Assessment of the Phase 1 of the Asian Clam Treatment at Sand Harbor State Park June - November 2017

Report to the Nevada Division of State Lands and the Tahoe Regional Planning Agency

Draft

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January 2018

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Introduction

A small population of Asian clams was first discovered in the vicinity of the boat ramp at Sand Harbor State Park, Nevada in September of 2014. The UC Davis, Tahoe Environmental Research Center (TERC) conducted several surveys in the area documenting the population's growth and spread over time (Senft 2014, Senft and Allen 2015, Senft et al. 2016). In the spring of 2017, Nevada Division of State Lands (NDSL) and the Tahoe Regional Planning Agency (TRPA) decided to treat the population using EDPM rubber pond liner anchored to the lake bottom. Prior to the treatment TERC researchers conducted additional surveys to determine if the clams had escaped the area of the boat launch (Allen and Senft 2017) and to what extent the population had expanded during the previous reproductive season (Allen et al. 2017). Results of these surveys found that the clams had not established populations outside the immediate vicinity of the boat launch at Sand Harbor State Park but that the population now covered an area of at least 5.5 acres. Clam density varied across the area with the highest density of clams located immediately in front of the boat launch and to the south. The area north of the boat launch and lake-ward (deeper) than the manufactured rock breakwaters supported a low density, dispersed population, indicative of new colonization (Allen et al. 2017).

The use of EDPM rubber bottom barrier has had mixed results in the treatment of Asian clam populations. Success has varied based on bathymetry and physical hydrology of the location being treated as well as the area of infestation. The key to a successful treatment is prolonged depletion of dissolved oxygen under the barriers. On level sand substrate the barriers were shown to reduce oxygen to lethal levels in the substrate within 24 hours of deployment and maintain depleted levels for months. This resulted in 100% mortality of the treated population when temperatures were above 15 ^{0}C (Wittmann et al. 2012). A treatment on the sill of Emerald Bay, a submerged terminal moraine joining the bay to Lake Tahoe resulted in 90% mortality after an 18 month deployment. The diminished mortality was due to hyporheic flow providing oxygenated water beneath the rubber bottom barriers. In Lake George, New York a treatment of 8 acres was attempted by deploying rubber bottom barriers. Due to the large size of the treatment area, deployment and maintenance of 600 bottom barriers proved too extensive. Asian clams continue to proliferate in Lake George emphasizing the importance of acting quickly when isolated clam populations are first discovered.

Surveys of the clam population at Sand Harbor State Park indicated that treatment with rubber bottom barriers would have a high likelihood of success. The substrate consisted of gently sloping sand substrate, largely enclosed behind natural and artificial breakwaters. Being protected from wave action and strong nearshore currents it was more likely barriers would maintain connectivity with the substrate, ensuring depleted dissolved oxygen and requiring limited maintenance. The largest concern was the spatial area of clam infestation. The 5.5 acres delineated in the 2017 survey was equal to the largest area previously treated in Lake Tahoe. The management agencies opted for a multi-year treatment, covering the area of highest clam density during the 2017 summer reproductive season (4.5 acres), allowing for population expansion prior to the subsequent winter treatment (Phase 2, up to 4.5 acres).

Methods
Due to the observed variability in treatment effectiveness for Asian clam populations it is important to evaluate the parameters effecting clam survival within a treatment area. The Sand Harbor treatment was scheduled for more than a single summer season. Monitoring the dissolved oxygen under the barriers, observing barrier integrity with the substrate, and assessing mortality following the summer deployment allowed agencies to reassess effectiveness before investing in additional treatment time (Phase 2). Treatment success was based on the reduction of live clams within the treatment area (percent mortality) and measured dissolved oxygen levels under the barriers.

Pre-treatment density and percent survival
On 5 and 6 June 2017 TERC collected clams within the Phase 1 treatment area to determine pre-treatment clam survival. Ten, one meter square plots were placed on the bottom using a stratified random method to ensure coverage of the area while not biasing individual plot placement (figure 1). Each plot was divided in half ($0.5m^2$) providing replicate samples at each location. All clams (live and dead) were collected from the replicate plots and taken to the lab for enumeration.

Dissolved oxygen loggers
Dissolved oxygen loggers (miniDOT® Logger manufactured by Precision Measurement Engineering, Inc.) were deployed in the treatment area to monitor the immediate changes and prolonged reduction of dissolved oxygen under the barriers. Three loggers were placed under separate barriers shortly after the completion of barrier deployment. A fourth logger was attached to a TERC nearshore monitoring station (2m depth) within the treatment area to serve as a control. The loggers were equipped with wipers (miniWIPER) which prevented biofouling of the optical sensors. In order to ensure continued function of the wipers and to help prevent loggers from being buried in the sand, the logger-wiper assembly was placed in a steel housing with open ends allowing water flow (figure 4).

To assess the initial barrier effectiveness and logger viability, one of the logger assemblies deployed under a barrier was pulled, inspected, downloaded, and replaced one week after its initial deployment. The logger and wiper were in good operating condition. The data showed dissolved oxygen under the barrier had dropped to near zero indicating barrier effectiveness would be high with continued adherence of barriers to the substrate. This information was provided to TRPA.

The dissolved oxygen logger assemblies were collected and downloaded shortly before barrier relocation with the commencement of Phase 2 of the treatment.

The Phase 1 treatment area was surveyed by TERC researchers on a monthly basis when other work in the area was being conducted. Any minor adjustments to the barriers in order to ensure their integrity with the substrate were done. Observations of large-scale disturbances were reported to the TRPA. Only one occurrence of a major disturbance to the barriers was identified. Two barriers had become detached from the bottom allowing lake water to reach the substrate. This occurred directly off the boat launch and may have been due to propeller wash as recreational boaters were accessing the ramp.

Post-treatment density and percent survival
Following barrier relocation to the Phase 2 treatment area (October 2017), TERC researchers assessed clam survivorship in the Phase 1 area by collecting all clams (live and dead) from ten 1m^2 plots (figure 2). The same procedure was used as described above in the pre-treatment assessment. Collected clams were taken to the lab for enumeration.

Findings
Pre-treatment density and percent survival
Prior to the Phase 1 treatment, clam densities were highly variable but nearly all clams were found to be living. Of the 142 clams recovered from the ten 1m^2 excavation plots, only 4 were found to be dead (2.8% mortality) (table 1). This is indicative of a relatively new population (4 years or less) where the full life cycle of the clams has not yet been reached. In contrast, the clam population in Marla Bay established in 2002 exhibits large numbers of dead clams on the surface of the substrate. The clam shells from deceased clams are lighter than the granitic sand substrate allowing them to settle on the surface following disturbance.

Live clam density was highly variable over the treatment area (0 - 79/m^2) with clams only appearing in six of the ten plots. The variability could be due to differences in substrate conditions, a young population that hasn't yet filled in the available habitat, or both.

Dissolved oxygen loggers
The dissolved oxygen loggers deployed under the bottom barriers recorded a rapid and prolonged depletion of oxygen while the lake water above the barriers remained saturated (figures 5-8). The conditions around loggers 2 and 3 (figure 6 and 7) quickly became anoxic (<1mg/L) and remained so throughout the treatment period. Logger 1, also deployed under a barrier, was checked after one week of deployment (7 August). It experienced significant oxygen depletion compared to the control but showed variability over time (.2 mg/L - 6.9 mg/L, 2.2 mg/L average) (figure 5). It was located directly off the boat launch facility and may have been subjected to disturbance by boat activity. This was also the area where two barriers were compromised for a short duration.

The dissolved oxygen logger attached to the TERC water quality station continued to record saturated oxygen conditions (6.4 - 8.8 mg/L, 7.6 mg/L average) throughout the treatment (figure 8).

Post-treatment density and percent survival
Clam surveys following the Phase 1 treatment indicated a high degree of success in eliminating live clams under the barriers. Seven of the ten 1m^2 excavations recovered clams accounting for 393 clams. Of these 390 were found to be dead (99.2% mortality).

Two of the three clams found alive were recovered from a plot at the edge of the barrier deployment located in front of the boat launch facility (plot 8, figure 3). As described earlier, two barriers in this area were disturbed, allowing oxygenated water to reach the substrate for a brief period of time. Additionally, it is expected that edge effects will be observed where barriers end and uncovered substrate exists. It is possible for clams to move back and forth short distances from the treated and untreated area. The edge also represents the greatest opportunity for water exchange.

Overall the Phase 1 treatment provided clam mortalities consistent with experimental deployments in Marla Bay and Lakeside (Wittmann 2012). The lack of strong currents and hyporheic flow allowed bottom barriers to maintain uninterrupted contact with the substrate resulting in rapid and prolonged oxygen depletion.

Recommendations for Phase 2

It is recommended that the area immediately in front of the boat launch remain covered during Phase 2 of the treatment, and that additional weight be used in order to prevent lifting of the barrier due to propeller wash. The Phase 1 clam mortality assessment found a few live clams persisting in this area. An additional benefit would be providing continuity along the edge of the two treatments, preventing small gaps of untreated substrate.

It is also recommended that a scientific survey be done to reestablish the area of untreated clam infestation. More than an acre of clam infested habitat was left untreated during the 2017 reproductive season. With unusually high lake temperatures this year, clams left uncovered had the opportunity to disperse veligers from July through October. Based on the findings of the survey a feasibility assessment should be conducted to determine the likelihood of long-term clam control success.

References

Allen, B.C. and K.J. Senft 2017. Nearshore Surveys to Assess the Presence or Absence of Asian Clams (*Corbicula fluminea*) Prior to a Proposed Treatment at Sand Harbor State Park, Nevada. Report to Nevada Division of State Lands and Tahoe Regional Planning Agency, November 2017

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Senft 2014. Personal communication. UC Davis, Tahoe Environmental Research Center 291 Country Club Drive, Incline Village, NV 89451

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Wittmann, M.E., A.E. Gamble, B.C. Allen, K. Webb, J.E. Reuter, S. Chandra, and S.G. Schladow. 2012. Final Report: The Control of Asian clam (Corbicula fluminea) in Lake Tahoe with Benthic Barriers: The Influence of Water Temperature on Mortality. Submitted to the Tahoe Resource Conservation District.

Figures and Tables

Phase I: Pre-Treatment Asian Clam Density and Mortality

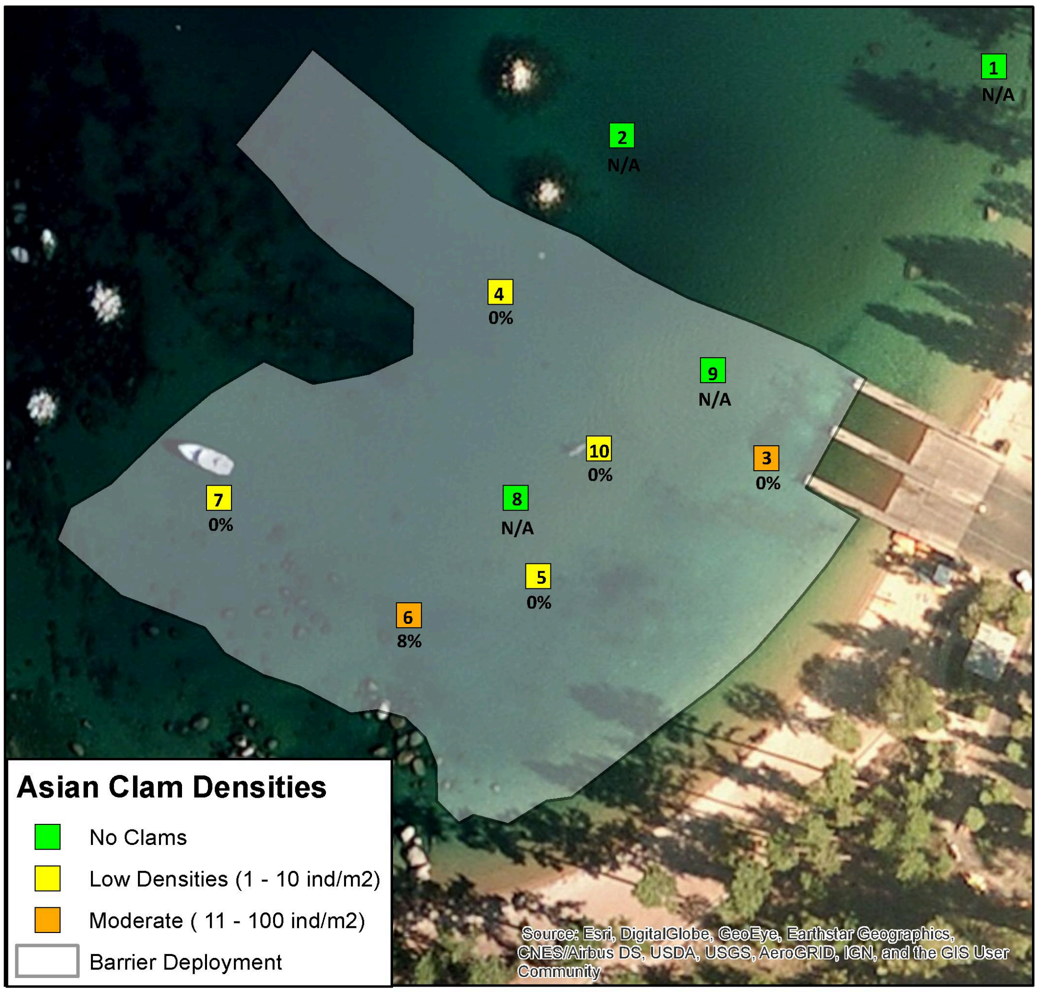

Figure 1: Location map of pre-treatment 1m^2 collections for density and percent mortality

Pre–Treatment 1						
Density Plot	Rep A (Ind/m2)	Rep B (Ind/m2)	Total Clams (Ind/m2)	Alive	Dead	% Mortality
1	–	–	No Clams	–	–	–
2	–	–	No Clams	–	–	–
3	32	46	78	78	0	0%
4	1	–	1	1	0	0%
5	1	–	1	1	0	0%
6	30	20	50	46	4	8%
7	1	–	1	1	0	0%
8	–	–	No Clams	–	–	–
9	–	–	No Clams	–	–	–
10	2	8	10	10	0	0%

Table 1: Pre treatment (Phase 1) clam density and percent mortality

Phase I: Post-Treatment Asian Clam Density and Mortality

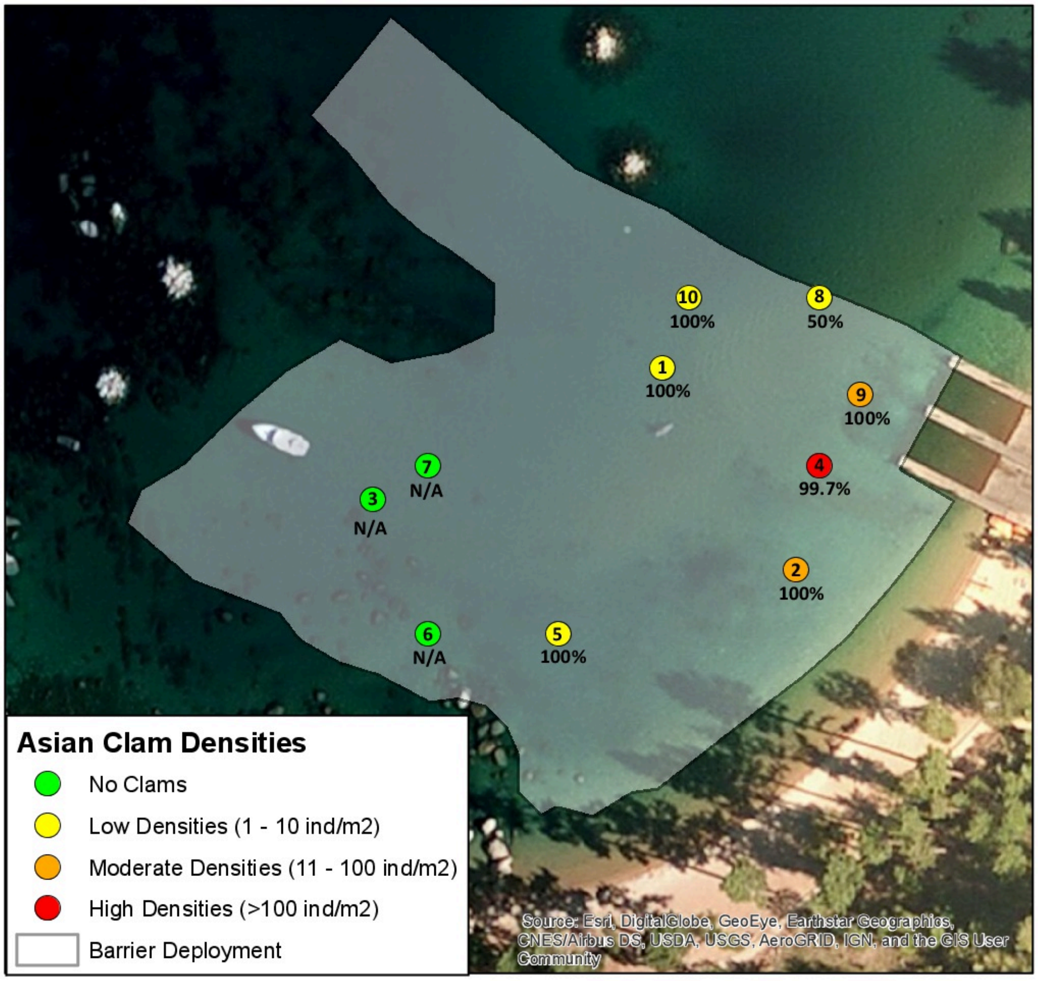

Figure 2: Location map of post-treatment 1m^2 collections for density and percent mortality

Density Plot	Rep A (Ind/ m2)	Rep B (Ind/ m2)	Total Clams (Ind/m2	Alive	Dead	% Mortality
1	–	1	1	0	1	100%
2	40	36	76	0	76	100%
3	–	–	No Clams	–	–	–
4	125	141	266	1	265	99.70%
5	4	1	5	0	5	100%
6	–	–	No Clams	–	–	–
7	–	–	No Clams	–	–	–
8	1	3	4	2	2	50%
9	14	25	39	0	39	100%
10	2	–	2	0	2	100%

Table 2: Post treatment (Phase 1) clam density and percent mortality

Phase I: DO Logger Locations

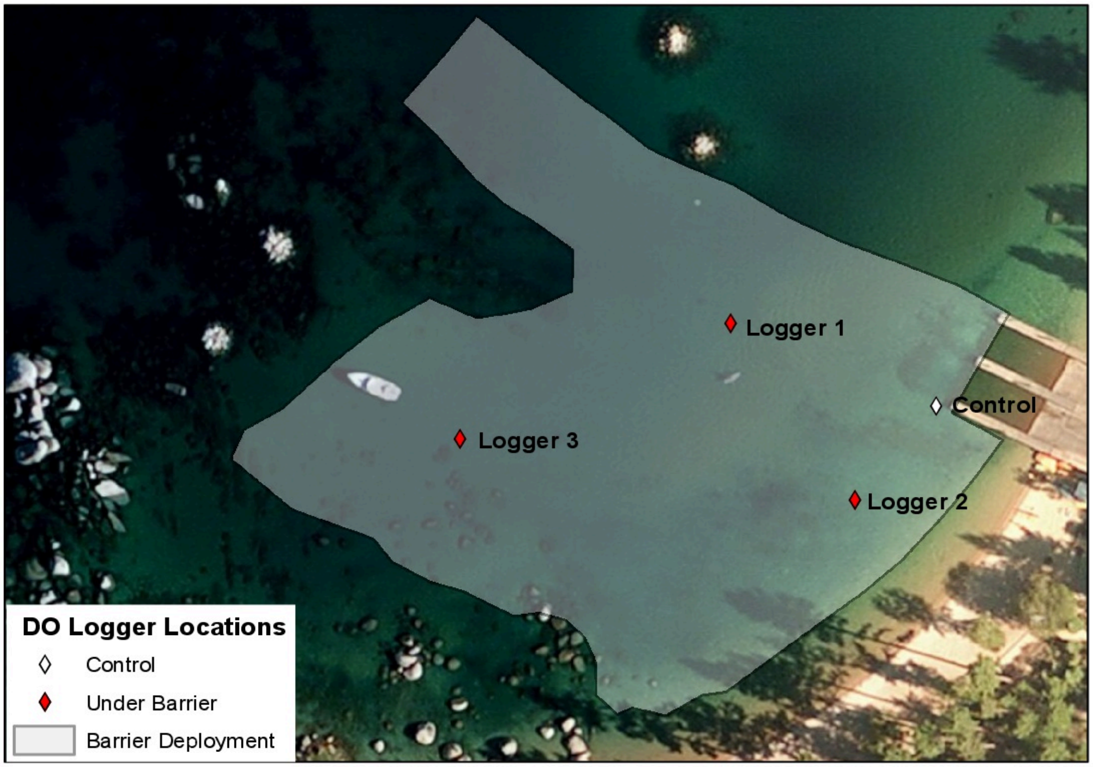

Figure 3: Map of dissolved oxygen logger deployment locations

Figure 4: Dissolved oxygen logger and sensor wiper in protective housing ready for deployment under EDPM bottom barrier

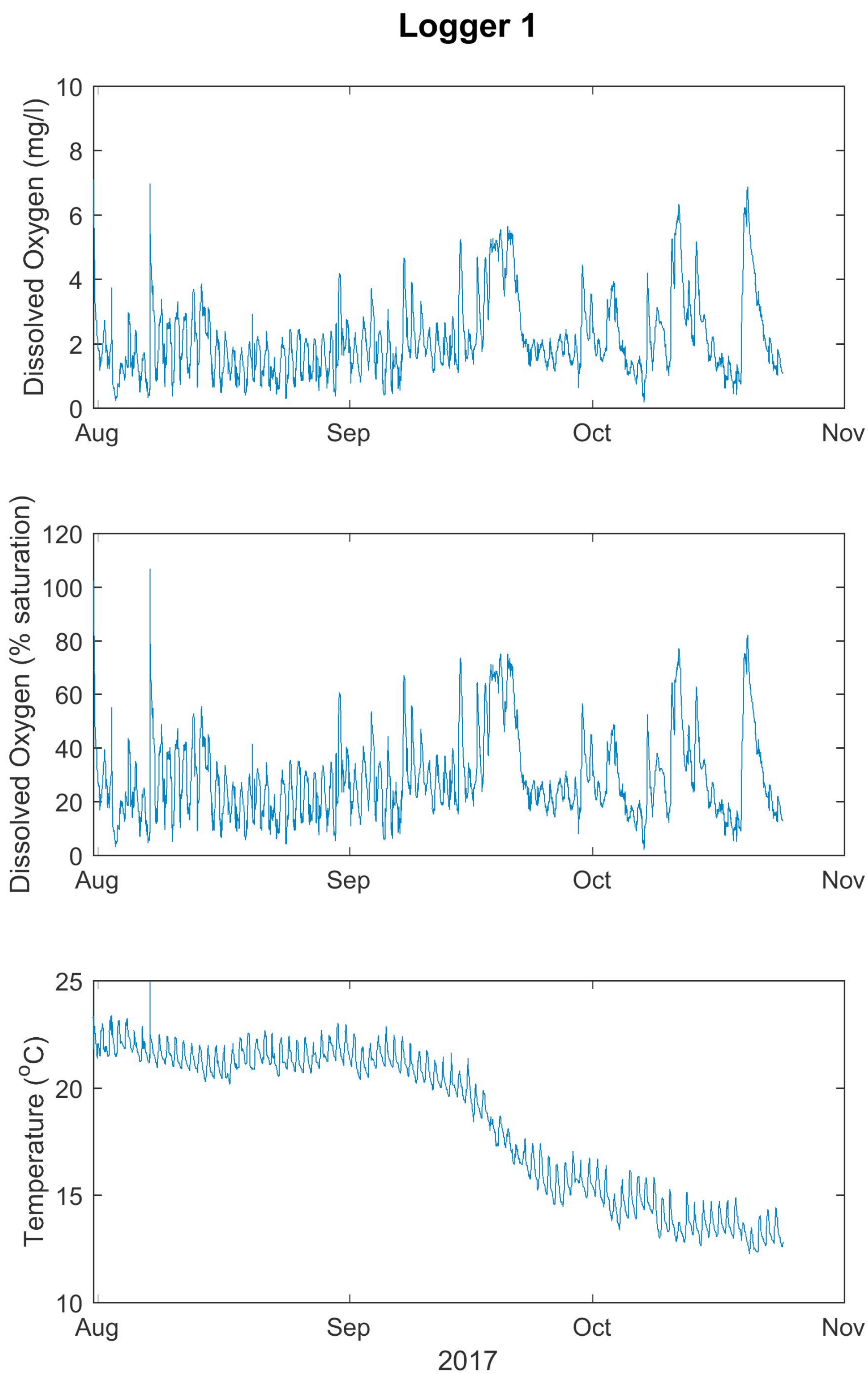

Figure 5: Dissolved oxygen logger #1 under bottom barrier

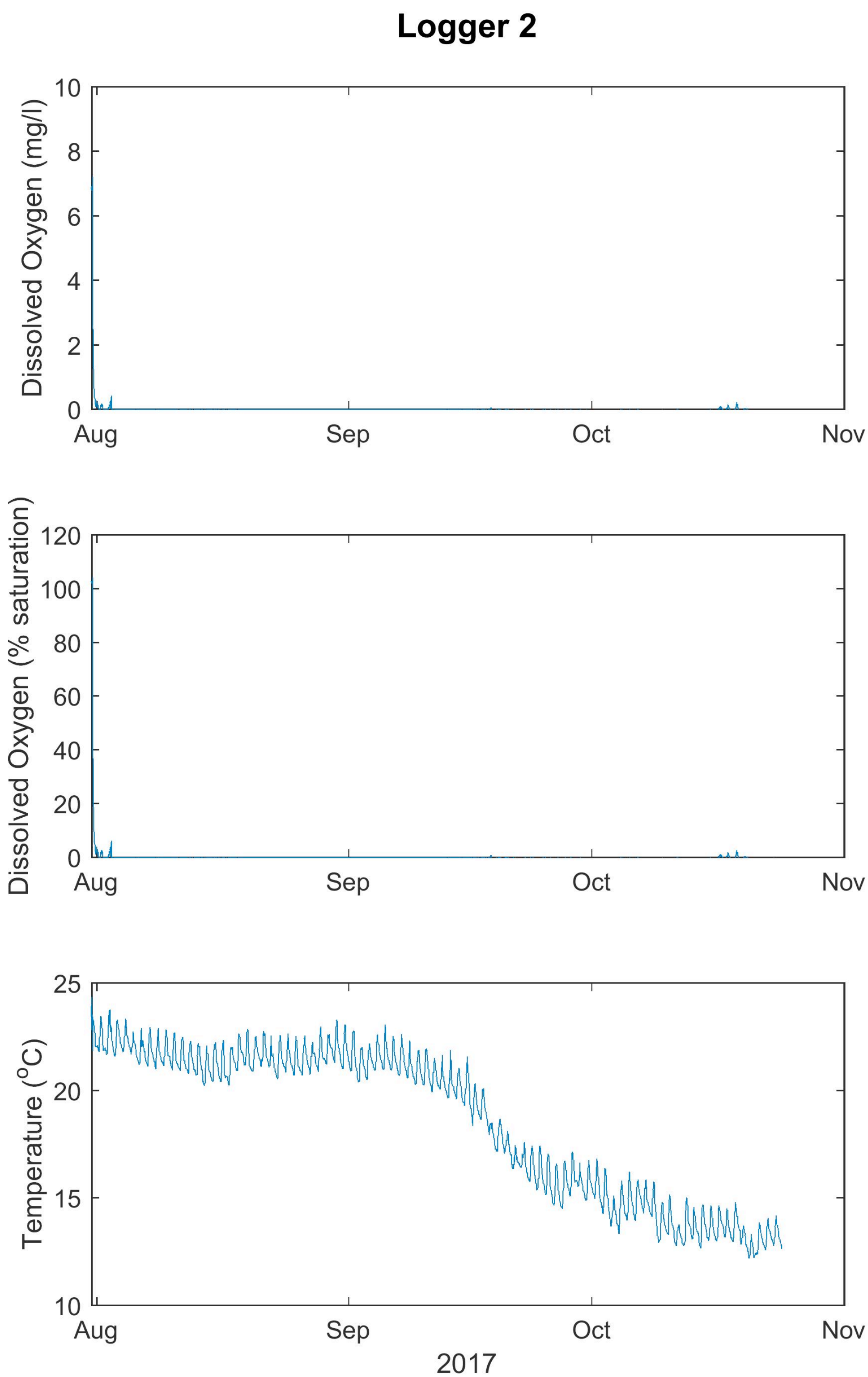

Figure 6: Dissolved oxygen logger #2 under bottom barrier

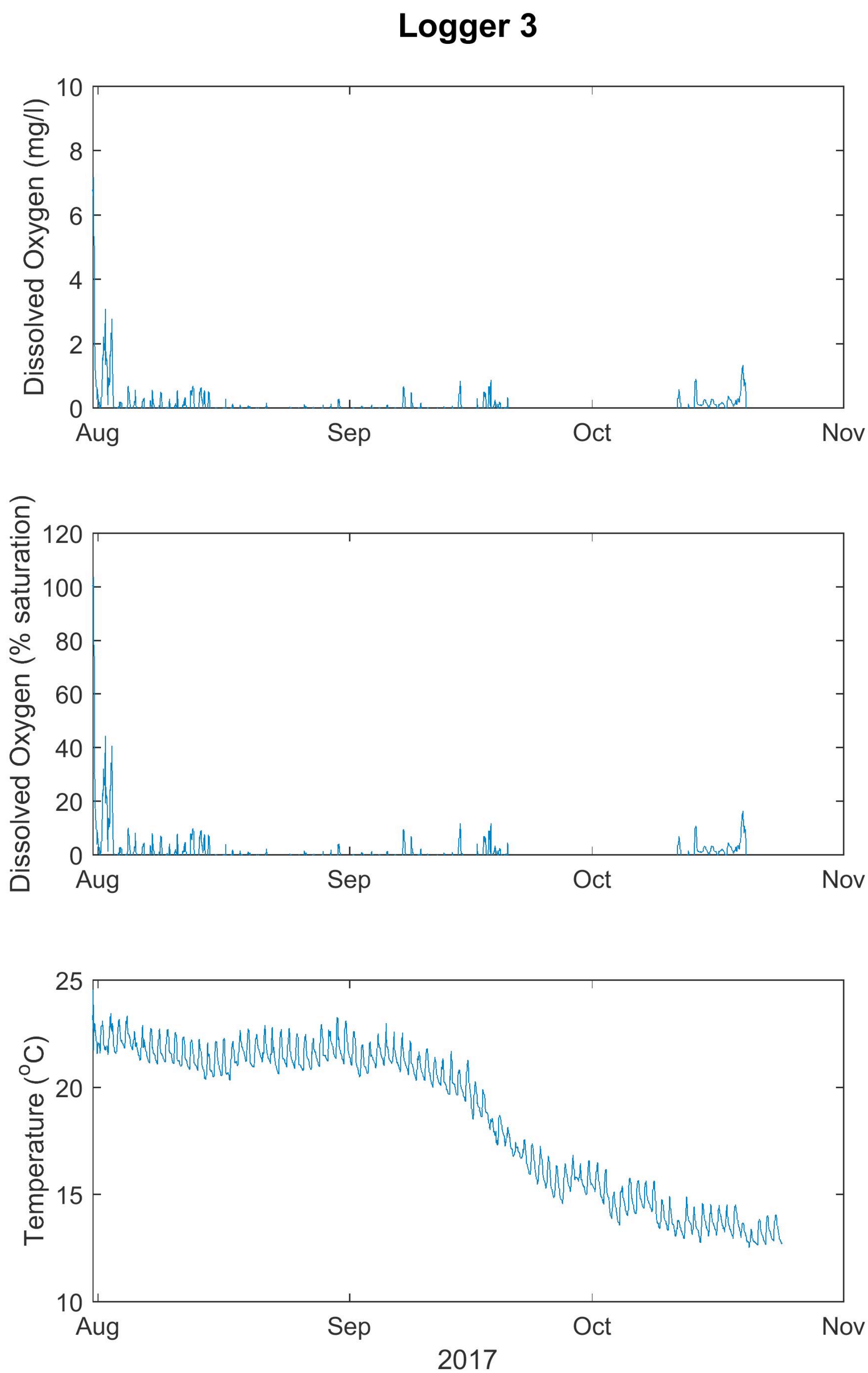

Figure 7: Dissolved oxygen logger #3 under bottom barrier

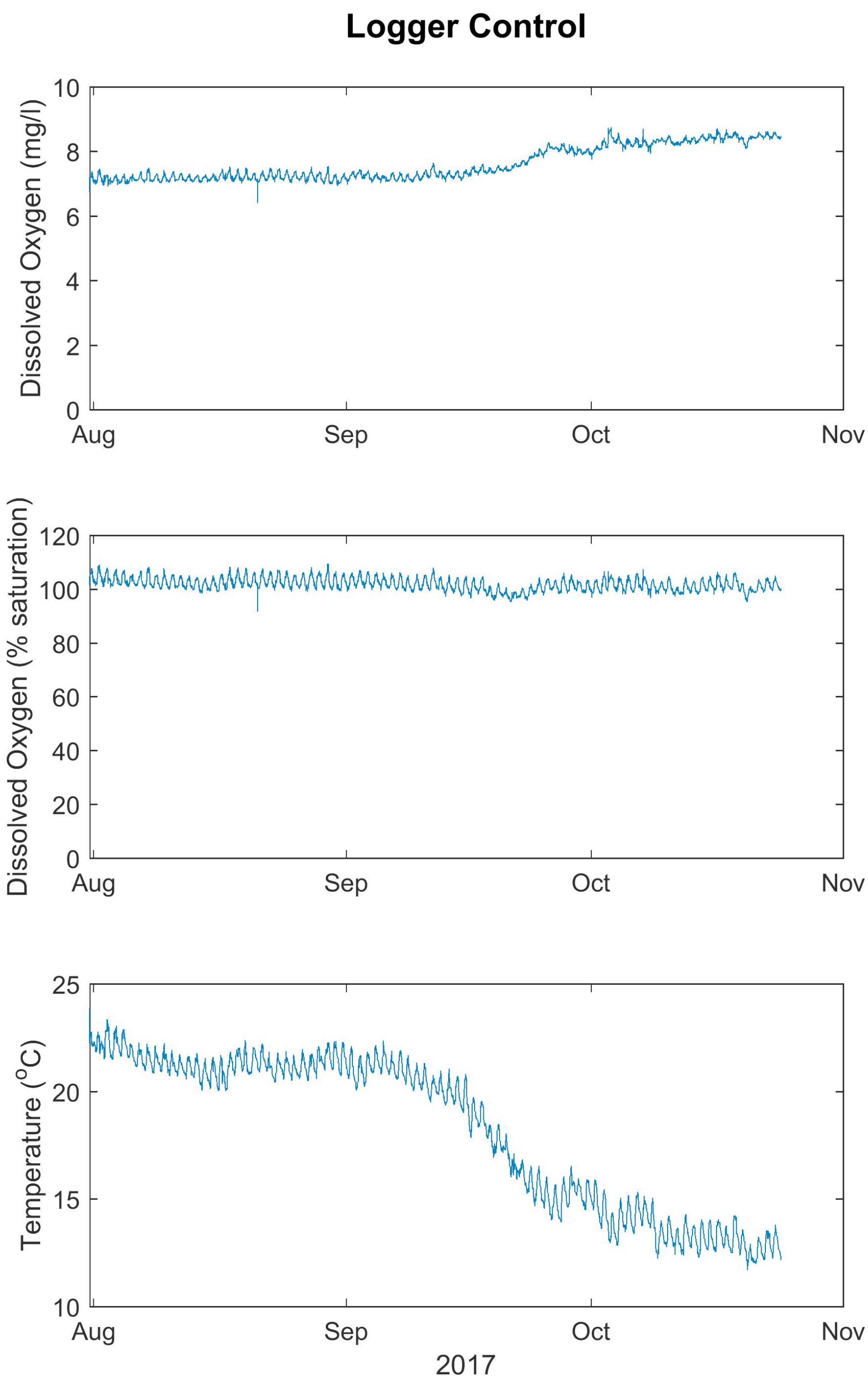

Figure 8: Dissolved oxygen logger #4 attached to TERC nearshore station at 2m depth on top of bottom barrier adjacent to the Sand Harbor boat launch. This logger served as a control during the Phase 1 deployment.