 m^{-1}

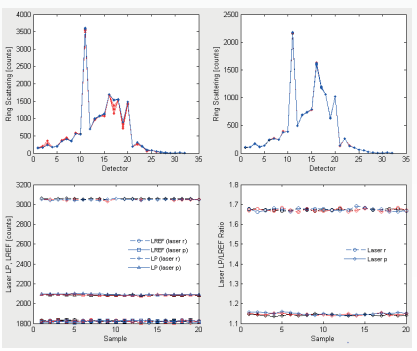
Technology

- Solid state diode laser @ 515 nm

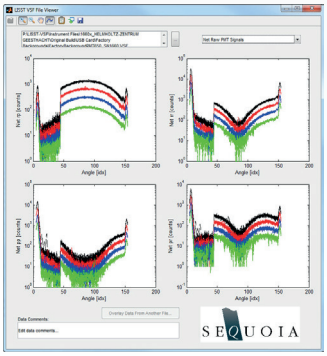
Mechanical and Electrical

- Dimensions [Ø × L]: 12.7 cm × 95.7 cm (5.0” × 37.7”)
- Weight [air]: 13.1 kg (28.9 lbs)
- Depth rating: 300 m (NOTE: 50 m operational depth)
- External power supply: 12 VDC to 15 VDC
- Power drain [sampling]: 1.5 A
- Sampling rate: Approximately 2 s for a full measurement of VSF and P12
- Storage: 128 GB, equivalent to 24,000 measurements
- Rechargeable NiMH battery pack (included) @ 14.4 V nominal, 15 Ah

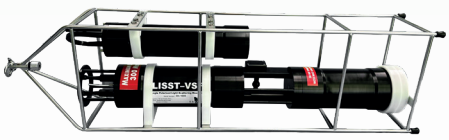
LISST-VSF battery housing and charger, cable



Detail of the LISST-VSF view display



LISST-VSF Matlab GUI



LISST-VSF frame

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HYPER-a

HYPER-SPECTRAL ABSORPTION INSTRUMENT

The Hyper-a is designed for precision absorption measurements of dissolved and suspended material in water (bulk properties). The instrument features an enclosed flowthrough integrating sphere attached to one end. Two quartz windows inside the sphere are used to emit light into the sphere and record the resulting spectrum. An external submersible pump is used to flow water through the integrating sphere. The Hyper-a uses a broadly emitting xenon arc lamp as a light source. A spectrometer viewing the interior of the integrating sphere measures the light level at sub-nanometer resolution. A second spectrometer views the light source internally, providing a reference. A removeable ND filter in the cavity wall can be used to track instrument drift.

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Tools and Research for Particle Intelligence

FEATURES

- High precision absorption measurements.
- High-performance depth and temperature sensors.
- Internal data storage.
- Powered from external battery pack (optional accessory), CTD, or up to 50m power/communication USB cable.
- Up to 3 spectral filters for correcting for phytoplankton and other fluorescence.
- Included SeaBird pump (SBE 5P)

SPECIFICATIONS subject to change without ntoice

General / Electrical

- Parameters measured/derived: Absorption Coefficient (1/m)
- Data interface: RS-232 serial, 19200 baud, 8 bits, no parity, 1 stop
- Sample rate: Sampling rate will vary with signal level
- Input voltage: 9 V to 30 V
- Current draw @12 V: Max 2.5 A
- Storage: Internal datalogger with 1 GB microSD memory

Mechanical / Environmental

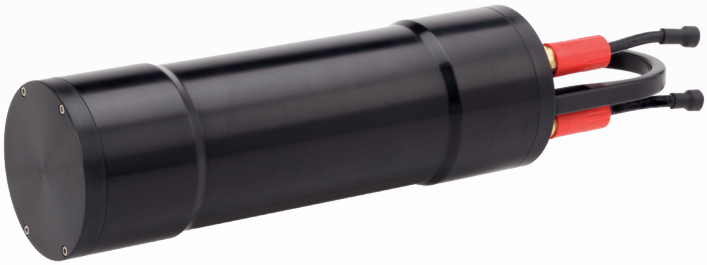
- Operational temperature range: -3 °C to 40 °C
- Storage temperature range: -20 °C to 60 °C
- Dimensions [Ø X L]: 11.3 cm × 57.6 cm (5.25” x 22.7”) including handle
- Weight [air / water]: 8.2kg / 2.9kg (18.1 lbs / 6.5 lbs)
- Depth rating: 600 meters

Optical

- Measurement wavelength range: 300-750 nm
- Spectral resolution: 300-350 nm @ 5 nm; 350-750 nm @ 2 nm

Hyper-a optics endcap showing ND filter (black) for calibration and plug (white) used during operation

Hyper-a optics endcap open showing integrating sphere interior and emit and receive windows



Optional External Battery

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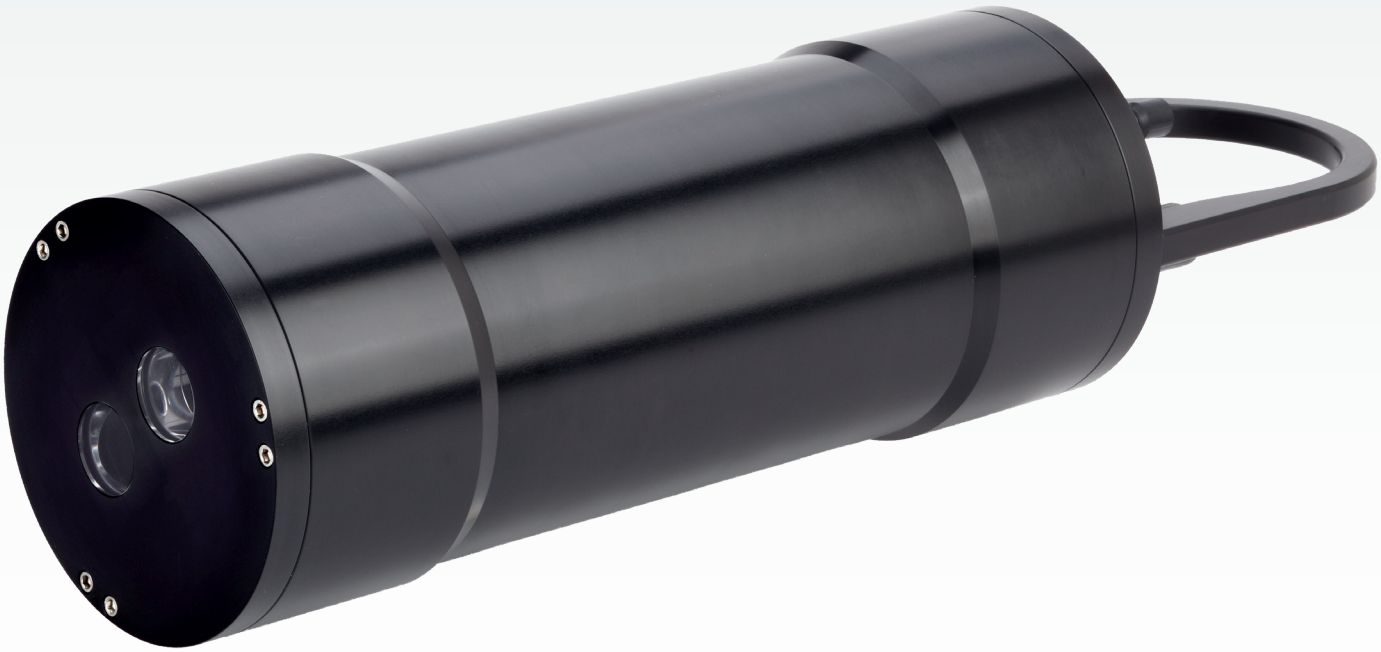
HYPER-bb

HYPER-SPECTRAL BACKSCATTER INSTRUMENT

Sequoia presents the world's first commercially available hyperspectral backscatter instrument, Hyper-bb. The Hyper-bb is a submersible singleangle backscattering instrument with configurable spectral channels. The primary measurement delivered by the Hyper-bb is spectral backscattering over the wavelength range 430 nm to 700 nm. Hyperbb also has high-performance depth and temperature sensors. Data is saved onboard the instrument in non-volatile memory, which can be later downloaded via the Hyper-bb software.



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Tools and Research for Particle Intelligence

FEATURES

- Spectral backscattering over the wavelength range 430 nm to 700 nm
- High-performance depth and temperature sensors
- Internal data storage
- Powered from external battery pack (optional accessory), CTD, or 2 m to 50 m power/communication USB cable

SPECIFICATIONS (subject to change without notice)

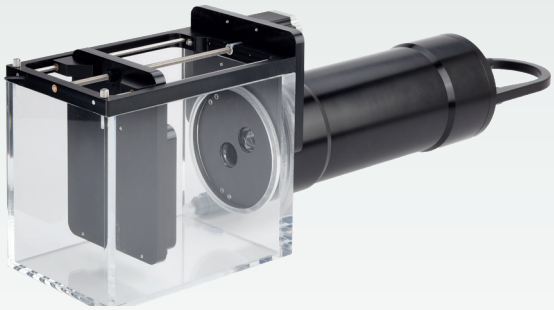
Optical

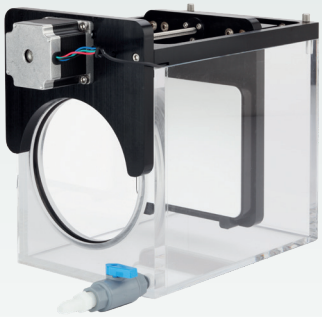
- Centroid angle ~ 135°
- Sample volume ~ 2 mL
- Beam diameter ~ 12 mm
- Spectral coverage ~ 430 nm to 700 nm
- Spectral bandwidth ~ 9 nm (blue) to ~ 17 nm (red)
- Scan speed ~ 5 s for 430 nm to 700 nm with a 10 nm channel spacing, i.e. channels @ 430, 440, 450,…, 690, 700 nm (220 measurements per channel)

Mechanical and Electrical

- Dimensions [Ø × L]: 13.4 cm × 51.9 cm (5.25” × 20.42”) including handle
- Weight [air / water]: 6.0 kg / 1.2 kg (13.3 lbs / 2.6 lbs)
- Depth rating: 600 m
- External power input: 12 VDC nominal, 8 VDC - 26 VDC
- Communication: RS-232, 9600 baud, 115k baud for data download
- Storage: Internal datalogger with 1 GB microSD memory

Hyper-bb frame


Hyper-bb inserted in calibration tank


Hyper-bb Calibration Tank


Hyper-bb Zebra Wiper


Hyper-bb flow through chamber


Optional External Battery

Sequoia Scientific, Inc.
2700 Richards Road, Suite 107, Bellevue, WA 98005 USA
Tel +1 (855) 753-3313
email info@SequoiaSci.com
www.SequoiaSci.com

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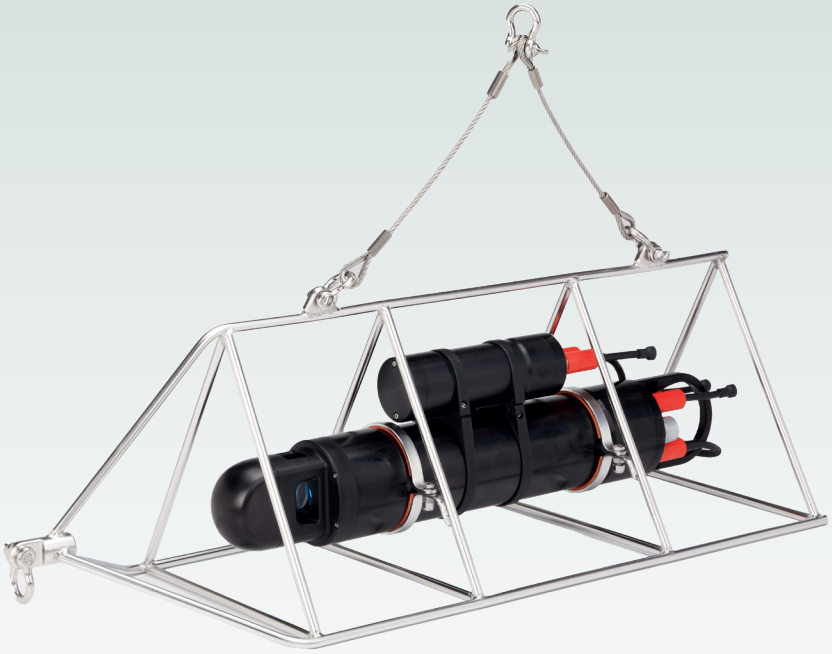
Accessories

LISST-200X



Mounting Frame

Small Battery Housing Clamps

BioBlock Clamps

Large & Small External Battery Housings

BioBlock

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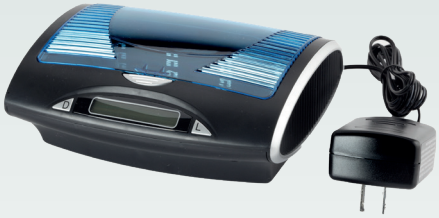
Background Test Chamber

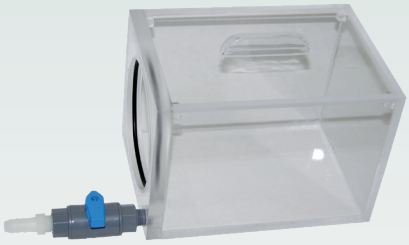
Intergrated Comm & Power Cables

Scoop (for diverting flow of water through optical path)

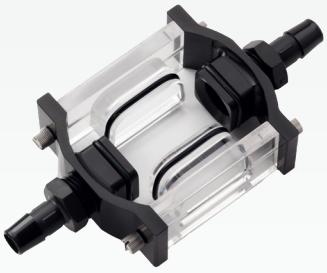
Optical Path Reduction Module



LISST-200X charger



LISST-200X Large Background Chamber



Full Path Flow Through Chamber

Short Battery Cable

Replacement Rechargeable Batteries

Sequoia Scientific, Inc.
2700 Richards Road, Suite 107, Bellevue, WA 98005 USA
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email info@SequoiaSci.com
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Sequoia Instrument Cable Summary

Instrument	Standard short cable, 2 meters except as noted SEQ-AC-____	Short cable included with instrument?	Power source *(if not USB, power supply is included)*	Custom-length deployment cable			Notes
				Base item SEQ-AC-____	**Female Pigtail 24in to Unterminated (Tinned) Wires**	**Length item** *qty in meters, min 5, max 50* **SEQ-AC-LISSTCBL_**	
LISST-200X	L200X-CBL02	Included	USB	L200X-CBLB	SEQ-AC-LISST-PT5F	Y	
LISST-ABS	ABS-CBL02	Optional	USB	ABS-CBLB	SEQ-AC-LISST-PT8F	G	Includes USB & pigtail adapters
				LISST-CBL8FU			USB only, no adapters
LISST-AOBS	AOBS-CBL02	Optional	12V	AOBS-CBLB	SEQ-AC-LISST-PT8F	G	Includes USB & pigtail adapters
				LISST-CBL8FUP			USB + Power only; no adapters
LISST-Tau	LTAU-CBL02	Included	USB	LTAU-CBLB	SEQ-AC-LISST-PT6F	Y	
LISST-HAB/ -Black	HAB-CBL02	Included	15V	HAB-CBLB	SEQ-AC-LISST-PT5F	Y	
Hyper-bb	HYPERBB-CBL02	Included	15V	HY-PERBB-CBLB	SEQ-AC-LISST-PT5F	Y	
Hyper-a	HYPERA-CBL02	Included	15V	HYPERA-CBLB	SEQ-AC-LISST-PT5F	Y	
LISST-Holo2	LHO2-CBL02 (PWR)	Included	19V	LHO2-CBLB	---	Y	For power only, not data
	LHO2-RJ45-1M (Data)		---	LHO2-RJ45-CBL (specify length)		B	Special order, requires custom quote, longer lead time
Nexsens X3 Logger	---	---	---	DL-UWCBLB		SEQ-AC-DL-UWCBL	For use with LISST-ABS/ AOBS/-Tau Waterproof cable connections