

Title:	Development of a risk model to determine the expansion and potential environmental impacts of Asian clams in Lake Tahoe
Subtheme this proposal is responding to (choose only one)	Invasive species
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**Project abstract.**

In the last 40 years many private and public resources have been expended to restore Lake Tahoe's fragile ecosystem and water clarity. Recently, the expansion of an invasive species, the Asian clam, was documented in the southeastern part of the lake. Further, this summer there were dense, filamentous algal blooms co-located with Asian clam beds. These blooms occurred in less than 10 meters of water and were detected by local homeowners, residents and lake visitors and reported to local agencies. The rapid expansion of Asian clam in one year combined with the demonstrated potential to alter the ecology of the lake via unprecedented levels of algal biomass in the near shore represents a major new threat to Lake Tahoe. This proposal is motivated by concerns of agency staff requests for assistance in developing control methods, predicting likely future locations for clam colonization, and assessing the impact of clams on both a local and entire-lake scale. The invasion of Asian clam in a high elevation, oligotrophic, coldwater lake is unique; most introduced species in Lake Tahoe show various life history adjustments and/or phenotypic plasticities compared to other populations in North America. The early detection of this common invader in Lake Tahoe allows for critical research at the beginning stages of an invasion in a rare environment. This research will greatly contribute to invasive species research literature as well as to management within the basin. The major objectives of this project proposal are to advance the state of the science for freshwater bivalve invasion, and to develop a longer-term risk assessment of Asian clam growth, spread and impact.

**Justification statement.**

The invasive freshwater bivalve *Corbicula fluminea* (Asian clam) is currently established in Lake Tahoe. Since its initial introduction in Washington State along the Columbia River in the late 1930s, its spread in the United States has been both rapid and extensive – it now is found in water bodies in 38 states. Because of its economic and ecologic effects it is considered to be the most important aquatic non-indigenous aquatic animal in N. America (McMahon 1999). For example, the Asian clam is the most abundant bivalve in the Sacramento-San Joaquin Delta, where it consistently out competes many native clam species for food and space and fouls manmade infrastructure by clogging of water intake pipes, affecting power, water, and other industries (Karatayev et al. 2003, Lucas et al. 2002, Hakenkamp et al. 2001, Pimentel et al. 2005).

Asian clam was first observed at Lake Tahoe in very low numbers in 2002, but its population has apparently increased to a level where it is now having apparent environmental impacts. For example, the Asian clam (1) excretes elevated levels of nitrogen and phosphorus into the water and bottom sediments – stimulatory to algal growth, (2) filters extremely high volumes of water - potentially impacting both water quality and pelagic communities including Lake Tahoe sports fisheries, (3) could facilitate the invasion of zebra or quagga mussels by creating localized high calcium environments as dead shells leach this potentially limiting element, and (4) competes with Tahoe native benthic species such as the Montane Pea clam (*Pisidium* spp.) and the Ramshorn snail (Planorbidae). Scientists from the Universities of California- Davis and Nevada-Reno conducted a series of experiments in the summer (2008) that demonstrated a likely link to the large nuisance blooms of green algae (metaphyton) observed on the southeast shores of Lake Tahoe. Its current known distribution (area ~1 million m<sup>2</sup>) is patchy along the southeast shore from Zephyr Cove (NV) to El Dorado Beach (CA) is changing due to its rapid growth rate and ability to colonize in the abundant sandy bottom. Asian clam has both pelagic and benthic life stages, enabling it to spread long distances by boats and lake currents and locally by diffusive growth. Management concerns for Lake Tahoe and surrounding water bodies are focused on the effective in-lake control of Asian clam as well as the prevention of future quagga and zebra mussel introduction and establishment. This information is intended to advance the scientific literature in invasion biology and to assist managers in developing a management plan for Asian clam in Lake Tahoe.

**Background and statement of problem Lake Tahoe: a history of invasions.**

During the last 130 years numerous nonnative fish, invertebrate, and plant species have been introduced intentionally and unintentionally to Lake Tahoe altering aspects of its ecology. The first series of fish introductions occurred at the end of the 19<sup>th</sup> century through the 1940's. Only rainbow trout (*O. mykiss*), brown trout (*Salmo trutta*), lake trout (*Salvelinus namaycush*), and brook trout (*S. fontinalis*), and kokanee salmon (*O. nerka*) still persist today. Predatory impacts from lake trout combined with over fishing, hybridization, and siltation of spawning streams contributed to the extirpation of Lahontan cutthroat trout from Lake Tahoe by 1939 (Cordone and Frantz 1968, Moyle 2002). A second round of fish invasions occurred in the late 1970's and 80's but this time in the near shore environment (Reuter and Miller 2000). The warm water fish introductions (largemouth bass and bluegill) were illegal and not part of any management strategy. These invasions are thought to have contributed to reductions in nearshore, native fish through predation and competition (Kamerath et al. 2008). Aquatic plants have been a

problem in the nearshore area of Lake Tahoe for a few decades. Aggressive non-native species such as Eurasian water milfoil (*Myriophyllum spicatum*) and Curly leaf pondweed (*Potamogeton crispus*) initially established in the Tahoe Keys lagoon where costly and annual control using mechanical harvesters has occurred since the mid-1980s. These species have since established along the south shore and various marinas and embayments including Emerald Bay, and are continuing to spread to other locations in the lake (Anderson 2006). Thus, over time managers are increasingly concerned of these near shore invasions because of negative ecological and aesthetic change and the direct interface between the nearshore and the public. Present goals are to control and manage the current invasions as well as to prevent future introductions.

### **The Asian Clam: a new, nearshore invader**

In the Pyramid/Truckee/Tahoe Basin, the Asian clams were first reported in the Lower Truckee River in 1981 (Pyramid Lake Paiute Tribe Study) and was first detected in Lake Tahoe at Nevada Beach at very low numbers in 2002 (Hackley et al. 2008). In late April 2008, the clam was shown to have expanded in abundance and range at seven sites along the southeast shore of the lake (Hackley et al. 2008). It is a freshwater species that has high dissolved oxygen requirements (anoxia intolerant), though it can tolerate salinities of up to 13 parts per thousand, and temperatures between 2 and 30° C. While there has been no definitive study on the impact of calcium on Asian clam, it appears that at 6 mg Ca/L and a pH > 6.5 populations can be relatively successful (Cooper 2007). Dissolved calcium levels in Lake Tahoe are consistently in the range of 8-10 mg/L and pH exceeds 6.5. Spawning can continue year round but water temperature must be above 16°C for larval release; a single clam can release an average of 400 juveniles per day, with reproductive rates highest in the fall (Aguirre and Poss 1999).

In 2008, researchers and managers in the Tahoe basin became increasingly concerned at the apparent expansion of clam beds in the southeastern part of Lake Tahoe and the possible tie to eutrophic conditions developing resulting in a large scale visible algal bloom (Wittmann et al. 2008). Concerned about the impact of these clams on the lake's ecology, researchers immediately to requests from agency staff and local citizens and conducted a rapid, preliminary assessment of the infested area in Lake Tahoe. Preliminary data collected by the Universities in late summer 2008, suggests that clams are found buried in mostly sandy sediments with 70 to over 3000 individuals per meter squared in (at least) the top 10-15 cm of substrate. Clams were found at lake water depths ranging from 2 to 39 meters -with highest densities between 3 and 10 meters (Figure 1). Asian clams have not been found at depths greater than 39 meters in any transects taken to date, although they have been found at >40 m depth in a variety of sediment types (silt, mud, gravel) in other systems such as Lake Mead (Chandra and Wittmann, unpublished data).

Laboratory experiments conducted in Sept 2008, showed that Lake Tahoe Asian clams excrete nitrogen and phosphorus at elevated levels (Figure 2) (several orders of magnitude greater than ambient lake levels), and this excrement caused a threefold increase of phytoplankton algae in bioassays (Figure 3). While Asian clams are capable of aggressive filter feeding of pelagic algae as well as substrate feeding within sediments, it is unknown at what rate and which mode of feeding Asian clam prefer in Lake Tahoe. This feeding strategy can have major impacts on both water quality and sediment condition. Using the results of the excretion experiments it was calculated that to support the nuisance levels of the filamentous green metaphyton, *Zygnema*, that were found associated with the existing clam beds, a clam population of approximately 900 individuals/m<sup>2</sup> would be required. The fact that the *in situ* populations were in this range provides further weight of evidence that the Asian clam is having an effect in Lake Tahoe. The ability of invasive bivalves to influence light penetration, deliver nutrients to the lake benthos, and influence the growth of metaphyton and other benthic plants has been previously reported (e.g. Lowe and Pillsbury 1995; Bosch et al. 2001).

By altering water column and substrate characteristics, as well as by adding substrate on which to colonize, Asian clam may facilitate the invasion of other invasive bivalve species such as the quagga mussel, an invader found within the region at Lake Mead and in Southern California. September 2008 surveys suggest live Asian clam beds have elevated concentrations of sediment porewater nitrogen and phosphorus compared to sediments where clams are absent. Additionally, a sediment porewater calcium sample (N=1) taken from within a pile of dead clam shells show dissolved calcium level of 26 ppm - twice as high compared to areas without shells (Figure 4). In addition to showing signs of local environmental impacts, Asian clam are also actively reproducing in Lake Tahoe, with a large abundance of juveniles and generational cohorts found in summer surveys. In other systems, Asian clam juveniles (<14mm) are capable of long distance dispersal via transport in the water column. A one time deployment of surface current trackers in August showed that currents circulate through Marla Bay and head to other portions of the lake

within 24 hour periods (Figure 5). Predicting future spread of Asian clam will rely on an understanding of nearshore and lake-wide surface current transport.

### **Knowledge gaps and key questions**

The findings collected to date by our research team highlight that immediate actions are needed to develop a risk assessment model that predicts future spread of Asian clams. It is critical that resource agencies have a management plan that includes an evaluation of the potential range for Asian clam colonization within Lake Tahoe. We are currently working with the Lake Tahoe Aquatic Invasive Species Working Group (LTAISWG) and other agency representatives to develop pilot projects related to testing various control methods (bottom barriers, suction removal, molluscicides) on Asian clams. In this proposal we focus on understanding initial key questions needed for a risk assessment of Asian clam distribution at the Lake Tahoe. Specific questions that will be addressed include, but are not limited to:

- What are the environmental parameters that may control the existing patches of Asian clams?
- What is the life history and growth of these clams in an oligotrophic, subalpine lake and can we develop a model that identifies what adult clam growth will be into the future and in other parts of the lake?
- What is the role of lake currents in the transport of larval/juvenile stages to other locations in the lake?
- What are the potential impacts to the lake's planktonic community?

Addressing these questions will provide initial steps to creating a risk-based management model of future Asian clam distribution, abundance, and impact to Lake Tahoe.

### **Goals, objectives, and hypotheses**

The primary goal of this proposal is to develop a risk analysis of Asian clam distribution and its environmental impact by examining the structure, transport, life history, and energetics of existing populations discovered in the lake. The specific objectives are to:

1. Determine the environmental parameters that contribute to the establishment and expansion of clam beds,
2. Develop a life history-growth model based on existing beds that can be applied to other locations to determine potential growth and reproduction,
3. Create a transport model that estimates the most favored pathways of transport of young life stages of Asian clams from the existing beds and the influential conditions they would be exposed to (temperature, light, UV and travel time) en route,
4. Develop a preliminary understanding of clam impact on particle size distribution of phytoplankton and fine sediments – the important determinants of water clarity in Lake Tahoe. Nutrient excretion rates based on different food sources will be evaluated to link findings back to our current understanding of the relationship between Asian clams and the nuisance blooms of metaphyton.

### **Locations of research and methods**

The primary research location will be in the currently infested areas in the Southeastern portion of the lake (Zephyr Cove, Marla Bay, Stateline, El Dorado Beach, Timber Cove and Pope Beach). These study sites are ideal for accomplishing Objectives 1, 2 and 3 since it is likely that reproduction from these dense patches will contribute to local and regional spread of these species. The method for each objective is presented below.

**Objective 1. Determine the environmental parameters that contribute to the establishment of existing clam beds.** Lake Tahoe has a wide margin of sandy substrate along most of the nearshore (Figure 6) (Herold, Metz and Romsos 2007). Furthermore, discussions by agency staff suggest an immediate pilot scale assessment of control methods of clams (e.g. suction device) of infested area to begin in Fall 08. This may further create bare sediment on which clams can colonize. Colonization of the nearshore habitat by clams may also be possible if there is enough calcium, appropriate sediment substrate, and food availability (periphyton, pelagic phytoplankton, detritus) to support growth and reproduction. In this part of the study we will revisit 4 transects where clam beds were first detected in the southeastern region of Lake Tahoe (Figure 1). Benthic grabs will be collected from each location from 0-39 meters depth, the dominant depth distribution of clams found previously at these sites, at 10 meter intervals using a Shipek sampler. Locations **with** clams and adjacent areas **without** clams will be sampled. The density and biomass of live clams and shells (dead clams) will be recorded as a dependent variable. Special attention will be made to collect clam densities from a broad spectrum and patch size (area). The substrate type and

composition (fine sand, grains size, organic content) will be characterized for each grab following the methods in (Gordon et al. 1992). Along each grab a diver will measure the size and extent of each clam patch. The environmental parameters will be collected by SCUBA divers to avoid disturbing the clam beds twice in the year (early and late summer). Sediment particle size, porewater and water column nutrient content, (calcium, dissolved inorganic nitrogen, dissolved phosphorus, and reactive phosphorus) will be collected and analyzed. Micro and macronutrients will be analyzed using standard methods (American Public Health Association 2006). Ultra violet light and PAR information will be collected from each location and I-button temperature loggers will be deployed to record temperature changes in each bed over seasons. We will use Canonical Correspondence Analysis (CCA) to examine the relative importance of measured environmental parameters to numbers of individuals collected for each taxon (log-transformed).

**Objective 2. Develop a life history-growth model based on existing patches that can be applied to other locations to determine potential growth, dispersal and reproduction.** Asian clam have rapid growth and dispersal rates, are hermaphroditic, and have variable frequencies of reproductive events during the year (McMahon 2002). A majority of studies concluded that this species reproduces twice a year (Sousa 2008): one occurring in the spring and continuing during the summer and the other beginning in late summer and continuing through the fall. However, some studies found only one reproductive event, while in others three were found with differences among years even at the same locations (Doherty et al. 1987). Both individual clam growth and reproduction is controlled by temperature, but also by food availability (Rajagopal et al. 2000, Cataldo et al. 2001). Thus understanding Asian clam life history and growth dynamics in environmentally heterogeneous, existing patches in Lake Tahoe will allow us to determine the potential rates of growth and reproduction in other Lake Tahoe locations (Morris and Doak 2002).

We will create demographic models based on growth and fecundity of Asian clam in low and high density population patches (a proxy for environmental suitability for growth and reproductive rates) in the southeastern portion of Lake Tahoe (Figure 1). We will use environmental data collected in Objective 1 as independent variables, and growth and fecundity will be used as dependent variables. We will validate the predictions of the model with the following data: (1) Shipek grab samples to identify size class (generational cohort) distribution in the low and high density patches, (2) individual clam fecundities during the reproductive season-- measured by weighing the gonadal structure. A subsample of the gonad by weight will be counted to determine individual gametes per unit biomass, and (3) live clam specimens in the field marked at the beginning of the season (June 1) and recaptured at the end of the season (November 1) to determine growth rates. While there are many techniques that have been used to collect growth information from bivalves (modal-length frequency data, clam aging through growth rings, etc.), true estimates of habitat specific growth from a given location is to conduct *in situ* experiments (Mathews et al. 2003). This will be done using a mark-recapture technique of individuals (n=50 per location) representing three sizes (small, medium, and large) from low and high density populations in the study area. Growth will be measured as changes in length from anterior to posterior which will be determined using digital vernier calipers. Individuals will be marked using water-proof paper held with Selly-Araldite 5 minute dry glue. At the onset of the marking period, half of the marked population will be returned to the sediments while the other half will be placed in cages made of mesh (243 um) and PVC pipe and anchored to the bottom of the lake in the same location to ensure recapture. Previous research suggests similar growth rates between cage and uncaged bivalves (Mathews et al. 2003).

We will apply this model to a locality in Emerald Bay to predict the likelihood of establishment, and potential growth and reproduction. We selected Emerald Bay as a suitable potential receiving habitat based on preliminary surface current data (Figure 5) showing probable cross-lake transport from clam bed areas, its predominantly sandy substrate (Figure 6), the presence of existing aquatic invasive species (Eurasian watermilfoil and curly leaf pondweed), and its protection from high energy wave action. A sediment synoptic sampling of similar environmental parameters as those collected in Objective 1 from the southeastern portion of the lake will be collected from the nearshore margin of Emerald bay for model input. Likelihood of Asian clam establishment, growth and fecundity can then be estimated for Emerald Bay. This model can be applied toward a lake-wide risk assessment at a later time given an understanding of environmental parameters in other locations.

While this model captures the dynamics of growth and reproduction of Asian clam, it does not incorporate dispersal or range expansion from existing plots. To address this, we will mark four 3 m<sup>2</sup> areas with known infestations of Asian clam at the onset of the project, and measure the spread outside of these zones monthly until the reproductive period concludes. We will have two treatments of this experiment: one within Asian clam pilot control plots (see

Knowledge Gaps and Key Questions), and the other in areas outside of the control plots. This will allow for observation of range expansion within existing beds.

**Objective 3. Create a transport model that estimates the general location of transport of young life stages of Asian clams from the existing beds.** UC Davis has developed a hydrodynamic circulation model for large lakes (Rueda and Schladow 2003; Rueda et al. 2008a). This has been successfully applied to Lake Tahoe (Rueda et al. 2003) although the horizontal grid cell size was 500 m – this was satisfactory for whole-lake circulation patterns. Under Round 7 SNPLMA funding, this model is being extended by developing the methodology to include an embedded fine scale mesh at the lake boundary at one location. This new model will allow the entire lake to be modeled with 200 m horizontal grids, and with the nearshore areas simultaneously being modeled with resolution as low as 20 m, thereby capturing near-shore circulation patterns as well.

As part of the current project proposal, the model will be further refined to allow a finer scale mesh to be included around the entire perimeter of the lake. This will be the model we will use to predict the transport of young life stages of Asian clams. Using spatially interpolated wind fields from 6 meteorological stations around the lake, the model will be run for different times of the year to produce predictions of lake circulation (down to a resolution of approximately 20 m at the boundaries). GPS drifter data has been collected, and will continue to be collected to provide validation of the circulation patterns predicted by the model. Using a recently developed Monte-Carlo based approach (Rueda et al. 2008b), probability density functions of the likelihood of the current trajectories will also be produced. An existing particle tracking model (Rueda et al 2008a) will be used to “seed” the flow in the area of the existing clam beds with particles (i.e. young life stages of clams) and their trajectories recorded. In addition, the exposure of the “particles” to temperature, light, and ultraviolet, as well as the total time of travel can be determined, and hence a statistically based prediction of their fate can be produced. Measures controlling the survival of young clams during transport are not being addressed in this study. A second proposal, “UV Radiation as a control of the invasive Asian clam (*Corbicula fluminea*) in Lake Tahoe: Phase II – Field Experiments and UV Threshold Index” will be submitted by our collaborators for SNPLMA Round 8 ( research funding).

**Objective 4. Develop a preliminary understanding of clam impact on particle size (algae and sediment) distribution and nutrient excretion rates with different food sources.** Pilot research in late summer 2008 suggested that Asian clams may be linked to the algal blooms of *Zygnema* in Marla Bay (Wittmann et al. 2008). It is unclear however if clams may impact the structure of seston (phytoplankton, sediment, and detritus) within the lake water column. In other ecosystems, invasive clams have altered the dominant zooplankton population by out-competing them for algal resources or preying on early life stages (Kimmerer et al. 1994). The Asian clam has been found to have variable filtration rates of seston depending on the temperature and food concentration in the water (Lauritsen 1986). While the ultra-oligotrophic waters of Lake Tahoe have low algal biomass the nearshore environment has variable periphyton biomass depending on the location (TERC 2008). In order to develop a preliminary understanding of the impact of varying clam densities on the pelagic ecology of the lake, we will conduct short-term (24 hour) laboratory experiments with four treatments: three clam densities (low, medium, high) found within the lake and a control (no clams). Each treatment will have 5 replicates and the mean clam size found in the lake will be used for each replicate. Three experiments will be conducted representing different seasons (late Spring, early Summer, and late Summer). They will be maintained at ambient lake temperatures representing these seasons. The following parameters will be measured before and after the experiment: seston particle size, chlorophyll *a* (pheophytin corrected), and nutrients (nitrate-nitrite, ammonium-ammonia, soluble reactive phosphorus). Analysis of variance will be employed to compare seasonal treatments.

**Relationship of the research to previous relevant research, monitoring, and/or environmental improvement efforts in accordance with TRPA Regional plan standards.** In the Summer-Fall of 2008, members of the LTAISWG and UCD-UNR science team began to develop a strategy to control the existing Asian clam beds in Lake Tahoe. This has been a rapidly evolving discussion given that the full spatial extent of the clam beds was just being discovered in August, and research/monitoring of Asian clam in Lake Tahoe has been going on for less than three months. It was recommended that a pilot investigation be conducted soon (target time: winter 2008-2009) to field test various control alternatives including suction removal, bottom barriers and chemical treatment options in the laboratory. Agency executives from the Tahoe Regional Planning Agency, Nevada Division of State Lands, Lahontan Regional Water Quality Control Board and the California Tahoe Conservancy directed the LTAISWG and the UCD-UNR science team to begin development of these pilot removal investigations and to develop a science plan to evaluate these actions and provide managers with the knowledge needed to devise a full-scale management

plan. This SNPLMA proposal is being submitted as part of this overall effort. Investigations and control of all aquatic invasive species is a topic expressly called out in the Basin's Environmental Improvement Plan (EIP) and this work on controlling existing bivalve invasive species is being done in concert with a recently initiated plan to prevent the future introduction of zebra and quagga mussels, etc. through an extensive boat inspection program.

**Strategy for engaging with managers**

Informally we will be in close contact with the LTAISWG as the pilot clam removal project commences in the winter of 2008-2009. We will formally engage managers by presenting quarterly updates in either an oral or written format to the LTAISWG. This working group was created over two years ago to address invasive species issues within the Tahoe basin and will serve as a Management Advisory Group for this project. It is comprised of agencies and researchers actively involved with controlling, managing and researching invasive species in the Tahoe basin. When requested we will convene one technical meeting with agency staff and one public outreach meeting each year. Results from our project and reviews of other useful information related to Asian clam ecology and management will be posted on the UCD website (terc.ucdavis.edu) and the UNR website (environment.unr.edu). Results of the research will also be presented at the biennial Tahoe Research Symposium.

**Deliverables/products**

There is an urgent need to develop a risk analysis and predictive model for describing the impact of clams on Lake Tahoe. Lake managers are seeking information on the efficacy of various control methods in managing clam populations. This will be addressed in secondary proposals developed with agency staff and personnel in October 2008. In this proposal we are providing critical information on the potential areas these clams will spread along the lake margins as well as impacts to lake clarity (nearshore and offshore) and nuisance metaphyton. We will provide quarterly progress reports, a preliminary report (end of first year), and a final report (end of project). As part of this project we also expect to make presentations at annual scientific meetings (e.g. ASLO, ESA, regional meetings), submit manuscript(s) for publication, and make public presentations of data as requested.

**Schedule of Events/Reporting and Deliverables**

<b>Milestone/Deliverables</b>	<b>Start Date</b>	<b>End Date</b>	<b>Description</b>
Submit quarterly progress reports	June 09	May 11	Submit brief progress report to Tahoe Science Program coordinator by the 1st of July, October, January, and April.
Objectives 1, 2: Field collections	June 09 June 10	Nov 09 Nov 10	Initiate field collections for assessing size structure of the population for the demographic model and environmental parameters driving establishment and growth
Objectives 1, 2: Lab processing	Nov 09 Nov 10	May 10 Jan 11	Processing samples in laboratory for demographic model development, analyze environmental parameter samples, repeat in second year as needed
Objective 3: Field collection and data processing, model development	June 09	Feb 09	Place sensors to measure currents and develop data for the refining a nearshore circulation and transport model
Objective 4: Experimental set up and implementation	Sept 09	Aug 10	Conduct 3, short term experiments documenting potential impacts to lake seston
Present quarterly updates to the LTAISWG and relevant agencies (TRPA, USFS, NTCD, ACE, BOR, etc.)	June 09	May 11	Present brief updates to the LTAISWG at regular meetings, call a special meeting if needed to present information that may help managers develop control methods for Asian clams

**Budget justification.**

The primary funds for this project will be used to hire staff and undergraduate students to collect, process field samples, and to run experiments describing the impacts of clams on Tahoe seston. Furthermore funds will be used by the subcontractor to assess the potential transport of younger stages of clams to other regions of the lake. Secondary costs include paying for travel and field operating costs. **NO FUNDS HAVE BEEN REQUESTED**

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## Figures

Figure 1. Locations and densities of Asian clam populations based on grab sample transects in 2008.

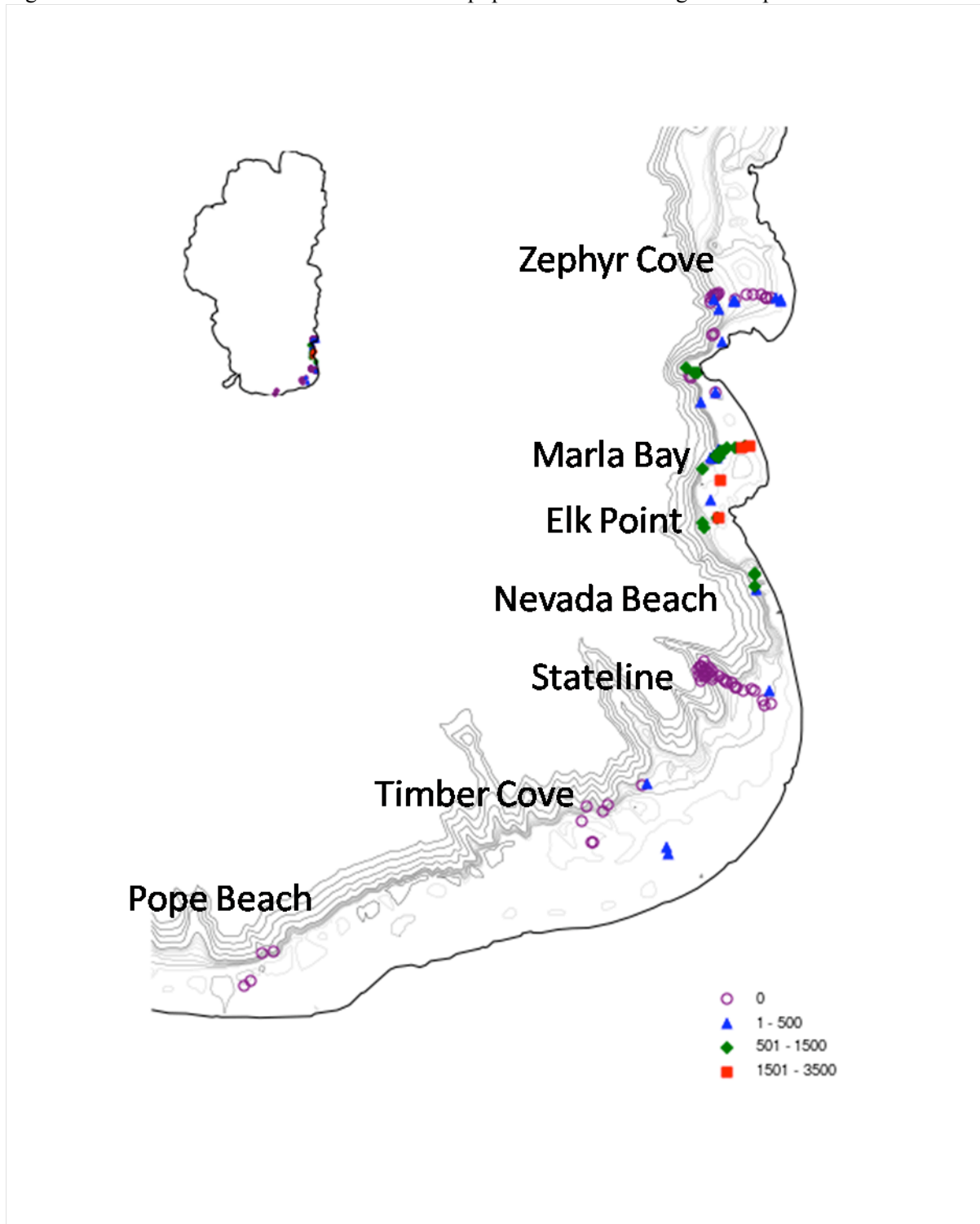


Figure 2. Asian clam nutrient excretion (ppb) per day by shell length at 19° C and 4° C.

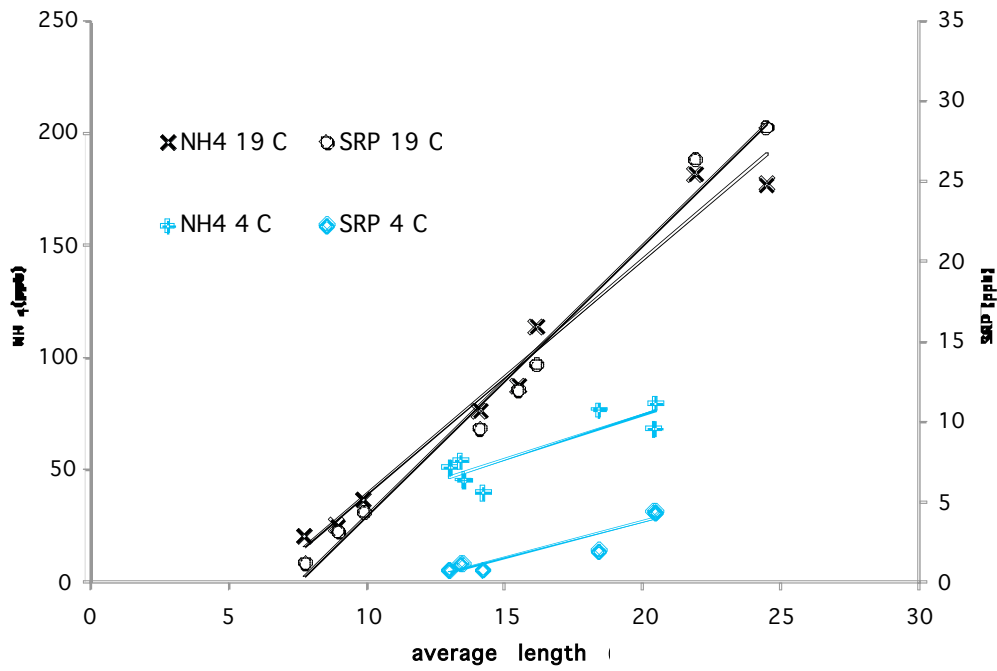


Figure 3. Phytoplankton bioassay results after a 7 day period using clam excrement dilutions with Lake Tahoe water

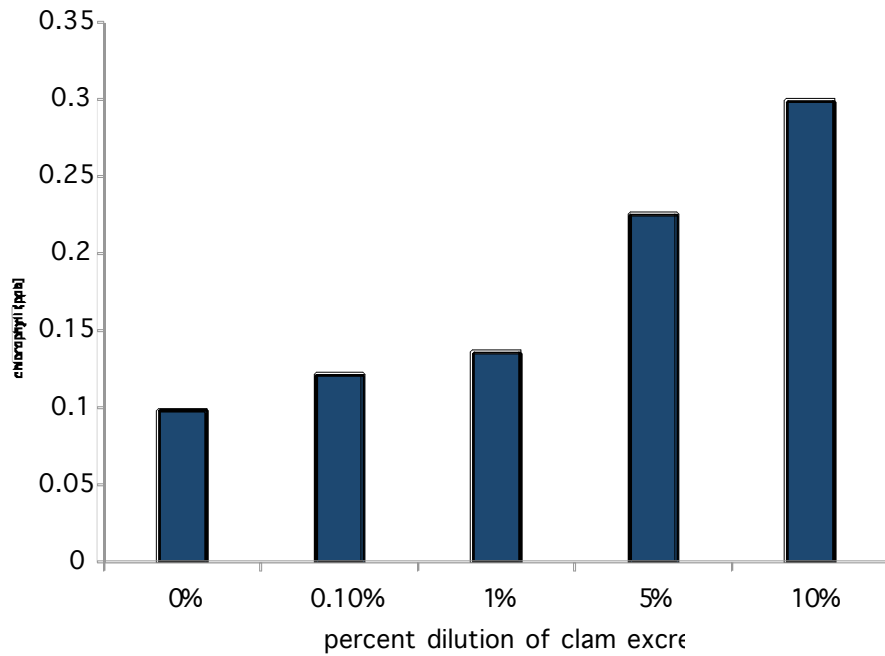


Figure 4. Calcium concentrations in Lake Tahoe sediment porewaters.

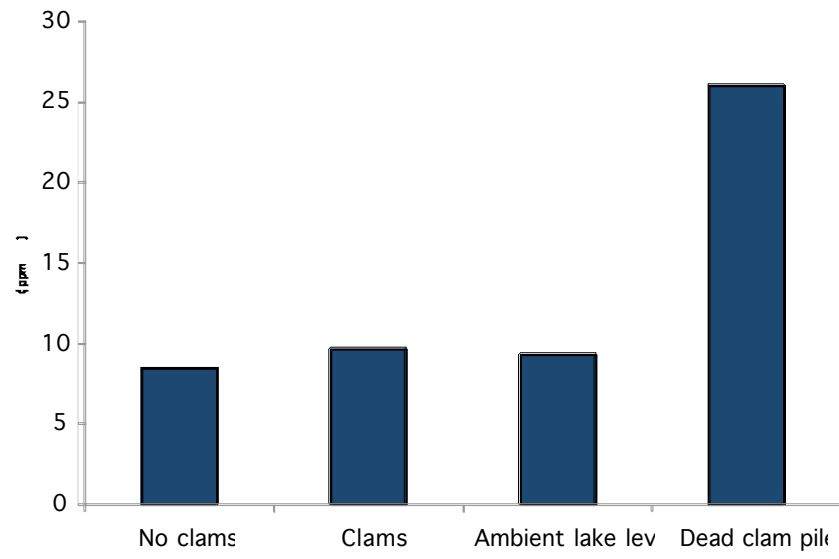


Figure 5. Surface current trackers, Lake Tahoe August 2008. Time sequence progresses over a 5 day period from left to right.

