Water Quality

New monitoring buoy keeps a close watch on Lake Taupo

NIWA's new monitoring buoy.

Photo: Max Gibbs

***Max Gibbs** explains that, in the case of Lake Taupo, "what we don't know we don't know" may be more important than "what we know we don't know". A new monitoring buoy is set to expand our field of enquiry for this iconic New Zealand lake.*

Keeping tabs on Taupo

- NIWA scientists have accumulated a long-term record for the water in Lake Taupo.
- A new instrumented buoy transmits almost continuous data to a receiver on shore.
- Real-time data will help scientists pinpoint relationships between water temperature and chemistry and events such as algal blooms.

Lake Taupo is big and deep, with a surface area of 620 km^2, a mean depth of 100 m (plunging to 162 m in places), and a total volume of about 60 km^3. The lake lies within the caldera of a dormant supervolcano whose last major explosion was recorded in 182 AD, when the ash cloud was seen as far away as China and Rome.

Taupo's water is clear, with an average visibility of about 15 m (maximum 25 m), and over a white sandy bottom it shows a blue tint characteristic of high-quality water. On average, a drop of water in Lake Taupo takes about 10.5 years from the time it enters the lake until it leaves. This extended residence time also means that effects from changes in land-use and climate change are slow to appear.

NIWA scientists have studied Lake Taupo periodically since 1973. Since 1994 we've run a routine fortnightly monitoring programme for Environment Waikato. This continuous long-term dataset has greatly improved our knowledge about lake processes and allowed us to detect and quantify a trend of decline in the lake's water quality.

Our findings contributed to Variation 5 (RPV5) in the Waikato Regional Plan, legislation enacted to reduce the nitrogen inputs to the catchment draining into Lake Taupo. The aim is to drop nitrogen levels in the lake by 20% by 2020. We'll continue our monitoring to determine the effectiveness of this management strategy and to better understand the complex nature of Lake Taupo itself.

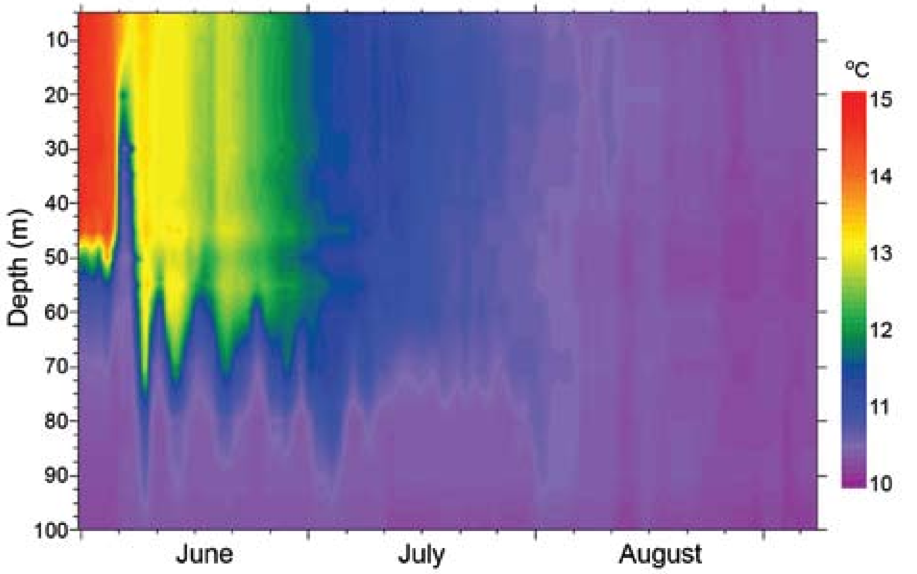
Time for a closer look

In December, we took a giant step forward by setting up an instrumented buoy in the centre of the lake. Hanging from the buoy is an array of sensors that can monitor data at different depths and report those measurements every 10 minutes back to an onshore receiving station via telemetry. Why do we need to look so closely at the lake's processes?

By coupling the routine monitoring data with targeted research studies, we've already learned a lot about Lake Taupo and how it works. The data show that the bottom waters of the lake have warmed by almost 1 °C since the early 1970s and now stand at just over 11 °C. By using the monitoring data in computer models, we've determined that geothermal heating warms the lake's bottom waters. The lake cools in winter and the water mixes from top to bottom; cold Tongariro River and Tokaanu Tailrace waters flow along the bed of the lake. According to the model, without the geothermal heating the bottom waters would be at least 3 °C colder. If climate change causes the Tongariro River to warm, then the bottom-water temperature will rise further.

While a warmer lake might be nicer for water sports, microbial processes which consume the organic nutrient load from the catchment are temperature dependent, and, in Lake Taupo, even a small change in temperature may have a large effect on nutrient cycling, and consequently algal growth. We can see the relationship between the annual temperature and algal biomass cycles in the lake based on the measurements from our routine monitoring.

However, while these data are sufficient to show the algae's annual growth cycle, they are not adequate for understanding algae growth cycles which have much shorter periods. Typically, algae populations double in 1 to 2 days. Algae respond rapidly to changes in light over the day–night cycle and different algal species have different requirements in water turbulence; for example, heavy silicon-sheathed diatoms require rough weather to keep them from sinking while cyanobacteria (blue-green algae) require calm weather to allow them to float to the surface where there are higher light levels.



The internal wave (seiche) in Lake Taupo is the oscillation of the boundary between the cold bottom waters and warm surface waters. The boundary moves up and down every two days, sloshing like the water in a bathtub. In this example from 1997, the initial oscillation was 90 m, beginning in early June, and by the end of June the waters had begun to mix.

During deployment, the new buoy dangles high above the lake, the instrumented mooring line hanging below. The instruments record light, temperature, turbidity, conductivity, and chlorophyll levels every 10 minutes and the buoy transmits the data to an onshore receiver.

Photos: Max Gibbs

Catching internal waves

To study these processes, we need to collect data at time scales much shorter than a day and in all weathers. Trials with temperature sensors recording data at 15-minute intervals have already shown that the water column (from the surface to the lake bed) can be highly dynamic. The boundary between the upper and lower water masses can move up and down as much as 90 m. Currents associated with this internal wave can move nutrient-enriched bottom water into the surface water, stimulating rapid growth of algae which might previously have been attributed to other causes.

The sensitive temperature loggers have also captured short-term events. We now know that the geothermal heat source to Lake Taupo includes geothermal fluid. It's not a steady input but can be pulsed, suggesting episodic small hydrothermal eruptions from the volcanic vents near the Horomatangi Reef. We don't know how often they occur, how big they can be, or anything about their chemistry.

The beauty of the buoy

The disadvantage of non-telemetered temperature recorders is that they have to be retrieved before the data can be evaluated. Consequently, a scientifically interesting event may have long passed before we are aware of it. Similarly it's not possible to interactively study in-lake processes if we don't retrieve the data until several months after the event.

The new telemetered monitoring buoy will provide a wide range of data measurements at 10-minute intervals in real-time and in all conditions. The data stream will include weather conditions, air temperature, and water temperatures at 21 depths from the surface to 150 m. It will also include measurements of chlorophyll, turbidity, and light at key depths, and dissolved oxygen concentrations in the upper and lower waters. The new high-resolution data will augment the data from the routine monitoring programme, which, in turn, will cross-check the precision of the data from the new monitoring buoy. The prospect of receiving lake data of this quality in real time is exciting as we don't know what new information it will show about Lake Taupo. W&A

NIWA divers Rod Budd and Cliff Hart enter the water to ensure that the instruments are all properly placed and ticking over.

Max Gibbs works in NIWA's Freshwater team, based in Hamilton. He is a specialist in lakes and sediment–water processes, and has studied Lake Taupo since 1974.

This research project is a joint venture between NIWA, Ngati Tuwharetoa, and Environment Waikato. Data can also be made available to the international science community through GLEON (Global Lake Ecological Observatory Network) to study climate change and other issues affecting lakes around the world.