Analyzing The Potential Spread and Impacts of Invasive New Zealand Mudsnail Regarding Capitol Lake Estuary Restoration Plan

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Capitol Lake History

Before the installation of the 5th Avenue Dam, the Capitol Lake Basin served as an important natural estuary providing habitat and ecosystem services benefiting marine life, cultural significance to local native tribes, and recreational enjoyment for the city of Olympia, Washington. As stated by the Washington State Department of Enterprise Services (DES), in an attempt to advance the visual appeal of the Washington State Capitol Campus, officials started building the 5th Ave. Dam in 1949, which restricted the salt water input from Budd Inlet from mixing with fresh water from Deschutes River, creating a stagnant body of water named Capitol Lake (DES, 2022). Without the constant mixing of brackish water, Capitol Lake began to lose its beneficial attributes and introduced unexpected consequences. Sediments began to build uncontrollably and nutrient levels spiked which led to a harsh reduction in water quality, leaving a lake which is now unusable to the public and unfit to support a diverse ecosystem (Hayes et al., 2008).

Introduction of the New Zealand Mudsnail

The altered and declining aquatic conditions of Capitol Lake did not deter various invasive species from settling. In 2009, the discovery of the invasive aquatic New Zealand mudsnail in Capitol Lake influenced its official closure to the public (DES, 2022; Johannes, 2021; Stockton-Fiti, 2018). The New Zealand mudsnail (*Potamopyrgus antipodarum*, NZMS) is a species of gastropods, belonging to the phylum Mollusca, which has been spreading through waterways of the United States since the 1980's (Johannes, 2021). This organism can pose a particularly challenging threat as an invasive species due to the speed of population growth and ability to withstand a range of environmental conditions (Stockton-Fiti, 2018; Paolucci & Thuesen, 2020). Spread of NZMS occurs passively when individuals are transported by adhering to traveling marine debris, animals, and especially through human activity including boats (DES, 2022; Paolucci & Thuesen, 2020).

Implications of Estuary Restoration on New Zealand Mudsnail Spread

Capitol Lake's primary stakeholders, the DES, worked with the Squaxin Island Tribe, government officials, and community members to develop a preferred estuarine restoration plan that involves removing the 5th Ave. Dam and reintroducing the natural tidal flow from Budd Inlet. As explained in the DES Final Environmental Impact Statement (DES, 2022), the estuary restoration plan was one of four proposals which included a managed lake, hybrid, and no action option. The DES concluded restoring the input of sea water to the Capitol Lake surpassed the other options and met the recognized goals for long term management of the waterbody: to improve water quality, manage sediments, improve ecological functions, and enhance community use. Consequently, when the 5th Ave. Dam is removed, there will remain a 500 ft. wide pathway between the NZMS infested Capitol Lake and uninfested Budd Inlet. Some researchers are concerned that removing the dam will put surrounding waters and ecosystems at risk of NZMS colonization which may lead to negative effects on native species.

The first argument by scientists against the dam removal is that NZMS will survive and reproduce regardless of the salinity increase from salt water input. Hoy et al. (2021) conducted a study to test osmotic tolerance of two NZMS populations from different environments. The New Zealand Mudsnail originates from freshwater ecosystems but has now been documented in multiple estuaries which opened the question if this species is salt water adaptable. The salinity exposed population was collected from an estuarine site along the Columbia River (Hammond Harbor, OR) and the other population was from a freshwater lake (Devil's Lake, Lincoln City, OR). By testing the two population's survival rates under varying salinities, they found that the Devil's Lake population had a larger number of mortalities on the first day in salinities over 20 PSU compared to the Hammond Harbor population. However, when the Devil's Lake population was exposed to gradually increasing salinities from 10-34 PSU over 24 days, there was not a substantial amount of mortalities until reaching 34 PSU after 18 days . In all tests the Hammond Harbor population showed the most resistance to salinity increases, though the change in Devil's Lake NZMS mortalities shows the ability for salinity acclimation.

Paolucci et al. (2020) also studied the osmotic tolerances of the New Zealand Mudsnail in addition to thermal shock from specimens collected in the winter and fall from Capitol Lake. Their findings on osmotic tolerances agreed with Hoy et al., that mortality rates of NZMS increase when salinity reaches high levels. An important distinction Paolucci et al. notes is the variability in mortality based on season and temperature. During low temperature winter months, NZMS might be under stress that makes them more vulnerable to changing conditions. Lastly, the exposure length to high salinities of 30 PSU needs to be from 7-40 days to cause 100% mortality. Due to the specificity of the NZMS biological tolerances it is unlikely that the species will suffer high mortality rates from salt water input to Capitol Lake.

If NZMS are able to survive and reproduce after the estuary restoration, there is concern for cascading effects on the local food web. In a lab study by Vision and Baker (2008), exploring the nutritional value of NZMS, rainbow trout fed an unlimited amount of only NZMS lost an average of 0.15, 0.14, and 0.48% of initial body weight per day during the three experimental periods. In contrast, rainbow trout which were fed amphipods in the experiment increased body weight per day by 0.64, 1.37, and 0.99%. Fecal samples gave evidence that the trout were not fully digesting NZMS, of 468 mudsnails found only 8.5% were shell remainders which were believed to be fully digested. The remaining mudsnails from the fecal samples were either dead but intact (37.6%) or still alive (53.8%).

New Zealand Mudsnail Spread Counterarguments and Prevention

Johannes (2021) argued that the history of Capitol Lake NZMS colonization shows an unlikelihood for them to spread to nearby areas in the future. The gates of the 5th Ave. Dam are already periodically opened when water flow from the Deschutes River increases in winter months (Johannes, 2021; Hayes et al., 2008). Regardless of the occasional removal of the gate barriers and increased probability of passive transport, Budd Inlet is still free of NZMS colonization. Tidal movement will also increase with removal of the dam, which could possibly inhibit the ability of NZMS to attach to passing debris and substrate leaving the basin. Johannes also acknowledged that further study of NZMS osmotic tolerances is necessary before concluding their true ranges, and predicted that the NZMS population from the Columbia estuary studied by Hoy et al. (2021) was most likely only exposed to extreme salinities for limited periods.

The complete eradication of the Capitol Lake NZMS population will most likely not occur by restoring the estuary, stated Stockton-Fiti (2018), in agreement with Paolucci et al., and Hoy et al.. However, Stockton-Fiti emphasized proper prevention management can prevent the spread of the species outside of the lake and keep population numbers controlled. Providing decontamination stations in accessible locations to thoroughly clean any gear and vehicles used in infested waters can help drastically reduce likelihood of NZMS spread.

Contrary to the experimental findings by Vision and Baker (2008), Brenneis et al. (2011) concluded that NZMS were consumed in low amounts by wild caught estuarine fish when another food source was available and there was not a significant direct interaction (though they agreed that when ingested, NZMS are a poor source of nutrition). Interestingly, when NZMS were present in a multiple prey experiment, crayfish and sculpin predation increased towards the native amphipod species (*Americorophium salmonis*). These findings differ from the expectation of an invasive species to replace native food sources in an ecosystem (Brenneis et al., 2011).

Conclusion

Though the Capitol Lake NZMS population will most likely survive in a restored estuarine habitat, it is unlikely they will invade Budd Inlet and the upper Deschutes River. Additionally, there is inconclusive evidence on NZMS osmotic tolerances and suggestions that the survival of NZMS will negatively impact the surrounding food web are unsupported. Future monitoring of Budd Inlet and the Deschutes waterways should continue to test the efficiency of decontamination stations and control strategies implemented by DES to prevent NZMS contamination. The ecological and recreational benefits of restoring the estuarine environment of the Capitol Lake Basin by removal of the 5th Ave. Dam seem to warrant the low risk of NZMS spread, as long as proper prevention management protocol is followed.

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