New Zealand Mudsnail Surveys At National Wildlife Refuges within the Lower Columbia River Basin 2012

Jennifer Poirier

June 2013

Columbia River Fisheries Program Office

United States Fish and Wildlife Service

1211 SE Cardinal Court, Suite 100; Vancouver, Washington 98683

Table of Contents

List of Figures and Tables

Figures and Tables Continued

Introduction

The New Zealand mudsnail (NZMS), *Potamopyrgus antipodarum* is an exotic aquatic snail species that has invaded brackish and freshwater habitats of Australia, Europe, Asia and North America. As its common name implies, this snail is native to New Zealand and may have been introduced globally through contaminated ballast water (Zaranko et al. 1997; Gangloff 1998), the transport of live fish or eggs (Bowler 1991; Bowler and Frest 1992), or in shipments of aquatic ornamental plants (Alonso and Castro-Díez 2008). In North America, the NZMS was first discovered in the middle Snake River (Idaho) in 1987 (Bowler 1991). Since this time, the NZMS has become established in ten Western states, five Great Lakes states and two Canadian provinces (British Columbia and Ontario) (Davidson et al. 2008; Benson 2011) (Figure 1).

The rapid spread of NZMS within the United States has been attributed to the snails biological and morphological traits. Adult NZMS range from 3-6 mm in length. In low densities, the small size of NZMS makes it difficult to detect thereby increasing the likelihood of unknowingly transporting and introducing the snail to new locations. In the United States, NZMS populations are comprised almost exclusively of self-cloning parthenogenetic females. The brood size of an individual female ranges from 20-120 embryos, each of which may mature to produce an average of 230 offspring per year (Alonso and Castro-Díez 2008; Cheng and LeClair 2011). Under favorable conditions, a single snail has the reproductive potential to establish a new population. In its non-native range, NZMS inhabit a wide range of aquatic ecosystems (e.g., estuaries, rivers, lakes and reservoirs), and tolerate broad range of aquatic conditions (e.g., temperature, salinity, turbidity, water velocity, productivity and substrate types) (see ANSTF 2007 and references therein). The broad environmental tolerances of the NZMS enable it to successfully colonize a wide array of aquatic habitats. New Zealand mudsnail have a rigid operculum that is used to seal off the shell opening making it relatively impervious to mild pollutants and highly resistant to desiccation (Richards et al. 2004; Schisler et al. 2008). Larger snail can survive up to 24 hours without water and for several weeks on damp surfaces (Cheng and LeClair 2011). This exceptional hardiness may provide ample time for the snail to be transferred from one water body to another. The shell wall of NZMS is very thick and is difficult for many species to thoroughly digest. In some circumstances, the snail may pass through the digestive tract of fish and birds unharmed (Aarnio and Bonsdorff 1997; McCarter 1986; Bruce et al. 2009).

New Zealand mudsnail may be introduced to new locations through many natural and human-related processes. Within a watershed, snails may be transported on the fur or feathers of terrestrial wildlife, livestock and waterfowl or consumed and dispersed in the excrement of local fish species. New Zealand mudsnail may be scoured downstream by high water velocity, float passively on aquatic vegetation or move volitionally at a rate of up to 3 m /hour (Sepulveda and Marczak 2011). Long distance dispersal of NZMS has been attributed to ballast water discharge, the movement of commercial aquaculture products (i.e., fish, eggs, and ornamental plants), contaminated hatchery transplants, transport by migratory birds, or the translocation of infested recreational watercrafts, trailers and personal gear such as boots and waders.

In 2005, the NZMS was discovered at Minidoka National Wildlife Refuge (NWR) in south-central Idaho (Benson 2011). This is the first and only NWR where NZMS are currently found, although it is unclear how many NWR are actively monitoring for this particular species on refuge lands. The United States Fish and Wildlife Service currently manages over 560 National Wildlife Refuges for the conservation and management of fish, wildlife, plants and their habitats. One of the many challenges NWR face is managing the growing number of invasive and nuisance species that threaten conservation efforts. As of 2011, 2.4 million acres of invasive plants and over 3,800 animal species had infested NWR lands (USFWS 2011). In response to concerns about this burgeoning problem and to meet federal (Executive Order 13112) and mission requirements (Fulfilling the Promise), the refuge system developed a national strategic plan for the management of invasive species. Out of this plan came the development of a number of management tools and programs (e.g., interactive invasive species database, Hazard Analysis and Critical Control Point (HACCP) plans, early detection rapid response (EDDR) strike teams, invasive survey and restoration volunteers), with the goal of reducing instances of infestations, controlling existing infestations more efficiently, and preventing new infestations from occurring. Monitoring (i.e., repeated measures over time) is at the core of many of these programs. Performing annual surveys of areas considered vulnerable to infestation may detect invasive species before they become established or are inadvertently spread to new areas.

In spring 2012, the Columbia River Fisheries Program Office (CRFPO) was granted the funds to perform NZMS surveys at lower Columbia River National Wildlife Refuges. This report presents results of New Zealand mudsnail surveys conducted by U.S. Fish and Wildlife Service CRFPO personnel in 2012.

Methods

Six lower Columbia River Basin National Wildlife Refuges were surveyed for New Zealand mudsnail including: Franz Lake, Julia Butler Hansen, Pierce, Steigerwald Lake, Ridgefield, and Willapa National Wildlife Refuges (Figure 2). Surveys were conducted over a one week period from 1 October to 5 October, 2012. Prior to conducting the survey, refuge managers, biologists and staff were interviewed to identify areas where snails may access the refuge complex as well as to determine if refuge personnel had observed suspicious snails on refuge property. Refuge staff was also provided with informational brochures or voucher specimen of NZMS to aid in future identification of the species. New Zealand mudsnail surveys had not been conducted at the refuges previously, so sample sites focused on areas perceived as likely introduction points such as public boat ramps and areas with connectivity to the Columbia River or estuary. All sample locations were georeferenced using a Trimble handheld global positioning system (GPS), and a photograph was taken to document current physical habitat conditions. Two field personnel visually inspected up to a 50 meter portion of a water body upstream and downstream of each survey location for approximately 15 minutes. Surface substrate was manually flipped over at random intervals, aquatic vegetation was sifted through by hand and surfaces of refuge structures (i.e., tide gates, culverts, bridge abutments) were closely examined (visually and by hand) for the presence/absence of NZMS. In water depths greater than 0.6 m, substrate, aquatic vegetation and refuge structures were visually inspected using an underwater viewing scope. If field personnel observed an aquatic snail, the date and location of the snail was recorded and a single specimen was collected and placed in an individual vial with 70% ethanol for preservation. Snail specimen were individually photographed and carefully examined under a dissecting microscope. Magnified photographs of specimen were sent to Robyn Draheim (Center for Lakes and Reservoirs) and Ed Johannes (Deixis Consultants) to identify down to genus level.

Results

A total of 30 sites were surveyed for NZMS at six lower Columbia River Basin National Wildlife Refuges (Table 1). Eleven snail specimens were collected and taken back to the CRFPO laboratory for examination. Species identification results revealed specimen belonged to six unique families and eight genera (Table 2). Freshwater snails of genus *Juga* and genus *Fluminicola* were the species most commonly observed at National Wildlife Refuges. Non-native invasive Asian clams (*Corbicula fluminea*) and a single species of native freshwater mussel were also observed at refuges. No NZMS were observed during field surveys or examination of collected snail specimen.

Franz Lake NWR

A single site was surveyed for NZMS at Franz Lake NWR in 2012 (Figure 3). Surveyors observed freshwater snails of genus *Fluminicola*, as well as a high density of invasive Asian clams (Table 2).

Julia Butler Hansen NWR

There were 12 sites surveyed for NZMS at Julia Butler Hansen NWR in 2012 (Figure 4). A total of three different snail genera were observed on the refuge. *Juga* and *Fluminicola* were the most common snails observed, present in six and eight sites respectively. A single *Planorbella* shell was found outside of Winter Slough tide gate, but no live snail were observed in the area. With the exception of *Fluminicola*, all snail genera were observed outside of tide gates. Invasive Asian Clams were also observed exclusively outside of tide gates in three sample locations. A single species of native mussel (Oregon Floater, *Anodonta oregonensis*) was observed in three survey locations, however, live mussels were only observed inside of tide gates on Winter Slough (Table 2).

Pierce NWR

There were four sites surveyed for NZMS at Pierce NWR in 2012 (Figure 5). A total of five unique snail genera were observed on the refuge, three of which were observed at the mouth of Lena's Lake. A single Oregon floater shell was also observed at the mouth of Lena's Lake, and invasive Asian clam shells were found at the mouth of Hardy Creek (Table 2).

Ridgefield NWR

There were three sites surveyed for NZMS at Ridgefield NWR in 2012 (Figure 6). The City of Ridgefield boat ramp was also surveyed for NZMS due to its close proximity (110 meters) to the refuge. A total of five different snail genera were observed on the refuge, including a freshwater limpet that was observed at the Ridgefield boat ramp. Invasive Asian clams were observed at the old ferry boat ramp, and a single Oregon floater shell was found at the south end of Bachelor Island (Table 2).

Steigerwald Lake NWR

There were three sites surveyed for NZMS at Steigerwald Lake NWR in 2012 (Figure 7). A single snail of genus *Fluminicola* was observed at the mouth of Gibbons Creek, and two different species of *Juga* (*Juga silicula* and *Juga plicifera*) were observed approximately two kilometers upstream at the Gibbons Creek water control structure (Table 2).

Willapa NWR

There were five sites surveyed for NZMS at Willapa NWR in 2012 (Figure 8). No mollusks were observed in any of the survey locations.

Discussion

To date, no NZMS have been found in the six Lower Columbia River Basin National Wildlife Refuges included in this survey. Although no NZMS were observed, invasive Asian clams were observed in four of the six refuges surveyed. Ecological impacts of Asian clam are generally similar to those of the New Zealand mudsnail. Dense populations of clams may displace native benthic invertebrates, decrease food availability, and alter aquatic food webs. This may lead to a decrease in the diversity and abundance of native snails, mussels, and aquatic insects that many organisms depend on. In addition to Asian clams, one species of native freshwater mussel (Oregon floater) and eight native freshwater snail genera were found at survey locations. A second species of native freshwater mussel (western pearlshell, *Margaritifera falcata*) can usually be found in streams within Willapa NWR, however, no western pearlshell mussels were observed during our surveys. Mollusks such as snails and mussels generally benefit aquatic ecosystems by improving water quality, contributing to the cycling of nutrients in food webs, and providing an important food source for a variety of fish and wildlife species. Conducting a baseline inventory of native snail and mussel species currently present at Lower Columbia River Basin National Wildlife Refuges is an important way to document the existing diversity in these areas. Changes in native snail and mussel populations over time (i.e., decline in species richness or abundance) may indicate changes within the aquatic ecosystem (e.g., water quality, stream productivity, habitat availability) or the presence of an aquatic invader such as the New Zealand mudsnail.

New Zealand mudsnail were first discovered in the lower Columbia River in 1996 (Bersine et al. 2008). Today they can be found throughout the Columbia River Estuary (including peripheral bays, lakes and tributaries), along the Oregon coast near the mouth of the Columbia and Rogue Rivers, and in multiple locations along the lower Deschutes River (Benson 2011). The relative close proximity of lower Columbia River National Wildlife Refuges to established NZMS populations should be cause for concern (Figure 9). Common management practices and public recreational opportunities may increase the threat of NZMS invasion at lower Columbia River National Wildlife Refuges. Maintenance and construction activities such as dredging and water manipulation (e.g., flooding, diversions, drawdowns) may increase the spread of NZMS if mud, dirt, and plant parts are inadvertently transported on equipment from an infested water body to an uninfested water body. The accessibility of public boat ramps, hiking trails, and hunting blinds for recreational activities such as fishing, hunting, birding, hiking and kayaking may introduce or transport NZMS by a multitude of pathways (e.g., boats, trailers, fishing gear, waders, boots, hunting dogs). Livestock, deer and waterfowl may also be a vector of spread given the potential for NZMS to be transported on the fur and feathers of wildlife. Migratory birds may pose the greatest threat of spread given their seasonal movement between lakes, reservoirs and other water bodies. The discovery of NZMS in Southern Europe, Western Asia, and expansion within the Azov-Black Sea region has been attributed to the transport of live snail in the plumage, on the legs, or in the stomachs of migratory birds. (Son 2008; Naser and Son 2009; Butkus et al. 2012). There is currently no known method for eradicating NZMS once they infest a water body. Continuation of annual monitoring for New Zealand mudsnail at Columbia Basin National Wildlife Refuges is important because early detection is critical to the prevention, control and management of the species and may significantly reduce the risk of spreading the snail to new areas.

Acknowledgements

A big Thank You to Jim Clapp (Franz Lake, Pierce, Steigerwald Lake NWR); Joel David and Paul Meyers of Julia Butler Hansen NWR; Chris Lapp, Randy Hill and Alex Chmielewski of Ridgefield NWR; and Jackie Ferrier and Bill Ritchie of Willapa NWR for taking time out of their schedule to provide suggestions for potential sample sites and acquainting me with refuge grounds. I would also like to thank Donna Allard for her help with conducting the snail surveys, and Robin Draheim and Ed Johannes for providing guidance and assistance with identification of snail specimen. Funding for this project was made available through the U.S. Fish and Wildlife Service Fisheries Operating Needs System FONS# 13310-2012-279.

References

Aarnio, K. and E. Bonsdorff. 1997. Passing the gut of juvenile flounder, *Platichthys flesus*: differential survival of zoobenthic prey species. Marine Biology 129:11-14.

Alonso, A. and P. Castro-Díez. 2008. What explains the invading success of the aquatic mud snail *Potamopyrgus antipodarum* (Hydrobiidae, Mollusca)? Hydrobiologia 614:107-116, DOI: 10.1007/s10750-008-9529-3.

ANSTF (Aquatic Nuisance Species Task Force) and National Invasive Species Council. 2007. National management and control plan for the New Zealand mudsnail (*Potamopyrgus antipodarum*). Aquatic Nuisance Species Task Force. Available at http://www.anstaskforce.gov/control.php (Accessed June 2013).

Benson, A. J. 2011. New Zealand mudsnail sightings distribution. U.S. Geological Survey, Nonindigenous Aquatic Species Program. http://nas.er.usgs.gov/taxgroup/mollusks/newzealandmudsnaildistribution.aspx (Accessed June 2013).

Bersine, K., V. E. F. Brenneis, R. C. Draheim, A. M. W. Rub, J. E. Zamon, R. K. Litton, S. A. Hinton, M. D. Sytsma, J. R. Cordell and J. W. Chapman. 2008. Distribution of the invasive New Zealand mudsnail (*Potamopyrgus antipodarum*) in the Columbia River Estuary and its first recorded occurrence in the diet of juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Biological Invasions, DOI: 10.1007/s10530-007-9213-y.

Bowler, P. A. 1991. The rapid spread of the freshwater Hydrobiid snail *Potamopyrgus antipodarum* (Gray) in the Middle Snake River, Southern Idaho. Proceedings of the Desert Fishes Council 21:173-182.

Bowler, P. A. and T. J. Frest. 1992. The non-native snail fauna of the Middle Snake River, Southern Idaho. Proceedings of the Desert Fishes Council 23:28-44.

Bruce, R. L., C. M. Moffitt, and B. Dennis. 2009. Survival and Passage of Ingested New Zealand Mudsnails through the Intestinal Tract of Rainbow Trout. North American Journal of Aquaculture 71:287-301, DOI: 10.1577/A08-033.1.

Butkus, R., E. Šidagytė, and K. Arbačiauskas. 2012. Two morphotypes of the New Zealand mud snail *Potamopyrgus antipodarum* (J.E. Gray, 1843) (Mollusca: Hydrobiidae) invade Lithuanian Lakes. Aquatic Invasions Volume 7, 2:211-218, DOI: http://dx.doi.org/10.3391/ai.2012.7.2.007.

Cheng, Y. W. and L. L. LeClair. 2011. A quantitative evaluation of the effect of freezing temperatures on the survival of New Zealand mudsnails (*Potamopyrgus antipodarum* Gray, 1843), in Olympia Washington's Capitol Lake. Aquatic Invasions 1:47-54, DOI: 10.3391/ai.2011.6.1.06.

Davidson, T. M., V. E. F. Brenneis, C. de Rivera, R. Draheim, and G. E. Gillespie. 2008. Northern range expansion and coastal occurrences of the New Zealand mud snail *Potamopyrgus antipodarum* (Gray, 1843) in the northeast Pacific. Aquatic Invasions 3:349-353, DOI: 10.3391/ai.2008.3.3.12.

Gangloff, M. M. 1998. The New Zealand mud snail in Western North America. Aquatic Nuisance Species 2:25-30.

McCarter, N. H. 1986. Food and energy in the diet of brown and rainbow trout from Lake Benmore, New Zealand. New Zealand Journal of Marine and Freshwater Research 20:551-559.

Naser, M. D. and M. O. Son. 2009. First record of the New Zealand mud snail *Potamopyrgus antipodarum* (Gray 1843) from Iraq: the start of expansion to Western Asia? Aquatic Invasions Volume 4, 2:369-372, DOI: 10.3391/ai.2009.4.2.11.

Richards, D. C., P. O'Connell and D. C. Shinn. 2004. Simple Control Method to Limit the Spread of the New Zealand Mudsnail *Potamopyrgus antipodarum*. North American Journal of Fisheries Management 24:114-117.

Schisler, G. J., N. K. M. Vieira and P. G. Walker. 2008. Application of Household Disinfectants to Control New Zealand Mudsnails. North American Journal of Fisheries Management 28:1172-1176, DOI: 10.1577/M07-028.1.

Sepulveda, A. J. and L. B. Marczak. 2011. Active dispersal of an aquatic invader determined by resource and flow conditions. Biological Invasions, DOI: 10.1007/s10530-011-0149-x.

Son M. O. 2008. Rapid expansion of the New Zealand mud snail *Potamopyrgus antipodarum* (Gray, 1843) in the Azov-Black Sea Region. Aquatic Invasions Volume 3, 3:335-340, DOI: 10.3391/ai.2008.3.3.9.

USFWS (U.S. Fish and Wildlife Service). 1999. Fulfilling the promise: the National Wildlife Refuge System. The National Wildlife Refuge System, U.S. Fish and Wildlife Service Department of the Interior. http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1 (Accessed June 2013).

USFWS. 2011. Invasive Species Program: National Wildlife Refuge System Update FY2011. U.S. Fish and Wildlife Service Department of the Interior. http://www.fws.gov/invasives/pdfs/InvasiveSpeciesFW2011FactSheet.pdf (Accessed June 2013).

USOFR (United States Office of the Federal Register). 1999. Executive order 13112-invasive species, Federal Register 64: 25 (3 February 1999):6183-6186.

Zaranko, D. T., D. G. Farara and F.G. Thompson. 1997. Another exotic mollusk in the Laurentian Great Lakes: the New Zealand native *Potamopyrgus antipodarum* (Gray 1843) (Gastropoda, Hydrobiidae). Canadian Journal of Fisheries and Aquatic Sciences 54:809-814.

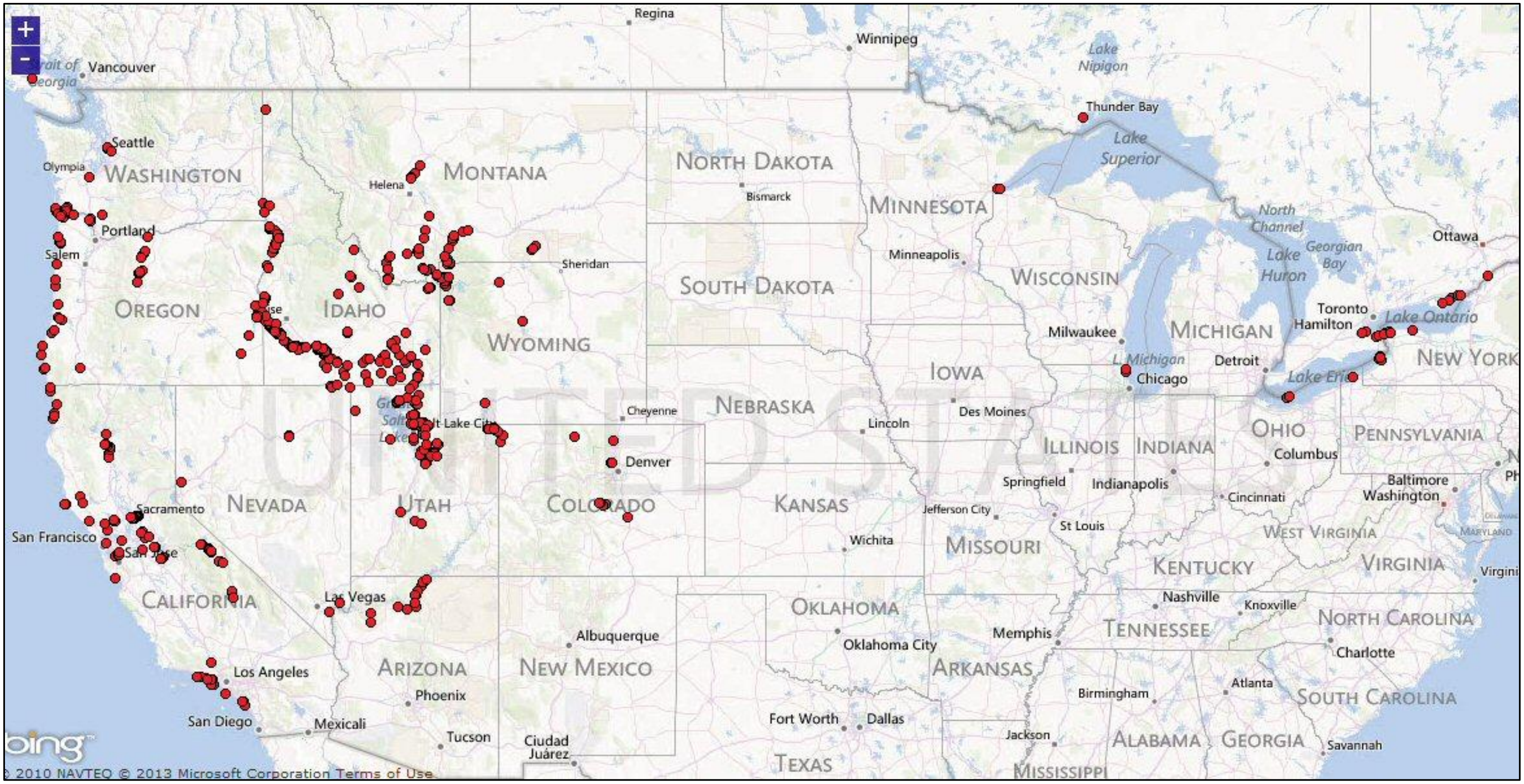


Figure 1. Map of New Zealand mudsnail sightings in the United States and Canada from 1987 through 2013. U.S. Geological Survey, http://nas.er.usgs.gov.

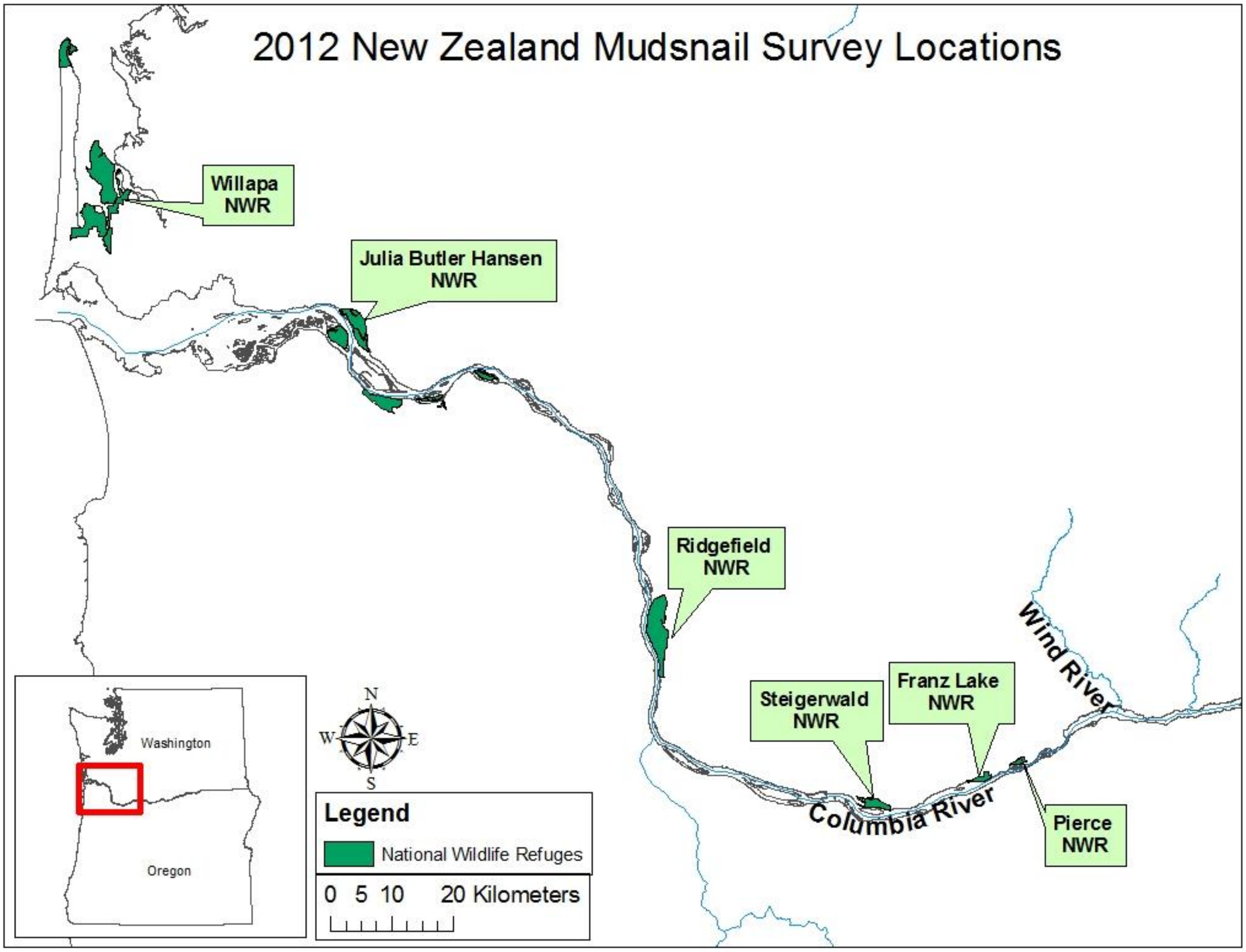


Figure 2. Map of USFWS Lower Columbia River basin National Wildlife Refuges surveyed for New Zealand mudsnail during 2012.

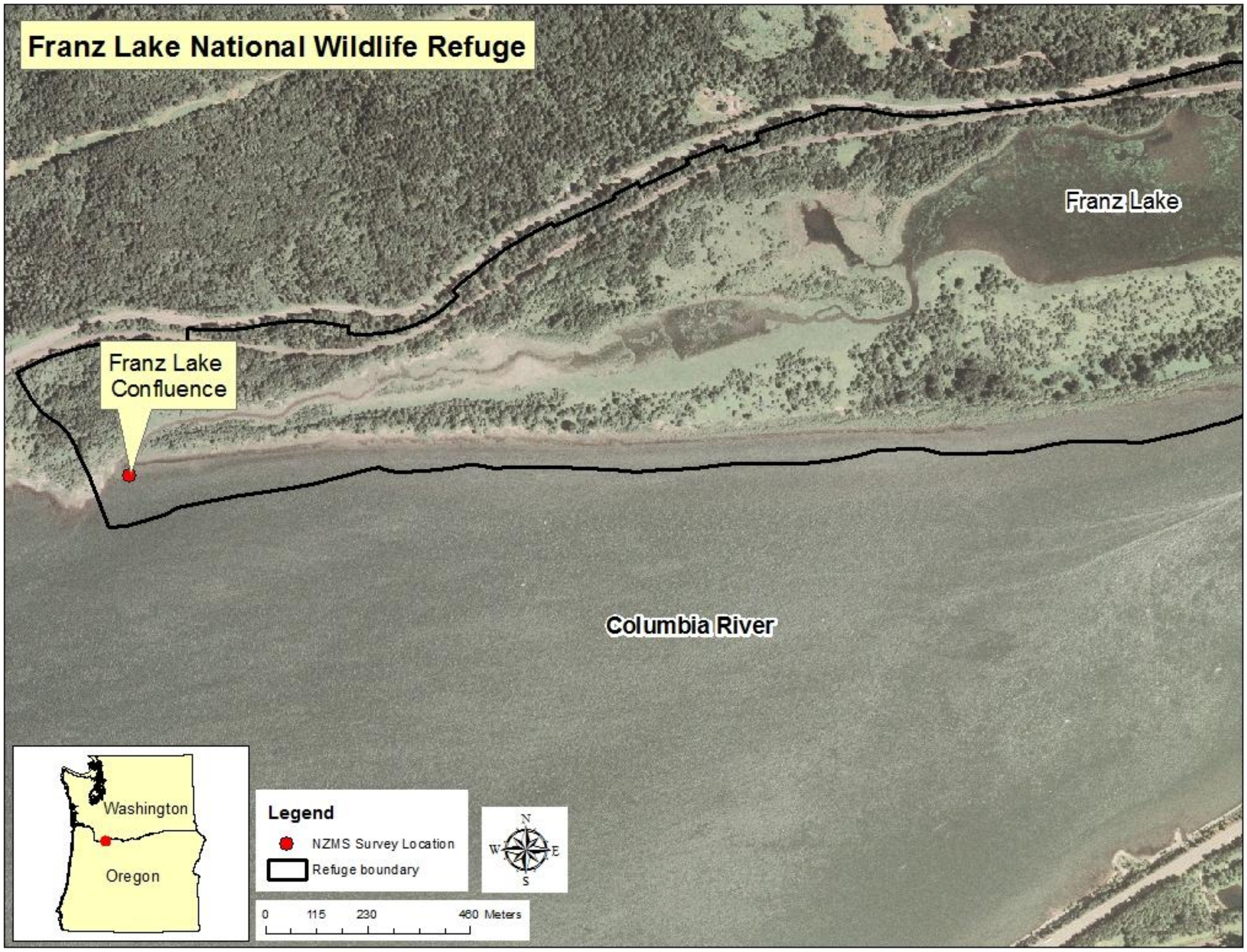


Figure 3. Franz Lake NWR 2012 New Zealand mudsnail survey sample sites.

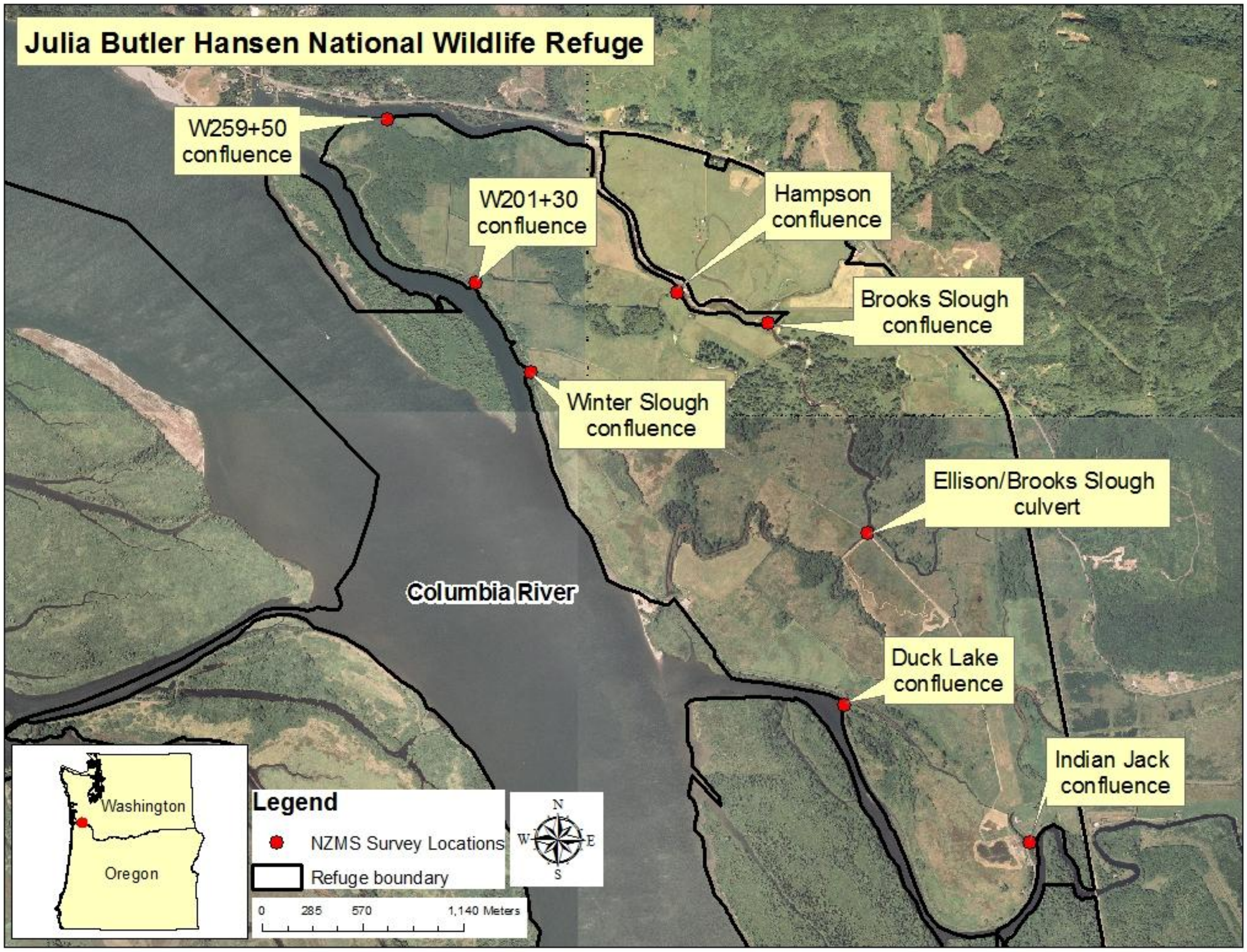


Figure 4. Julia Butler Hansen NWR 2012 New Zealand mudsnail survey sample sites.

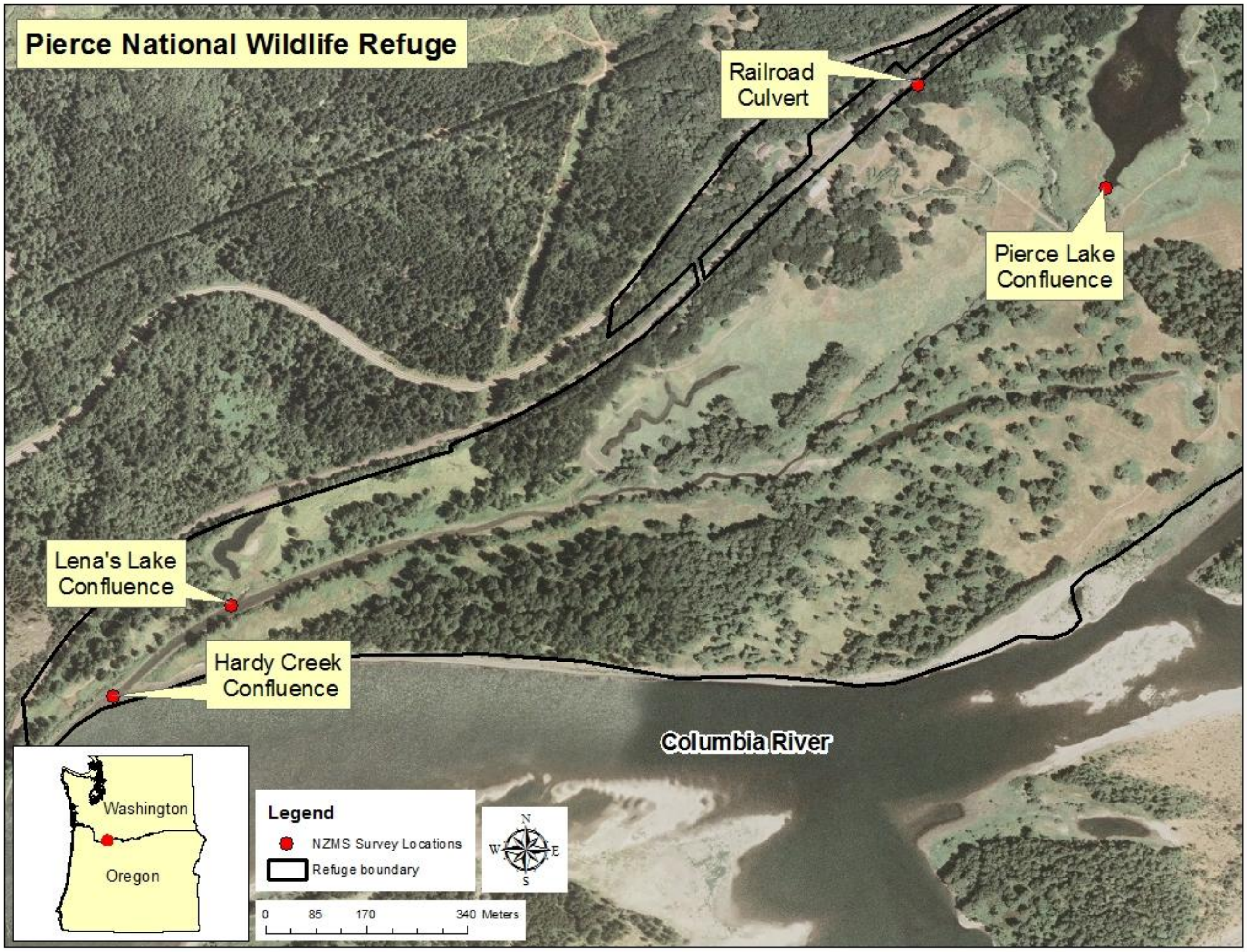


Figure 5. Pierce NWR 2012 New Zealand mudsnail survey sample sites.

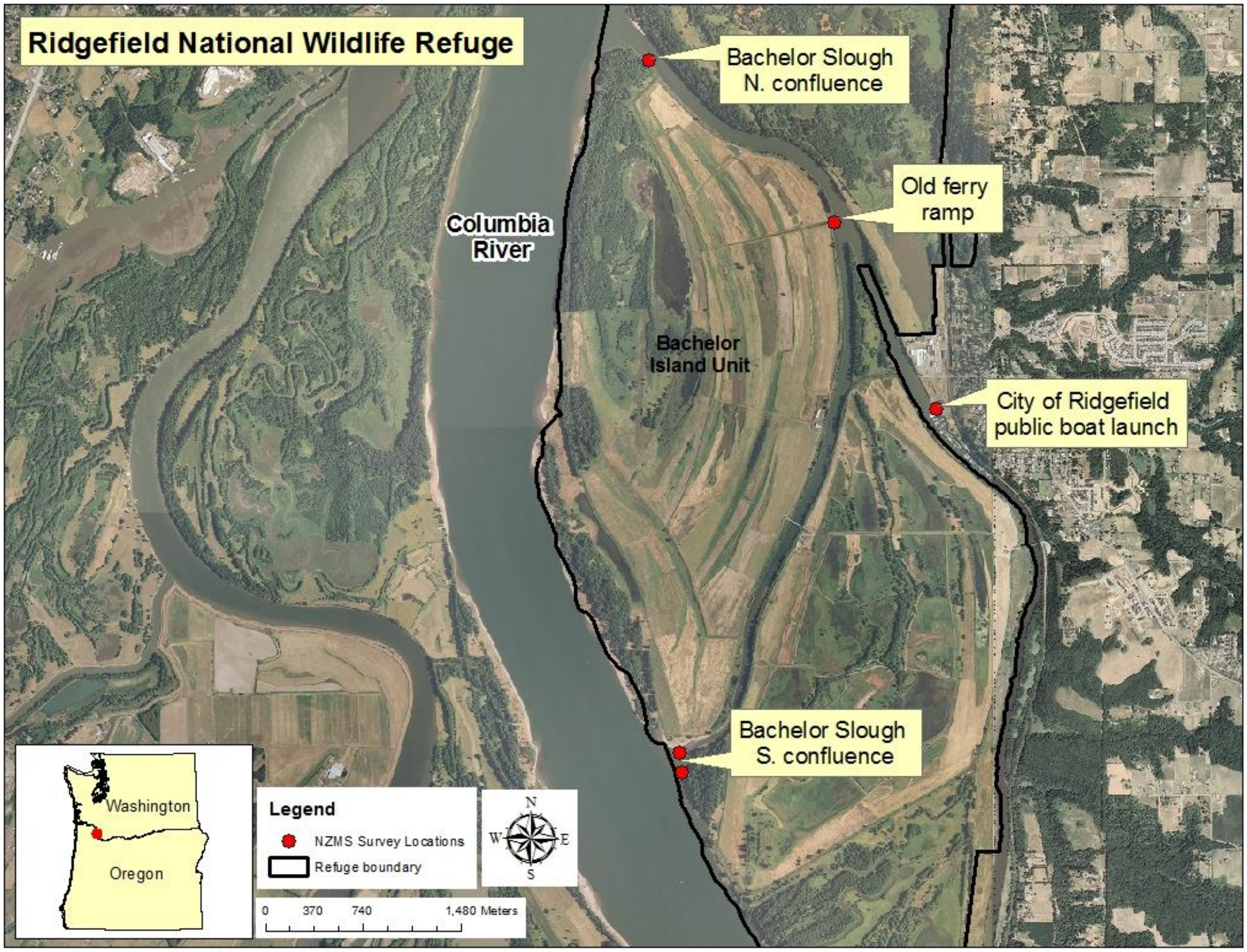


Figure 6. Ridgefield NWR 2012 New Zealand mudsnail survey sample sites.

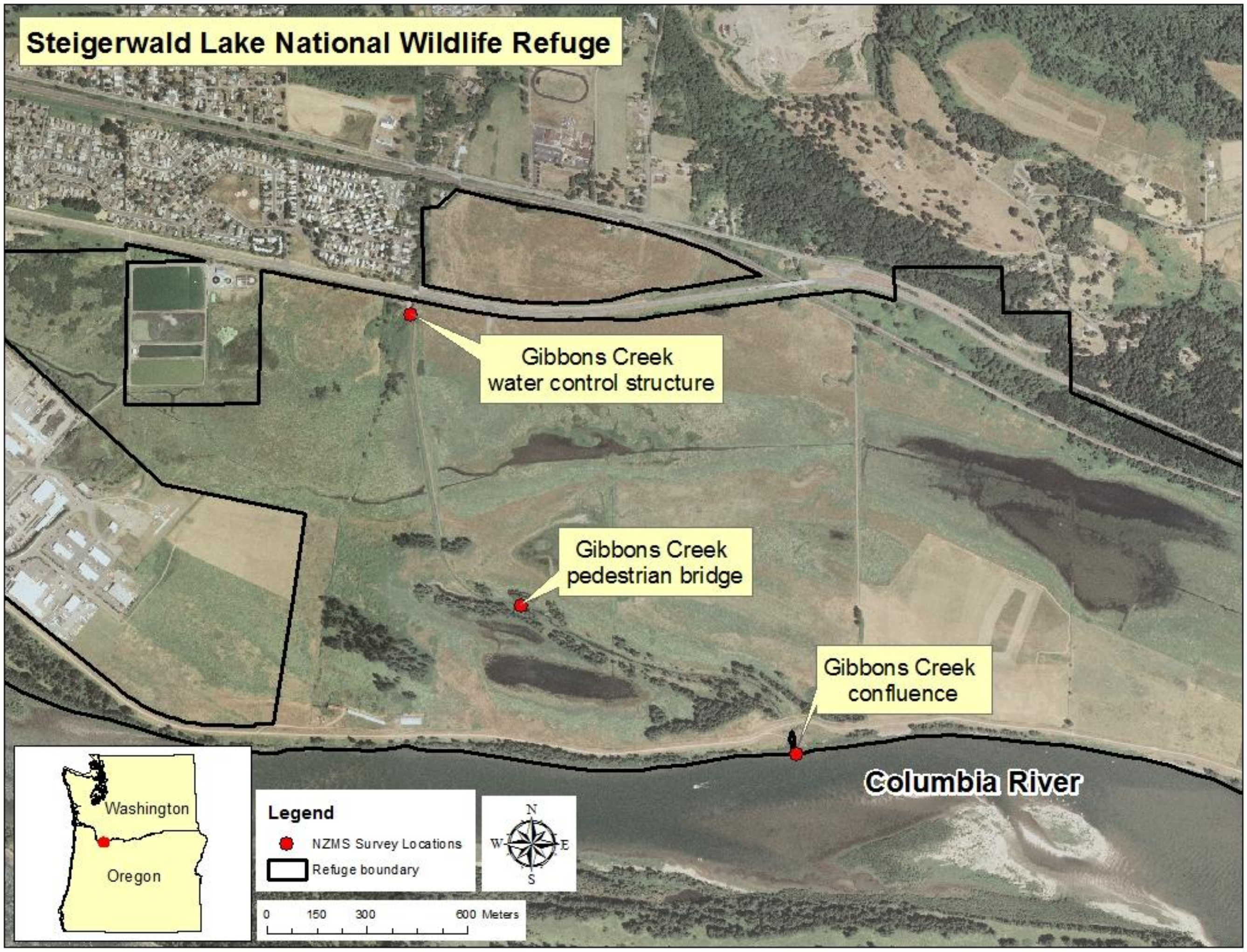


Figure 7. Steigerwald Lake NWR 2012 New Zealand mudsnail survey sample sites.

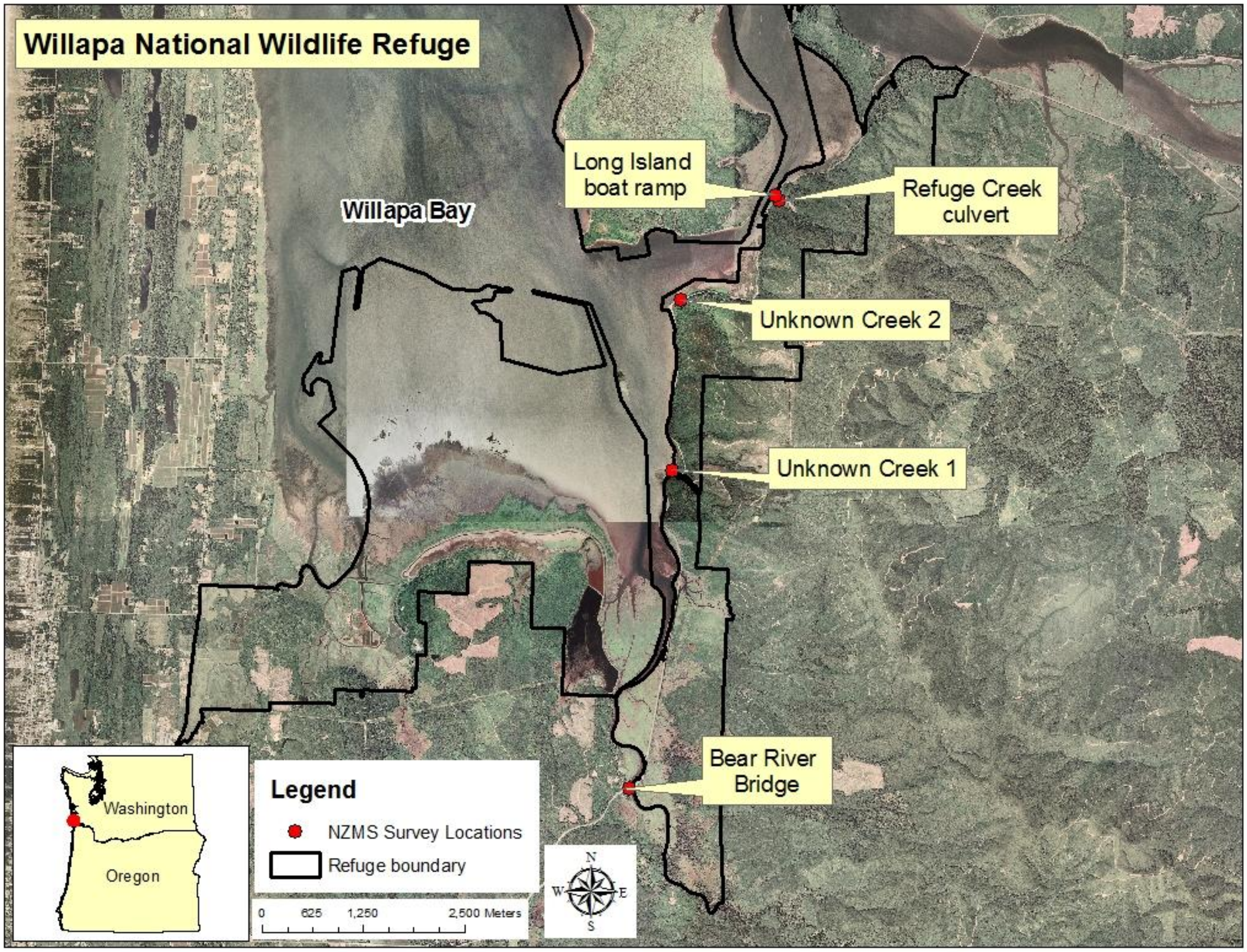


Figure 8. Willapa NWR 2012 New Zealand mudsnail survey sample sites.

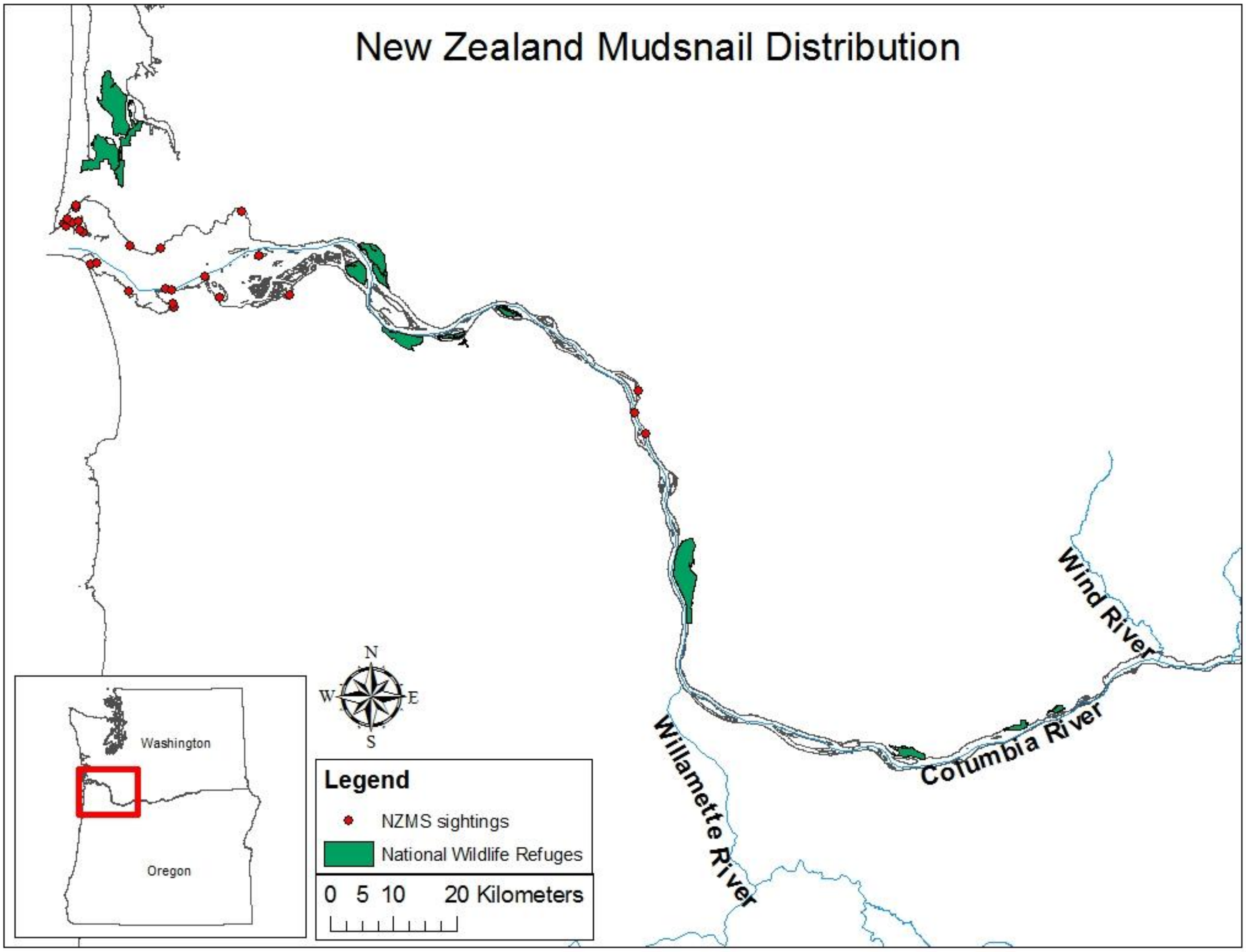


Figure 9. 2012 NZMS sample locations and distribution of NZMS on lower Columbia River.

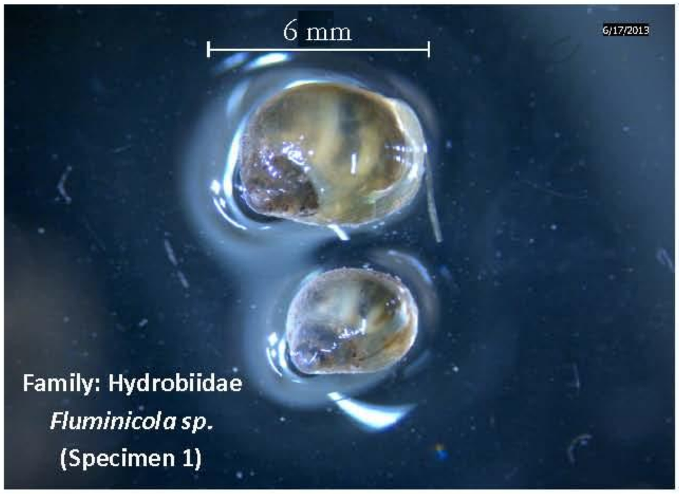
Table 1. Results of 2012 New Zealand mudsnail surveys of Lower Columbia River Basin National Wildlife Refuges.

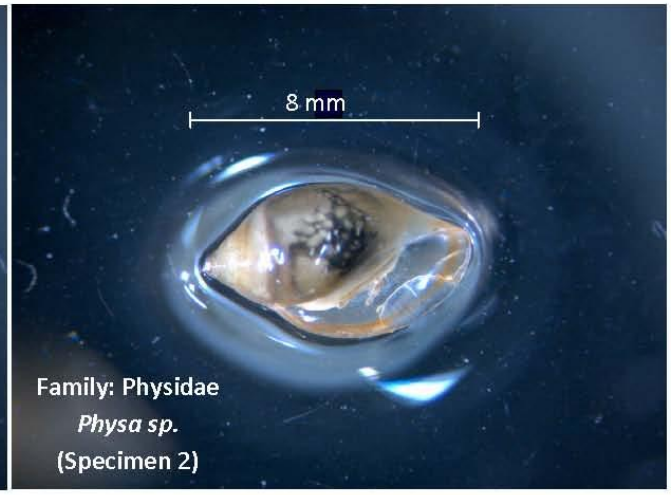
Date	National Wildlife Refuge	Location	Specimens Collected	NZMS Found	GPS Coordinate System: UTM			
					Zone	Datum	Northing	Easting
10/1/2012	Franz Lake	Franz lake confluence	None	None	10	NAD 1983 (Conus)	5049936.49	569665.31
10/2/2012	Julia Butler Hansen	Indian Jack Slough outside tide gate	Sample 7	None	10	NAD 1983 (Conus)	5119825.11	469241.71
10/2/2012	Julia Butler Hansen	Indian Jack Slough inside tide gate	None	None	10	NAD 1983 (Conus)	5119825.11	469241.71
10/2/2012	Julia Butler Hansen	Duck Lake outside tide gate	None	None	10	NAD 1983 (Conus)	5120609.40	468187.63
10/2/2012	Julia Butler Hansen	Duck Lake inside tide gate	None	None	10	NAD 1983 (Conus)	5120609.40	468187.63
10/2/2012	Julia Butler Hansen	Brooks/Ellison culvert connection	None	None	10	NAD 1983 (Conus)	5121585.31	468322.62
10/2/2012	Julia Butler Hansen	Winter Slough outside tide gate	Sample 11	None	10	NAD 1983 (Conus)	5122493.66	466408.53
10/2/2012	Julia Butler Hansen	Winter Slough inside tide gate	None	None	10	NAD 1983 (Conus)	5122493.66	466408.53
10/2/2012	Julia Butler Hansen	W201+30 outside tide gate	None	None	10	NAD 1983 (Conus)	5123000.35	466094.76
10/2/2012	Julia Butler Hansen	W259+50 outside tide gate	None	None	10	NAD 1983 (Conus)	5123930.75	465596.89
10/2/2012	Julia Butler Hansen	Hampson Slough outside tide gate	None	None	10	NAD 1983 (Conus)	5122948.57	467239.89
10/2/2012	Julia Butler Hansen	Hampson Slough inside tide gate	None	None	10	NAD 1983 (Conus)	5122948.57	467239.89
10/2/2012	Julia Butler Hansen	Brooks Slough outside tide gate	None	None	10	NAD 1983 (Conus)	5122772.60	467754.07
10/1/2012	Pierce	Hardy Creek confluence	Sample 1	None	10	NAD 1983 (Conus)	5052974.64	576582.61
10/1/2012	Pierce	Lena's Lake confluence	Sample 2,3,4	None	10	NAD 1983 (Conus)	5053127.32	576781.63
10/1/2012	Pierce	Pierce Lake confluence	None	None	10	NAD 1983 (Conus)	5053829.40	578251.24
10/1/2012	Pierce	Railroad culvert	Sample 5	None	10	NAD 1983 (Conus)	5054002.92	577936.90
10/5/2012	Ridgefield	Old ferry ramp	Sample 8	None	10	NAD 1983 (Conus)	5075114.06	518650.29
10/5/2012	Ridgefield	Bachelor Slough N. confluence	None	None	10	NAD 1983 (Conus)	5076339.08	517251.60
10/5/2012	Ridgefield	Bachelor Slough S. confluence (N. shore)	Sample 9	None	10	NAD 1983 (Conus)	5071101.82	517476.45
10/5/2012	Ridgefield	Bachelor Slough S. confluence (S. shore)	None	None	10	NAD 1983 (Conus)	5070947.98	517496.14
10/5/2012	Ridgefield	City of Ridgefield boat launch	Sample 10	None	10	NAD 1983 (Conus)	5073697.32	519421.35
10/1/2012	Steigerwald Lake	Gibbons Creek water control structure	Sample 6	None	10	NAD 1983 (Conus)	5046589.94	553374.92
10/3/2012	Steigerwald Lake	Gibbons Creek bridge	None	None	10	NAD 1983 (Conus)	5045720.37	553705.79
10/3/2012	Steigerwald Lake	Gibbons Creek confluence	None	None	10	NAD 1983 (Conus)	5045277.12	554526.64
10/3/2012	Willapa	Refuge Creek culvert	None	None	10	NAD 1983 (Conus)	5140506.73	428152.46
10/3/2012	Willapa	Long Island boat ramp	None	None	10	NAD 1983 (Conus)	5140570.94	428100.75
10/3/2012	Willapa	Unknown Creek 1	None	None	10	NAD 1983 (Conus)	5137168.79	426827.42
10/3/2012	Willapa	Bear River bridge	None	None	10	NAD 1983 (Conus)	5133221.74	426299.03
10/3/2012	Willapa	Unknown Creek 2	None	None	10	NAD 1983 (Conus)	5139273.07	426935.05

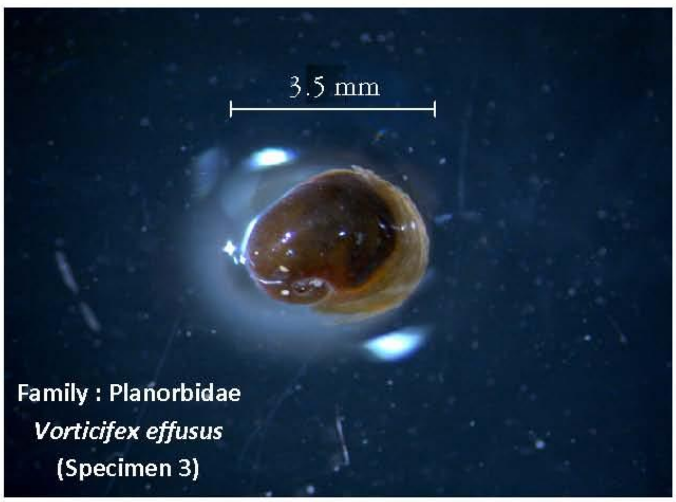
Table 2. Summary of freshwater mollusk genera observed at lower Columbia River National Wildlife Refuges, 2012.

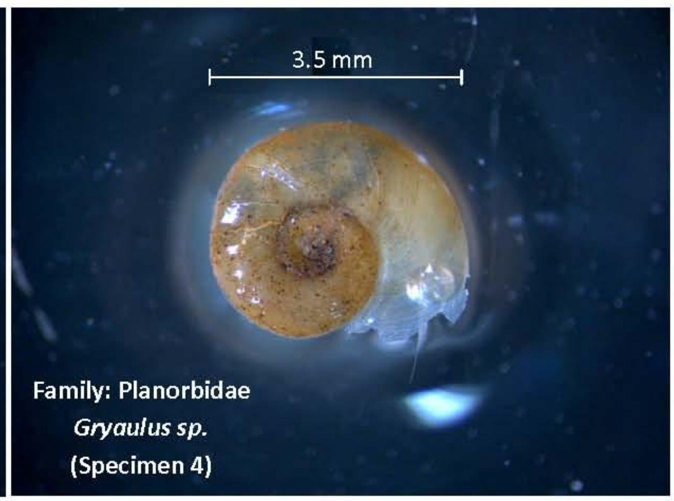
	Freshwater Mollusk Genera										
Survey Location	**Fluminicola**	**Physa**	**Vorticifex**	**Gryaulus**	**Juga Silicula**	**Juga Plicifera**	**Family: Lymnaeid**	**Ferrissia**	**Planorbella**	**Corbicula**	**Anodonta**
Franz Lake: Franz Lake confluence	**X**									**X**	
JBH: Indian Jack Slough outside tide gate	**X**					**X**				**X**	
JBH: Indian Jack Slough inside tide gate											
JBH: Duck Lake outside tide gate	**X**					**X**					
JBH: Duck Lake inside tide gate	**X**										
JBH: Brooks/Ellison culvert connection											
JBH: Winter Slough outside tide gate	**X**					**X**			**X - shell**	**X**	
JBH: Winter Slough inside tide gate											**X**
JBH: W201+30 outside tide gate	**X**					**X**				**X**	**X - shells**
JBH: W259+50 outside tide gate											
JBH: Hampson Slough outside tide gate	**X**					**X**					
JBH: Hampson Slough inside tide gate	**X**										
JBH: Brooks Slough outside tide gate	**X**					**X**					
Pierce: Hardy Creek confluence	**X**									**X - shells**	
Pierce: Lena's Lake Confluence		**X**	**X**	**X**							**X - shell**
Pierce: Pierce Lake confluence											
Pierce: railroad culvert					**X**						
Ridgefield: Old ferry ramp				**X**			**X**			**X**	
Ridgefield: Bachelor Slough N. confluence	**X - shell**										
Ridgefield: Bachelor Slough S. confluence (N.)	**X**					**X**					**X - shell**
Ridgefield: Bachelor Slough S. confluence (S.)	**X**										
Ridgefield: City of Ridgefield boat launch								**X**			
Steigerwald Lake: Gibbons Cr. WC structure					**X**	**X**					
Steigerwald Lake: Gibbons Creek bridge											
Steigerwald Lake: Gibbons Creek confluence	**X**										
Willapa: Refuge Creek culvert											
Willapa: Long Island boat ramp											
Willapa: Unknown Creek 1											
Willapa: Bear River bridge											
Willapa: Unknown Creek 2											

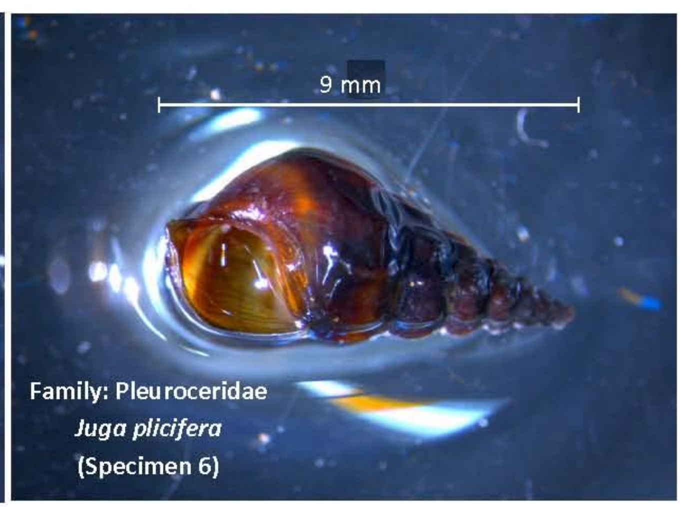
Appendix A: Photographs of Snail Specimen







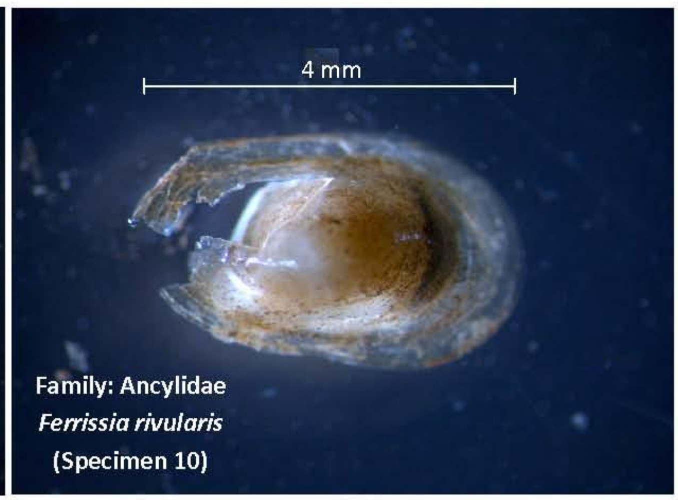




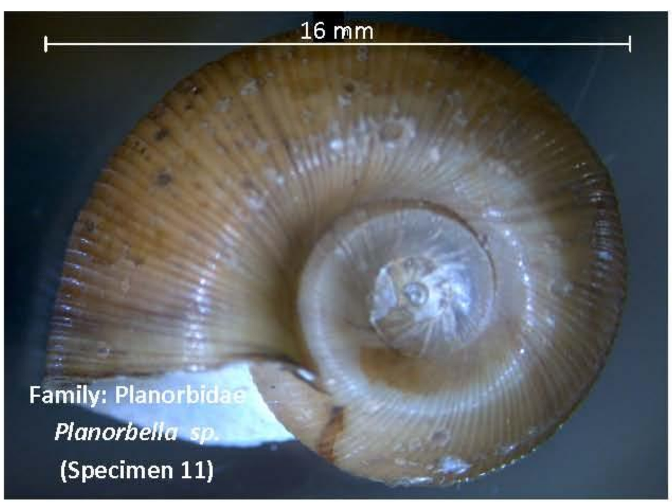
Family: Hydrobiidae
Fluminicola sp.
(Specimen 7)

Family: Lymnaeid
(Specimen 8)

Family: Hydrobiidae
Fluminicola sp.
(Specimen 9)



Family: Ancylidae
Ferrissia rivularis
(Specimen 10)



Family: Planorbidae
Planorbella sp.
(Specimen 11)

Family: Unionidae
Anodonta oregonensis
Oregon floater

Family: Corbiculidae
Corbicula fluminea
Asian clam

Family: Hydrobiidae
Potamopyrgus antipodarum
New Zealand mudsnail