Platform 3 – Isotope and Nuclear Sciences

GNS Science is exploring how and why lakes across Aotearoa have changed over the past 1000 years, funded by the Lakes 380 Endeavour programme and the Global Change Through Time Strategic Science Investment Fund (SSIF) programme. Sediment in a lake is laid down year-by-year and the layers are preserved. Researchers are collecting and analysing sediment cores, which tell us the history of the lake and its surrounding environment and extend our knowledge of a variety of processes such as weather events, vegetation changes and human impact through time. The programmes rely on strong research partnerships with a multidisciplinary team of experts.

Environmental data exists for fewer than 5% of New Zealand's 3,800 lakes and these data sets are typically only 20 to 30 years long. There is need for robust evidence documenting when and why changes occurred, and to establish natural condition throughout a cross section of New Zealand lakes. The intent is that the Lakes380 data will help in setting realistic restoration aspirations and identifying lakes in need of protection. This aligns with the strategic intent of our Isotope and Nuclear Sciences SSIF Platform, with a focus on using research and development of isotopic and elemental tracers to improve understanding of biological, chemical and geological processes and evaluate the impact of human activity on New Zealand's environment.

Analysis of water and sediment samples from 305 lakes is providing a wealth of new knowledge. These unique data sets cover a huge range of lake types, ranging in size, depth and altitude, and with a range of surrounding land-uses. One highlight is the development of a novel molecular based bacterial index derived from environmental DNA which accurately estimates the trophic level index of lakes. This method has now been used to predict the trophic level index of all lakes sampled, greatly enhancing knowledge on contemporary lake health.

Similarly, indices that predict changes in lake health through time are being developed using cutting-edge techniques including hyperspectral core scanning technology. This technique provides a rapid and highly detailed assessment of historical changes in algal abundance over tens to thousands of years. This represents a new capability for New Zealand and the first of its kind in the Southern Hemisphere.

GNS Science has invested in the development of this approach through validation with the analysis of organic compounds using traditional techniques including organic biomarkers and pigments and exploring the development of additional indices of lake ecosystem changes such as lake water column oxygen depletion. This investment also supports capability development around establishing data quality protocols and analytical frameworks to study hyperspectral datasets at regional and national scales. This development relies heavily on our partnerships with international experts including Professor Nick McKay and his PhD student (Northern Arizona University, USA). We are contributing to advancing this field internationally through our research collaborations and methodological studies.

Sediment core data is also enabling stakeholders to determine natural baseline conditions and variability of lake health through time. Once fully validated, stakeholders will be able to apply these tools to develop a holistic view of lake health. These data sets will be invaluable in enabling end users such as MfE to make informed nationwide predictions of lake health using datasets that are representative of all lake types.

A key strength of these research programmes is the diversity of complementary analytical methods, ranging from traditional approaches (e.g., pollen and diatoms) to cutting-edge techniques such as hyperspectral core scanning and eDNA. When combined, these multiproxy datasets have provided many novel discoveries. For example, generating new knowledge on responses of biological communities to large earthquakes and volcanic eruptions, variability in toxic cyanobacteria,

effectiveness of riparian planting, impact of initial vegetation reduction by Māori, impact of agricultural intensification and much more. These unique insights have taught us that, while there are many generalisations that can be made, each lake has its own unique story and there is huge value in understanding this for effective restoration and/or protection.

Our collaborators and funding

Our collaborators in this research are a team of experts from Cawthron Institute (co-leaders for the Lakes 380 programme), Victoria University of Wellington, University of Otago, Waka Taurua Ltd, Matana Consulting, Ngāti Kahungunu ki Wairarapa, The University of Auckland, more than 10 international organisations, and iwi around the country. This research is co-funded by our SSIF funded GCT programme (~$210K) and the Lakes380 MBIE Endeavour Programme (~$225K).