



# Vehicle Platforms

YOUR VEHICLE TO BETTER DATA, BETTER DECISIONS

# What Will You Do With a YSI Vehicle?

YSI has worked with global experts to design vehicle platforms for our customers' applications, ranging from pure environmental research to drinking water reservoir management to search and rescue missions. Almost any outdoor application that would require a YSI or SonTek sensor can be done faster and with less operational expense, and the value only increases with sensor combinations. The Table below will help you understand the differences in these platforms, and a YSI Representative will be ready to review these options to help you plan your mission!

	Description	rQPOD	HYCAT®	i3XO
<b>Key Sensor Options</b>	YSI EXO1 Water Quality Sonde (4 ports)	No	No	Yes
	YSI EXO2 Water Quality Sonde (7 ports)	No	Yes	No
	SonTek HydroSurveyor™ M9	Yes	Yes	No
	SonTek RiverSurveyor®(M9 or S5)	Yes	Yes	No
	Advanced Doppler Velocity Log	No	No	Yes
	Magnetometer	No	No	Yes
	Side Scan Sonar	No	Yes	Yes
<b>Key Features</b>	Autonomous Operation	In development	Available through HYPACK MAX	Available through VectorMap
	Remote-control	Yes	Yes	Yes
	Underwater Operation	No	No	Yes
	Undulating Missions	No	No	Yes
	Inertial Navigation System	No	No	Yes
	Real-time Data Acquisition	Within BlueTooth™ range	Yes, within 5.8 GHz Radio range	Vehicle health only, through Acoustic comms
	Onboard Camera	No	Yes	No
	Field-swappable Battery	Yes	Yes	Yes, with spare tail section
	Single-person Deployability	Yes	No	No
	Sensor Expansion Ports	No	No	Yes
	Run time on One Battery Charge (at survey speed)	4-6 hours	6-8 hours	8-12 hours

# Why Would You Use a Vehicle Platform?

 **Data Quantity**

Collect exponentially more data than you can in a boat or with point sampling.

 **Mission Control**

Pre-program your mission for autonomous operation, or stay in full command with remote control, or use both!

 **Data Quality**

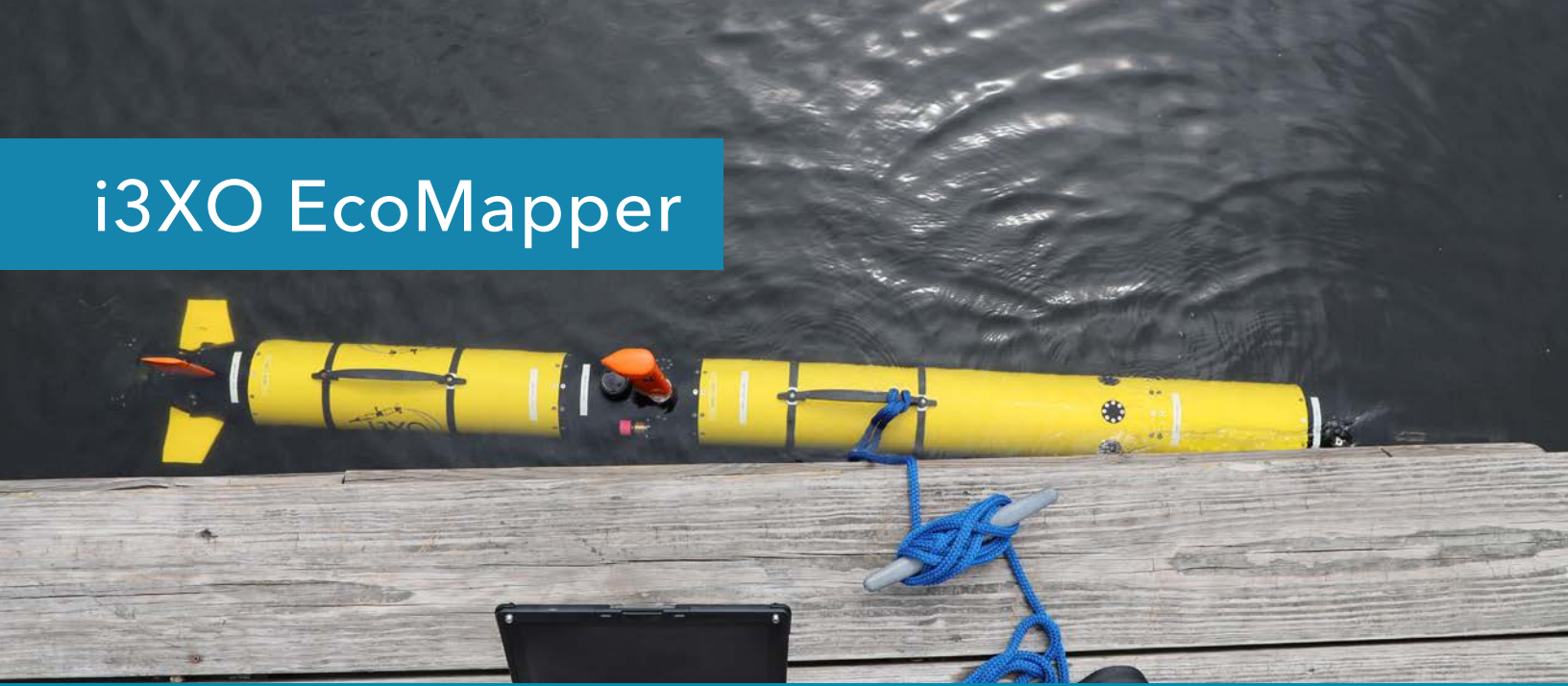
Xylem's industry-leading sensors are used with top-quality sonar and positioning technologies.

 **Safety**

Less time on boats and exposed to the elements, when days of manual profiling are replaced by a single mission.



# i3XO EcoMapper



## Survey-Grade Autonomous Underwater Vehicle

The **i3XO** (a.k.a. EcoMapper®) is YSI's most sophisticated vehicle, and our only autonomous underwater vehicle (AUV). It breaks down for easy shipping and carrying, and allows you to generate high-resolution, geo-referenced, three-dimensional maps of water quality, currents, and sonar images. Designed in partnership with Ocean Server (owned by L3 Harris) this is YSI's flagship vehicle.

### Outstanding features available standard or as options include:



Inertial Navigation System (INS) tracks global position: 97% accuracy over 10,000 meters!



Forward object avoidance to protect your vehicle.



Nose-mounted EXO1 sonde adapted specifically to this platform.



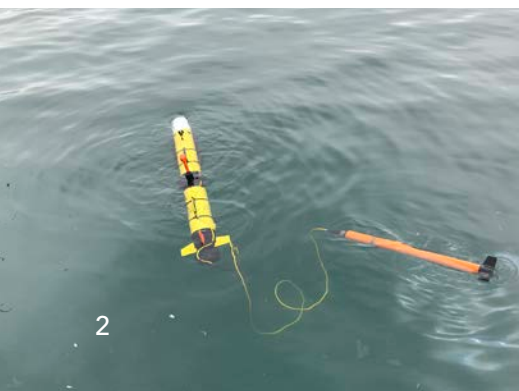
Point-and-click mission planning with intuitive VectorMap software.



Acoustic communications system for mission changes on-site.



Easy-to-use touch-screen handheld for full control in the field.



## Vehicle Overview

Optical Dissolved Oxygen, ph/ORP, Conductivity/ Temperature, Turbidity...or any EXO sensor!

Expansion ports to explore unique sensor solutions

Multi-beam / Side Scan Sonar

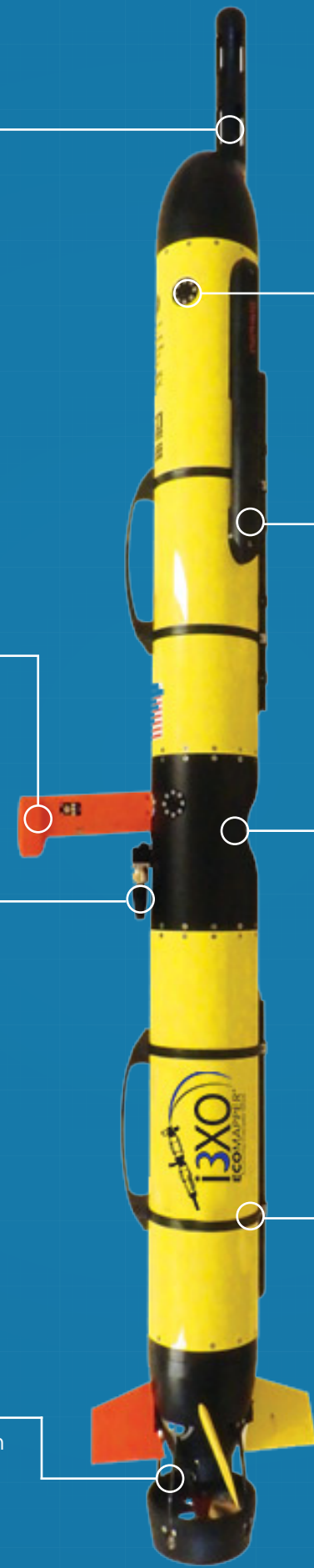
GPS + WiFi + 2.4 GHz antenna, with lights for navigation and visibility

Advanced Doppler Velocity Log for bathymetry and downward-looking current profiling

External charge, sensor, and communications port

Field-swappable battery & propulsion section, with rechargeable Li-ion battery

Magnetic seal prevents water intrusion by isolating the propulsion system from drive electronics



# Scientists Rely on AUVs

*Instrumentation Enables Real-Time Mapping, Sensing*

## Case Study

**Autonomous Underwater Vehicles like the i3XO are the go-to solution when multiple types of sensor data are required to study or manage a system.**

Similar to the way that cell phones and other portable electronic devices have advanced over the past decade, the i3XO is possible because of instrumentation that is smaller, more robust, and more affordable. It also is possible because of a years-long relationship between YSI and OceanServer Technology, Inc., which today is part of L3 Harris, Inc. This perfect pairing of YSI's sensor and application expertise with OceanServer's AUV expertise has made both the i3XO and its predecessor, the EcoMapper, the most exciting unmanned water monitoring technology available.

### Cutting-Edge Technology that Respects the Field Experience

Compared to our industry-changing EcoMapper, the i3XO has even more technology and an even deeper respect for what the Field Engineer needs on site.

An excellent example is the optional Inertial Navigation System (INS). Older AUVs handled positioning with a method known as dead reckoning, which relies on the compass and Doppler Velocity Logs (DVLs) to estimate the vehicle's speed and positioning. The typical accuracy for dead reckoning is roughly 1% distance traveled. So for every 1000 m traveled underwater, one would see an ~10 m error in positioning when the AUV resurfaces. This could cause issues ranging from poorly mapped data to lost vehicles.

With INS the i3XO is able to get an accuracy of 0.3% distance traveled! This allows the vehicle to stay underwater for an extended period without having to come to the surface for a positional adjustment using GPS. The user will experience less lost time for resurfacing, and more time to actually run the survey.

Overall the cost per data point may be reduced by as much as 10X with this new technology!

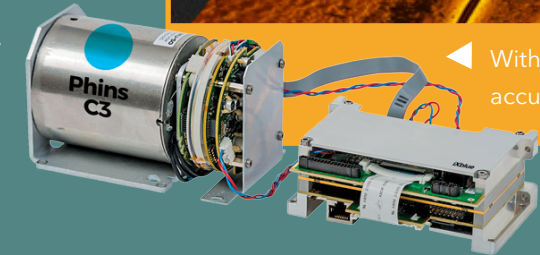
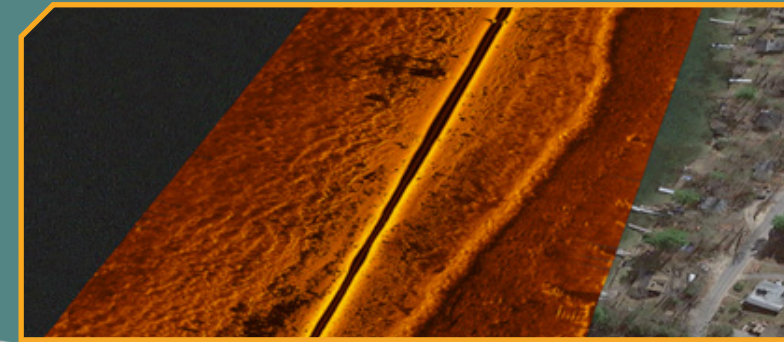
The i3XO also has up to 3 different location identifiers so that the end-user always knows the exact GPS coordinates of the unit, and the vehicle can notify the user of its whereabouts when in mission mode. Those identifiers include a location pinger with a specific frequency and ping sequence, an acoustic communications unit for underwater updates, and an Iridium modem for location updates on the surface. These tools enable the user to track the vehicle the entire time, whether it is on the surface or underwater, to ensure it is on path and error-free.

The INS optimizes performance of the sonar instrument available with the i3XO, and which supports both multibeam and side scan sonar (SSS). Improved object detection with dual frequency allows the i3XO to quickly identify targets and obstructions on the sea or lake floor, in high resolution. This makes the i3XO an excellent tool for search and recovery missions or identification of unexploded ordnances (UXOs). The multibeam portion enables swath bathymetry, which also was previously enjoyed mostly by those with military-level budgets, but can now be used by all of us.

This technology allows the user to cover up to 12 times compared to the less than 1:1 coverage of a single beam. With a single beam running at 10 m from the bottom, the overall coverage one can obtain is less than 10 m. With the multibeam running at that same height, coverage of up to 120 m is possible. This translates to fewer runs to cover the same ground, saving time and money.

Military-grade technology is even brought to i3XO users with the Getac computer that doubles as a notebook, and is IP67 rated. This is an option with every i3XO and is one way to communicate with the i3XO via wireless, or with some of the onboard sensors via Bluetooth.

Other field-minded features of the i3XO are that it can be mission-programmed for up to 6-10 hours, and has a Li-Ion battery that supports long missions and a quick recharge. A key upgrade relative to the EcoMapper is that the i3XO battery compartment and



With INS the i3XO is able to get an accuracy of 0.3% distance traveled!

propulsion system module can be hot-swapped in the field. With an extra battery on hand a day of surveying can be extended from dusk to dawn.

### Who Uses i3XO?

The i3XO is used by leading scientists in the world, including some at the United States Geological Survey and the U.S. Army Corps of Engineers. The vehicle is a workhorse in the field, helping these agencies reduce hours for their people on the water, while collecting more data than ever before possible.

The EcoMapper and i3XO are also a favorite of educational institutions, where a single vehicle is often shared by multiple departments or programs, and even used in teaching. In all cases, YSI's i3XO provides critical data without the tedious hours of human observation that would otherwise be required. The improvements in portability, plug-and-play sensors, and intuitive user interfaces, the vehicles are used in many applications across the globe.

Whether it is with your own vehicle, or with YSI at your side providing vehicle-related services, the i3XO can transform your data collection like it has for these scientists.



Learn more about the i3XO EcoMapper at: [YSI.com/EcoMapper](https://www.ysi.com/EcoMapper)

# HYCAT



## Multiple Sensors, One Complete Solution.

**HYCAT** is a unique Autonomous Surface Vehicle (ASV) with a foam-filled unsinkable catamaran hull, carrying its suite of sensors never before available in one platform. It fits into most trucks and SUVs, and can easily be deployed by two people anywhere you can carry it.

### Outstanding features available standard or as options include:



The most sensor-rich platform available: YSI EXO2s, SonTek HydroSurveyor M9, Side Scan sonar in one system!



Ruggedized handheld unit for effortless switching between autonomous and remote-controlled modes.



Data are viewed in real time on shore.



Onboard camera gives you a unique look at your study site.



Field-swappable Li-ion battery keeps you operating all day.



Includes HYPACK MAX software for full data analysis.

# Vehicle Overview

Onboard Windows 10 Data Acquisition Computer with HYPACK MAX software

5.8 GHz Wireless comms

Hemisphere AtlasLink™ RTK GNSS Receiver

Health LED, Safety Kill Lanyard, and IP67 USB port

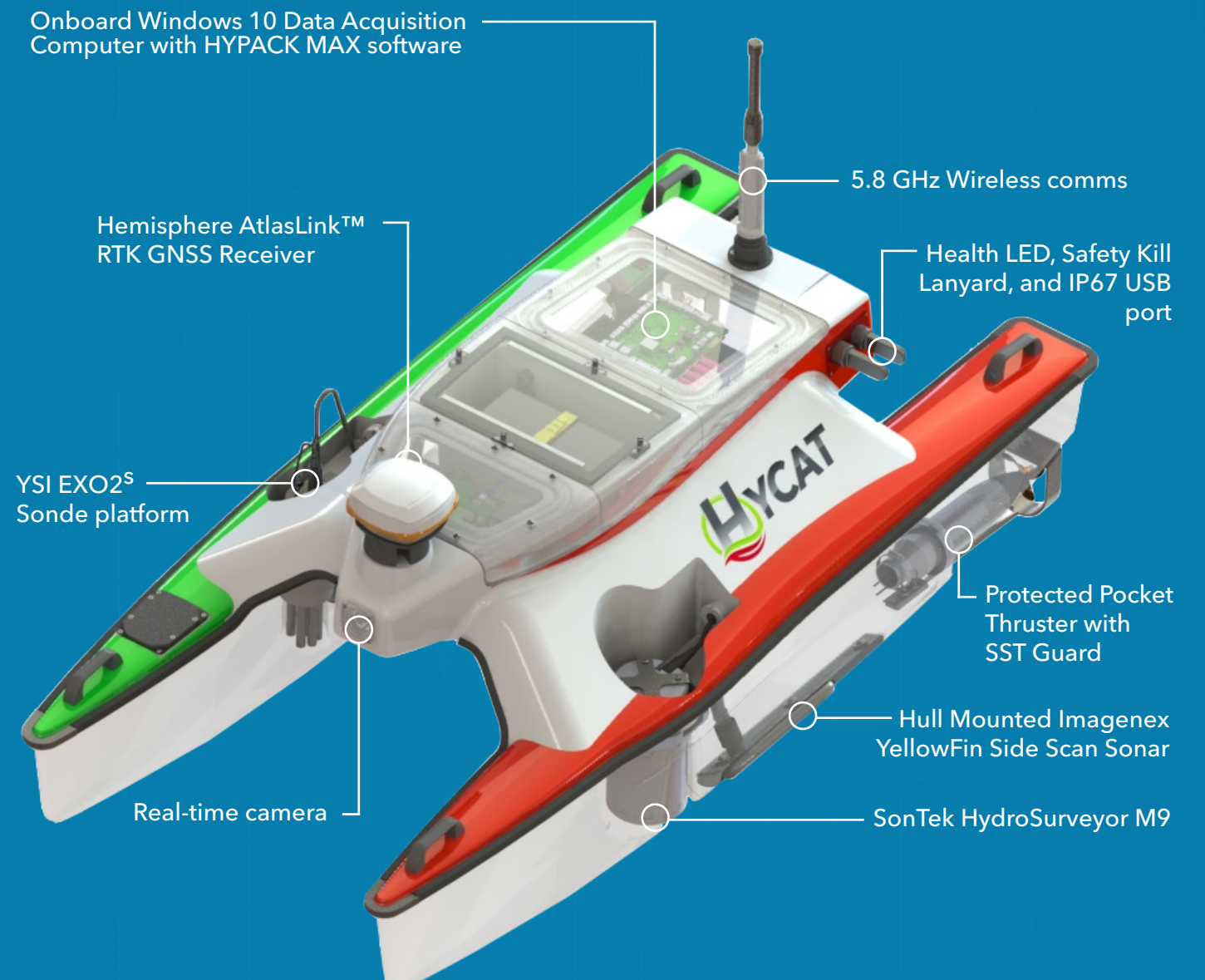
YSI EXO2<sup>s</sup> Sonde platform

Protected Pocket Thruster with SST Guard

Real-time camera

Hull Mounted Imagenex YellowFin Side Scan Sonar

SonTek HydroSurveyor M9



# For the Love of Charles

Famous "Dirty Water" is on the Rebound

## Case Study

To rock 'n roll fans of a certain age—and Boston sports fans celebrating points with a verse or two of The Standells' 1966 hit "Dirty Water"—the **Charles River** is synonymous with pollution. On its way to Boston Harbor, the 80-mile-long river winds through one of America's oldest industrial regions, supplying water, power and drainage to the hub of Massachusetts' economy for more than 350 years.

As the Bay State's economy soared in the 17th, 18th, and 19th centuries, water quality in the Charles experienced a steady decline. Slowed even further by a string of 20 dams installed before the end of the 1800s, its naturally sluggish flow ground nearly to a halt while pollution flowed in from the textile mills, factories and cities along its banks. In 1875, the federal government recommended abandoning clean-up efforts on the lower half of the river and focusing instead on the upper reach. By the middle of the 20th century, combined sewer overflow (CSO) from Boston and Cambridge turned the Charles into a gutter during storms—an annual average of 28 CSO events and more than 1.7 billion gallons of combined discharge.

But in 1965, just months before the release of "Dirty Water" stamped the Charles with its grungy identity, a group of locals banded together to turn the river's fortunes around.

### New Report Card

"Charles River Watershed Association was formed in 1965 by a group who was disgusted by the state of the river and wanted to clean it up," says Lisa Kumpf, an aquatic scientist who heads up the association's field science programs. "Since then, we've been cleaning up the river by working with the cities and towns in our watershed to get combined sewers separated, to make sure that

stormwater that is going into the river is clean. We also have advocacy and law branches of our organization to advocate for laws around stormwater and sewage."

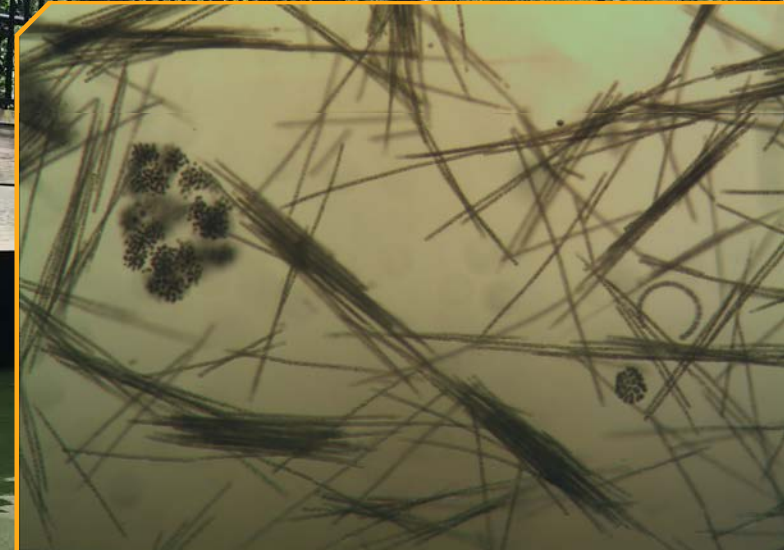
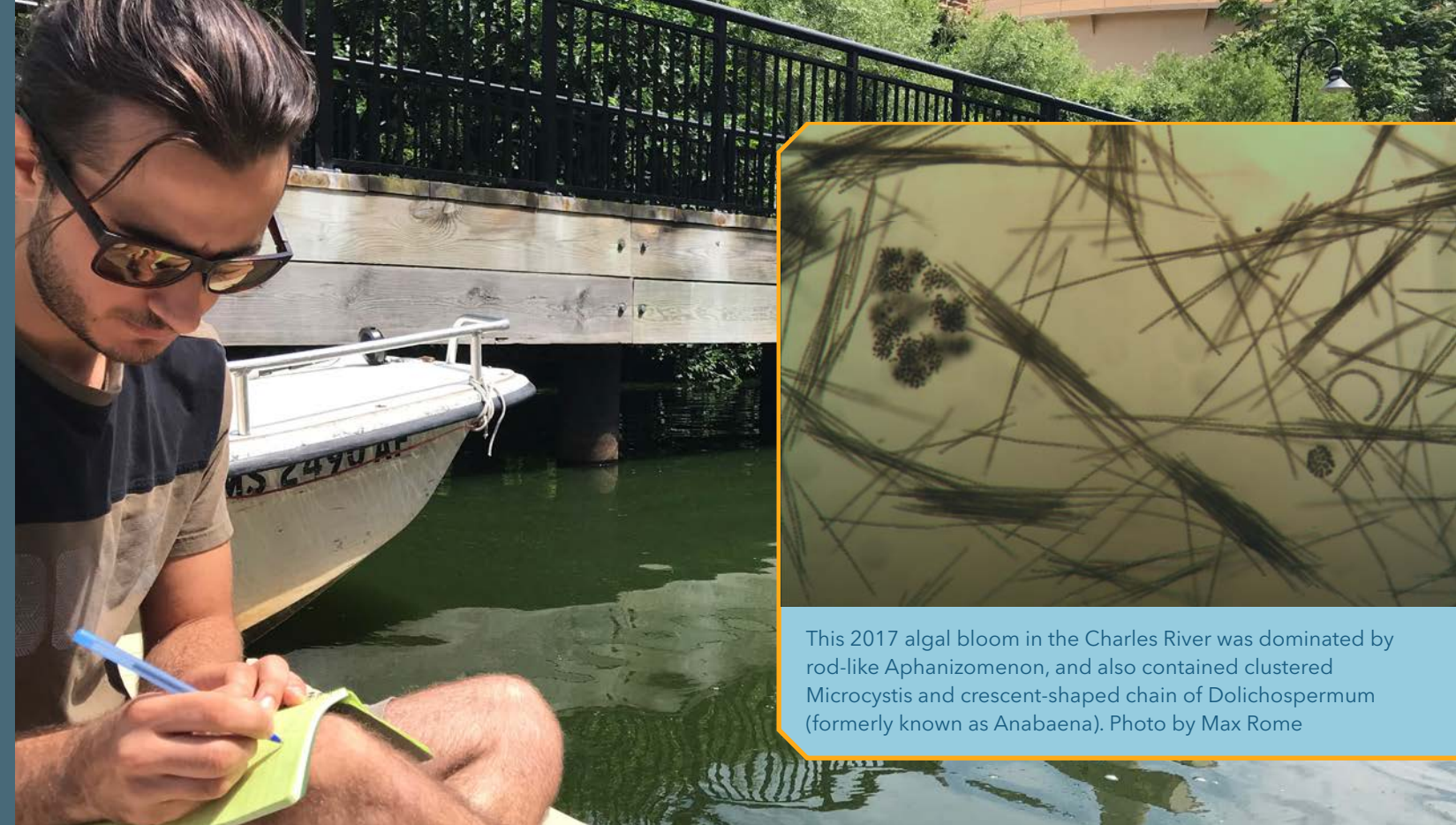
Improvements in water quality in the Charles have been documented by the U.S. Environmental Protection Agency. EPA began issuing an annual "report card" grade for the lower reach of the river in 1995 based on water quality data collected by the association's volunteers.

"We still have a lot of work to do, but in 1995 the basin was estimated to have a grade of D and now, in 2018, the most recent grade was a B," Kumpf says. "We have come a long way, but there is still work to do."

The association—which goes by the acronym CRWA—was instrumental in opposing the construction of flood control dams in the 1960s that would have destroyed 8,000 acres of wetlands that now serve as valuable habitat and a cleansing buffer for the river. The group's cleanup efforts got a significant boost in the 1980s, when the Massachusetts Water Resources Authority closed several of the combined sewer overflows that regularly dumped raw waste into the river, notes Max Rome of Northeastern University, who works with the Charles River Conservancy.

Over the past three or four decades, separating stormwater and sewer systems, building new storm drainage systems, and closing CSO outfalls has reduced CSO discharges into the Charles River basin by 98 percent, and improvements continue.

"Especially from 1995 on, you start to see water quality getting better and better and better to where we are today," Rome says. "If you look at the whole river, it would be safe with respect



This 2017 algal bloom in the Charles River was dominated by rod-like *Aphanizomenon*, and also contained clustered *Microcystis* and crescent-shaped chain of *Dolichospermum* (formerly known as *Anabaena*). Photo by Max Rome

▲ Charles River Watershed Association intern Glauco Cavino records data during a 2019 harmful algal bloom.

to *E. coli*-based bacterial swimming standards somewhere between 50 and 70 percent of the time, but there are certain sites that are safe for swimming close to 90 percent of the time during the summer."

### Blue-Green Algae: Growing Concern

Since 1995, volunteers have made monthly visits to CRWA's network of 35 monitoring stations along the river to collect water samples and send them to a lab for *E. coli* testing. Additional samples are collected quarterly to test for chlorophyll, phycocyanin (a pigment produced by cyanobacteria, or blue-green algae), enterococci, turbidity, total phosphorus, total nitrogen and several other parameters for a more comprehensive exploration of the river's water quality.

In addition, CRWA taps into the data stream from the U.S. Environmental Protection Agency's buoy-mounted multi-parameter sonde, which measures temperature, dissolved oxygen (DO), pH, specific conductance, turbidity, chlorophyll and phycocyanin every 15 minutes. The EPA buoy, backed by monitoring work by Kumpf and Rome, helps CRWA



track blooms of cyanobacteria, which have been a growing concern for the association and other stakeholders along the Charles.

CRWA has been monitoring harmful algal blooms in the Charles since 2006, and is still discovering important details about them.

“People know a lot about *E. coli* bacteria and what kind of health effects it can have, but the research around cyanobacteria is not as robust,” says Kumpf. “Studying where we have continuous phycocyanin measurements is very valuable to see what’s going to happen with these emerging contaminants.”

“The past several years, we’ve had at least one cyanobacteria bloom from mid-summer to early fall, and that’s largely due to excess nutrients that are in the river as a result of stormwater runoff and high temperatures,” she adds. Those blooms are a major focus in Rome’s research at Northeastern.

“One of the really interesting things about the blooms in the Charles is they are very dominated by *Aphanizomenon*, which is not one of the most

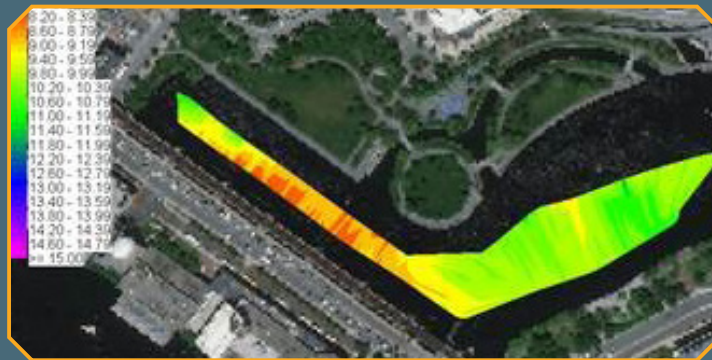
commonly studied species,” Rome points out. “A lot of the guidances are written for *Microcystis*. What we see in the river is a little bit different, so we’re really interested in understanding *what are the optical properties of Aphanizomenon? How do we track it? How is it responding to nutrient concentrations and temperature? And what are the cyanotoxins that are most associated with the species in the river?*”

Rome adds that stakeholders are also interested in one of the most basic mysteries of the blooms: how big are they?

### Send in the Robots

CRWA got a unique opportunity to explore algal blooms in the Charles when Kumpf and her team partnered with YSI to deploy two of the company’s new robotic systems—the HYCAT Autonomous Surface Vehicle (ASV) and the i3XO EcoMapper Autonomous Underwater Vehicle (AUV)—in a section of the Charles that includes a popular swimming area.

Innovative software allows the technician to plot a course for the autonomous systems using a georeferenced image of the study area. In one day detailed insights were gained that exceeded anything that had been collected in nearly four centuries prior.



◀ The HYCAT Autonomous Surface Vehicle helps CRWA researchers generate high resolution water quality, bathymetry, and flow data at once along the river.



The HYCAT ASV is a six-foot-long, foam-filled catamaran designed to collect water quality, bathymetry and flow data at once, says YSI Integrated Systems and Services Product Manager Tom Goucher. The 115-pound vessel houses a YSI EXO2 sonde with seven ports for water quality sensors; a SonTek HydroSurveyor M9 acoustic Doppler current profiler (ADCP) to collect data on current direction, flow and discharge throughout the water column; a side-scan sonar for habitat mapping; a real-time camera; an onboard computer and 5.8 GHz wireless communications.

Using a georeferenced image of the study area, the HYCAT operator used HYPACK software to set a single GPS waypoint and pulled on a set of polygons to chart a “lawnmower grid” for the ASV to follow as it methodically gathered its data. The same software package provided real-time data visualization and post-processing.

Beneath the surface, the i3XO EcoMapper followed its own “lawnmower grid,” gathering up to eight water quality parameters with its nose-mounted EXO1 sonde and charts of the banks and bed with its bottom-mapping system and side-scan sonar. Together, the two new autonomous systems provided detailed insights into the river that exceeded anything that had been collected in nearly four centuries.

“YSI developed these integrated systems in response to the growing need for algal bloom research and monitoring,” says Goucher, whose office, conveniently, is in Massachusetts. “The Charles River provided an outstanding opportunity to test how well we could map chlorophyll and other parameters, as well as physical characteristics of the river system, using the HYCAT and the EcoMapper.”

“We are seeing remarkable versatility with these vehicles in real-world situations like the Charles, operating in currents up to 6 knots,” he adds. “These are going to be extremely powerful tools for people like Lisa and Max who are studying rivers, ponds, estuaries, and near-shore systems.” In addition to sales of HYCAT or EcoMapper units, YSI has developed new service-based programs.

Kumpf and Rome are eager to put the

autonomous systems back to work in the Charles during an algal bloom.

“Being able to get the HYCAT or the EcoMapper into the water during a bloom would be so incredible because it would give us a chance to see the profile and the cell density throughout the whole basin,” says Rome. “That’s a really big question right now that nobody has the answer for.”

### Big Changes

After centuries of acting as an open sewer for the communities along its banks, the Charles has become the centerpiece of CRWA’s Blue Cities Initiative. Through Blue Cities, CRWA evaluates opportunities for restoration projects that work with—rather than against—the watershed’s natural hydrology. Through projects that range from building retrofits to runoff treatment basins and greenways, the association is developing cost-effective stormwater management systems and helping beautify the 35 communities in the watershed.

But challenges persist.

“It’s so much better than it used to be, but we still face a lot of issues and we are going to see those issues become worse with climate change,” warns Kumpf. “For climate change in the Northeast, we’re looking at higher levels of precipitation and more intense storms that make combined sewer overflows happen more often and cause more issues with stormwater runoff. So making sure that we are investing now in the water quality we want to see in the future is very important.”

That should give a new generation of Boston songwriters something to sing about.



Learn more about the Charles River Watershed Association at: [CRWA.org](http://CRWA.org)



Learn more about YSI’s Autonomous Vehicles at [YSI.com/HYCAT](http://YSI.com/HYCAT) or [YSI.com/EcoMapper](http://YSI.com/EcoMapper)

# rQPOD



## Cost-Effective, Flexible and Innovative Surveying Tool

The **rQPOD** is a compact motor that can be field-installed via wetmate connectors, transforming our unique Torrent Board into a remote-controlled vehicle! Talk to your representative to explore the modular options this platform offers, and to design a system just for you!

### Features available as standard or options include:



Sensor flexibility—SonTek River Surveyor (M9 or S5) for flow, or HydroSurveyor (M9) for bathymetry, and more to come in future!



Removable thrusters and batteries for field serviceability.



Patent-pending rQPOD motor is adaptable to other floating platforms.



Rugged Torrent Board withstands harsh water quality and moderate flow conditions.

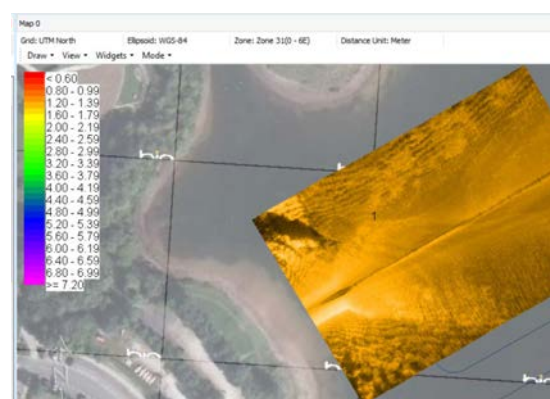


Its small size and low draft makes this our most nimble vehicle platform.



At <26 lbs (12 kg) and with the supplied backpack, system can be carried, assembled and deployed by one person.

# Vehicle Overview





# Remote Bathymetric Survey in Kalgoorlie Mine Pits, Australia

## Case Study

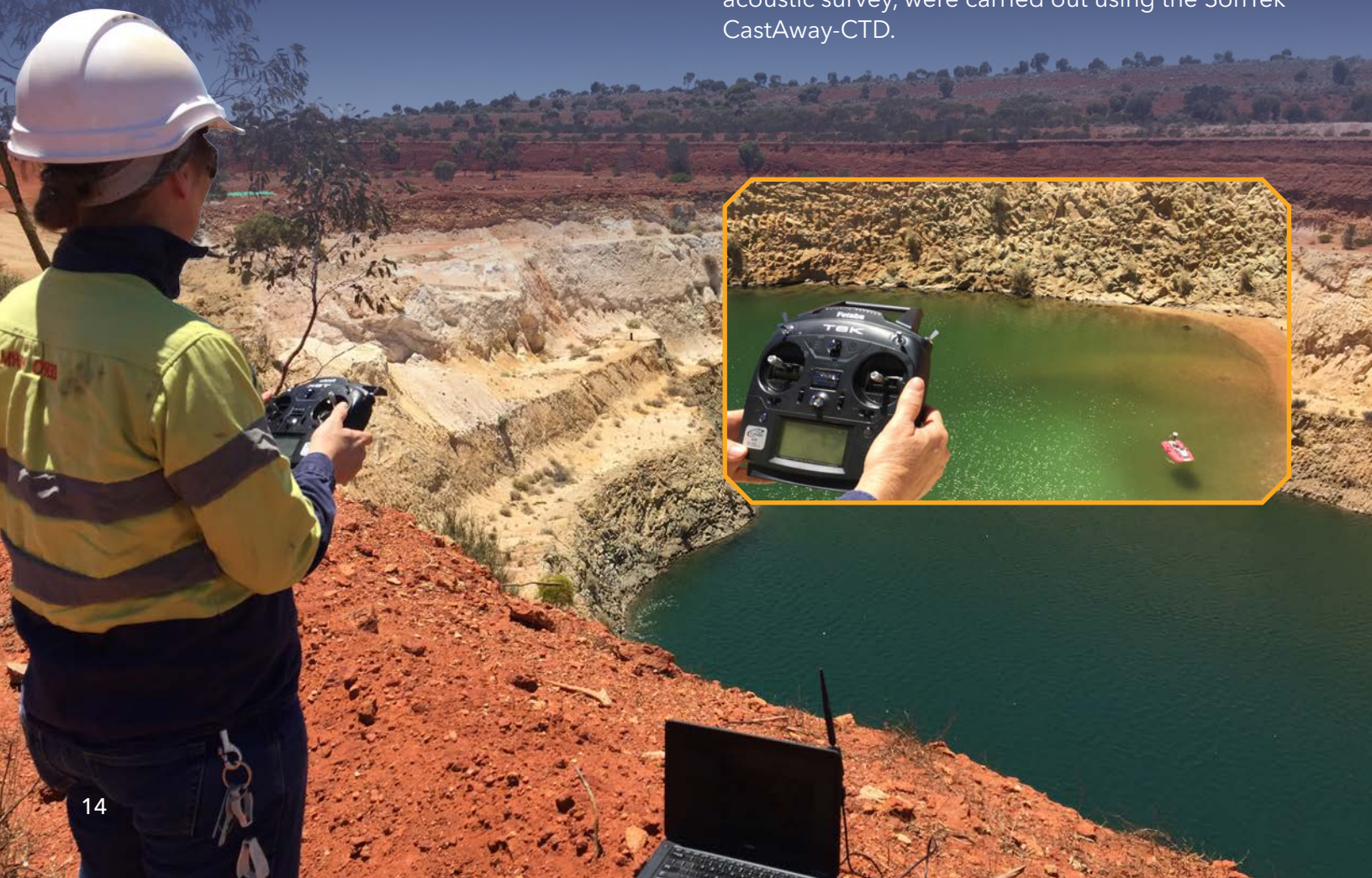
Norton Gold Fields Limited operates a gold mining and processing operation in Kalgoorlie, Australia. Impounded waters are part and parcel of gold mining from the development of mining pits and dewatering operations.

Previously, volume surveys of impounded waters in pit lakes had been undertaken using total station positioning and soundings taken from a boat on the lake. This was a labor intensive process with up to four people required for the survey. In addition to this was the safety concerns associated with working on the water in boats. Kellie Carter, Senior Environmental Advisor, approached Xylem regarding any possible solutions to make this process more efficient.

**"This was a labor intensive process with up to four people required for the survey. In addition to this was the safety concerns associated with working on the water in boats."**

Having previously undertaken a successful bathymetric survey of a pond in the Tropicana Mining Lease using a radio controlled boat, Xylem was engaged to undertake bathymetric surveys at three of the Pit Lakes within the Norton Gold Fields.

These surveys in January 2018. Speed of sound in water corrections, an integral part of any acoustic survey, were carried out using the SonTek CastAway-CTD.



HYPACK software managed the preparation, survey, processing, and outputs for the survey.

The survey assignment was unique with a large and very shallow lake (maximum depth 1.6 m) followed by a very deep, steep walled mining pit (maximum depth 56 m). The final lake, maximum depth of 6 m was a steep walled figure eight pit. As such, the radio controlled boat had to be operated from up to 362 meters away.

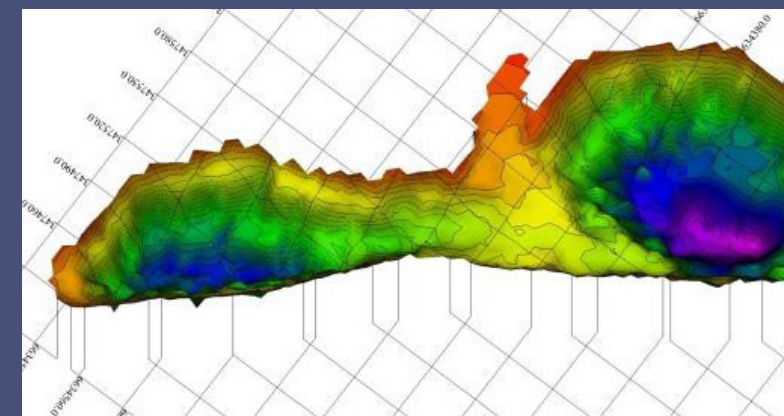
### Key Statistics from the Survey

Furthest distance RC boat operated	362 m
Maximum depth	56 m
Total distance surveyed	18,000 m
Total area surveyed	175,000 m <sup>2</sup>

The resultant bathymetric data is used to build a model of the surveyed area and volume can subsequently be determined. Accurate volumes of impounded water are a key environmental reporting requirement. Kellie Carter also mentioned that she could see the value for quickly and safely determining volumes of water required for dewatering and thus ensuring correct pumping capacities as well as suction placement can be assessed.



▲ HYPACK software managed the preparation, survey, processing, and outputs for the survey.



▲ Bathymetric data is used to build a model of the surveyed area.



Learn more about Norton Gold Fields Limited at: [Nortongoldfields.com.au/](http://Nortongoldfields.com.au/)



SonTek HydroSurveyor-M9



SonTek CastAway-CTD



SonTek RQPod Remote Survey Boat


# Service





## Your Vehicle to Better Data!

A Vehicle Platform with all of its sensors is a big commitment, and we want to ensure that you get all the benefits that this great technology has to offer.

### Examples of services we provide include:

 Factory training when you purchase a vehicle.

 Refresher training or training for new users.

 Maintenance contracts for all of your sensors.

 Full service packages where our experts run the technology for you—without a purchase!

 [YSI.com/Services](https://www.ysi.com/Services)



# YOU'RE DATA-DRIVEN Let YSI Drive

Some users wouldn't use a vehicle frequently enough to justify a purchase, such as those needing a bathymetry survey for a special event like dredging or equipment installation. YSI can bring a vehicle and operator to you!

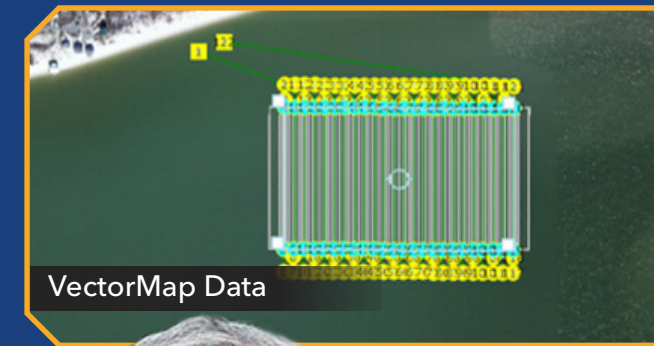
### Take these 5 Steps to get all the benefits of our unique Autonomous Vehicles:

- 1 Contact your YSI Representative to discuss your project.
- 2 Place your order and schedule the service dates.
- 3 Plan your vehicle mission with a YSI application expert.
- 4 Our expert will arrive with a fully-loaded, calibrated vehicle to execute the mission.
- 5 The data and reports will be delivered as defined by your order.

 [YSI.com/Let-YSI-Drive](https://www.ysi.com/Let-YSI-Drive)



Custom Waypoints



VectorMap Data



# Xylem |'zīləm|

- 1) The tissue in plants that brings water upward from the roots;
- 2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

**For more information on how Xylem can help you, go to [www.xylem.com](http://www.xylem.com)**

## Who's Minding the Planet?®



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