

# AQUARIUS

OCEAN BOTTOM SEISMOMETER WITH ACOUSTIC TELEMETRY



Compact, free-fall ocean-bottom seismometer with multi-disciplinary research capabilities and optional features for earthquake or tsunami early warning, without cables.

## KEY FEATURES

- > Advanced force-feedback triaxial broadband seismometer with a flat response between 120 s and 100 Hz
- > User-selectable long-period corner from 120 s to 1 s
- > Fully operational at  $\pm 90^\circ$
- > Two-way acoustic communications allows for wireless communication of full waveform data, State of Health parameters and triggered event notifications
- > Up to 18 months operation at 6000 m depth

# Aquarius

A revolutionary free-fall ocean-bottom seismometer (OBS) with acoustic telemetry capability that delivers near-real-time seismic data from the ocean floor to the surface without cables.

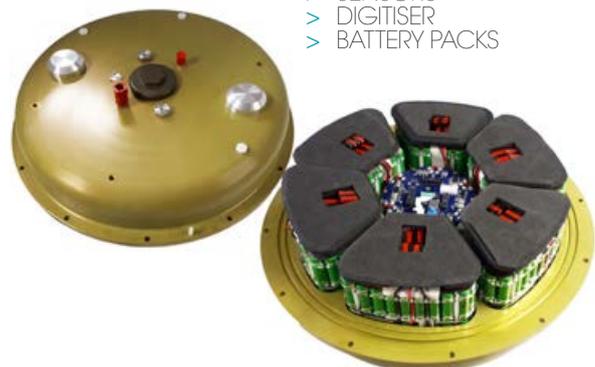
AQUARIUS OBS



ACOUSTIC TELEMTRY PROVIDES NEAR-REAL-TIME DATA TRANSFER BETWEEN THE AQUARIUS OBS SYSTEM ON THE SEABED AND THE SURFACE

ENCASED WITHIN THE SYNTACTIC FOAM BUOYANCY IS THE PRESSURE VESSEL CONTAINING:

- > SENSORS
- > DIGITISER
- > BATTERY PACKS



The Aquarius OBS system is a compact, free-fall seismic underwater observatory, with capability for near-real-time seismic data transfer without cables.

Key features include:

- > The advanced triaxial, broadband seismometer is fully operational at  $\pm 90^\circ$ , making it ideal for free-fall deployment onto the sea floor at depths of up to 6000 m
- > A three-axis magnetometer and a MEMS accelerometer record the seismometer's 3D position on the seabed for data rotation during post-processing
- > The seismometer has a flat response between 120 s and 100 Hz, with a user-selectable long-period corner from 120 s to 1 s, so you can tailor the response to the environment
- > Battery is sized to record seismic data for up to 18 months, with options to extend this if required
- > Game-changing acoustic telemetry capabilities:
  - > Following deployment you can transfer state-of-health parameters and noise performance plots from the seabed, select the desired response of the sensor and measure the time offset of the digitiser
  - > Transmit seismic waveforms and STA/LTA triggered event data to a receiver located at the surface in near-real-time for alert applications.
  - > Achieve up to 9000 bps data transmission between the surface and the Aquarius on the seafloor

In addition to the seismometer, Aquarius is fitted with an absolute pressure gauge (APG) and a hydrophone. The APG has an accuracy of 0.25% of full scale. This is used to activate the recovery aids when the system is approaching the surface.

If desired, an additional high performance APG (e.g. Paroscientific APG), essential for tsunami detection, can be incorporated.

The standard hydrophone has a frequency response of 2 Hz - 30 kHz, with the option to upgrade to an ultra-low frequency version of 100 s (0.01 Hz) to 8 kHz.

## Key features

Advanced triaxial broadband seismometer operational at  $\pm 90^\circ$ , with a flat response between 120 s and 100 Hz and a user-selectable long-period corner from 120 s to 1 s

Transfer state-of-health parameters and noise performance plots from the seabed, select the desired response of the sensor and measure the time offset of the digitiser following deployment

Transmit seismic waveforms and STA/LTA triggered event data from the seafloor to a receiver located at the surface in near-real-time for alert applications throughout deployment

Up to 9000 bps transmission of data between seabed and surface

## Discovery software platform

Discovery's suite of powerful tools dramatically simplifies instrument and data management and aids in the system management and recovery. See more on pages 4-5.

## Recovery and re-deployment

Data are stored locally in a dual redundant 128 GB Micro-SD card and can be downloaded using a Gigabit Ethernet after recovery.

A single cable connecting the Aquarius to the Guralp deck unit powers the system for data retrieval and system configuration. This allows for separate and concurrent charging of the batteries via a dedicated connector to an external charger, so that the system can be re-deployed as rapidly as possible.

The system is equipped with rechargeable lithium-ion batteries for fast and easy re-deployments, equating to approximately one hour to re-charge, for each month deployment.

## Applications

- > Local and regional seismic research
- > Energy exploration
- > Carbon storage
- > Noise surveys
- > Aftershock monitoring
- > Earthquake/tsunami Early Warning

Single cable connection to the Guralp deck unit for Gigabit Ethernet data download, system configuration and external power

Dual redundant 128 GB Micro-SD card

Acoustic burn-wire release mechanism actived through acoustic command, pre-programmed time-out or optional critical level battery trigger

Satellite tracking system issues location alerts visible on Discovery and/or sent via email and SMS

Discovery acoustic localisation function and LED strobe light simplify navigating to the precise location of the surfaced OBS system

### Easy and precise deployment

Aquarius is the most compact OBS, with acoustic telemetry data transfer capability, available in the market. This minimises transportation and installation costs and allows for deployment from smaller vessels.

Once on the seabed, the Aquarius can be accurately located using integrated location and ranging software. It is also compatible with Sonardyne USBL systems.



### The recovery system

The Aquarius recovery system is initialised either via the acoustic link, through a pre-programmed time-out, or with the optional critical level battery trigger.

Once activated, a burn-wire system releases the ballast for recovery of the instrument. The syntactic foam around the aluminium pressure vessel provides sufficient buoyancy to bring the instrument back to the surface.

A satellite tracking system hosted in a pressure glass sphere tracks the instrument on the sea surface, following deliberate release but also in the unlikely event of accidental release.

Messages from the tracking system can be viewed in Discovery and can be automatically sent by e-mail or text messages (to both satellite or standard mobile phones).

Once tracking information is received and the recovery boat is deployed, Discovery can provide a precise location using its acoustic ping localisation tool that calculates the slant range between the recovery boat and the OBS as the boat navigates near the expected location of the OBS. To aid night recoveries, the OBS also has a strobe LED light.

# Aquarius Discovery Toolkit

USE DISCOVERY TO REQUEST EVENT DATA VIA ACOUSTIC TELEMETRY.

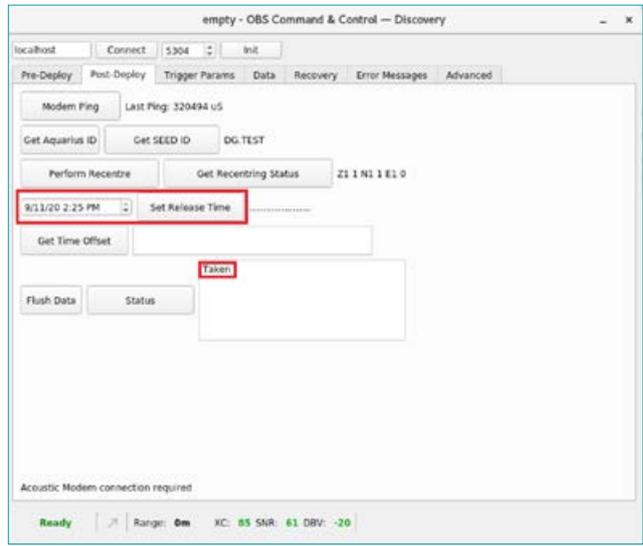
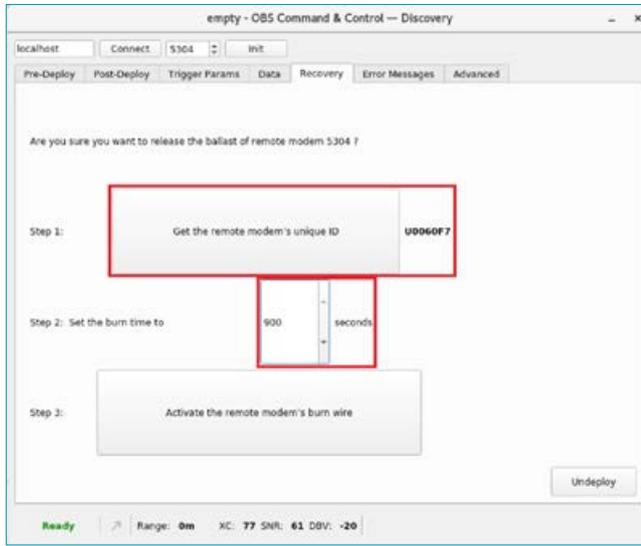
DATA ARE SENT AUTOMATICALLY TO THE DATA VIEWER

The image displays three overlapping screenshots of the Aquarius Discovery Toolkit software interface. The top-left screenshot shows the 'OBS Command & Control - Discovery' window, which includes a menu bar (OBS On Deck, Acoustic Configuration, Post Deploy, Trigger Parameters, Data, Recovery, Error Messages) and a list of channels: 1L.HDF, 1N.CHZ, 1N.CHN, and 1N.CHE. Each channel has a 'Get Events' button, a 'Get Data' button, and a 'Hide channel' button. The bottom-left screenshot shows a 'Request OBS Data - Discovery' dialog box with fields for 'Data Source', 'Location ID', 'Channel', 'Start Date/Time', and a 'Request Data' button. The bottom-right screenshot shows a 'Selected data window' with a waveform plot and a 'Full waveforms statistics' window.

## AQUARIUS RECOVERY SYSTEM

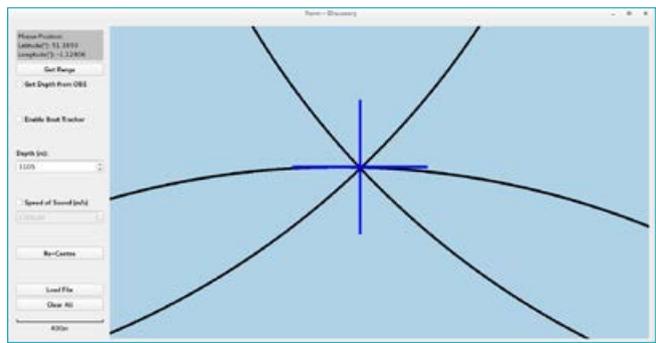
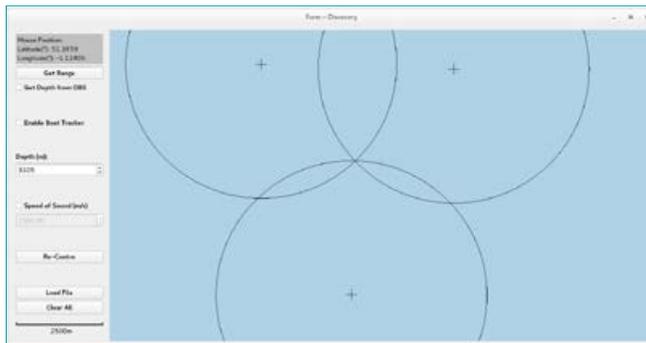
USE DISCOVERY TO REQUEST BURN-WIRE RELEASE USING ACOUSTIC COMMAND...

...OR CONFIGURE PRE-SET TIME-OUT



## AQUARIUS RECOVERY SYSTEM

DISCOVERY ACOUSTIC LOCALISATION TOOL TRIANGULATES THE PRECISE LOCATION OF THE OBS

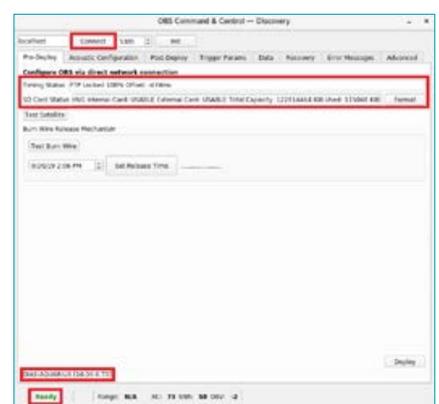
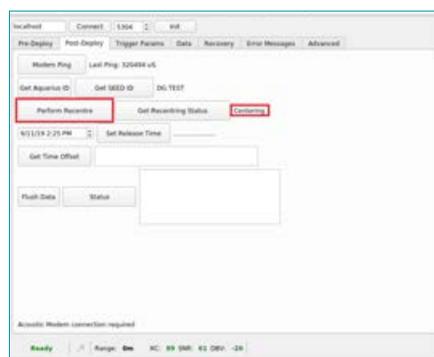
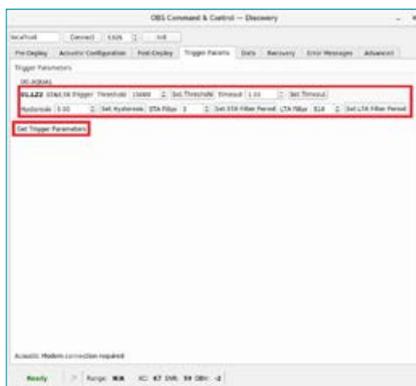


## CONFIGURE INSTRUMENT AND DIGITISER SETTINGS AFTER THE OBS DURING DEPLOYMENT

SET TRIGGER PARAMETERS

RE-CENTRE MASSES

COMPARE DIGITISER OFFSET WITH PTP TIMING



## SPECIFICATIONS

<b>BROADBAND SEISMOMETER</b>		<b>POWER</b>	
Technology	Force-feedback (force-balance) sensor	Battery life:	Up to 18 months at 6,000 m depending on application Options to extend battery life - please enquire
Configuration / Topology	Triaxial orthogonal (XYZ with ZNE output)	Battery recharge time	1 hour per month deployment (approx.)
Velocity output band (within -3 dB crossing points)	120 seconds to 100 Hz standard	<b>ACOUSTIC COMMUNICATIONS AND RECOVERY</b>	
Output sensitivity	Nominal velocity response: 2000 V/ms <sup>-1</sup>	Acoustic modem	Omnidirectional transceiver compatible with USBL systems for accurate instrument location on the seabed
Self noise below NLNM (New Low Noise Model; Peterson, 1993, USGS)	-173 dB re (m/s <sup>2</sup> )/Hz @ 10 s	Release mechanism	Acoustically-operated burnwire release, critical battery level trigger or timed release option
Tilt tolerance	±90 °	Recovery location tools	Satellite tracking system LED strobe light Discovery acoustic localisation tool
<b>ABSOLUTE PRESSURE GAUGE</b>		<b>PHYSICAL / ENVIRONMENTAL</b>	
Resolution	1 mm variation in 1000 m of water	Operating temperature range	-20 to +75° C
Accuracy	0.25% of full-scale	Pressure vessel casing material	Aluminium with corrosion-resistant treatment and anodic protection
<b>HYDROPHONE</b>		Operational depth	6,000 m maximum
Frequency response	2 Hz to 30 kHz	Buoyancy	Syntactic foam buoyancy (glass micro-spheres) for extended life and durability
Sensitivity	Max -162 dB re: 1 V/μPa (562 V/Bar); Min -240 dB re: 1 V/μPa (0.1 V/Bar)	Dimensions with buoyancy and ballast	1000 mm Ø  Height to top of buoyancy 459 mm Height to top of lifting bar 725 mm
<b>ADDITIONAL CHANNELS &amp; STATE-OF-HEALTH</b>		Weight with buoyancy and ballast:	328 kg in air 36 kg in water
Environmental channels	Three-component digital compass composed of a MEMS accelerometer and Magnetometer Temperature sensor Humidity sensor Supply voltage	<b>ACCESSORIES</b>	
<b>24-BIT DIGITISER</b>		Deck control unit	Acoustic command module and OBS communications unit for instrument control/ configuration and clock synchronisation
Primary digitisation channels	Four at 24 bits	Battery charger	Suitable for on-deck charging
ADC converter type	Delta-sigma	<b>OPTIONAL UPGRADES/ADDITIONS:</b>	
Output format	32-bit	<b>ULTRA-LOW FREQUENCY HYDROPHONE</b>	
Dynamic Range	>142 dB at 100 samples per second	Frequency response	100 s (0.01 Hz) to 8 kHz
Output sample rates available	250 samples per second for seismic channels and 5 samples per second for environmental, auxiliary sensors and MEMS channels	Sensitivity	-194 dB (1 V/μPa)
Decimation filters	÷2, ÷3, ÷4, ÷5 (Causal / Acausal)	<b>HIGH PERFORMANCE ABSOLUTE PRESSURE GAUGE</b>	
Trigger modes for alert options	STA/LTA	Accuracy	<0.01% of full-scale
<b>DATA STORAGE</b>		Calibrated temperature	-2 to +40° C
Data recording formats	miniSEED (metadata stored in dataless SEED format, RESP and StationXML)	Hysteresis	≤± 0.01% Full Scale
Flash memory and storage	128 GB dual redundant  Up to 2 TB cards available upon request	Resolution	4.5 parts per billion
Direct data download	Via Gigabit Ethernet connection. Data streaming protocols:  GCF (Scream!), GDI-link <sup>1</sup> and SEEDlink <sup>1</sup> ( <sup>1</sup> metadata sent in RESP, StationXML and dataless SEED file formats)	<b>CLOCK AND CALIBRATION</b>	
Typical drift per day	VCXO clock: <1 ms (fully correctable during post-processing) Atomic clock option available.	Timing synchronisation sources	PTP on Ethernet link through Güralp surface deck unit
Calibration signal generator	1 Hz sinewave, step, triangle, broadband or white noise, all with adjustable amplitude		

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