

Supplementary Materials for:

Assessing the Fish Stock Status in Lake Trichonis: A Hydroacoustic Approach

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Extended methodology section

To further study fish aggregation behavior, as well as to explore potential impact of high fish density on the analysis results, average cell TS (dB) histograms were produced as empirical distribution functions (EDFs) for the set of all ensonified cells, as well as the set of only cells with Sawada N_v index <0.1 , using a 2-dB bin size. The corresponding cumulative empirical distribution functions of the two distributions were compared for the existence of mean difference. Average Sawada N_v values per depth layer were compared at the 1-sigma confidence interval (shown as error bars) between day and night to determine the most suitable time of day for higher-reliability measurements. Fish size distributions, as counts classified in 1-cm bins, were also calculated as a complement to TS distributions, with classes matched by corresponding TS ranges in dB.

Extended Results section

The effect of excluding measured cells with Sawada N_v index >0.1 did not have a significant effect on the resulting TS distributions both for day (K-S D-value = 0.2143, $p = 0.9205$) and night (K-S D-value = 0.167, $p = 0.9985$). Overall, TS ranged between -66 dB and -38 dB with peak frequencies during the day equal to 25.48% of TS values for cells with $N_v < 0.1$ and 17.62% of TS values among all cells. Peak frequencies during the night were 30.56% of TS values for cells with $N_v < 0.1$ and 17.84% of TS values among all cells. All peak frequency values were located in the bin of -64 dB to -62 dB for both day and night (Figures S1 and S2).

The distribution using equally sized TS value ranges as bins, instead of equally sized fish size bins results in a distinctly different distribution shape. That is because the relation between TS and length, which was used to derive fish target sizes, is complex and definitely not linear. Furthermore, the 1-cm class sizes do not correspond to proportionally sized TS classes, i.e., the difference from 1 to 2 cm corresponds to a TS difference, which is not the same as the one corresponding to, e.g., the size difference between 3 and 4 cm. As a result, class 1–2 cm includes the entire peak of the corresponding TS distribution (Figure S1), thus producing a significantly narrower distribution shape.

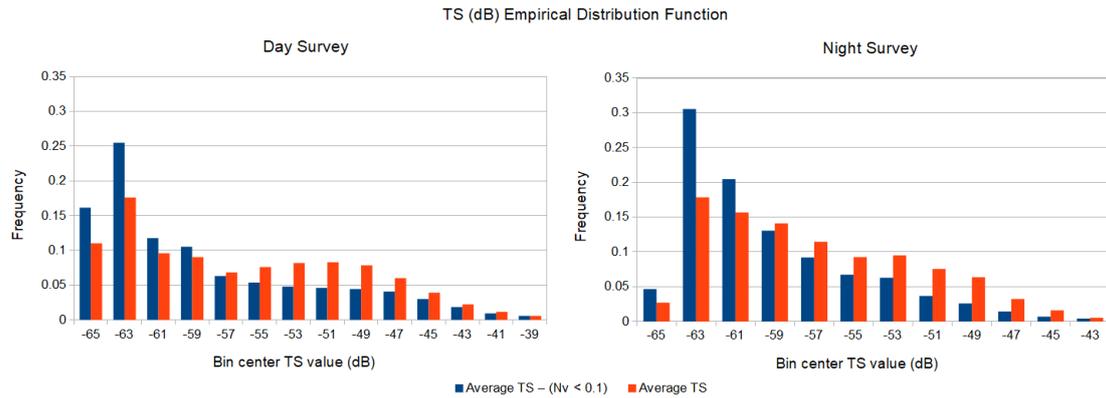


Figure S1. Empirical distribution functions for TS, categorized in 2-dB bins separately for day and night, as well as for the sets of all sampled cells, and of only cells with $N_v < 0.1$.

Sawada N_v index was also averaged per layer and the N_v vertical distribution was compared between day and night. While no significant difference was calculated between day and night for the entire depth range, a significant difference between day and night was found for vertical N_v distributions up to the depth of 35 m ($p = 0.031$) with night exhibiting higher values on average. For this reason, the analysis was focused on this range, which is also shown to be the range, beyond which fish density approaches zero. During the day, the overall average per layer for layers up to 35 m of depth was equal to 0.0497 ± 0.223 fish per sample volume, whereas during the night, it was equal to 0.0888 ± 0.0774 fish per sample volume (Figure S2).

Day and night N_v distribution peaks also confirm a vertical displacement of ~ 9 meters between overall fish aggregations, meaning that fish gather on average 9 meters deeper during the day. The vertical distribution and the 1-sigma confidence intervals of the difference between day and night N_v values reveal a piece-wise significance, with layers between 11–21 m of depth having significantly larger N_v values during the night, whereas layers between 25–27 m of depth have significantly larger N_v values during the day (Figure S2).

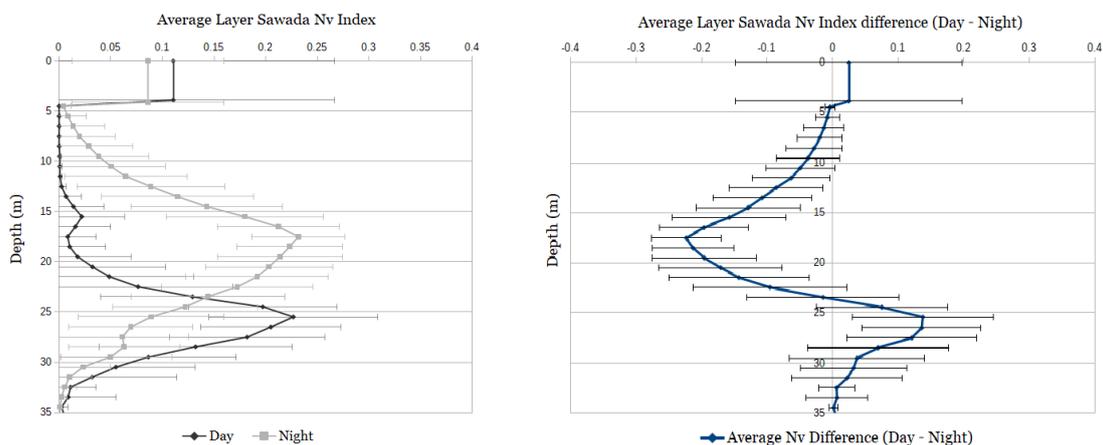


Figure S2. Sawada N_v index vertical distribution with 1-sigma confidence intervals (left) and day-night difference, i.e., day values minus night values (right).