Sand Harbor Asian Clam Survey – 2021 Annual Report

FINAL REPORT

Submitted to Nevada Division of State Lands
February 2022

UC DAVIS Tahoe Environmental Research Center

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Introduction

The invasive bivalve, Asian clam (*Corbicula fluminea*) was first documented in Lake Tahoe in 2002 by the UC Davis – Tahoe Environmental Research Center (TERC) (Hackley, 2008). The original population was found off Nevada Beach on the south-east shore. Contiguous range expansion occurred over the next decade, filling in the south and southeast shoreline from Baldwin Beach to Glenbrook Bay. It wasn't until 2012 that the first non-connected population was discovered on the sill of Emerald Bay State Park, California. This was followed in 2014 by the discovery of an isolated population at the boat ramp within Sand Harbor State Park, Nevada. These isolated populations are believed to have been established via anthropogenic in-lake boat transport of Corbicula's veliger life stage.

The impacts of Corbicula at Lake Tahoe are still a matter of scientific concern. It is possible that dense populations may raise localized calcium concentrations within the range suitable for other dreissena invaders (e.g. zebra mussel, quagga mussel) to build shells (Davis et al. 2015). At present, the largest impact comes from the high nutrient concentrations present in the excretion from Asian clams and their stimulatory effect on algal growth. Within six years of Asian clam establishment along the south shore of Lake Tahoe, dense patches of metaphyton algae began to form over the clam beds. Metaphyton refers to free floating (unattached), filamentous green algae species (Hackley et. al. 2020). These alga exploit the nutrient enriched water provided by clam excreta at the sand water interface. Because metaphyton mats are not attached to the substrate, they move with water currents. The bathymetry, shoreline complexity and winds create localized currents that can move the metaphyton onto beaches where it accumulates and decomposes over weeks to months.

The treatment of Asian clams at Sand Harbor State Park has occurred in three phases (TRPA 01.03.01.0021 - Sand Harbor Aquatic Invasive Asian Clam Control), each using EPDM rubber pond liner as described by Wittmann et al. 2012. The four year (2017-2020), $2.5 million project treated a total of 9.3 acres in the vicinity of the Sand Harbor Boat Launch.

Following the multi-year control project, a comprehensive survey was conducted in summer, 2021 and is described here. The goal of the survey was to assess clam density throughout the aquatic portion of Sand Harbor State Park. The findings serve as a follow up to the treatment described above and as a baseline for potential clam population expansion in future years.

Methods

A survey area was outlined by Nevada Division of State Lands (NDSL) that encompassed the lakeward areas from the shoreline to a depth of approximately 15m (lake surface elevation = 6229.1 feet) surrounding Sand Harbor State Park. The delineated area was approximately 539,000 m^2 (53.9 hectares). A systematic scuba survey was designed that covered the entire region while simultaneously quantifying clam densities within the substrate. The identical transects can be used over the next two years (and extended if needed) to determine trends in clam abundance and distribution.

Scuba Transects

The survey area was divided into four sections representing changes in the shoreline structure or geographic orientation. These included (1) the large south facing swim beach here to referred to as Big Beach, (2) the rocky point, (3) Divers Cove, and (4) the boat ramp and adjoining beaches. Forty linear transects, spaced at 25m intervals, were established parallel to shore from the full lake water line (6229.1 ft elevation) to a depth of 15m (Figure 1). Three shoreline transects, located at the high water line, were included in the forty transects. At Big Beach, Divers Cove, and the boat ramp, the shallowest dive transect was above the high water line during the survey period (lake surface elevation 7 Sept. 2021 = 6223.62 ft; USGS gage height Tahoe City, CA). These transects were surveyed by walking the beach. In future years the area may be inundated, providing adequate clam habitat.

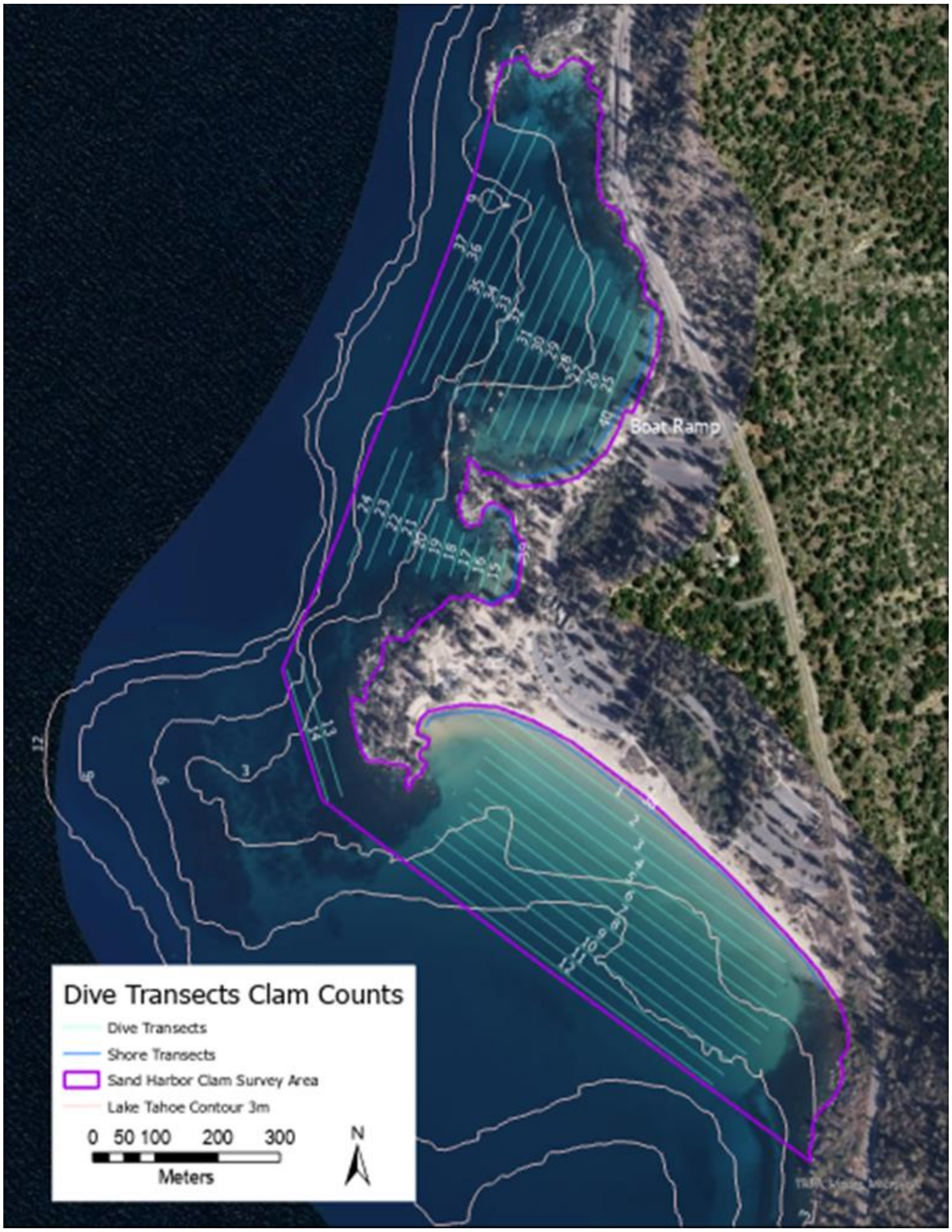

Figure 1: Sand Harbor clam monitoring area with dive and shore transects.

Marker buoys were placed at either end of each scuba transect. Dive teams used compass headings based on the buoy locations in order to swim the survey lines. GPS coordinates were recorded for each buoy placement enabling annual repeatability.

Approximately every 5m, each dive team member sieved an area of about $0.04m^2$ of sediment to a depth of ~15cm using a fine mesh (6mm) minnow trap. Clams were counted on site and noted on underwater data sheets so that changes in clam abundance would be known along each transect. Clam counts from each diver were averaged and are reported in Appendix 1. The data from the sieving along each of the 40 transects was represented as a “heat map” showing the relative abundance of clams throughout the survey area (Figure 2).

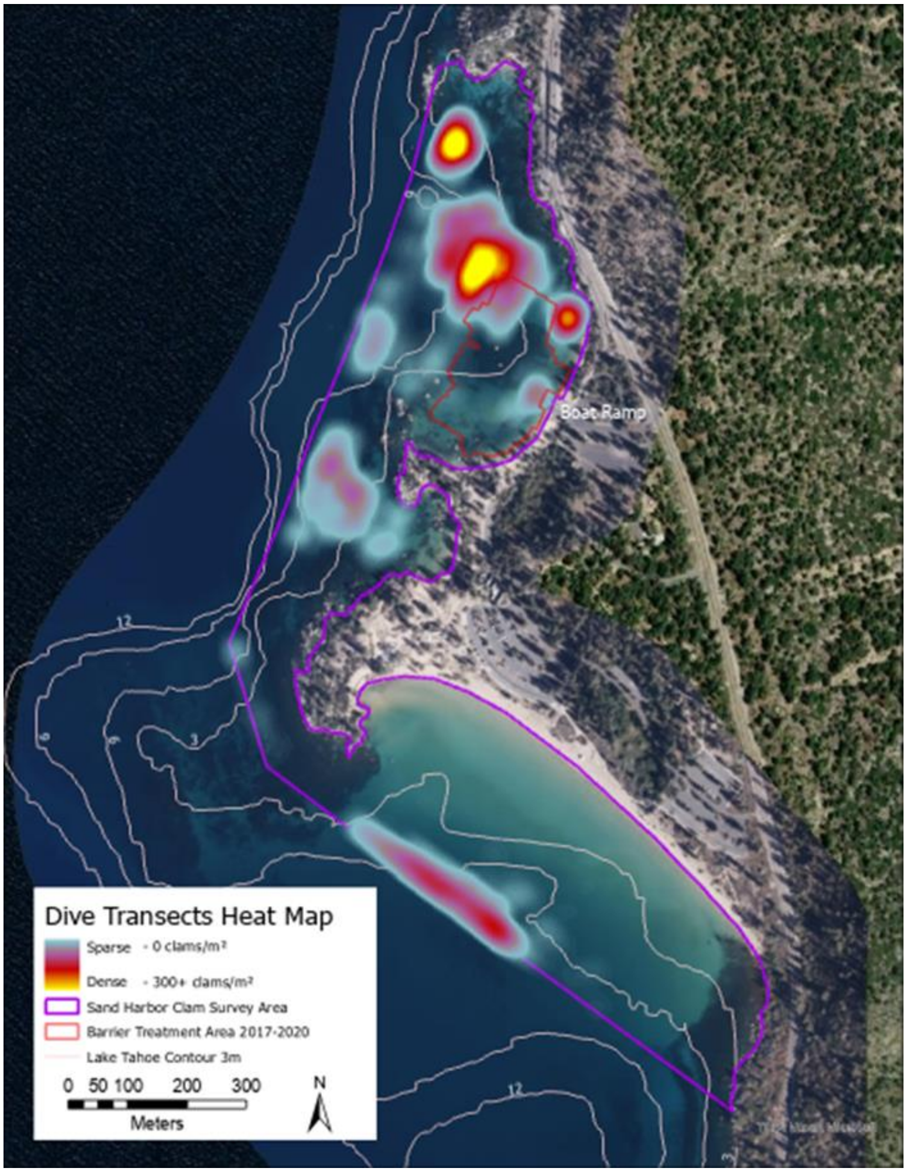

Figure 2: Dive transects clam abundance heat map.

Density Plots

In order to better quantify the density of the clam population through the study area, 60 randomly generated excavation plots were created. Following the scuba transects described above, an additional six plots were strategically located to ensure adequate coverage in areas observed to have higher clam abundance. All plots were georeferenced with GPS coordinates allowing them to be resurveyed in future years (Figure 3).

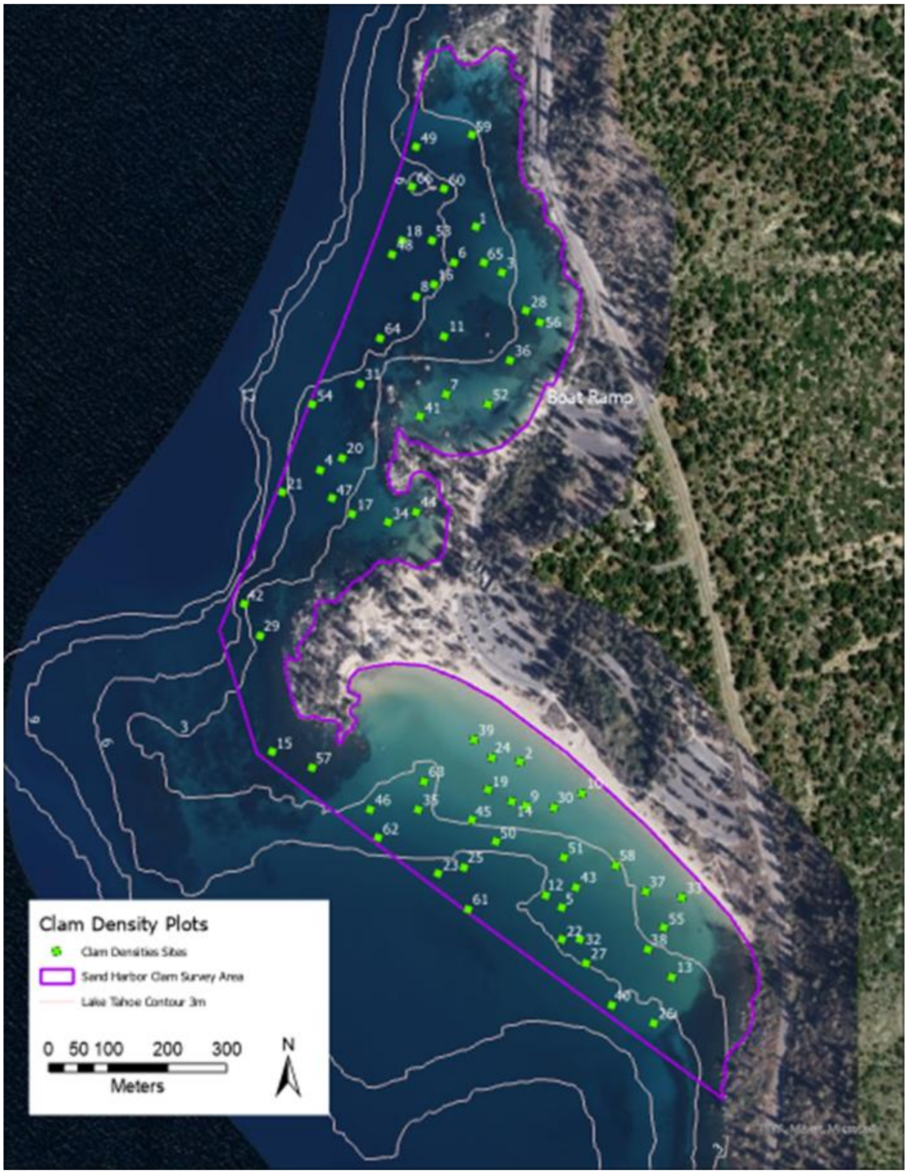

Figure 3: Plot number and location of clam density excavation plots.

A weighted 1m^2 PVC frame was placed on the substrate. Clams were removed from within the plot using a fine mesh minnow trap. Clams collected from each plot were taken to the laboratory and preserved in 80% ethanol until counting and size determination could be completed. Clam shells that were open and contained no attached tissue were counted as dead clams. Shells that were closed or slightly open and contained clam tissue were considered to be live individuals at the time of collection. The length and width of each clam was measured to the nearest 0.01mm using digital calipers.

Clam size is used to estimate the age structure of the population and whether new recruitment of young is occurring. For the purposes of this survey, clams <11mm were classified as juvenile with those >11mm representing the adult, reproductive segment of the population. These sizes are based on findings of maturity and fecundity in Lake Tahoe (Denton et al. 2012). A determination of the percentage of the population that is of reproductive size gives an indication of the potential for population expansion the following year.

Orthomosaic Drone Imagery

Unmanned aerial vehicle (UAV) monitoring at Sand Harbor State Park was completed to obtain aerial imagery data associated with potential metaphyton growth inside the park. UAV flights were conducted in conjunction with SCUBA surveys to provide concurrent assessment of metaphyton coverage during monitoring.

The UAV was a DJI Phantom 4 Pro©. The Phantom 4 Pro is a quadcopter format consumer/professional grade UAV. The integrated 20 megapixel camera provides detailed imagery with a sufficient ground sample distance (GSD) for data acquisition. Flight planning and image capture were collected through ESRI Sitescan software. The standard 'lawnmower' flight path was executed to maximize coverage for mapping the clam survey area. Three separate flight paths were completed to cover the Sand Harbor clam survey area; flights were completed over the boat ramp, Divers Cove, and Big Beach. Adequate overlap between flight paths ensured sufficient coverage of the designated survey area. Flight path parameters were consistent between flights and archived for future repeatable operations. Metaphyton monitoring missions were flown at a height of 107m (350 feet). The 107m altitude allows for a larger area to be photographed while retaining a GSD of under 3 cm/pixel. Sufficient image overlap parameters ensure effective 'stitching' of successive images. Metaphyton monitoring flights used a front overlap of 75% and a side overlap of 65%. Employing high percentage overlaps delivers a higher probability of stitching images together and reconstructing a large scale geo-referenced image, or orthomosaic map, of the site. These techniques have previously been used to assess metaphyton coverage along the southeast shore of Lake Tahoe (Hackley 2020).

Post processing of aerial imagery involves calibrating and stitching UAV images together using photogrammetry to create an orthomosaic. An orthomosaic is a geo-referenced large scale aerial image of an area composed of multiple photographs. Analysis of UAV aerial images and processing of orthomosaics is completed using ESRI Sitescan® software. Images collected by the UAV are individually calibrated and geo-referenced in the initial pre-processing of the software. Images are then 'stitched' together using generated keypoints by the Sitescan software. Keypoints are matched up between consecutive images, allowing for a seamless stitching of images into one large image. Generally, orthomosaic processing is difficult to complete over water because of the homogeneity of a water body. However, due to the clarity of Lake Tahoe's water, images of the nearshore (<10m) can be successfully processed. Natural environmental factors such as submerged rocks and woody debris can positively affect the ability to successfully recreate an orthomosaic (additional reference points) while surface glare, turbidity, and dissolved organic matter (DOM) hinder the process. Therefore, the natural characteristics of the site in addition to weather and time of day can impact orthomosaic generation.

Determination of percent cover of metaphyton at Sand Harbor was evaluated using ArcGIS Pro®. Completed orthomosaics are assessed in ArcGIS Pro and used to determine metaphyton coverage in the established survey area. Orthomosaics are evaluated using a machine based learning tool known as image classification. Image classification is the process of extracting information classes from multiband remote sensing images. Supervised image classification is used to assign specific class categories to image pixels (rock, sand, metaphyton, etc.). These class categories are trained on a per-pixel basis, where the spectral characteristics of the individual pixel determines the class to which it is assigned. A new image/layer is produced displaying each pixel assigned to its classification with each classification represented by a different color.

Results

Clam transects and density plots

Scuba surveys conducted from 6 to 17 September 2021 detected established clam populations in the waters surrounding Sand Harbor State Park. Generally, clams were found off the large south facing swim beach, Big Beach, around the rocky point, in Divers Cove, and throughout the boat launch area at depths greater than 3m. These findings were supported by both the relative abundance found along survey transects and by quantified densities from the density plots. Despite the large area with a viable clam population, densities were generally low (0 – 30 clams/m^2) with the exception of the outer most transect off Big Beach (75 and 86 clams/m^2) and the north side of the cove encompassing the boat ramp (115 – 542 clams/m^2) (Figure 4).

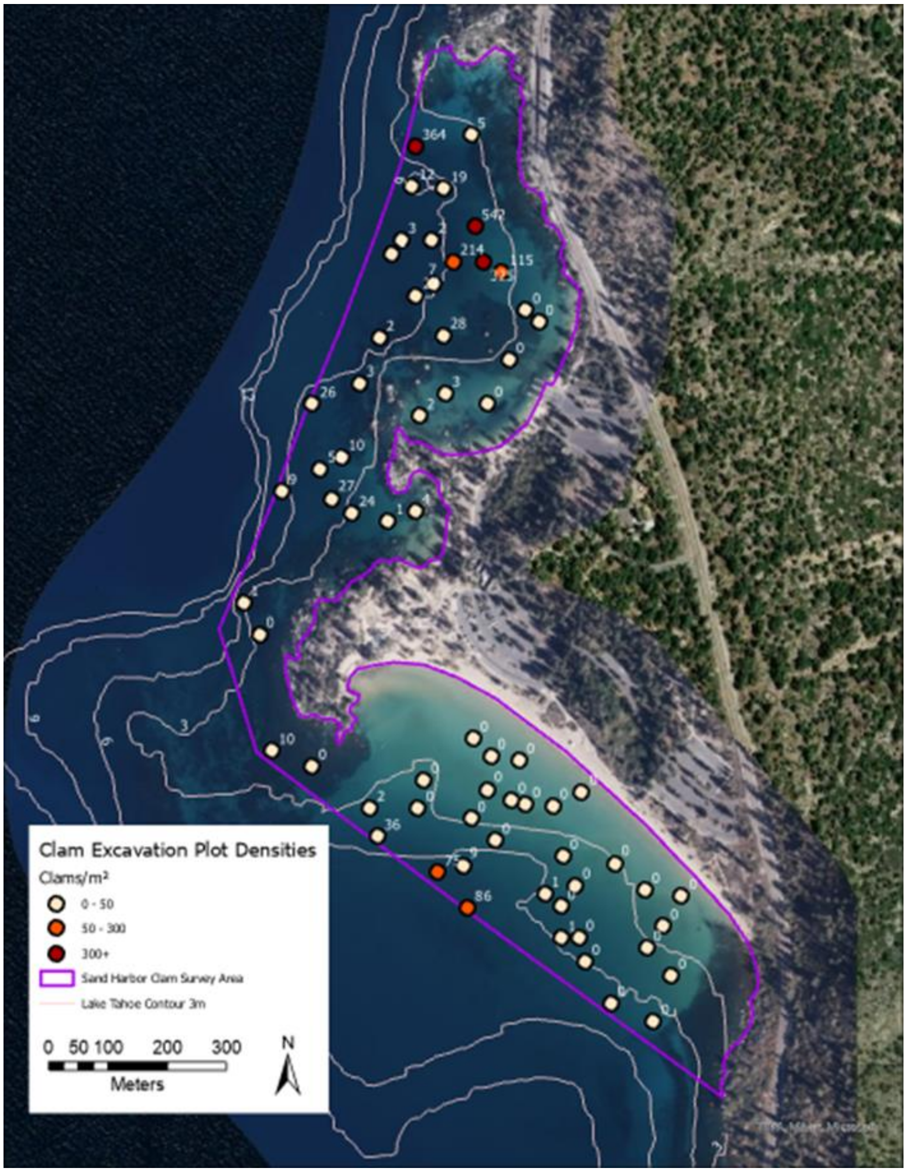

Figure 4: Clam excavation plot densities displayed in number of live clams per square meter.

The population in the area north of the boat ramp was made up of both juvenile and adult clams. In the density plots with the highest numbers of clams collected (Plot #1, 49, 65), 40 - 70% were juveniles (<11mm). This indicates a high level of reproduction during the summer months. Within the two density plots (Plot #23, 61) in the deepest survey area off big beach, 27% and 28% of the clams were juveniles. The lower density of juveniles may be reflective of the shorter reproductive season at greater depths (>10m) due to lower temperatures.

Observations in areas of established clam growth on the south shore of Lake Tahoe indicate that clam densities greater than 100 clams/m^2 are capable of supporting heavy metaphyton algae growth. This was corroborated by observations at the state park during the September scuba surveys. While still relatively small, numerous metaphyton patches up to 0.5m across were observed over the highest clam densities north of the boat ramp (Figure 5). Additionally, very low growth metaphyton was observed over the sand associated with the elevated clam densities off Big Beach.

Figure 5: Metaphyton patches observed north of the boat ramp at Sand Harbor State Park.

Orthomosaic Drone Imagery

Orthomosaic imagery of the clam survey area at Sand Harbor was completed and processed with the SCUBA surveys in September, 2021 (Figure 6). The aerial imagery provides a concurrent dataset of the Sand Harbor area during the time of SCUBA surveys. Metaphyton algae was found present in the survey area during SCUBA surveys. Small (0.5m across) patches of metaphyton were discovered in the northern section of the survey area. Due to the small size of metaphyton growth, percent cover of metaphyton at Sand Harbor was not quantifiable using aerial imagery. However, the aerial imagery data collected during the 2021 survey will provide a baseline for metaphyton growth at Sand Harbor. Based off environmentally similar sites containing clams in Lake Tahoe, it is likely that metaphyton will continue to increase at Sand Harbor in the future under unmitigated clam population growth. Continued aerial remote sensing at Sand Harbor associated with clam monitoring will allow for an accurate assessment of potential metaphyton growth and its transport through 2023.

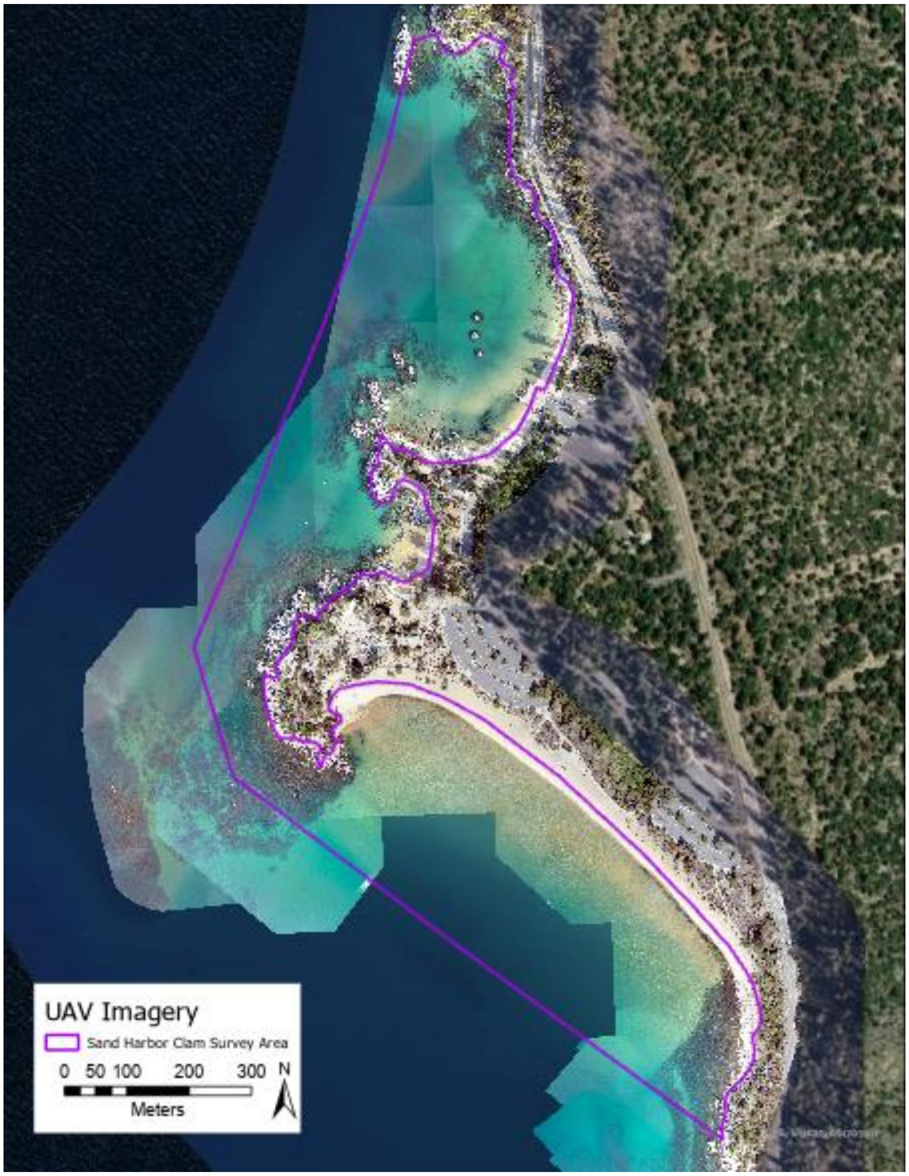

Figure 6: UAV orthomosaic imagery of Sand Harbor survey area.

Discussion

While a viable clam population exists off Sand Harbor State Park, the area wide densities are still relatively low. Clams were absent from 47% of the excavation plots with 86% displaying low densities (<30 clams/m^2). However, a few locations exhibited elevated clam densities (542 clams/m^2 max density from 1m^2 excavation plots). Wittmann et al. (2012) found densities of 6,000 – 10,000 clams/m^2 using a petite Ponar sampler (0.023m^2), lowered from a boat, at specific sites in Marla Bay on Tahoe's southeast shore. These densities were associated with extensive blooms of metaphyton algae that washed up on the beach. Since previous studies did not quantify clam densities by employing full 1m^2 plots excavated using scuba, we converted the clam abundance values from our survey transects to density estimates for comparative purposes only. The sediment scoops collected with minnow traps along transect lines assessed an estimated area of 0.04m^2. The highest number of clams collected using this method was 34, resulting in an estimated density of 774 clams/m^2 at that location. While this clam density is a reason for concern at Sand Harbor, it remains 6-10 times lower than that discovered in Marla Bay, forecasting the potential for exponential population growth at the state park.

The low density of clams throughout most of the area surrounding the Sand Harbor boat ramp is likely due to the success of the bottom barrier treatments performed from 2017 – 2020. Unfortunately, not all clams were covered by the EDPM rubber mats and thus the untreated population continued to expand its range. The highest densities discovered north of the ramp were not covered by barriers during any phase of the control project and displayed unmitigated increases in their localized densities.

The population off Big Beach is believed to have arrived after the first discovery of clams in the vicinity of the boat ramp (Senft et al. 2016). It is unclear if this population arrived from another location within the state park, via boat transport, or by natural population expansion from the south. Regardless of the means of arrival, it is expected that over time, clams will exploit the remaining sandy substrate toward shore.

Based on the current survey, the Sand Harbor clam population living deeper than ~10m displays slower rates of reproduction. This is based on the small percentage of juvenile clams collected from density plots at all of the deeper sites (Figure 7). Because clam reproduction occurs at water temperatures >14 ^{o}C with veliger release occurring at temperatures >16^{0}C (Denton et al 2012), deeper habitat has a shorter reproductive season. Temperature data from the TERC nearshore station, located at a depth of 1 - 1.5m near the boat ramp, indicated the reproduction temperature threshold was met from the first of June through mid-October, 2021, providing adult clams 4.5 months of reproduction at shallow depths. A study of Asian clam in Lake Tahoe (Denton et al. 2012) has shown each adult clam is capable of producing 10 $\pm$2 veligers per breeding cycle, with a single breeding per summer in Lake Tahoe. This reproductive rate is dramatically lower than that found in more productive systems. The majority of studies have found Asian clams reproduce twice annually with reproduction potential being controlled by temperature and food availability (Sousa et al. 2008). While survival of all offspring is unexpected, it appears clams in Tahoe face limited predation even at the veliger stage. Therefore, based on the fecundity of Tahoe clams, localized populations could increase 10 - 20 fold annually until food limitation becomes restrictive. This would be consistent with the rapid expansion of clams observed in Marla Bay following initial discovery.

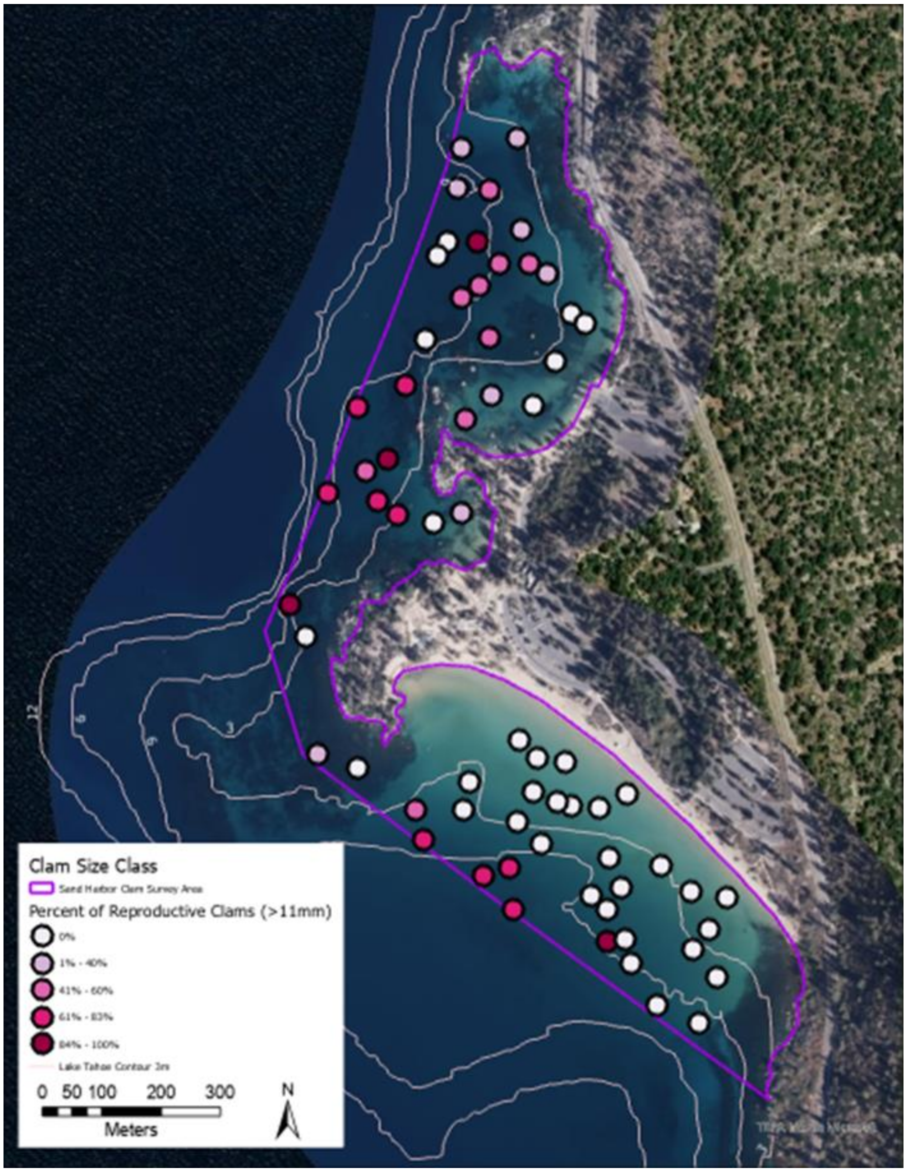

Figure 7: Clam size class densities as percent of reproductive clams (>11mm) at each site.

An unregulated expansion of the existing clam population is expected to produce heavier metaphyton mats over larger areas of Sand Harbor in future years. The potential and the timing for these mats to create nuisance algae on beaches is unknown and dependent on local nearshore currents and future lake conditions. Generally, metaphyton that is established in deeper water and outside a natural embayment is more likely to be swept offshore, eventually sinking to the lake bottom well offshore. Metaphyton that develops within constraining areas, whether natural or man-made, are more likely to remain in the shallow nearshore zone. Both situations have been observed at Lake Tahoe with algae transport to beaches along the south shore becoming a greater concern.

Recommendations

Based on the extent of the Asian clam population outlined in the 2021 survey, clams are likely to continue to maintain a presence at Sand Harbor. The area of infestation likely exceeds that which can be effectively and economically treated using bottom barriers if the goal is eradication. Therefore, consideration should be given to targeted maintenance strategies aimed at preserving the Tahoe aesthetic represented by the nearshore of Sand Harbor State Park.

A strategic implementation plan, specific to Sand Harbor, should be developed based on previous experience with Asian clam control measures, findings from the annual surveys currently being conducted by TERC, and a greater understanding of lake currents surrounding the state park. New techniques for clam removal should be explored (for example, suction removal). Alternatively, if the greatest threat is considered to be the increasing metaphyton blooms, then methods to remove algal mats prior to their washing up on the beach should be explored.

Key features of the implementation plan should include, but may not be limited to the following

Understanding the duration of bottom barrier treatment efficacy

The bottom barrier treatments in the vicinity of the boat ramp were very effective at reducing the viable clam population. Within the treatment area, clam densities found during this survey were <5 clams/m^2 (Figure 8). The repopulation of formerly treated areas is important to continue monitoring as the time required for clam reestablishment will determine the need for future action. If the threshold for metaphyton development is 100 clams/m^2, it could be several years before follow up action is required, even in the shallow, warm water environment where clam reproduction is greatest. Expansion of populations in deeper water is expected to be slower due to the reduced reproductive season.

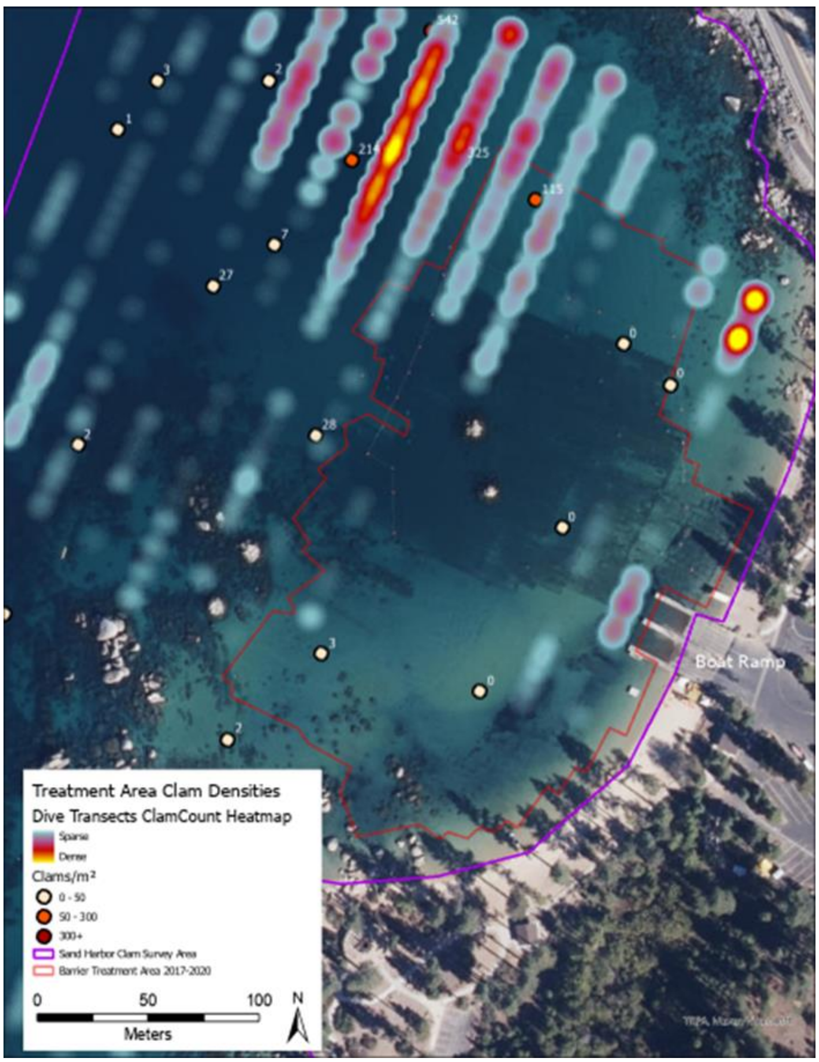

Figure 8: Bottom barrier treatment area (2017 – 2020) indicated by red line with present clam abundances.

Rapid response to clam densities >100 clams/m^2

One of the keys to effectively controlling the exponential increase in clam density and spread is a rapid response. This could be accomplished through the use of annual survey data (heat maps) guiding implementation to localized, small scale areas. This would prove more cost effective than large scale treatments, be less aesthetically intrusive, allow for alternative treatment strategies, and could be built into the annual budget.

Develop a localized current map for Sand Harbor nearshore

Perhaps the most immediate issue with the clam population at Sand Harbor is the potential for metaphyton growth. The 2021 survey already found small patches of green filamentous algae associated with clam densities exceeding 100 clams/m^2. The metaphyton is subject to transport by water currents and may or may not pose a nuisance on beaches based on where it ends up. Using a combination of drogues (drifting buoys), acoustic Doppler current profilers (ADCP), and UAV imagery, a more detailed understanding of the potential for metaphyton deposition on beaches could be achieved. These methods would also yield important information on the spread of veligers during the clam reproductive season, thereby anticipating the future spread of clams. Such a predictive ability could be achieved with numerical modeling as well, as was done by Hoyer et al. (2015).

Seek alternative clam treatments appropriate to small scale population reductions

Suction removal of clams was tested in Lake Tahoe during the very early stages of aquatic invasive species (AIS) control. The objective, at that time, was clam eradication. Suction removal was not deemed effective as small clams (<7mm) were the same size as the granitic substrate. In order to remove all the clams, all the substrate would also have to be removed from the bottom of the lake. Additionally, the suction application, designed for AIS plant removal, was not appropriate for the size of the infested area. Since then, other clam vacuum techniques have been developed that separate clams from substrate. A renewed exploration of suction removal techniques may provide options not previously available.

Explore techniques for the removal of metaphyton

TERC researchers recently completed a study on Tahoe metaphyton (Hackley et al. 2020). Sampling techniques were developed to remove metaphyton from known areas to obtain a quantitative assessment of the metaphyton biomass. It may be possible to use similar techniques to remove larger areas of metaphyton. Aside from removing nuisance algae, TERC is exploring the nutrient load (nitrogen and phosphorous) stored in the metaphyton, with algae removal potentially providing both a more visually pleasing nearshore and a net reduction in Tahoe's nutrients.

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Appendix 1

Table A1

Average number of clams collected per minnow trap scoop at boat ramp survey area

	LAKE TAHOE																				
		Baseline (m) from Start Point																			
Transect #	Direction	20	15	10	5	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
37						1.5	0	0	0.5	1	0.5	1.5	0.5	0	0.5	1	1.5	2.5	3	0.5	0
36						2.5	1	1.5	3.5	3	4	3.5	2	2.5	4.5	3	1	1.5	0.5	1	0.5
35						0	0	1	0.5	1	1	0.5	0	1.5	0.5	0	1	0	0.5	0	0
34						0	0.5	0	0	1.5	0.5	0.5	1	0	0	0	0	0	0	0	0
33	S					2	1.5	1.5	1.5	0.5	0.5	0	0.5	0.5	0	0	0	0.5	0.5	0	0.5
32	O					0	0	1.5	0	0	1.5	1.5	3	1	0.5	0.5	1.5	0	0	0	2
31	U	0	0	0	0.5	0	0.5	0	0	0.5	0.5	0	0	0	0	1	0	0.5	0	1	0
30	T	0	0	0	0	0	0	0	2.5	0	0.5	0.5	0	0	0	0.5	0.5	0	0	0	0
29	H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	4
28		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26						0	0	0	0	1	1	0	2.5	0.5	0	0	0	1	0.5	1	0.5
25						0	0	0	0	1	0	0	0	0	0	0	1	7	2	4	9
	SHORELINE																				

Transect #	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205
37	0.5	0	0.5	1	1	1	1	0.5	0	0	0	0	0	0.5	0	0.5	0.5	0.5	0	0.5	0	0	0.5	0	0	0.5
36	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0	0.5	0	1	1	0.5	0	0	0	1	1	0.5	1	0.5	0	1.5
35	0.5	0	0	0	0.5	0	0	0	0	0.5	0	0.5	0.5	0.5	0.5	1	0	1.5	0	3	5	1.5	3	0.5	5	5
34	0.5	0	0.5	1.5	6.5	11.5	8.5	13.5	15	8	5	8.5	6.5	5	5	10.5	5.5	0.5	0.5	1						
33	3	4	13	8.5	2.5	11.5	13	6.5	7.5	5	7.5	8	6													
32	2	2.5	5.5	9.5	15	21.5	26	22	32.5	28	21	24.5	23.5	22	7	1.5	3.5	5	8							
31	0	2	1.5	1.5	1.5	1.5	5.5	6	7	5.5	10	16.5	20.5	13.5	12.5	13	7.5	5.5	21.5							
30	0	0	3	2	3.5	3	1.5	3.5	4.5	3.5	3.5	5.5	10.5	7.5	13.5	3.5	4	6.5	10.5	7						
29	3	2	4.5	7	3	9	7.5	5	3.5	3.5	5.5	2.5	3	10												
28	0	0	0	0	0	0	0.5	0	0.5	0	1	0	3	3	3.5	4.5										
27	0	0	0	0	0	0	0	0.5	0.5																	
26	0	0	0	0	0	0	0	0	0	0	0.5	0	6	1.5	4.5											
25	1	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	4	4	34	8

Transect #	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325	330	335	Direction
37	2	0	0.5	2	0	0	0.5	0	0	0	1	0	1	6	7.5	15	17	17	19.5	25	14.5	15.5	15.5	7.5	15	6.5	
36	0	0	0	1	0.5	2.5	2.5	2	0.5	12	16	17.5	20.5	7.5	1.5	5	1.5										
35	10.5	1.5	1	0.5	0.5	0.5	0	0	0																		
34																											N
33																											O
32																											R
31																											T
30																											H
29																											
28																											
27																											
26																											
25	3	10	32																								

Table A2

Average number of clams collected per minnow trap scoop at diver's cove survey area

	LAKE TAHOE																												
		Baseline (m) from Start Point																											
Transect #	Direction	15	10	5	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	Direction
24		1.5	0	2	2.5	1.5	0.5	0	0	0.5	3	3.5	1	1	3.5	0	3	3	3	5	7	5.5	3.5	4	2	3	2	3.5	2	
23			0.5	1	0.5	0.5	0.5	1	1.5	2	2	1	2	0	3.5	2	0.5	2	4	7.5	4.5	4	1.5	0.5	1	2.5	1			
22	S		1	2	2	2	0.5	0	0	0.5	0.5	0.5	0.5	1	0	1.5	0.5	2.5	1.5	2.5	3.5	6.5	5	1	2.5	2	0.5			N
21	O		0	0.5	0	0.5	1	4.5	2	2.5	0.5	1.5	2	3	1.5	1	1	3	3.5	4.5	2	1	1	0	0	2.5	2			O
20	U				-	-	0	0	0	1	0	1	0	0	1	2	0	0	0	1	1	1	1	-	-	-	-			R
19	T				-	1	3	1	0	0	2	3	0	0	0	0	0	0	1	1	0	0	0	0	0	-	-			T
18	H				-	-	-	1	3	0	0	2	1	1	1	0	0	1	0	0	0	1	3	0	2	-	-			H
17					-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-			
16					-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-			
15					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	SHORELINE																												

Table 3A

Average number of clams collected per minnow trap scoop at rocky point survey area

	LAKE TAHOE																												
		Baseline (m) from Start Point																											
Transect #	Direction	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	Direction
14	S	0	0	0.5	0	0	0	0	1.5	0	0	1	0.5	0.5	0.5	0	0	0.5	0.5	0	0.5	0.5	0	0.5	2	2.5	0.5		N
13	E	-	-	-	0.5	-	0	0.5	0	0	-	-	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	W
	SHORELINE																												

Table 4A

Average number of clams collected per minnow trap scoop on southeast portion of big beach survey area

	LAKE TAHOE																																																	
		Baseline (m) from Start Point																																																
Transect #	Direction	240	235	230	225	220	215	210	205	200	195	190	185	180	175	170	165	160	155	150	145	140	135	130	125	120	115	110	105	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0
12							0	0	0	0	0	0	0	0	0	0	0	0.5	0	0.5	0	0	0	0	0.5	0	0	0	0	0	0.5	0	0	0.5	0	0.5	2	0.5	0.5	0.5	2.5	1	0.5	1.5	4.5	4	7	5.5	7	6.5
11	S								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0.5	0	0	0	0	0.5	0	0.5	0	0	0.5	0	0.5
10	O										0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0	0	0	0	0	0	0	0.5	0.5	0	0.5	1.5	0.5	1	0.5	0	0.5	0	0	0	0	0
9	U										0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	2
8	T								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1	0	0	0	0	0	0	0
7	H										0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	A					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	S					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	T		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2																											0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1																																										0	0	0	0	0	0	0	0	0	0
	SHORELINE																																																	

Table 5A

Average number of clams collected per minnow trap scoop on northwest portion of big beach survey area

Lake Tahoe																																																			
Baseline (m) from Start Point																																																			
0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	Direction	Transect #
6.5	6	8.5	4	6	6.5	4	7.5	5	6	6	4	7.5	7.5	9	7.5	7.5	13	5.5	7.5	5.5	7.5	7	11.5	5.5	5	8	5.5	6.5	5.5	6.5	6.5	5.5	6	7	2.5	5	9.5	8.5	5.5	3.5	3.5	4.5									12
0.5	0	3	4	3	4	2.5	2.5	3.5	2	5	3.5	4	3.5	4	3	1	3	1.5	2	2	0.5	2.5	1.5	1	1.5	2	0.5	1.5	0.5	0.5	0	0	0	0	0.5	0.5	0	0	0	0	0.5									N	11
0	0	0	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												O	10
2	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												R	9
0	0.5	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0.5	0	0	0	0	0	0	0	0										T	8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											H	7
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			W	6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							E	5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							S	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					T	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											1
Shoreline																																																			

Appendix 2

Link to Sand Harbor State Park Asian clam monitoring (2021) web map.

https://experience.arcgis.com/experience/f9aabae550f84bb7955b2f48a107029f/