AOTEAROA LAKES

CITIZEN SCIENCE FOR OUR LAKES

Lake Tikitapu

Qualitative Assessment

May 2022

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Ko au te roto ko te roto ko au

1 Introduction

On the 15th of May 2022 Aotearoa Dive hosted an event at Lake Tikitapu (Blue Lake) with the purpose of removing rubbish from the passive recreation areas. As part of this clean up dive Aotearoa Lakes completed a general observational survey across a portion of the western passive recreation area (Figure 1). The qualitative assessment focused on identifying discrete habitat types, signs of environmental impact, general lake health indicators, macrophyte species composition and macrophyte extent.

Lake Tikitapu (Blue Lake) is a 150-hectare monomictic volcanic lake with a maximum depth of 27.5 meters. It has a 620-hectare catchment largely composed of native forest land cover. The lake has no surface inlets or outlets and is fed predominantly by precipitation and overland flow, some groundwater connectivity exists but the extent/contribution is unknown. The small catchment, forested land cover and underlying geology is responsible for the low nutrient inputs into the lake. As a result, Tikitapu is considered a relatively low productivity system and is currently classified as mesotrophic.

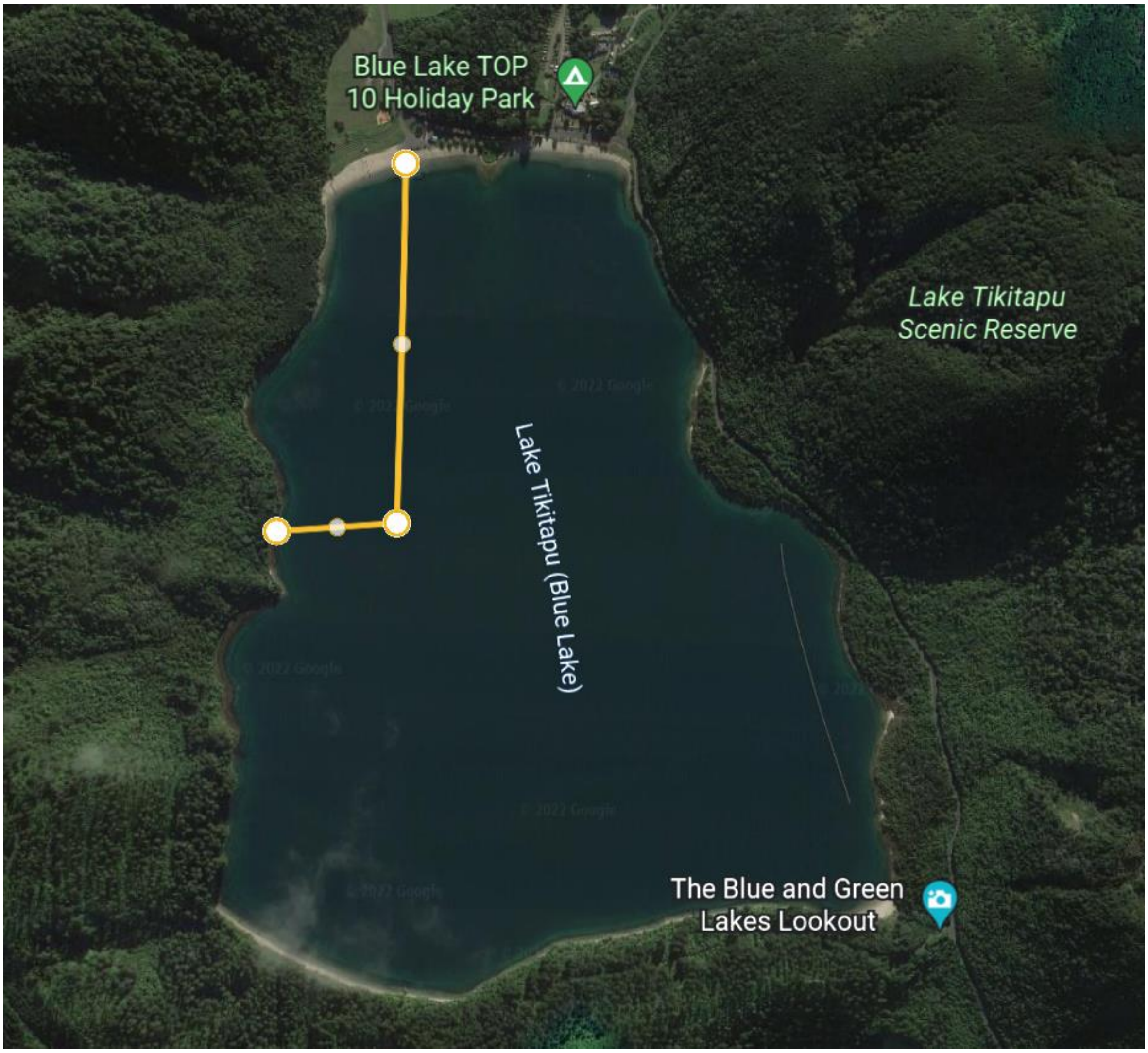

Figure 1: Survey area

2 Methods

The survey area was largely confined to the portion of the western passive recreation area closest to the boat ramp (Figure 1). The assessment involved traversing three main depth contours: the deep contour (10 – 15 m), mid contour (5 – 9 m), shallow contour (1 – 4 m). These zones were delineated based on an initial transect from shore toward the center of the lake and represent the littoral, limnetic and benthic zones. The maximum depth was limited to 15 m due to the constraints of operating within the passive recreation areas.

Discrete habitat types were delineated across this area as well as substrate changes, all macrophyte species were identified and their extent noted (upper and lower). Fauna sightings, behaviour patterns and habitat preferences were documented. An assessment of general ecosystem functions and signs of eutrophication as well as general environmental impacts were also noted. All these observations were used to construct a high-level indication of general lake health.

3 Substrate Characteristics

General substrate characteristics were noted across the survey area and common characteristics were assigned to areas along a depth gradient.

The shallow contours (1 – 4 m) ranged from flat to gently sloped toward the east. The substrate in this zone was sandy with a medium (0.2 – 0.63 mm) to fine (0.063 – 0.2 mm) grain size, there were areas with a coarse grain size (0.63 – 2.0 mm). There was a thin surficial layer of silt (0.002–0.0063 mm) across majority of this zone. The upper extent of this zone (1 - 2 m) had a thick layer of silt which was particularly pronounced in and above areas with dense *Lagarosiphon major* growth (Figure 2). This excessive deposition of fine silt is likely due to the dense macrophyte beds attenuating incoming fine sediment from the surrounding catchment. The relatively flat bathymetry in this zone facilitates great sediment deposition so a finer substrate grain size and surficial silt is to be expected. Large amounts of organic matter were observed between 1 – 2 m, majority of which consisted of decomposing *Lagarosiphon major* (Figure 2).

Figure 2: Sedimentation and decomposing Lagarosiphon in the shallows

The mid contours (5 – 9 m) had a steep bathymetric slope toward the east (center of the lake). The substrate in this zone was similar to the shallower zone with a medium (0.2 – 0.63 mm) to fine (0.063 – 0.2 mm) grain size and thin surficial layer of silt (0.002–0.0063 mm). There was very little deposition of fine silt and clay in this zone, presumably due to the steep sloping. Large sections of this zone were covered by benthic algal mats (Figure 3). These mats are commonly associated with nutrient enrichment, but it is surprising that they were not observed in the shallower areas. Their absence from the shallows could be a result of wind induced scouring. Persistent winds mobilize fine sediment which cause a scouring effect along the lakebed in the shallows. This scouring could be responsible for preventing large scale benthic algal mat development.

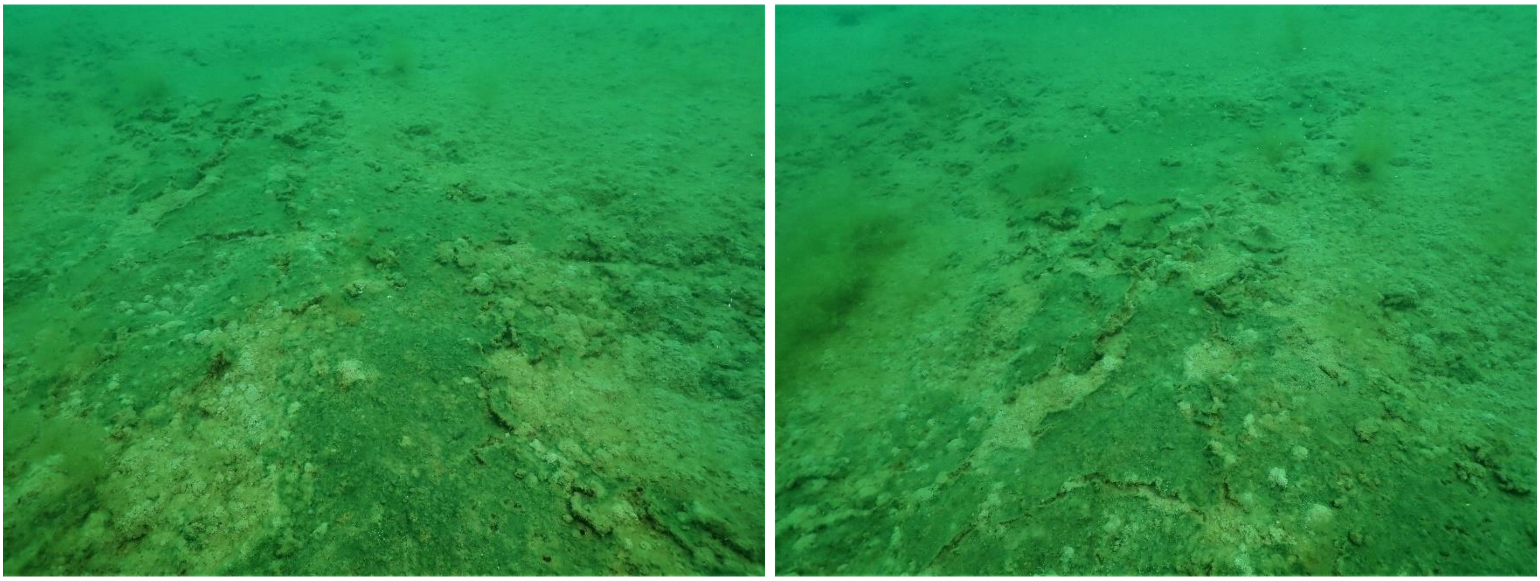

Figure 3: Benthic algal mats along the mid contours

The deep contours (10 – 15 m) started at the base of the sloping mid contours and had a flat bathymetric slope that extended out toward the center of the lake. Being at the base of a slope this flat area is considered as a depositional zone. This zone was also dominated by native macrophyte beds which aid in the attenuation of fine sediment (Figure 4). As a result, the underlying substrate had a medium (0.2 – 0.63 mm) to fine (0.063 – 0.2 mm) grain size with sections of thick surficial silt, particularly in and around the macrophyte beds (Figure 4). Large banks of clay/mud like deposits were noted at 8 - 10 m, these deposits formed a network of shelves that native fauna use as cover (Figure 5). Sporadic benthic algal mats were noted but the overall cover was significantly lower than mid contours. This may be a result of the extensive macrophyte growth in the area.

Figure 4: Nitella beds along the deeper contours (silt accumulation can be seen around the edges of the beds)

Figure 5: Mud banks at 8 - 10 m

4 Macrophyte Assessment

The shallow sections of the littoral zone (1 – 4 m) are dominated by invasive *Lagarosiphon major* with small clumps of native Nitella species (*Nitella pseudoflabellata* and *Nitella leonhardii*) sporadically dispersed amongst the Lagarosiphon beds. The Lagarosiphon growth started in 0.5 m and extended to a maximum depth of 4.5 m with dense coverage between 1 – 4 m (Figure 6). *Lagarosiphon major* is typically a tall growing macrophyte but in Lake Tikitapu it appears to be heavily stunted (Figure 7), this stunted growth pattern has been attributed to low alkalinity, calcium, and silicon levels in the lake. Their shallow maximum depth extent is likely a result of the stunted growth, stems cannot grow taller to exploit the deeper sections of the lake. Sections of the Lagarosiphon bed in the shallows (0.5 – 3 m) was smothered by a thick layer of fine silt (Figure 2).

Figure 6: Dense *Lagarosiphon major* beds from 1 - 4m

Figure 7: Stunted *Lagarosiphon major* in the shallows

The mid contours of the lake (5 -9 m) were largely devoid of vegetation with only small sporadic clumps of Nitella between 3 – 6 m. No macrophyte growth was observed from 8 – 11 m, this area is at the base of the sloping mid contours before the bathymetry flattens out into the deeper zone. As discussed above this area is a deposition zone and has banks of clay and mud, the soft silty substrate and constant deposition of silt contributes the lack of macrophyte establishment in this area.

The flat contour between 12 – 14 m had extensive Nitella beds (*Nitella pseudoflabellata* and *Nitella leonhardii*) with an average of 51 - 75% cover (Figure 4). The true maximum depth extent for Nitella species is unknown as the survey was restricted to the passive recreation area and as a result a maximum depth of 15 m.

All Nitella beds/clumps were coated with thick epiphytic algal growth (Figure 8 & 9). This epiphytic growth was observed across the entire survey area and existed almost exclusively on Nitella species. The lack of epiphyton seen on *Lagarosiphon major* may be a result of allelopathic compounds in the plant tissue or the preference for a more complex host structure (high perimeter to surface area ratio and high fractal dimension). The scouring effect discussed above could also play a role in regulating epiphytic growth in the shallows (where *Lagarosiphon major* is found) however, epiphyton was observed on Nitella in the shallows. The epiphyton on low growing clumps of Nitella in the shallows could be shielded from potential scouring by the taller Lagarosiphon. The presence of dense epiphytic algae on deep Nitella beds is due to high water clarity as light penetration is a principal limiting factor.

Epiphytic algae can reduce the intensity and quality of light able to be absorbed by the macrophyte host and they also compete for nutrients. In this way the epiphytic growth could contribute to regulating Nitella extent in Lake Tikitapu. Despite being smothered by epiphytic algae fruiting bodies were commonly seen on the terminal ends of Nitella (Figure 10).

Figure 8: Epiphytic algae on Nitella beds

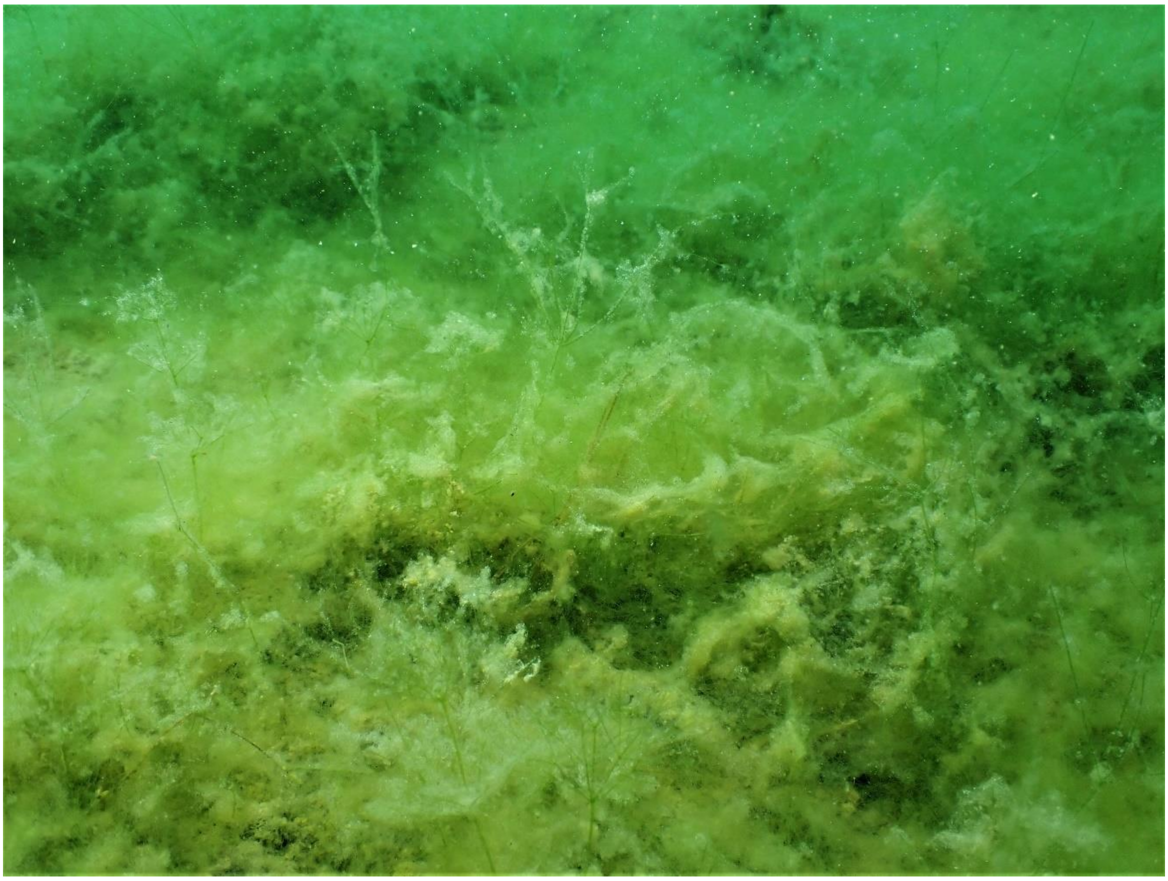

Figure 9: Close up of epiphytic algae smothering Nitella

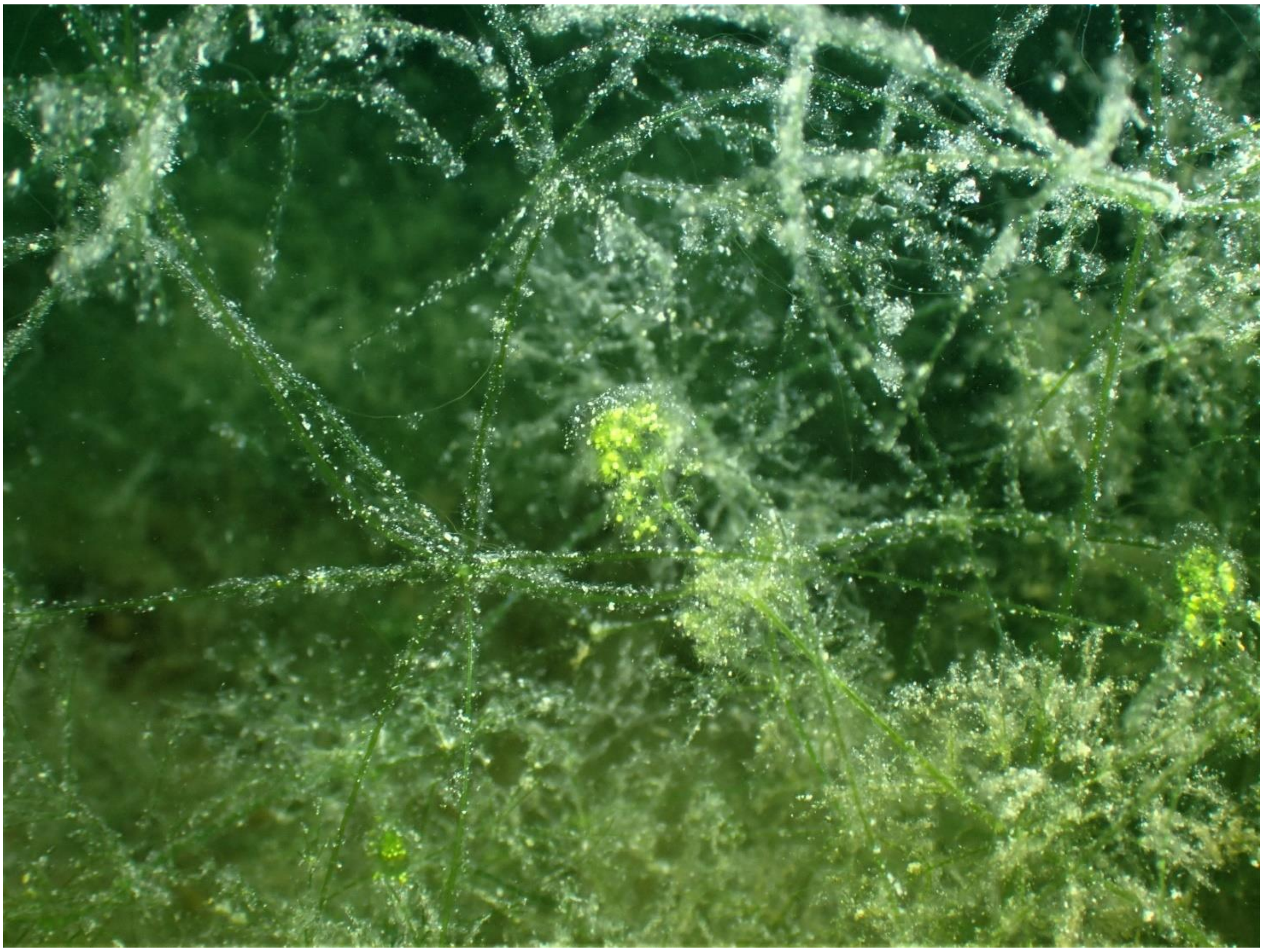

Figure 10: Fruiting body of Nitella

5 Fauna & Habitat Assessment

Three distinct habitat types were delineated across the survey area, shallow Lagarosiphon beds (1 – 4 m), mud banks (7 – 9 m) and deep Nitella beds (12 – 14 m).

The only macro fauna sighted during the survey was common bullies (*Gobiomorphus cotidianus*) and kōura (*Paranephrops planifrons*) (Figure 11). Small numbers of common bullies were observed in the shallows amongst the dense *Lagarosiphon major* beds. Only the odd individual was seen in the open lakebed along the mid contours (5 – 9 m), this is a result of the lack of cover in this zone. Large schools of bullies were seen along the deeper depths, particularly in/around the Nitella beds (12 – 14 m) and mud banks (7– 9 m) (Figure 12). The bullies use the Nitella beds as cover in the otherwise barren environment. The mud banks at the base of the sloping mid contours (7 – 9 m) have a network of undercuts, tunnels and holes (created by kōura) that provided refugia for bullies (Figure 13).

Figure 11: kōura (*Paranephrops planifrons*)

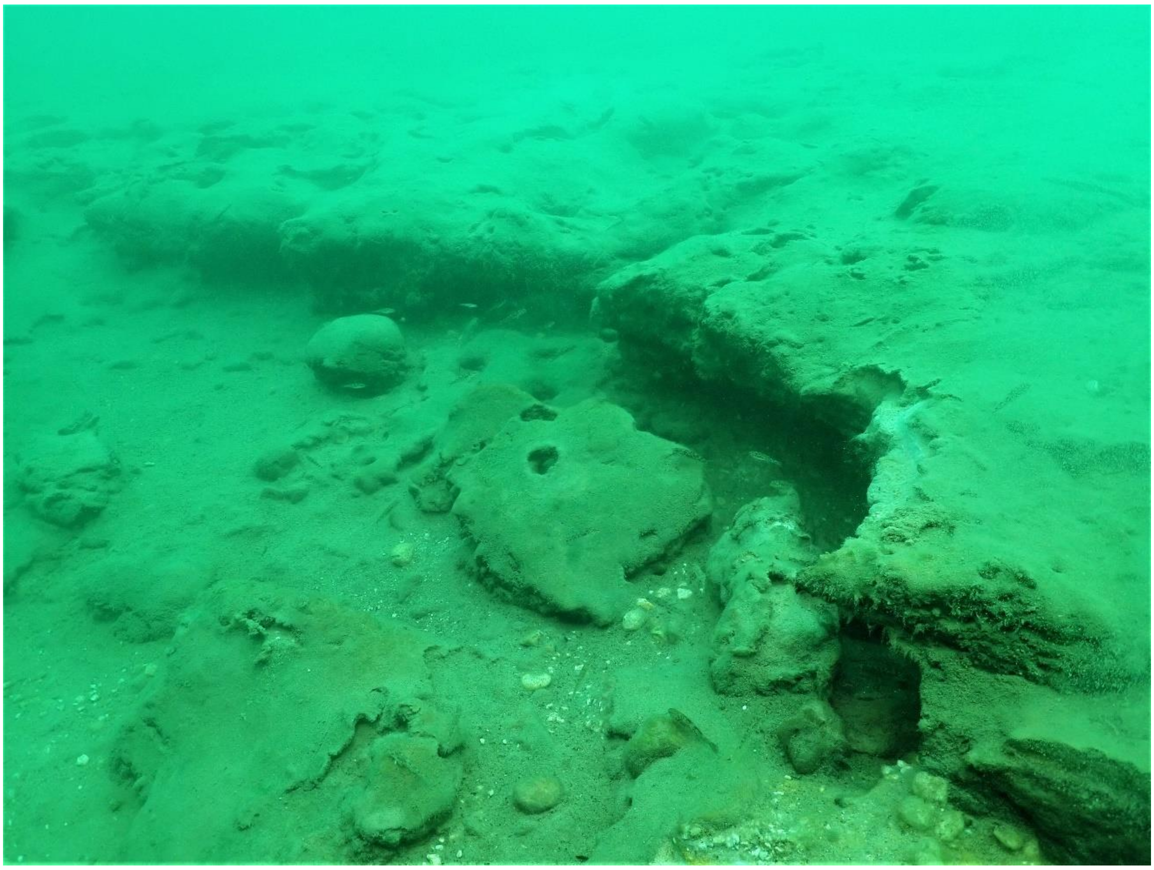

Figure 12: Bullies schooling along the mud banks

Figure 13: Common bully (*Gobiomorphus cotidianus*) hiding in the undercuts of the mud bank

Large numbers of kōura were seen in burrows and tunnels along the mud bank at the base of the mid contours (7 – 9 m) (Figure 14 & 15), this was the only refugia seen outside the macrophyte beds. Individual kōura were occasionally seen walking across the open sections of lakebed and amongst the deep Nitella beds. No kōura were sighted amongst the shallow Lagarosiphon beds.

The mud banks at 7 - 9 m held the highest numbers of in-lake fauna and clearly serves as an important habitat space. This area is a depositional zone which creates the ideal substrate characteristics for burrowing, organic matter is also deposited in this zone and provides a valuable food source for both bullies and kōura.

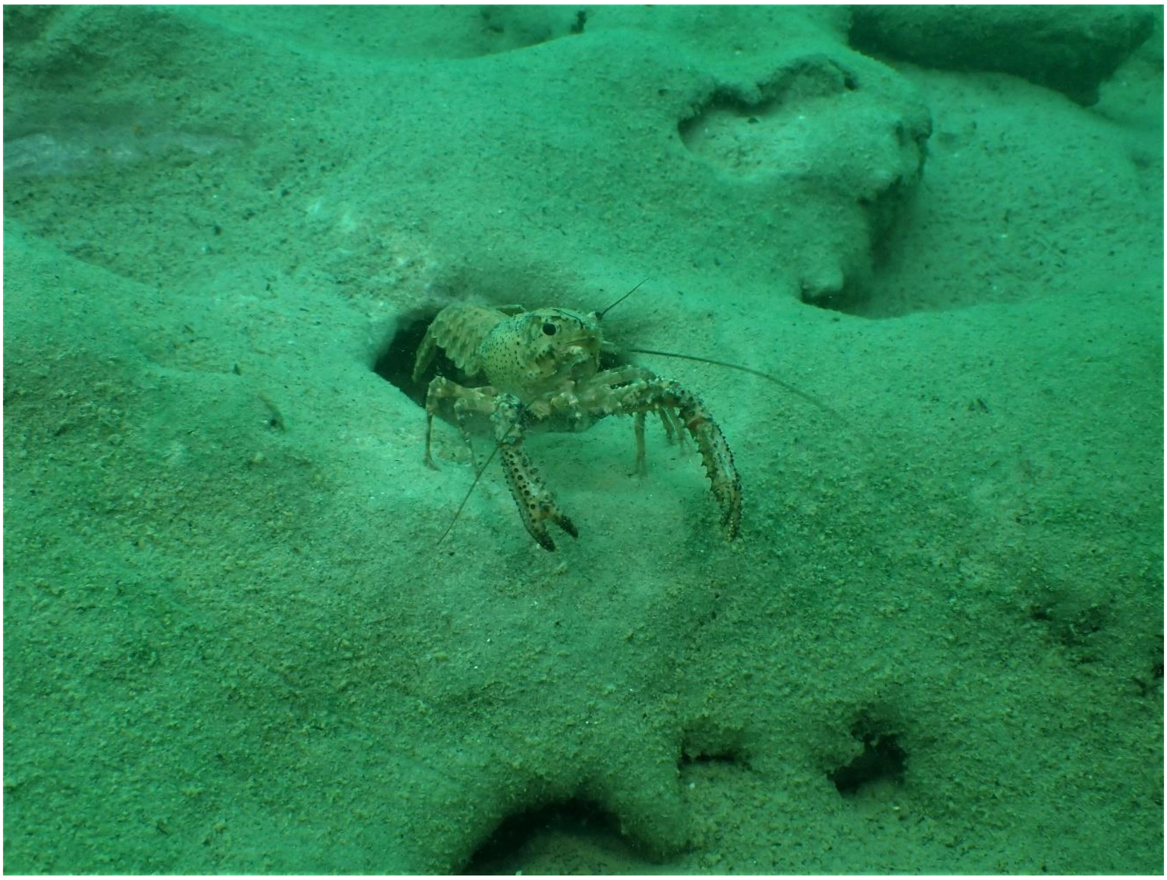

Figure 14: Kōura emerging from a tunnel

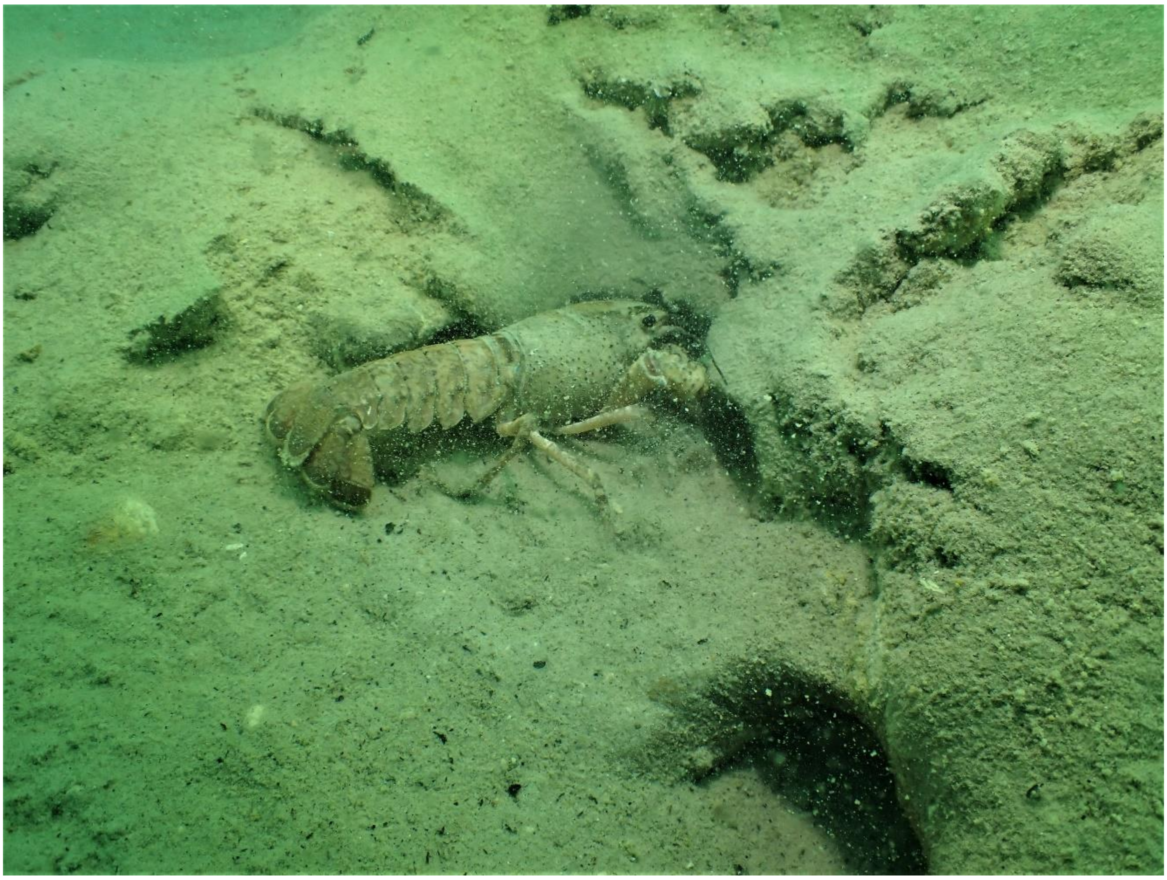

Figure 15: Kōura digging a tunnel into the mud bank

6 General Lake Health

There were no alarming signs of environmental impacts however subtle indicators were observed. There was a noticeable build up of silt in the shallow (0 – 3 m) and in some areas this silt had smothered large sections of Lagarosiphon. A surficial layer of silt and mud was present across the survey area indicating a degree of sedimentation is occurring.

No obvious signs of persistent anoxia were observed, these signs are typically noted during the summer months so a definitive conclusion cannot be made. The average water temperature during the survey was 16°C (± 0.5°C). Considering Lake Tikitapu stratifies seasonally it is assumed that at the time of the survey the lake would likely be close to isothermal. A thermocline could have been present at the deeper depths as the bathymetry resembles a deep bowl. The isothermal nature of at least the top 15 m and the amount of wind driven mixing is indicative of a high oxygen environment, this coupled with no obvious signs of anoxia lead to the assumption that dissolved oxygen is not limited throughout the epilimnion/surface water (0 – 15 m). The well mixed, oxygenated water and high numbers of bullies and kōura indicate suitable conditions for native fauna. In this case food availability is likely the limiting factor for fauna rather than dissolved oxygen or temperature.

The only invasive species sighted during the survey was *Lagarosiphon major* which was stunted and confined to a very narrow depth range (1 – 4.5 m). This means the total biomass is likely to remain stable provided the water quality does not deteriorate. This invasive species has displaced native macrophytes from the shallow margins and will contribute to the organic matter load in the lake but, considering the total biomass appears to be small relative to the lake size the impacts are likely to be limited.

The stable low impact land cover in the surrounding catchment is unlikely to deliver increasing concentrations of nutrients, additional nutrient loading could come from contaminated groundwater. Provided the land use does not intensify or change to a higher impact use the lake will remain in a mesotrophic state. This is reflected by the stable mesotrophic Trophic Level Index (TLI) values over the past ten years. Internal phosphorus loading from profundal sediments could be a potential future issue in this lake as it regularly stratifies but further investigations into hypolimnetic and sediment bound phosphorus loads is required to make an assessment.

There were areas of the lakebed with a high percentage cover of benthic algal mats, while these mats are common in most mesotrophic lakes, they can be a good indicator of nutrient enrichment. It is hard to tell the full extent of these algal mats until summer where they are more prolific. The more concerning observation was the almost 100% cover of native macrophytes by epiphytic algae. This reason for the prolific epiphytic growth and its apparent host specificity is unknown. Epiphytic algae are commonly associated with nutrient enrichment and could be used as an indicator of eutrophication. An assessment during the summer months would be helpful in understanding the extent and effect this epiphyton is having on the native macrophytes.

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