

#### 4. Lake Tungog Salvinia Removal Project

Salvinia (*Salvinia molesta*) is an invasive aquatic fern that originates from South America. In the Sabah context this plant is a noxious aquatic weed that has spread rapidly over the last 10-15 years across the freshwater lakes of the Lower Kinabatangan and other areas of Sabah. Salvinia weed infested the Tungog Lake between 2001-2002 during a major flood event. In Tungog Lake there is no permanent river entering the lake and hence there is no natural annual flushing of the lake making this an enclosed aquatic ecosystem. Given the right conditions Salvinia grows extremely rapidly forming dense mats covering the the surface of the lake. At present Tungog Lake is 90% covered by the Salvinia weed.

The presence of Salvinia covering the Tungog Lake has had a major impact on the overall water quality, species abundance, and aesthetics of the Lake. Salvinia has direct negative effects on water quality such as dissolved oxygen, chemical oxygen demand, pH, clarity, and electrical conductivity, which in-tern has a major implications on the aquatic ecosystem such as fisheries and food abundance for many wildlife species. Monitoring of the Tungog Lake water quality has been ongoing since 2012 through KOPEL's water quality monitoring program (Refer to page 16 in this document). The outcomes of the monitoring demonstrates the toxic impacts of the Salvinia weed on this lake ecosystem.

Efforts to remove the Salvinia has been ongoing since 2005. In 2007 KOPEL completely cleared the lake of the Salvinia weed and had an active monthly maintenance program until 2013. During this period the lake was completely open and clear of Salvinia, whereby many of the native wildlife species such as Otter (*Lutrogale perspicillata*, and *Aonyx cinereus*), Oriental Darter (*Anhinga melanogaster*), and Buffy Fish Owl (*Ketupa ketupu*) returned and were present at Tungog Lake.

Maintenance work ceased in 2013 for five months due to the closing of KOPEL operations during the Tando Crisis. During these five months the Salvinia weed rapidly spread covering approximately 25% of the lake. Since then the weed has rapidly spread outpacing KOPEL's monthly manual removal programs. The impacts of the Salvinia weed on Tungog Lake are multiple, with immediate decrease in aquatic dependent wildlife such as Otters and other water birds. Based on current observations, assessment and analysis of monitoring data (see page 16 above), the Tungog Lake is in a critical state of decline at present.

Data was collected on Tungog Lake in June 2016, June 2017 & June 2018 by The Tropical Restoration Ecology Field Course conducted by the University San Francisco (USF). These short term studies were conducted to describe the fish species, plankton, water invertebrates and wildlife on this lake, alongside establishing a profile of water quality across the lake. The objective of this work is to act as a baseline survey of the lake condition before the release of the biological control and to support ongoing monitoring of the weevil release.



**Figure 32:** Grass Suds growing on Salvinia at the North End of Tungog Lake.

The USF study involves the establishment of transects across the lake and taking water samples along the transects at specific depths. One transect runs across open water and a second over *Salvinia*-infested water. Water is sampled at three sites approximately 25 metres apart along the transects, at different depths, to measure temperature, dissolved oxygen, pH, clarity, depth, ammonium and nitrate. Comparisons were conducted and recorded along each. A fish survey was also conducted using three types of nets at each of the sampling points along the transect. A drip net for surface fish, casting net for pelagic species, and a trap for bottom dwelling species.



**Figure 33:** Open water being maintained manually at the Southern End of Tungog Lake, 2019.

Analysis of results from the USF Study shows the dissolved oxygen levels along both transects to be extremely low. Fish require between 4-15mg/l for survival, although some species are found to be tolerant of much lower levels of oxygen. Due to the low levels of dissolved oxygen the expectation of biodiversity and abundance of Tungog Lake are low, however results do show the lake is ecologically diverse with species at high trophic levels. These results and the amount of *Salvinia molesta* present indicate the conditions of the lake could experience further degradation.

In addition to the USF study and ongoing manual removal of *Salvinia* by KOPEL staff and volunteers, KOPEL started a more integrated approach in 2015 working with the Sabah Agriculture Department to introduce a biological control agent - the *Salvinia* weevil (*Cyrtobagous salviniae*). After more than three years of preparatory work, quarantine, breeding, and the establishment of release protocols, the weevil was finally released on October 27th 2018. Monitoring of Tungog Lake ecosystem is continuing in parallel with the weevil monitoring programme. This monitoring follows the release and monitoring protocols established by the Sabah Agriculture Department.

Twelve (12) sample sites—refer to figure 4, were established around the lake to monitor the progress of the weevil since its release. The sampling involved collecting 1kg samples of *Salvinia* weed and determining the presence or absence of the weevil within the *Salvinia* sample as well as the current weevil population. The *Salvinia* samples were also assessed for plant damage as a result of weevil establishment. Damaged buds are one indicator of weevil activity due to a direct relationship between the amount of bud damage and adults present.

The results of the monitoring activities confirm the weevil is present around the very first release site and have spread north, east, south and west from this site (sample sites 1, 2, 3, 4, 5, 6, 7, and 8—refer to figure 3). Release site 2 and 3 (site 11/12) and the surrounding sites (9/10) did not show the evidence of the Beetle within the sample taken. Despite this result the samples obtained from release site 3 did have 12% bud damage, indicating beetle activity regardless of beetle absence.

It should be noted that sample sites 9, 10, 11 and 12 on the most north end all inhibit vast amounts of grass on top of the *Salvinia* mat covering Tungog Lake, it is currently unclear how this is affecting the

weevil but sampling will continue to take place in 2020 to ensure a better understanding of the weevils presence and numbers. It is considered vital for the health of the Lake that the weevil continues to spread and Salvinia damage is ongoing, hence ongoing monitoring is required to understand the biocontrol dynamic and to assess the needs for future follow-up beetle release on Tungog Lake.

**Management Implications**

- I. The Salvinia covering Tungog Lake remains an immediate threat to Tungog Lake and the freshwater aquatic ecosystem. Tungog Lake is already identified as HCV 3.0 and is of critical importance at the site specific, ecosystem and landscape levels. Therefore, continuing to monitor the impacts of the biological control agent (*Cyrtobagous salviniae*) is of the upmost importance in management approaches in controlling the Salvinia on tungog lake.
- II. The Salvinia weevil has been successful at most sample sites thus far, ensuring these sites continue to thrive is absolutely necessary, whilst the unsuccessful sites and implications of the grass are addressed and possibly revised. Continuing to detect the spread and potentially modifying control methods is critical in this upcoming year in order to move forward.
- III. Based on the outcomes of measurable effectiveness indicators it is highly recommended that the monitoring efforts on Tungog Lake be revised, improved and expanded to provide more effective feedback for management of PSFR. Improvements suggested include (a) establishing a detailed and in-depth study of Tungog Lake to provide comprehensive base-line information on this unique aquatic ecosystem, (b) expanding the collaboration and partnerships to local universities and research partners to support building local capacity to continue monitoring of Tungog Lake, and (c) expanding the collaboration and partnerships with volunteer organisations to support the manual removal of the Salvinia water weed.

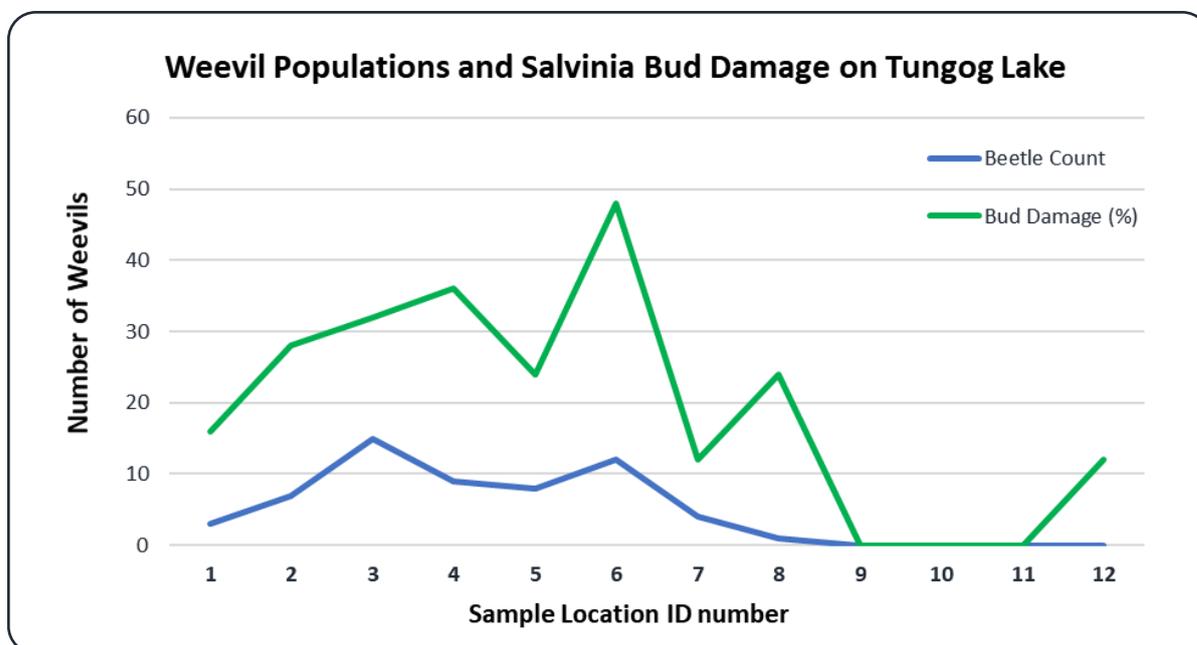


Figure 34: Weevil beetle count and percentage of salvinia bud damage per sample site



Figure 35: Location map of sampling points