Underwater Temperature Loggers:

Considerations for Selection and Deployment

Researchers and resource managers working in the world's rivers, lakes and oceans often need to monitor water temperature over time. Whether they are studying coral reef bleaching; assessing industrial thermal loading in lakes; modeling freshwater fish populations; or developing marine technology, users must have temperature data collection methods that are accurate, reliable, and practical for their particular field sites and studies.

Most researchers today rely on electronic underwater temperature logging devices for their monitoring needs, rather than on human data collection. The latest of these loggers are small, rugged, inexpensive and easy to use. These battery-powered devices can be programmed to gather data for months at a time and can stand up to a wide range of environmental conditions including wide temperature fluctuations, rushing rocky streams and ocean storms.

This report provides general information about monitoring water temperature, and serves as a guide to selecting underwater temperature loggers. It also identifies some of the challenges specific to particular field sites, and provides tips on deploying loggers in such environments.

Data loggers for monitoring

Most researchers turn to underwater temperature data loggers to address their monitoring needs. These devices are low-cost, compact instruments that incorporate built-in micro processing, high-accuracy temperature sensing, and battery power in a rugged enclosure designed for long-term underwater deployment. They range from cigar-sized units to bite-sized pendulums, typically with anchoring holes at one end. The latest models feature precision sensors that can measure water temperatures ranging from 0°C to 50°C in plastic housings (32°F to 122°F), and from 0°C to 125°C in stainless steel housings (32°F to 257°F). Typically, underwater data loggers are deployed for months at a time, collecting temperature data at user-defined intervals and storing it digitally into logger memory. By operating in a continuous, 24/7 monitoring mode, underwater loggers eliminate many of the hassles of traditional monitoring methods. And, because the devices are typically inexpensive, users are often able to deploy loggers at more points in a water body.

Underwater data loggers also simplify the process of reporting data. Instead of having to manually record times and temperatures, users can simply offload the logger data to a laptop PC and create detailed graphs or tables with the click of a mouse button. The charts can be easily printed or exported to other software applications as necessary.

Using underwater temperature data loggers

While specific logger operating procedures vary among manufacturers, the process of using underwater temperature loggers is relatively straightforward and involves three main phases: logger configuration and launch; deployment; and data retrieval and analysis.

Configuration and launch

A logger is typically configured by connecting it to a PC (with a cable or base station) and making a number of selections:

- Logging interval – This indicates how often the logger will take a water temperature measurement. The frequency of this interval will determine the maximum deployment time for the device.
- Logger start time – This allows the user to start the logger immediately or postpone it until a specific date and time.

Once these selections are made, the user simply clicks a start button in the logger software and the device is ready to start monitoring.

Deployment

Several steps are involved in deploying an underwater data logger, including site selection; anchoring the logger; documenting logger location; and retrieval. See the box below for specific field tips.

- Site selection – This refers to the particular location in a body of water where temperature sampling is needed. Choose a site with good mixing, such as the turbulent area below a rock. Also make sure that the location will still be submerged at the low water point, and consider potential impact from moving debris.
- Anchoring the logger – There are a number of ways to secure underwater data loggers in still, flowing, and marine waters. Some users tether a logger to a cement block or brick using nylon cord, whereas others choose to drive a rebar stake into the streambed or shoreline and tie or clamp a logger to the stake. For deepwater deployment, users usually attach a logger

to a mooring line or sand screw with plastic cable ties. See the box below for more tips specific to certain environments. For any deployment, users should think about potential natural and human factors that might dislodge or damage a logger, and consider protecting or camouflaging the device as necessary. Also consider whether you want to read out the logger's data during deployment. In that case, you can attach the device with a tether line so it can be pulled up.

- Documenting logger location – To ensure successful retrieval of underwater data loggers, it is important to document the specific location of each one during deployment. This is especially important if more than one person is working with the loggers. Documenting location in at least two ways is recommended, and can be done by taking a photograph of each monitoring site, marking the location on a map or aerial photograph, entering GPS coordinates, and using words to describe the location in a data book. Affixing a "please return to" label to the logger is also a good idea in the uncommon event that a logger becomes dislodged.

From the field: Tips for deploying underwater temperature loggers

Loggers have been launched in a wide variety of field conditions worldwide, and researchers have gained experience in making sure their devices stay put. Here are some notes from the field and factors to consider when deploying loggers in specific environments:

Stream/river deployment

Flowing waters are variable throughout the year and can change even on a daily basis. Logger must be positioned deep enough that it is always underwater. When choosing sites take into account incoming tributaries, human-generated thermal pollution (measure upstream and downstream of inlet) and shading (for sunny sites that are shallow it may be necessary to have a white protective boot to minimize solar heating). In rocky streams and rivers, heavy-duty garden tools are useful for shifting rocks during logger deployment and retrieval.

Ocean and lake deployment (deep water)

Wave action, currents, and storms are important considerations when securing data loggers in deep waters. Some users have been successful in anchoring loggers to mooring lines on sand screws or pins driven into solid substrate (widely available at boating equipment suppliers). Some users attach the logger to the screw or pin itself, and recommend using more than one cable tie in case one breaks loose. In marine environments, a scraping tool is useful if encrusting organisms colonize the logger. In particularly rough conditions, it is wise to secure the entire body of the logger, rather than just one end.

Intertidal deployment

Intertidal environments are alternately submerged in seawater and exposed to the air. They are also subject to wide temperature fluctuations, so logger anchoring materials must be able to withstand such varying conditions. Putty epoxy that cures underwater and in air has been used successfully to anchor loggers to rocks in the intertidal zone.

Areas of heavy human use

Humans use water bodies commercially and recreationally, and having curious people around field sites can be a challenge. In addition to boating and fishing activity, vandalism can potentially damage or dislodge a temperature logger. Camouflage is a necessity, and can be achieved by burying the logger under rocks or gravel; buying and painting a protective boot for the logger (boots are available from most manufacturers); or enclosing the logger in a secure wire cage. Labeling the logger with the title of your project or posting signs in the area can also inform people about the study.

TIPs:

- Develop your anchoring protocol carefully, and be sure to take into consideration such factors as how you might get a dozen cinder blocks out into a lake or up a mountain stream.
- Consider deploying more than one logger per location for data quality purposes, or if you suspect you might lose one in a storm or flood.
- Some metal fasteners can corrode quickly, especially in marine environments.
- Sending two people instead of one into the field to locate deployed loggers can save time over one person searching alone. This is especially true if a third party deployed the loggers, if they have been deployed for a few months, or if vegetation is heavy or the substrate is rocky.

Useful equipment
Following is a list of items that researchers have found useful during logger deployment and retrieval:

Written deployment protocol
– note any modifications at field sites

Securing materials
– cable ties (zip ties), wire, cable, wooden stakes, epoxy, nylon cord

Anchors
– cinder blocks, bricks, dive weights, metal stakes, rebar, sand screws, sand pins, mallet or sledge hammer

Tools for removing debris
- ax, machete, rake, hoe, diving knife, wire cutters, heavy-duty scissors, knife

Surveyor flagging

Digital or film camera

Laptop computer

Data shuttle (available from some logger manufacturers)

Hand-held GPS

Watch

Maps, aerial photos

Waterproof field notebook

Pencils

Boat, raft, float for holding equipment

Rubber boots, waders, scuba or snorkeling gear

Personal
– warm and dry clothing, water, sunscreen, insect repellant, appropriate outerwear, cell phone or radio, water and food

Data retrieval and analysis
After temperature data has been collected for a period of time, the next steps involve retrieving, offloading, and analyzing the collected data.

In the past, retrieving data from underwater temperature loggers meant bringing the loggers back to an office PC, or taking a laptop into the field and risking water damage. Today's loggers are equipped to transmit data optically to a waterproof pocket-sized data shuttle.

Once the data is offloaded onto a PC directly or via a shuttle, data analysis can be performed using the supplied data logger software. Typically, logger software applications allow the user to quickly and easily generate graphs over the given data collection period.

Capabilities to look for
There are a number of features and capabilities to look for when evaluating underwater temperature loggers.

First, it is important to make sure that the logger has a rugged, fully sealed enclosure that will withstand years of use in challenging conditions. Check device temperature and depth ranges, and ask about saltwater deployment, if applicable. For example, stainless steel will corrode when used for long-term saltwater deployment. Protective boots are available from most manufacturers.

Secondly, make sure the logger offers a range of options for offloading data at field sites. Dedicated data shuttles allow users to conveniently offload data at field sites without having to worry about getting a laptop PC wet. Optical data transfer capability means that data can be downloaded even when the logger is wet.

Depending on temperature measurement accuracy requirements and legal requirements, it may be important to choose an underwater data logger from a manufacturer that offers NIST (National Institute of Standards & Technology) testing and certification services. These manufacturers can provide a certificate that indicates the logger's temperature accuracy versus a NIST-traceable standard.

Finally, the supplied data logger software should enable you to quickly and easily perform tasks such as configuring parameters, launching the logger, and offloading data. At the same time, it should offer powerful data plotting capabilities, and enable you to easily export data to other programs for analysis. Also consider the operating platforms your users have; you may need software that is supported by both Windows and Macintosh operating systems.

Conclusion
As the demand for water temperature monitoring grows, so too will the need for instruments that make the process faster, cheaper, and more accurate. Underwater data loggers are the instruments of choice among researchers and resource managers because of their 24/7 operation, high-accuracy, ease-of-use, and PC-based analysis and reporting capabilities.

About Onset
Onset Computer Corporation has been producing small, inexpensive, battery-powered data loggers and embedded controllers since 1981, and has sold over

one million loggers that are used around the world by over 50,000 customers. The company manufactures a broad range of data logger and weather station products that are used to measure temperature, humidity, light intensity, voltage, and a broad range of other parameters. Onset products are used widely in research, commercial, industrial, and educational applications.

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