Lake Whatcom Aquatic Invasive Species

Incident Report

Notes on Visual Observations of Asian clams in Lake Whatcom
September 17-30, 2011

Lake Whatcom Management Program

Asian clam (*Corbicula fluminea)*

- Asian clams are also known as prosperity, pygmy, gold, or Asiatic clams.
- Asian clams are small (< 5cm) filter feeding bivalves with yellowish brown to black shells with concentric, evenly spaced ridges on the shell surface.
- Asian clams are native to southern Asia, Australia, and the eastern Mediterranean.
- This species was first collected in the United States in 1938 along the Columbia River in Washington State and is currently found in 38 states and the District of Columbia (**Figure 1)**.
- Asian clams are thought to have been deliberately introduced as a food item by Chinese immigrants but may also have been introduced as live bait or transported to the United States in ship ballast water.
- Asian clams may move from one waterbody to another by attaching to debris or vegetation that is unintentionally transported via watercraft and recreational equipment, through bait bucket introduction, release from aquarium dumps, and intentional introductions for ceremonial purposes or with intent for sale as a food item. Veligers may also be transported in live wells or bilge on watercraft or passively with water currents.
- Asian clams have high dissolved oxygen requirements and are generally found in lakes and streams with silt, mud, sand, and gravel substrate. Asian clams typically prefer sandy substrates although they have been found to live in silt or muddy substrates.
- They can tolerate salinities of up to 13 parts per thousand for short periods and temperatures between 2-36° C (35.6-96.8°F).
- While there has been no definitive study on the impact of calcium on Asian clams, it appears that at levels > 6 mg Ca/L and a pH > 6.5, Asian clam populations can be relatively successful (Lake Whatcom: 7.36-11.72 mg Ca/L and pH 6.3-9.3 in Basin 1).
- Asian clams are able to reproduce asexually and can release up to 100,000 juveniles throughout their lifetime. Temperatures must be above 16°C (60.8°F) for larval release.
- Asian clams can reach densities of up to 50,000 clams/m^2 (as observed in the San Francisco Bay).
- The maximum lifespan of Asian clams is 7 years, averaging from 2-4 years.
- Predators of Asian clams include birds, raccoons, crayfish, flatworms and a variety of fish species including carp, catfish, largemouth bass and sunfish.
- Due to the large population densities of Asian clams and their ability to tolerate a variety of environmental conditions while filtering large quantities of plankton from the water column, they are capable of altering nutrient cycles, outcompeting native species for food and space, making recreational areas hazardous, and fouling water conveyance systems.

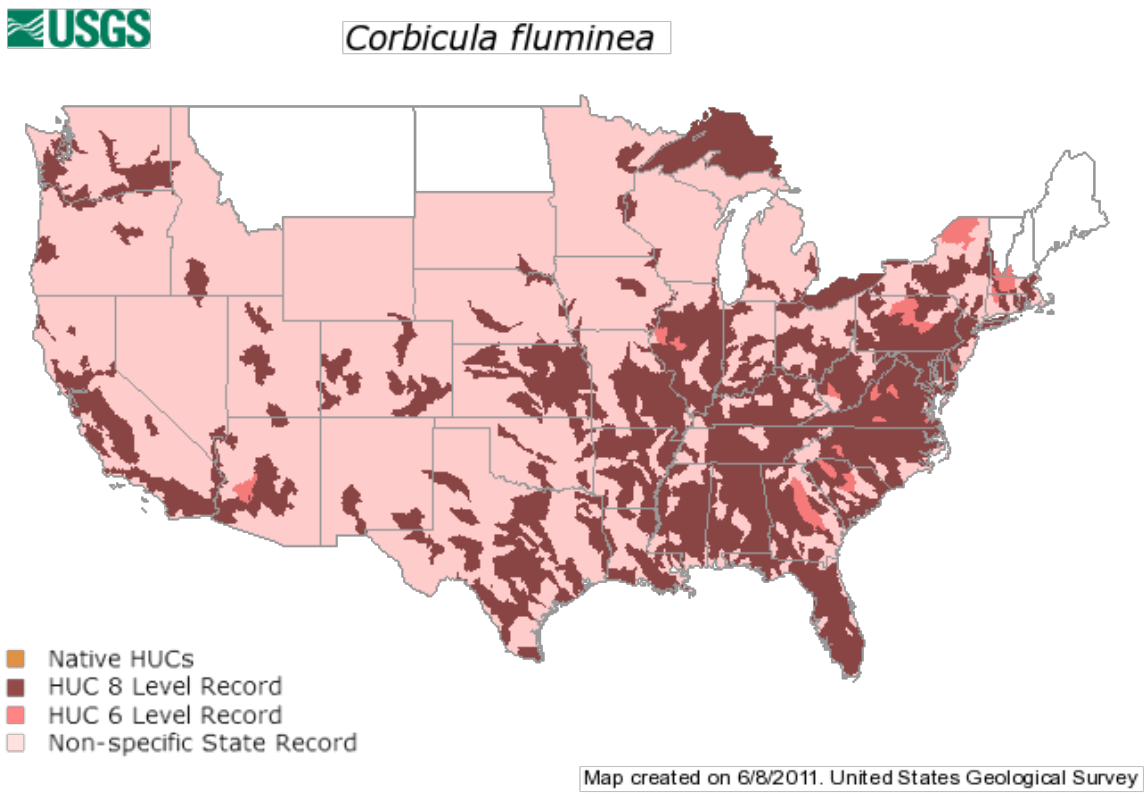

Figure 1. Map showing distribution of Asian clams, *Corbicula fluminea* in United States as of 6/8/2011 (USGS NAS Database Factsheet, http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=92).

Timeline of Events for Lake Whatcom

September 17, 2011

Washington Department of Fish and Wildlife (WDFW) officers conducted a demonstration boat inspection station at Bloedel Donovan Park. During the event, a resident from Basin 1 approached WDFW officers and City and County staff with a sample of unidentified mollusks that he had collected from his beach. WDFW enforcement officer Sergeant Carl Klein was able to field verify that the unidentified mollusks were Asian clams, *Corbicula fluminea.* Sergeant Klein took the clams back with him to Olympia where they could be verified by WDFW personnel.

September 19, 2011

Sergeant Klein contacted City staff to confirm that the clams collected by the resident from Basin 1 were Asian clams.

September 19-23, 2011

City staff began contacting aquatic invasive species personnel from the Washington Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, and the Washington State Department of Ecology to gather information on the potential impacts that might result from an Asian clam infestation in Lake Whatcom.

City staff began a more detailed review of the literature to gather information on the impacts that Asian clams have on ecosystems, recreation, and water supply infrastructure as well as response strategies currently being implemented in infested waterbodies.

September 26, 2011

City and County staff introduced the Lake Whatcom Aquatic Invasive Species Action Plan to City Council and informed the City Council that there is a confirmed Asian clam infestation in Lake Whatcom. Council were informed that City and County staff would be conducting shoreline surveys to determine the extent of the infestation and potential impacts to the City's intake.

September 27, 2011

City and County staff began conducting beach and shoreline surveys in Basin 1. Asian clams were located at two of the three sites surveyed, including in the swimming area at Bloedel Donovan Park. Initial surveys turned up mostly dead shells. Staff collected samples and recorded the location of surveyed sites using a GPS unit.

September 29, 2011

Staff gave an update to the Interjurisdictional Coordinating Team (ICT) on the preliminary findings from the surveys and from the literature review.

City and County staff continued communication with representatives from the Washington Department of Fish and Wildlife, the Washington Invasive Species Council, the U.S. Fish and Wildlife Service, and the Washington State Department of Ecology to discuss preliminary findings and potential response strategies.

September 30, 2011

City staff held a conference call with Allen Pleus, the Aquatic Nuisance Species Coordinator for Washington State and the Washington Department of Fish and Wildlife. Pleus called to get an update on the infestation and was able to answer staff questions regarding Asian clam impacts to water supply infrastructure and potential response strategies.

City and County staff continued to conduct beach and shoreline surveys in Basins 2 and 3. Asian clams were located in Basin 3. Surveys conducted at Lakewood turned up a substantial number of live clams at several locations along the shoreline with many clams found buried beneath the sediment. Samples were collected and the locations of surveyed sites were recorded using a GPS unit.

Upon completion of the survey, City and County staff returned to Basin 1 to check for clams below the sediment. Staff were able to find a considerable number of live clams below the sediment in the swimming area at Bloedel Donovan Park. Staff were also able to confirm the presence of Asian clams at the beach where the initial sample was collected by the resident from Basin 1.

Observations of invasive Asian clams (*Corbicula*) in Lake Whatcom from September 27-30, 2011:

Observations were made by City and County staff by wading or diving in shoreline areas to check for presence or absence of clams, collect samples, and to take photographs. No attempt was made at this time to conduct a detailed count of clams, although an estimated count was made at one site. **Figure 2** presents a map of the sites surveyed for the presence of Asian clams, *Corbicula fluminea* as of September 30, 2011.

Beach at Britton Road/North Shore Drive (September 27, 2011): Staff found less than 10 dead shells of Asian clams located close to shore along the public beach access. Substrate at this site was predominantly rocky/large cobble. Beyond the public beach access, at the Silver Shores Private Beach, staff discovered a large number of live Asian clams in woody debris as well as a large number of dead shells on the beach. No surveying was done to determine whether there were Asian clams buried in the sediment. Substrate at this site was predominantly sandy/small cobble.

Beach at North Shore Stormwater Facility (September 27, 2011): No clams were found at the beach located at the North Shore Stormwater Facility. Substrate at this location was predominantly silt and mud.

Beach at North Shore Residence (September 30, 2011): Staff found a large number of live Asian clams in woody debris and below the sediment surrounding the floating dock at this North Shore residence where the clams were first sighted.

Bloedel Donovan Park (September 27 and 30, 2011): During initial surveys conducted at the Bloedel Donovan swimming area, staff discovered a very large number of dead shells distributed throughout the swimming area. In one section of the swimming area, close to the pilings, staff found a significant number of large-sized Asian clams both dead and alive indicating that these clams have been present at this site for some time. Staff were able to map the extent of the infestation in the swimming area and found that the numbers of Asian clams diminished significantly as they approached the boat launch. Follow-up surveys conducted on September 30 showed a significant number of live clams were buried in the sediment that had not been observed during the previous survey. This follow-up survey suggests that the extent of the Asian clam infestation at this site is much greater than we initially observed. Substrate in the Bloedel Donovan swimming area is predominantly sandy with small cobbles while the substrate near the boat launch is dominated by larger rocks/cobbles.

Beach at Cable Street/Lake Whatcom Boulevard (September 30, 2011): No clams were found at the beach located in front of the pumping station at Cable Street/Lake Whatcom Boulevard. Substrate at this location was dominated by larger rocks/cobbles.

Beach at Strawberry Point Residence (September 30, 2011): No clams were found at the beach located at the residence at Strawberry Point. Substrate at this location was dominated by silt and sandstone rock formations.

Beach at Lakewood/WWU (September 30, 2011): Staff collected several Asian clam shells scattered on the beach at Lakewood. A significant number of live Asian clams were also discovered throughout the Lakewood site. Some of the live clams found were large in size indicating that these clams have been present at this site for some time. Staff continued to survey approximately 150-200 feet to the north of the Lakewood launch site to determine the extent of the Asian clam infestation at this location. Staff continued to find scattered pockets of large-sized live Asian clams as they walked to the north of the launch site. Staff were able to identify two very dense, well-established Asian clam colonies in the vicinity. At one of these locations, staff estimated their population density to be approximately 250 clams/m^2 (visible on the surface). Clams ranged in size from juveniles to well-established adults. Substrate at the Lakewood launch site was predominately sandy/small cobble and became more dominated by larger cobble to the north of the launch.

Beach at Sudden Valley Marina (September 30, 2011): Staff conducted a preliminary survey at the Sudden Valley Marina. While no live clams were found at this location, two clam shells were discovered and collected. Substrate at this location was sandy/small cobble. A more detailed survey of this area will be conducted in conjunction with Sudden Valley staff.

Beach at WDFW Launch (September 30, 2011): No clams were found at this location. Substrate was dominated by larger rocks/cobbles. Staff observed a lot of wave action at this site which may hinder the establishment of Asian clams.

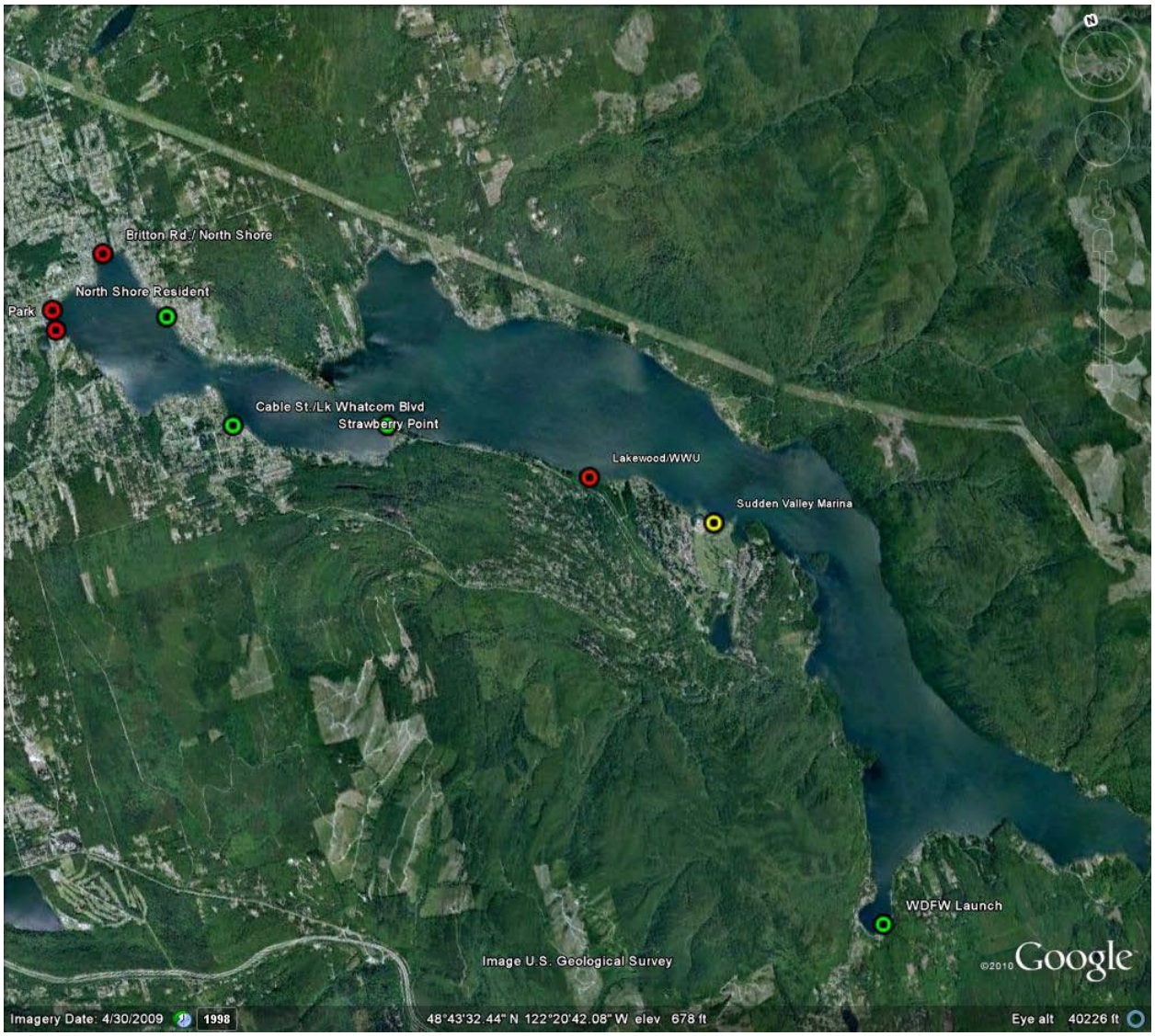

Figure 2. Map showing sites visited to check for presence of Asian clams, *Corbicula fluminea* along shoreline of Lake Whatcom from September 27-30, 2011. Red circles indicate surveyed sites where Asian clams were present (Bloedel Donovan Park, North Shore Residence, Britton Road/North Shore Beach, Lakewood/WWU). Yellow circles show surveyed sites where only dead Asian clams (shells) were discovered (no live specimens)(Sudden Valley Marina). Green circles show surveyed sites where Asian Clams were absent (Beach at North Shore Stormwater Facility, Cable St/Lake Whatcom Blvd, Strawberry Point Residence, WDFW Launch) (L. Baldwin).

Figure 3. Map showing sites visited to check for presence of Asian clams, *Corbicula fluminea* along shoreline of Basin 1 in Lake Whatcom from September 27-30, 2011. Red circles indicate surveyed sites where Asian clams were present (Bloedel Donovan Park, North Shore Residence, Britton Road/North Shore Beach). Thicker red lines show where the heavier densities are located. Green circles show surveyed site where Asian Clams were absent (Beach at North Shore Stormwater Facility) (L. Baldwin).

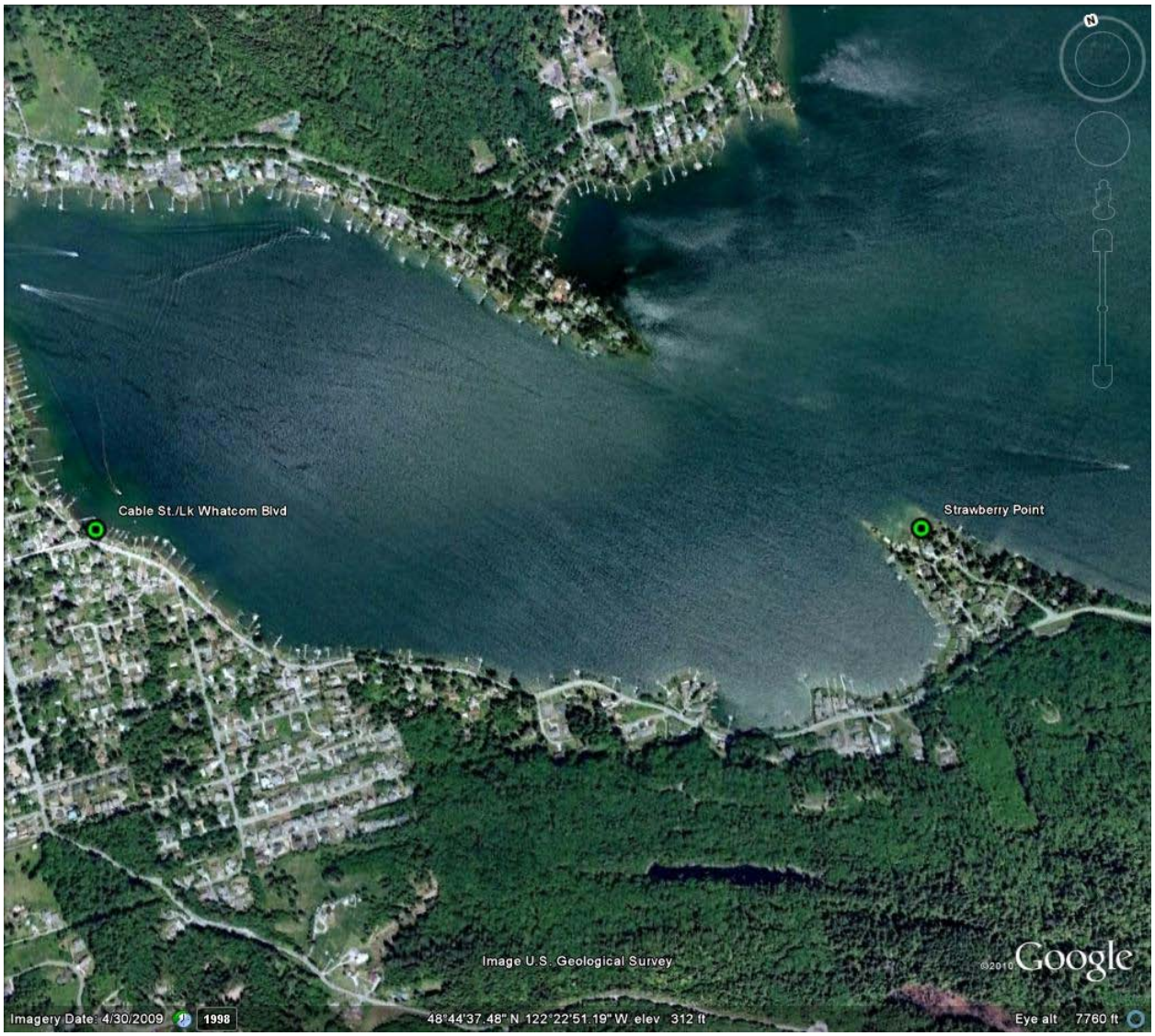

Figure 4. Map showing sites visited to check for presence of Asian clams, *Corbicula fluminea* along shoreline of Basin 2 in Lake Whatcom from September 27-30, 2011. Green circles show surveyed sites where Asian Clams were absent (Cable St/Lake Whatcom Blvd and Strawberry Point Residence) (L. Baldwin).

Figure 5. Map showing sites visited to check for presence of Asian clams, *Corbicula fluminea* along shoreline near Lakewood/WWU and Sudden Valley Marina from September 27-30, 2011. Red circles indicate surveyed sites where Asian clams were present (Lakewood/WWU). Thicker red lines show where the heavier densities are located. Yellow circles show surveyed sites where only dead Asian clams (shells) were discovered (no live specimens) (Sudden Valley Marina) (L. Baldwin).

Initial Observations and Conclusions from Preliminary Survey Results

Information gathered during these preliminary surveys indicate that Asian clam colonies are well established at two locations in Lake Whatcom. Additional shoreline surveys are needed to determine the full extent of the Asian clam infestation. Asian clam specimens collected in the swimming area at Bloedel Donovan Park and along the shoreline at Lakewood were close to an inch in size indicating that they have been established and reproducing in Lake Whatcom for at least two to four years. Both sites of established colonies are proximal to recreational areas with boat access. Lakewood is also proximal to the floatplane facility, Floathaven Seaplane Base.

Clarifications from literature review and communications with federal and state invasive species experts:

While an initial review of the literature suggests that Asian clams are similar to zebra/quagga mussels, further clarification from the literature and communications with federal and state invasive species experts leads us to conclude that there are considerable differences between these species that need to be discussed.

Mobility

Unlike zebra/quagga mussels, Asian clams do not have free-swimming larvae but brood their young in their shell and then release them into the current. Asian clam juveniles up to 5 mm have a small foot and a single long byssal thread that they can use to attach to the substrate or to debris to transport them through the water. Unlike the zebra/quagga mussels, they lack cilia to propel them through the water and must rely on currents, floating debris, aquatic vegetation, and human activity to be transported from one waterbody to another. Once the Asian clams become adults, they lose the byssal thread and so are incapable of attaching to hard surfaces as occurs with zebra/quagga mussels. While they are capable of moving with the current using a mucus dragline, they are generally found buried beneath the sediment.

Attachment

Due to the presence of a single long byssal thread during the Asian clam juvenile life stage, these clams are capable of attaching to surfaces such as woody debris, aquatic vegetation, and filamentous algae which may facilitate their transport between waterbodies. However, this byssal thread is insufficient for attachment to hard surfaces, such as pipes and hulls, making their method for fouling infrastructure quite different to that of zebra/quagga mussels.

Fouling

Zebra/quagga mussels are able to attach to and foul native biodiversity, watercraft and recreational equipment, and water conveyance structures using their byssal threads. However, as adult Asian clams do not have byssal threads, their mechanism for fouling water conveyance structures is quite different and in most cases is due to entrainment or indirect capture rather than direct attachment. In some cases, with pipes of small diameter, Asian clam shells can become lodged in the pipe and plug the opening so that any material or sediment accumulating behind the lodged shell will eventually impede the flow of water through the pipe. In other

cases, with pipes of larger diameter, shells may accumulate in low-flow areas reducing the flow and trapping sediment until the flow is greatly reduced or ceases completely.

Preferred Habitat/Substrate

Whereas zebra/quagga mussels prefer hard surfaces, Asian clams are generally found burrowed in sandy/small cobble substrates. However, Asian clams are highly adaptable and can also inhabit and reproduce in areas with rocky substrates. In these areas, they tend to burrow in the sediment, accumulate on the downstream sides of boulders or rocks, or in low-flow areas or under rocks where they can take refuge from the current.

Phosphorus and Nutrient Cycling

Asian clams are responsible for altering nutrient cycles through a variety of mechanisms including the deposition of feces and pseudofeces and by disturbing the sediments when burrowing or deposit feeding. Specifically, Asian clams make nutrients available to the system through the excretion of feces and pseudofeces that are high in nitrogen (as ammonia) and phosphorus (as soluble reactive phosphorus) that can then be rapidly absorbed by algae. Elevated excretion rates during warmer summer temperatures results in higher concentrations of nitrogen and phosphorus that are associated with dense algal blooms. For example,

> Along southeastern portions of Lake Tahoe during July-September 2008 dense algal blooms of the green filamentous algae *Zygnema sp*. and *Spirogyra sp*. were often co-located with Asian clam beds. These are both filamentous green algal species, which may exist attached or unattached to substrate, whose accelerated growth has been linked to increased levels of nutrient in the water column, sometimes as a result of bivalve excretion (Wittman et al. 2008).

Additionally, Asian clams can deposit feed using their muscular foot which allows them to remove nutrients from the sediment. During this process, Asian clams can disturb the sediments as they burrow down releasing any nutrients, such as phosphorus, that may be trapped in the sediment and making them available in the water column.

Calcium Availability

Asian clams are also thought to increase the risk of invasion for other aquatic invasive species, such as zebra/quagga mussels, through their ability to bioconcentrate calcium in sediments where dead shell matter has been accumulating. In Lake Tahoe, scientists observed that:

> Sediment calcium porewater concentration in live clam beds and in sediments where no clams are present are similar to water column levels—around 9 to 10 ppm. However, sediment porewater calcium concentrations in dead clam matter had a concentration greater than twice the ambient lake level at 27 ppm, suggesting that the dissolution of dead clam matter might be contributing to elevated calcium levels (Wittman et al. 2008).

While Lake Whatcom is considered to be a low-calcium waterbody, this study suggests that there is the potential for sites where dead clam matter is accumulating to become “Calcium hotspots” where other calcium-limited aquatic invasive species, such as zebra/quagga mussels, may be able to thrive.

Dissolved Oxygen

The high dissolved oxygen requirements of Asian clams may also be responsible for exacerbating dissolved oxygen deficits. Asian clams consume dissolved oxygen and release carbon dioxide through filter feeding and respiration. When found in large densities, this can result in dissolved oxygen deficits which may ultimately limit the clam's survivability.

Conclusions

1) Asian clams may have impacts on water supply intake pipes and infrastructure that is in contact with or has collected sediment or aquatic vegetation within the structure.

2) Asian clams will impact the quality of recreational beaches as shells accumulate.

3) Asian clams will impact ecosystem diversity by displacing native species, such as the native mussels, *Anodonta sp.*, observed by staff at all of the sites surveyed.

4) Asian clams will impact nutrient cycling and dissolved oxygen levels in Lake Whatcom through their ability to use dissolved oxygen and make nitrogen, phosphorus, and calcium available in the water column.

5) Increased nutrient availability will likely increase certain algal blooms.

6) Asian clams increase our risk for the establishment of other aquatic invasive species as a result of their ability to alter the benthic habitat and to make nutrients and calcium available in the water column.

Next Step

Staff will continue to map the extent of the infestation. Staff is also in the process of discussing response strategies that are being used in other infested waterbodies that may be employed to minimize the impacts associated with the infestation in Lake Whatcom. This infestation emphasizes the immediate need for us to invest in a prevention program for Lake Whatcom that will give us the capability to prevent future aquatic invasive species infestations while ensuring early detection and rapid response in the case that another infestation occurs.

Research Questions

1) What is the extent of the Asian clam infestation?
2) What are effective response options that can be employed in Lake Whatcom?
3) How long can Asian clams survive out of the water at freezing temperatures?
4) How much phosphorus is being added to the water column as a result of the Asian clam infestation?
5) How limiting is low dissolved oxygen to the survival of Asian clams?
6) Are the algal species benefited by the increase in nutrient availability likely to impact water plant operations?
7) How will Asian clams impact the City's intake pipe and residential direct withdrawal systems throughout the lake?
8) What impact will the Asian clams have on our native biodiversity?
9) What are the impacts of predation on Asian clams in Lake Whatcom?
10) Are there other vectors for spread that need to be addressed when creating an invasive species prevention program for Lake Whatcom (i.e. aquarium release, emptying of bait buckets, waders, etc)?

Photo 1. Photo of size range of Asian clams collected during surveys of Lake Whatcom with ruler for scale (L. Baldwin 9/30/2011).

Photo 2. Photo of live Asian clams collected during survey at Lakewood/WWU site (S. Bolivar 9/30/2011).

Photo 3. Photo of staff surveying for Asian clams at Lakewood/WWU site (S. Bolivar 9/30/2011).

Photo 4. Photo of live Asian clams collected at Lakewood/WWU site (S. Bolivar 9/30/2011).

Resources

Lake George Asian Clam Eradication Project. http://www.stoptheasianclam.info/

Plan to Eradicate the Infestation of the Invasive Species Asian Clam in Lake George. Lake George Asian Clam Rapid Response Task Force. http://www.lgpc.state.ny.us/PDF/Eradication%20Plan.pdf

Tahoe Environmental Research Center (TERC). Aquatic Invasive Species – Asian clams. http://terc.ucdavis.edu/research/aquaticinvasives.html

Tahoe Environmental Research Center (TERC). Tahoe: State of the Lake Report 2009 – Asian Clam. http://terc.ucdavis.edu/stateofthelake/StateOfTheLake2009_Chapter6.pdf

USGS NAS Database Factsheet - Asian clam (*Corbicula fluminea*) http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=92

USGS NAS Database – Asian clam distribution in Washington State http://nas.er.usgs.gov/queries/CollectionInfo.aspx?SpeciesID=92&State=WA

Wittman, M., Reuter, J., Schladow, G., Hackley, S., Allen, B., Chandra, S. and A. Caires. (2008). Asian clam (*Corbicula fluminea*) of Lake Tahoe: Preliminary scientific findings in support of a management plan. Tahoe Environmental Research Center. http://terc.ucdavis.edu/research/AsianClam2009.pdf