Aquatic Invasive Species Action Plan for Lake Whatcom Reservoir

Lake Whatcom Management Program
September, 2011

Aquatic Invasive Species Action Plan

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Image on cover: Zebra and Quagga Mussels threaten Clear Lake, California (Tackle It: Northern California's Fishing Authority, Available at: http://tackleit.com/standard.php?display=quagga)

Introduction and Background

Aquatic Invasive Species[G][1] (AIS) are non-native plants, animals, and pathogens that live primarily in water and are able to thrive in new environments. While not all non-native aquatic species are a threat, AIS are capable of causing economic loss, environmental damage, and harm to human health (Minnesota Sea Grant, 2010). Depending on the species in question, they can:

- Displace, foul and outcompete native species resulting in decreased biodiversity
- Disrupt entire food webs and nutrient cycles
- Bio-accumulate environmental contaminants and spread toxic algal blooms and pathogens
- Attach to and damage infrastructure, watercraft, and water conveyance structures
- Clog intake structures and impede the flow of water to municipal water supplies, irrigation operations, and power plants
- Cause long-term taste and odor issues in drinking water supplies
- Make shoreline areas hazardous and uninviting for recreational users and waterfront property owners

Aquatic invasive species are able to move from one waterbody to another via several introduction pathways. These pathways include:

- Being accidentally or deliberately released by individuals
- Becoming attached to boat hulls, motors, trailers and equipment
- Becoming attached to float planes
- Being transported in bilge tanks, live wells, and engine cooling water
- Becoming attached to field gear
- Being released when aquariums or bait containers are emptied into waterbodies
- Being transferred by waterfowl and other animals

Aquatic invasive species may also move between waterbodies by as yet unidentified pathways.

Washington is already home to a number of AIS, including:

Asian clam	(*Corbicula fluminea)*
Brazilian elodea	*(Egeria densa)*
Eurasian watermilfoil	*(Myriophyllum spicatum)*
European green crab	*(Carcinus maenas)*
Hydrilla	*(Hydrilla verticillata)*
New Zealand mudsnail	*(Potamopyrgus antipodarium)*
Purple loosestrife	*(Lythrum salicaria)*
Garden loosestrife	*(Lysimachia vulgaris)*
Variable-leaf milfoil	*(Myriophyllum heterophyllum)*

Washington State spends $15 million annually to prevent and control invasive species throughout the state (Washington Invasive Species Council [WISC], 2008). However, this amount is expected to rise as additional species invade Washington's waters, resulting in even greater control and mitigation costs. Several of these species are listed below. More detailed information on all of these AIS can be found using the links in **Appendix J**.

Asian carp (silver carp)	*(Hypophthalmichthys molitrix)*
Chinese mitten crab	*(Eriocheir sinensis)*
Quagga mussel	*(Dreissena bugensis)*
Zebra mussel	*(Dreissena polymorpha)*
Viral Hemorrhagic Septicemia Virus	*(VHS IVb strain)*

[1] A superscript [G] placed after a word formatted in **bold** denotes a word defined in the Glossary on pages 41-43

If any of these species were to become established in Washington waters, it could cause irreversible changes to ecosystems and cost millions of dollars in damages to infrastructure and facilities. Quagga and zebra mussels are notorious examples of AIS that have wreaked havoc on the waterways of the United States since the late 1980s. Their establishment in the Great Lakes has resulted in billions of dollars being spent on control and mitigation costs due to the damages they have caused to infrastructure, facilities, and communities. The year 2007 marked the first discovery of these mussels west of the 100th meridian, and since that time they have infested waterbodies in several western states. In recent years, the prevention of these mussels has become a top priority for many northwestern states, including Washington (See *Case Study: Zebra and Quagga mussels*).

The purpose of the *Aquatic Invasive Species Action Plan for Lake Whatcom Reservoir* (the Plan) is to act as a guide for the implementation of AIS prevention, monitoring, control, and education/outreach strategies in the Lake Whatcom Watershed.

Specifically, the Plan aims to inform decision-makers and the public on ways to:

- Prevent the introduction and establishment of additional AIS to Lake Whatcom
- Effectively monitor for AIS to ensure early detection and rapid response
- Control and mitigate infestations in a timely manner in order to diminish any harmful ecological, economic, or public health impacts that could result from the introduction of AIS into Lake Whatcom
- Limit the spread of existing AIS populations from Lake Whatcom to other uninfested waterbodies in the area

To accomplish these goals, the City of Bellingham and Whatcom County will need to invest in a comprehensive education and prevention strategy that may involve: the creation and distribution of outreach materials for residents and visitors, watercraft inspections, permits/stickers to limit watercraft access to low-risk watercraft only, cleaning stations (manned or unmanned), and informational signage throughout the watershed. Additionally, it is important to establish an effective monitoring program to ensure early detection and rapid response to AIS infestations. In the case of a successful invasion, approved control and mitigation procedures will need to be implemented in a timely manner to minimize harmful impacts associated with the infestation.

The first section of the Plan includes background information on the Lake Whatcom Watershed, a summary of different species threatening the watershed, a general overview of AIS introduction pathways, impacts, prevention and response strategies, and a risk assessment model. This first section concludes with a case study on zebra and quagga mussels that includes information on their introduction to the United States, the impacts and costs associated with infestations, the factors influencing their spread and survival, and potential prevention and control strategies.

The second section of the Plan, the AIS Management Plan, summarizes specific actions and procedures for the prevention and control of AIS in Lake Whatcom. This section is organized into subsections based on six objectives. Each subsection begins with an overview of the objective and is followed by a set of tasks and actions to be completed. Additional materials and supporting documents for the Management Plan are included as appendices.

This plan is intended to act as a local guidance document for preventing and managing AIS, such as zebra and quagga mussels, in the Lake Whatcom Watershed and is not intended to compete with any efforts being conducted at the state level.

Geographic Scope: Lake Whatcom

Introduction

The Lake Whatcom **Watershed**[G] is located in Whatcom County in the northwest corner of Washington State (**Appendix A**). Lake Whatcom is an open, multiple-use lake that is the drinking water reservoir for much of Whatcom County and is also host to **watercraft**[G] from all over Washington and Canada making it increasingly at risk for AIS infestations.

Lake Whatcom provides drinking water to 95,000 residents of Whatcom County and supports a variety of fish and wildlife species, both native and nonnative. The watershed is also home to over 15,000 residents, and is an active recreational site for residents and outsiders alike. The introduction of AIS into Lake Whatcom could seriously compromise the municipal water supply, dam, hatcheries, recreational infrastructure, and ecosystem integrity of the lake resulting in substantial control and mitigation costs. The City of Bellingham and its partners have created this Plan in an effort to guide prevention and response efforts to combat the imminent spread of AIS into Lake Whatcom.

Lake Conditions

The Lake Whatcom Watershed occupies 36,000 acres, and the lake, which is divided into three basins, has a total surface area of 5,000 acres. Lake Whatcom is about 10 miles long and just over a mile wide at its widest point. The lake holds approximately 250 billion gallons of water and has a depth of 328 feet at its deepest point in Basin 3. While there are approximately 36 tributaries that flow into Lake Whatcom, many of these do not flow year-round. The Lake Whatcom watershed is characterized as an open watershed and drains naturally into Bellingham Bay via Whatcom Creek. In 1938, a dam was built at the head of Whatcom Creek to provide additional water storage, maintain a higher lake water level, and provide flood control. The City of Bellingham uses this dam to control the level of the lake, which is also influenced by water added to the lake by a diversion aqueduct on the Middle Fork of the Nooksack River, though the legal maximum lake level cannot exceed 314.94 feet.

The water quality of Lake Whatcom has been closely monitored since the early 1960s. The lake played a significant role in the area's history of logging, mining, and lumber mills, which may still be influencing lake water quality today. Up until 2001, the largest user of Lake Whatcom water was the Georgia-Pacific Corporation Mill. As these industries closed, the watershed has become highly valued as an area for residential development, which has resulted in additional water quality problems.

In 1998, Lake Whatcom was listed on Washington's 303(d) list of polluted waterbodies due to dissolved oxygen deficits. The decline in dissolved oxygen from widespread algal blooms occurred as a result of phosphorus entering the lake from residential development, forest practices, natural processes and other sources. Additionally, 11 of Lake Whatcom's tributaries fail to meet state water quality standards for fecal coliform bacteria. In response to this listing, the Washington Department of Ecology is developing a **Total Maximum Daily Load**[G] (TMDL) for total phosphorus and fecal coliform load reductions required to return the lake to acceptable water quality standards.

In addition to these current water quality concerns, Lake Whatcom is predicted to face a number of new challenges in coming decades as a result of climate change. It has been suggested that increased variability in climate may further facilitate the expansion and establishment of AIS that are more able to adapt to new environments (U.S. Army Corps of Engineers [USACE], 2009). Even though environmental conditions may not be ideal for the establishment of certain AIS today, we must consider in planning for AIS infestations the adaptability of AIS as well as the possibility of more favorable environmental conditions developing in the future.

When calculating the level of risk of an invasion for a particular waterbody, it is important to take into account both the level of recreational activity taking place on the waterbody (e.g., number of watercraft present and their permanent slipping/mooring addresses, etc.) as well as the environmental conditions present in the waterbody that may facilitate or impede the establishment of AIS of concern. Given the amount of recreational activity taking place on Lake Whatcom, there are many **vectors**[G] available for introducing AIS into the lake, making it a high-risk waterbody. However, a closer look at the environmental conditions present in the lake suggests that there are some factors that have the potential to limit AIS establishment in Lake Whatcom.

Table 1 lists examples of factors that have the potential to influence the survival and successful establishment of AIS in Lake Whatcom: temperature, dissolved oxygen, food availability (chlorophyll), calcium levels, water velocity, pH range, salinity levels, substrate availability, and depth. The Lake Whatcom conditions listed for Basin 1 are from a 2008/2009 Lake Whatcom Monitoring Study completed by the Institute for Watershed Studies at Western Washington University (Matthews et al., 2010). The rightmost column of the table gives an indication of which of these factors may facilitate or impede the establishment of AIS, keeping in mind that these conditions are likely to change over time and tolerance levels may differ depending on the species in question.

Table 1: Lake Whatcom Environmental Conditions for 2008/2009 in Basin 1

Influential Factor	Conditions in Lake Whatcom			Suitability for Survival
Temperature	Min 4.4° C	Max 24.1° C	Mean 11.3° C	IDEAL
Dissolved Oxygen	Min 0.2 ppm	Max 12.3 ppm	Mean 8.3 ppm	POOR
Chlorophyll	Min 0.4 mg/m^3	Max 10.8 mg/m^3	Mean 3.4 mg/m^3	IDEAL
Calcium	Min 7.36 ppm	Max 11.72 ppm	Mean 8.24 ppm	POOR
Water velocity	Low water velocity in lake (may be higher in streams)			IDEAL
pH	Min 6.3	Max 9.3	Mean 7.3	IDEAL
Salinity	Low salinity (<2 ppt)			IDEAL (freshwater spp.)
Substrate	Plenty of hard and soft substrates for attachment			IDEAL
Depth	Min 3 m (Geneva Sill)	Max 100 m (South Basin #3)		IDEAL

As indicated in Table 1, Lake Whatcom has relatively low dissolved oxygen in some areas and low calcium concentrations (highlighted in blue) that may act as deterrents for the establishment of some AIS such as zebra and quagga mussels and Asian clams that require calcium for shell development. However, these species have the capacity to adapt to certain conditions and so remain a cause for concern for Lake Whatcom. The other influential factors, while they may act as deterrents for a number of species, are generally within the tolerance ranges for most AIS that have been listed on Washington's priority list of AIS (**Figure 2**)(WISC, 2009).

Problem Definition and Ranking

Lake Whatcom is already home to several populations of non-native plant and animal species that arrived in the Lake Whatcom Watershed using a variety of pathways. Several non-native species of fish, including brown bullhead, largemouth bass, and yellow perch, were illegally introduced to Lake Whatcom for sport-fishing purposes. Non-native fish species have been found to negatively impact native fish populations through acts of predation, the introduction of disease and parasites, and competition for food and habitat (Washington Aquatic Nuisance Species Committee [WANSC], 2001). In addition to these non-native species of fish, there are currently at least seven species of aquatic invasive plants that can be found in and around Lake Whatcom (**Table 2**).

Table 2: Examples of aquatic invasive species already present in and around Lake Whatcom

Aquatic Plants	Scientific Name	Location
Eurasian watermilfoil	*Myriophyllum spicatum*	Widespread throughout lake
Purple loosestrife	*Lythrum salicaria*	Along shoreline – Basin 1
Garden loosestrife	*Lysimachia vulgaris*	Along shoreline – Basin 1
Yellow flag iris	*Iris pseudacoras*	Widespread along shoreline
Fragrant water lily	*Nymphaea odorata*	Widespread throughout lake
Hairy willow-herb	*Epilobium hirsutum*	Widespread along shoreline
Yellow floating heart	*Nymphoides peltata*	Geneva Pond

These species are capable of outcompeting native aquatic plant species and altering the habitat and water quality through their ability to form dense populations under a variety of aquatic environmental conditions.

The pathways used by invasive species to spread to new locations are not always easily identified but may include:

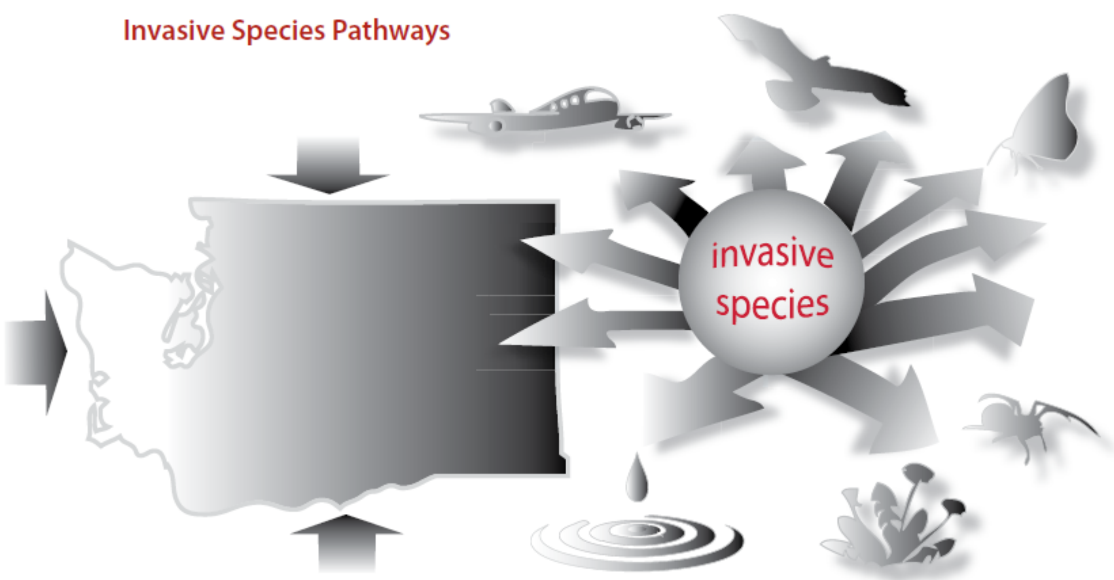
- Being accidentally or deliberately released by individuals
- Becoming attached to boat hulls, motors, trailers, and equipment
- Becoming attached to float planes
- Being transported in bilge tanks, live wells, and engine cooling water
- Becoming attached to field gear
- Being released when aquariums or bait containers are emptied into waterbodies
- Being transferred by waterfowl and other animals
- Being released when species used in live-food trade are released (such as crayfish or lobster)

In the case of the AIS already located in the Lake Whatcom Watershed, we can hypothesize that Eurasian watermilfoil may have been introduced via watercraft or other recreational equipment entering Lake Whatcom from infested waters, whereas purple and garden loosestrife were most likely introduced as ornamental plants or were transported to Lake Whatcom via waterfowl or other animals. Today, the most likely pathways for the introduction of AIS to Lake Whatcom are through recreational activities such as boating or fishing; however, the illegal dumping of aquariums, live aquatic food or bait, and transportation via streams, float planes, or by animals remain possible vectors for AIS spread. Given the amount of recreational activity occurring on Lake Whatcom, it is likely that additional AIS will become established in the near future unless some preventative action is taken.

The following section describes some general AIS pathways and impacts, a system for ranking species for management purposes, background information on several species of concern, a risk assessment for Lake Whatcom, and prevention and response strategies. More detailed AIS descriptions and species-specific management information can be found by going to the links listed in **Appendix J**.

Pathways

Invasive species can be transported using a variety of different **pathways**[G] (**Figure 1**) including boat hulls, aquarium trade, as frozen or live aquatic food and bait, and via pets and humans. Most of these introduction pathways are human-driven making AIS establishment a product of both the presence of suitable environmental conditions as well as the frequency of human activity on the waterbody. Lake Whatcom is a popular recreational site for boaters visiting from all over Washington and Canada making boating a primary vector for the introduction and spread of AIS to and from the lake. The potential for new AIS introductions to Lake Whatcom is of particular concern as watercraft return to Washington state after mooring in AIS-infested waters, such as Lake Mead. Additional pathways for introduction of new AIS to Lake Whatcom include recreational equipment such as fishing gear, floating devices, and jet skis, as well as monitoring equipment and field gear, including waders.



Transportation:

Air (planes, seaplanes, helicopters)
Water/aquatic (boat hulls, ballast water)
Land/terrestrial (cars, buses, ATVs, trains, subways, metros, monorails, construction and firefighting vehicles, hikers, horses, pets
Shipping (packing materials such as pallets and crates, containers interiors and exteriors, mail and internet)
Travel/Tourism/Recreation (humans, baggage/gear, pets, plants, food)

Living Industry Pathways:

Plants aquatic and terrestrial (importation of plants for research, includes seeds, bulbs, and roots, potting soils, plant trade such as agriculture, nursery and landscape)
Food (live seafood, plant and plant parts as food)
Non Food Animal Pathways (aquarium trade, animals for research, bait)
Nonliving animal and plant related pathways (frozen seafood, firewood, mulch, straw)

Miscellaneous Pathways:

Biocontrol (release of species to control another which then becomes invasive itself)
Interconnected waterways (freshwater canals, estuaries, domestic waste streams)
Natural Migration (ocean currents, wind patterns, migratory birds)
Ecosystem disturbance (logging, prescribed burning)
Garbage (landfill and transport of garbage)

Figure 1: Invasive Species Pathways for Introduction (WISC, 2008)

In order to prevent the spread of AIS into Lake Whatcom and surrounding waters, all potential vectors for individual AIS of concern will need to be identified and managed accordingly. Examples of introduction pathways for specific species can be found under the species descriptions located later in this section.

Impacts

Aquatic invasive species introductions can lead to a variety of environmental and economic impacts to aquatic ecosystems. If AIS are allowed to become **established**[G] in Lake Whatcom, we can expect them to:

- Clog water intake structures resulting in impeded flows to municipal water supplies
- Displace, foul, and outcompete native species of fish, plants, and wildlife
- Alter nutrient cycles and food webs in the lake
- Lead to even greater dissolved-oxygen deficits in the lake
- Foul fish ladders and pipes at hatcheries
- Bio-accumulate environmental contaminants and spread toxic algal blooms and pathogens
- Create long-term taste and odor issues in drinking water supplies
- Increase water treatment costs
- Foul and damage dams and other infrastructure in the lake
- Foul and damage recreational boats and boating equipment
- Reduce lakefront property values as a result of reduced aesthetic value
- Make shoreline areas hazardous for recreational users and wildlife

These are just some of the impacts that could result from the costly introduction of AIS into Lake Whatcom.

Ranking System

The ranking system used for this Plan was derived from the Washington Invasive Species Council 2009 Annual Report. In this report, the Council classified invasive species based on an impact score and a prevention score to determine a list of 50 priority species (both terrestrial and aquatic) requiring immediate action (**Figure 2**).

Terrestrial Plants	Aquatic Plants	Terrestrial Animals	Aquatic Animals	Insects/Diseases
Butterfly bush	Caulerpa seaweed	Feral swine	Asian carp	Bark-boring moths
Common crupina	Eurasian watermilfoil	Mediterranean snail	Atlantic salmon	Exotic apple fruit pests
Dalmation toadflax	Hydrilla		Bullfrog	Exotic leafrollers
Garlic mustard	Parrotfeather		Green crab	Lymantriids
Giant hogweed	Common reed		Marine clam	Wood-boring beetles
Hawkweeds	Purple loosestrife		Mitten crab	VHS type IVa
Himalayan blackberry	Spartina		New Zealand mud snail	VHS type IVb
Knapweeds	Variable-leaf milfoil		Northern snakehead	SVCV
Knotweeds	Water chestnut		Nutria	
Kochia	Brazilian elodea		Red swamp/rusty crayfish	
Kudzu			Tunicates	
Leafy spurge			Zebra/quagga mussel	
Rush skeletonweed				
Scotch broom				
Scotch thistle				
Tamarix				
Tansy ragwort				
Yellow starthistle				

Figure 2: Washington Invasive Species Council's 50 Priority Species (WISC, 2009)

The impact score was used to determine the species' level of threat (a high score indicates that the species poses a great threat to Washington's environment, economy, and human health).

The prevention score was used to estimate an agency's ability to take preventative or early action for that species (a high score indicates a greater likelihood for agencies to be able to prevent species establishment and respond quickly to new infestations).

Both of these scores were plotted in a management grid designed to guide management actions for particular species (**Figure 3)**. The species included in this assessment were identified by a workgroup of invasive species professionals. This list is likely to change over time as new species posing serious risks to Washington are identified. The full Management Grid with species included can be found in **Appendix C**.

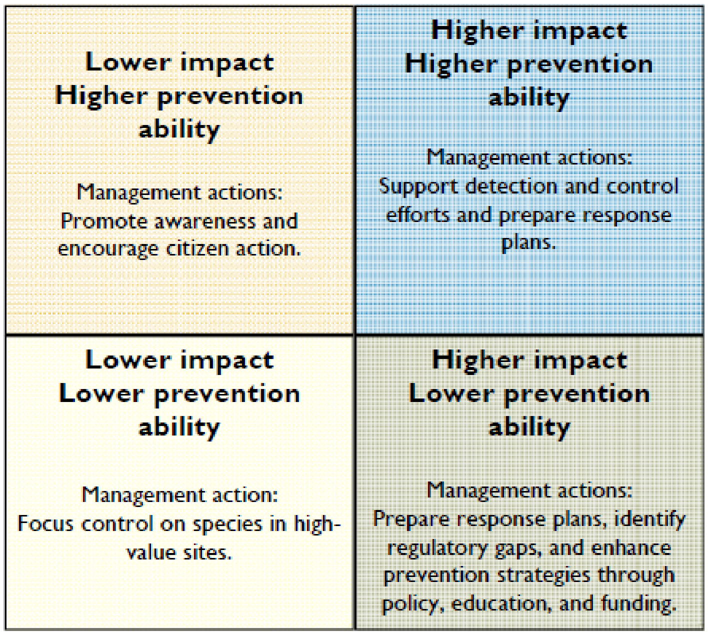


Figure 3: AIS Priority Management Grid (WISC, 2009)

Several of the species included in the species descriptions below were identified using the Washington Invasive Species Council's ranking system. While their grid cannot provide a direct list for Lake Whatcom due to regional differences, it was able to provide a baseline for comparing the level of impact with the ability to prevent certain species that had already been identified as threats to Lake Whatcom. This plan prioritizes species with high impact scores and high prevention scores, potentially providing a system to guide management actions that prevent the most harmful AIS from entering Lake Whatcom.

One additional species of concern for Lake Whatcom is the Asian clam, *Corbicula fluminea,* which was not included in the Washington Invasive Species Council's list of 50 priority species. This AIS has been present in Washington State since the 1930s but is not found in Lake Whatcom and so has been added to our list of species of concern due to the potential environmental and economic impacts associated with Asian clams.

While there are many AIS that could threaten Lake Whatcom in the near future, only a select group of these species has been included in this plan for illustrative purposes. For more information on species of concern, please contact your local AIS Coordinator and/or view the links provided in **Appendix J**.

Threats: Lake Whatcom's Most Unwanted Species

This section describes several examples of AIS of concern for Lake Whatcom. The list of species presented here includes four species that have not yet spread to the Northwest, four species that are already established in Washington waters outside of Lake Whatcom, and three species that are already threatening Lake Whatcom (**Table 3)**. Despite their varied distributions, all of these species could result in serious economic, environmental, and/or human health consequences for Lake Whatcom and its residents if preventative measures are not taken. More detailed descriptions of these species of concern can also be found below. For more information on the environmental conditions required for the survival of several of these AIS, see Table 5 in **Appendix B** .

Table 3: Lake Whatcom's Most Unwanted Species

	Common Name	Scientific Name	Nearest location
Viruses	Viral Hemorrhagic Septicemia (VHS) Virus IVb strain	*Novirhabdovirus* spp**.**	Great Lakes
Freshwater Snails	New Zealand mudsnail	*Potamopyrgus antipodarium*	Thornton Creek, Seattle and Capitol Lake, Olympia, WA
Freshwater Clams and Mussels	Asian clam	*Corbicula fluminea*	Lake Washington; Columbia, Snake, Chehalis, and Willapa rivers; Hood Canal and Aberdeen Lake, WA
	Zebra mussel	*Dreissena polymorpha*	UT, CA
	Quagga mussel	*Dreissena bugensis*	NV, CA, AZ, CO
Crabs	Chinese mitten crab	*Eriocheir sinensis*	Columbia River at the Port of Ilwaco, WA
Fishes	Asian carp (silver carp)	*Hypophthalmichthys molitrix*	Sunset Park Pond, Las Vegas, NV and Mississippi River
Aquatic Plants	Hydrilla	*Hydrilla verticillata*	Lake Lucerne and Pipe Lake, WA (Eradicated)
	Garden loosestrife	*Lysimarchia vulgaris*	Lake Whatcom, WA
	Purple loosestrife	*Lythrum salicaria*	Lake Whatcom, WA
	Eurasian watermilfoil	*Myriophyllum spicatum*	Lake Whatcom, WA

Viral Hemorrhagic Septicemia (VHS) Virus IVb strain *(Novirhabdovirus spp.)*

Viral Hemorrhagic Septicemia (VHS) is a deadly fish virus that affects a variety of fish species and can result in significant fish kills. The virus attacks the blood vessels of fish causing vessel breakage and severe blood loss which ultimately result in death. Two strains of VHS have been identified, IVa and IVb. The IVa strain was first reported in North America in 1988 when it infected spawning salmon in the Pacific Northwest (WISC Fact Sheet, 2010). The most likely mode of introduction of this virus to the United States was through ballast-water exchange. The IVb strain, a new and extremely deadly strain of VHS, was identified in 2003 in Lake St. Clair, Michigan (Wyoming Game and Fish Department, 2010). Since then, the virus has resulted in fish kills throughout the Great Lakes region. The new

Figure 4: VHS.
Photo by Jim Winton

IVb strain is a highly contagious fish **pathogen**[G] that is expanding its range across the United States. The Washington Department of Fish and Wildlife estimates that the IVb strain could impact 42 species of fish in the state, including salmonids and all major sport fish (WISC Fact Sheet, 2010). Viral Hemorrhagic Septicemia IVb can be introduced through a variety of pathways such as through the use of infected bait or in standing water on watercraft that have been transported from infected waters. The Washington Department of Fish and Wildlife is already exercising controls to prevent the introduction of VHS IVb into Washington waters and hatcheries (WISC Fact Sheet, 2010). To prevent the introduction of VHS IVb into Lake Whatcom, measures need to be taken to ensure that infected bait is not released into the lake and that watercraft coming from infested waters are decontaminated before launching or landing.

New Zealand mudsnail *(Potamopyrgus antipodarium)*

The New Zealand mudsnail is a very small (<5mm) snail that is native to New Zealand and has long been established in Australia, Asia, and Europe (Gustafson, 2005). This species was first discovered in North America in 1987 in the Snake River in south-central Idaho (Montana Aquatic Nuisance Species Technical Committee [MANSTC], 2002). Since that time, the snails have spread throughout many western rivers and have recently been found in Capitol Lake in Olympia, Washington. The initial introduction of New Zealand mudsnails was most likely through ballast-water transfer; however, their ongoing spread throughout western waters is mostly attributed to waterfowl, hitchhiking on recreational equipment and field gear, or in the guts of harvested or illegally transported fish (Haynes, Taylor, and Varley, 1985; Richards, O'Connell, and Shinn, 2004; New Zealand Mudsnail Management and Control Plan Working Group, 2007). New Zealand mudsnail population densities can reach up to 400,000 snails per square meter (Oregon Sea Grant, 2010). The snails are able to reach such high densities due to their ability to reproduce **asexually**[G]. High densities of New Zealand mudsnails can outcompete **native**[G] mollusks for resources, degrade native habitat, and may result in **biofouling**[G] of facilities if not controlled (Zaranko, Farara, and Thompson, 1997). Once established, these mudsnails are extremely difficult to **eradicate**[G] so preventing their spread by cleaning recreational equipment and field gear when moving between waterbodies is essential.

Figure 5: New Zealand Mudsnails. WDFW

Asian clam *(Corbicula fluminea)*

The Asian clam can reach lengths of up to 5cm and is native to southern Asia, Australia, and the eastern Mediterranean. This species was first discovered in North America in 1938 along the banks of the Columbia River in Washington (Counts, 1986). It is thought to have been deliberately **introduced**[G] 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**[G] (WANSC, 2001). Currently, it is found in 38 states and the District of Columbia (Foster, 2008). In the San Francisco Bay, Asian clams have reached densities of over 50,000 clams per square meter (Peterson, 1996). Asian clams are able to reproduce asexually and can release up to 100,000 juveniles throughout their lifetime, which is approximately seven years (Hall, 1984). Due to the clam's large population densities 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, and fouling water conveyance systems (WANSC, 2001). Asian clams are estimated to cost $1 billion in damages nationwide each year (U.S. Congress, Office of Technology Assessment, 1993). While this species can be found at several locations throughout Washington state, it has not yet been reported in Lake Whatcom. To

Figure 6: Asian clam. Wyoming Game and Fish Department

prevent the introduction of Asian clams to Lake Whatcom, watercraft and recreational equipment, including bait buckets, should be inspected and decontaminated before entering the lake.

Zebra and quagga mussels *(Dreissena spp.)*

Figure 7: Zebra mussel.
W. Baldwin, WDFW

Zebra mussels and quagga mussels are very small freshwater **bivalve**[G] mollusks that are native to the Caspian, Black, and Aral seas of Eurasia. These **Dreissenid**[G] species were first discovered in North America in 1988 in Lake St. Clair and are thought to have been introduced via ship ballast water (Benson and Raikow, 2010). By the early 1990s, zebra and quagga mussels had spread throughout the Great Lakes Region (Bossenbroek et al., 2007). Since that time, they have spread throughout the Mississippi River Basin and have been reported in waterbodies as far west as California. Since their initial introduction, the primary vector for spreading zebra and quagga mussels to uninfested waterbodies has been via trailered watercraft. Unlike native North American mussels, these mussels are capable of attaching themselves to a large variety of substrates using **byssal threads**[G]. This adaptation allows zebra and quagga mussels to spread easily to uninfested waterbodies by hitching a ride on boat hulls, motors, and recreational equipment, among other things (Benson and Raikow, 2010). Female mussels are able to produce up to one million eggs per spawning season (Anderson, 2010). The free-swimming **veligers**[G] (larvae) that emerge are able to disperse widely in water currents, bilge water, ballast water, or in any other standing water on watercraft. These mussels are able to form dense aggregates of up to 700,000 mussels per square meter (Griffiths et al., 1991) and can result in a variety of economic and environmental impacts including: damaging and fouling recreational equipment, clogging water intake pipes and impeding flows to municipal water supplies, and may cause irreversible damage to native aquatic ecosystems (WANSC, 2001). Where these mussels have become established, they have resulted in billions of dollars in damages and estimated annual control costs are at least $1 billion nationwide (Pimentel, Zuniga, and Morrison, 2005). These mussels have not yet been reported in the northwestern states but it is thought that they would thrive in many Washington waters, including Lake Whatcom (WANSC, 2001). Watercraft inspection programs are currently in place throughout Washington in an effort to stop watercraft transporting zebra and quagga mussels before they enter Washington waters. More detailed information on the zebra and quagga mussels can be found in the *Case Study: Zebra and Quagga Mussels*.

Chinese mitten crab *(Eriocheir sinensis)*

Figure 8: Chinese mitten crab.
Photo by Lee Mecum,
Maryland Invasive Species Council

The Chinese mitten crab is a **catadromous**[G] crab native to Korea and Southern China. The first report of this species becoming established in North America was in 1993 in the San Francisco Bay. By 1994, breeding populations had been observed at various locations throughout the Bay and the adjoining Sacramento and San Joaquin rivers (WANSC, 2001). While the most likely form of introduction to the western United States was via untreated ship ballast water, the mitten crab is also known to migrate long distances and is able to move quite readily over land to avoid dams and irrigation diversions. Mitten crabs may have also been introduced intentionally for their food value (WANSC, 2001). These crabs have been reported as far north as the Columbia River at the Port of Ilwaco, Washington (Benson and Fuller, 2010). Mitten crabs are able to dig burrows into levees that can damage and weaken their structural integrity. They are also capable of clogging water intakes and diversion screens due to their high densities and may compete with and prey on many species of native finfish and shellfish (WANSC, 2001).

Asian carp (silver carp) *(Hypophthalmichthys molitrix)*

Figure 9: Silver carp. USFWS

Asian carp consist of four species: bighead carp, silver carp, black carp, and grass carp. Silver carp are native to Southeast Asia and east Russia and were intentionally introduced to the United States in 1973 to a private aquaculture facility in Arkansas to improve water quality in the fish culture ponds (Fuller, Nico, and Williams, 1999). The species is now present in twelve states and is naturally reproducing (Nico, 2010). The silver carp is mainly found in the Mississippi River Basin and has not yet been confirmed in the Great Lakes. Silver carp populations feed on considerable amounts of phytoplankton, zooplankton, and detritus and therefore may compete with native fish species for food, disrupting entire food webs (Aitkin et al., 2008). They can weigh over 77 pounds and grow to up to 6 feet in length (Oregon Sea Grant, 2008). Silver carp are usually found in the upper portion of the water column and have been observed leaping out of the water when disturbed by the sounds of boats or personal watercraft (Schofield et al., 2005). This behavior has resulted in serious injuries to boaters and damage to equipment in waterways throughout the Midwest. In 2002, an electric barrier was installed in the Chicago Sanitary and Ship Canal to prevent Asian carp from entering the Great Lakes (Kolar et al., 2005). However, since 2009, environmental DNA samples from Asian carp have been found in the Calumet Harbor on Lake Michigan as well as throughout the network of manmade channels and re-routed streams that link the Illinois River to Lake Michigan, leading some to believe that these fish may have found a way across the barriers (Harger, 2010). Due to the voracious appetites of Asian carp, these fish are capable of seriously impacting the Great Lakes' annual $4.5 billion fishing industry if they become established (Oregon Sea Grant, 2008). While not yet in the Northwest, fishermen traveling from the Midwest may accidentally bring and release juvenile Asian carp as bait fish to Washington waters (Oregon Sea Grant, 2008). It is important that all boaters entering Lake Whatcom do not use Asian carp as bait and that they clean, drain, and dry their boats before entering the lake in order to prevent the introduction of Asian carp.

Hydrilla *(Hydrilla verticillata)*

Figure 10: Hydrilla. MD DNR

Hydrilla is a submersed aquatic invasive plant that is native to Asia and was first introduced to the United States in the 1950s for use in aquariums (MANSTC, 2002). It was most likely introduced into the wild near Tampa and Miami, Florida. It is currently found along the coast from Maine to Texas, and there have also been confirmed infestations in California, Idaho, and in Pipe Lake and Lake Lucerne, Washington (MANSTC, 2002). Hydrilla is most likely spread when plant fragments are dispersed by river flows, boats, trailers, kayaks, and fishing equipment. However, aquatic plant managers believe that the hydrilla in Washington was likely introduced via mail-order water lilies that were contaminated with hydrilla tubers (K. Hamel, Department of Ecology, personal communication, April 13, 2011). Hydrilla is very difficult to manage because it can reproduce by **fragmentation**[G], as well as using underground **tubers**[G], overwintering buds, and by seed, which makes it able to withstand winter conditions and herbicide treatments (WANSC, 2001). Hydrilla is able to form dense surface mats that can alter water quality, clog water conveyance structures, interfere with recreational activities, and displace native aquatic plant species (MANSTC, 2002). Hydrilla was confirmed in Pipe Lake and Lake Lucerne in King County, Washington, in 1995. Hydrilla has not been confirmed in any other location in Washington to date. Researchers speculate that hydrilla did not spread beyond this location, in part, because these connected lakes are privately owned with no public boating access (WANSC, 2001). However, to prevent the spread of hydrilla into Lake Whatcom, lake residents should never plant water lilies or other aquatic plants in the lake. In addition, all watercraft operators should remove any aquatic plant materials before entering other waterbodies.

Garden loosestrife *(Lysimachia vulgaris)*

Garden loosestrife is a large, upright perennial that grows along lakeshores, waterways, and in wetland areas. It is native to Eurasia and was introduced to North America as an ornamental landscaping plant (Whatcom County Noxious Weed Control Board, 2011). This aquatic invasive plant was first confirmed in Washington in 1978 in Lake Washington, King County (Washington State Department of Ecology, 2011). Since that time it has been confirmed along the shorelines of Lake Sammamish, Lake Washington, Chambers Lake, Loon Lake, and Lake Whatcom (Washington State Department of Ecology, 2011). While it is thought that garden loosestrife was originally introduced to Washington as an ornamental plant, it is able to spread through water dispersal of seeds, by plant fragments and **rhizomes**[G], and by seeds being transported by animals, humans, boats and vehicles (Washington State Department of Ecology, 2011). Garden loosestrife can get up to one meter tall and is distinguished by large yellow blooms that grow in a cluster at the top of the plant (Whatcom Noxious Weed Control Board, 2011). Preferring moist habitats, garden loosestrife has been known to out-compete other aquatic invaders, such as purple loosestrife, as well as native vegetation as it aggressively spreads into stands of established vegetation (King County Noxious Weed Control Program, 2011). When this aquatic invader forms large stands, it reduces the amount of preferred habitat available for waterfowl, wildlife, birds and fish (King County Noxious Weed Control Program, 2011). Though slow to invade new areas, garden loosestrife is extremely difficult to eradicate (King County Noxious Weed Control Program, 2011). Digging, cutting, or mowing are *not* considered effective control options for large infestations of garden loosestrife due to its ability to form new shoots and roots from cut plants. However, other control options to limit the spread of this aquatic weed may include the use of herbicides, cutting mature stems at the base in the late summer to prevent seed dispersal, and covering seedlings in black plastic to slow growth and seed production (King County Noxious Weed Control Program, 2011). To prevent the spread of garden loosestrife to other waterbodies, lake residents should never plant ornamentals in the lake. In addition, all watercraft operators should remove any aquatic plant materials before leaving and entering other waterbodies.

Figure 11: Garden loosestrife. Whatcom County Noxious Weed Control Board

Purple loosestrife *(Lythrum salicaria)*

Purple loosestrife is a large **perennial**[G] plant that grows along waterbodies and in wetland areas (WANSC, 2001). It is native to Europe, Japan, Manchuria China, Southeast Asia, and northern India (Georgia Invasive Species Management Plan Advisory Committee [GISMPAC], 2009) and has been established in North America since the early 1800s, when it was imported as an ornamental plant for its medicinal value and its purple blooms (Hanson and Sytsma, 2001). Purple loosestrife can now be found in 43 states, including Washington (Ling Cao, 2011). Today, this aquatic invasive plant is able to spread to uninfested waters through water dispersal of seeds and broken off plant material or seeds being transported unintentionally by animals, humans, boats and vehicles (Thompson, Stuckey, and Thompson, 1999). Once established, this plant is very difficult to eradicate. Purple

Figure 12: Purple loosestrife. Washington State Noxious Weed Control Board

loosestrife form very dense **monocultures**[G] and outcompete and replace native plants that provide higher quality food and habitat for wildlife (GISMPAC, 2009). Purple loosestrife is already established in and around Lake Whatcom. Hand pulling, digging, and herbicide application are the main control methods used; however, there are some **bio-control**[G] methods, notably *Galerucella* spp., a beetle that has been effectively used throughout Washington including in Grant and Whatcom Counties (L. Baldwin, Whatcom County Noxious Weed Board, personal communication, April 12, 2011; WANSC, 2001).

Eurasian watermilfoil *(Myrophyllum spicatum)*

Eurasian watermilfoil is a submersed aquatic invasive plant native to Europe, Asia, and Northern Africa (Jacono and Richerson, 2010). The first report of this species in North America occurred in 1942 in Washington, D.C., when it was thought to have been intentionally introduced (Couch and Nelson, 1985). Currently, Eurasian watermilfoil is present in 45 states and three Canadian provinces (Creed, 1998; Jacono and Richerson, 2010). These plants can reproduce by seed but mostly spread and reproduce via stem fragments, which can grow into new plants (WANSC, 2001). **Fragmentation**[G] can occur through wind and wave action and by boating and other recreational activities, as well as through autofragmentation by the plants, generally after flowering. Watermilfoil can reproduce extremely rapidly, forming dense mats along the surface of the water. This results in reduced light and can negatively impact native plant populations and alter water quality (Smith and Barko, 1990; Madsen, 1994). Eurasian watermilfoil is considered to be one of the most problematic freshwater invasive plants in Washington. Federal, state, and local governments, as well as lake and river property owners, spend millions of dollars each year for Eurasian watermilfoil control and mitigation (WANSC, 2001). Eurasian watermilfoil has been present in Washington since 1965 (Whatcom County Noxious Weed Board, 2008) and is thought to have spread to Lake Whatcom via recreational boaters transporting it from nearby lakes. Milfoil distribution in western Washington closely follows the Interstate 5 corridor, and milfoil continues to spread to uninfested waters each year (WANSC, 2001). Although Eurasian watermilfoil is already present in Lake Whatcom, it is important that watercraft operators remove any aquatic plant material before entering and leaving Lake Whatcom to prevent the spread of this aquatic invasive plant to surrounding waters.

Figure 13: Eurasian watermilfoil.
High County Resource Conservation and Development Council

Risk Assessment

Determining the level of risk associated with an AIS infestation occurring in a particular waterbody is partly dependent on the following factors:

- **The amount of recreational activity occurring on the waterbody**
- **The suitability of the waterbody to support the establishment of AIS**
- **The current distribution of AIS and their proximity to the waterbody**
- **The potential impacts and mitigation costs that could result from an infestation**
- **The existing level of protection**

Questions to consider when determining the level of risk associated with an AIS infestation occurring in your lake or reservoir include the following:

1) Does your lake or reservoir support fish, mussels, or other wildlife?
If yes, then the environmental conditions present in your lake or reservoir (water quality, food availability, dissolved oxygen, pH, etc.) may be suitable for AIS to survive.

Lake Whatcom supports fish, mussels, and other wildlife but has low calcium and low dissolved oxygen that may hinder the establishment of certain AIS. (LOW RISK)

2) Is your lake or reservoir used by boats, jet skis, or float planes?
If yes, then you have vectors present that could transport AIS into your waterways.

Lake Whatcom is used by boats, jet skis and float planes. (MODERATE RISK)

3) Are watercraft and recreational equipment coming from infested waters?
If yes, then without an inspection/decontamination program in place, your waters may easily become infested by AIS.

Lake Whatcom hosts watercraft from Canada and Washington but may also be used by watercraft operators and recreationists coming from infested waters. Until more information is gathered regarding watercraft and their recent history of use, Lake Whatcom risk levels remain moderate. (MODERATE RISK)

4) Do the watercraft coming to your lake include vessels that have been slipped and moored in other waters?
If watercraft have been slipped or moored in infested waters for more than 30 days (houseboats, cabin cruisers, or sailboats) they may be more likely to be infested with AIS.

Until more information is gathered regarding watercraft and their recent history of use, Lake Whatcom risk levels remain moderate. (MODERATE RISK)

5) Do you have any prevention measures already in place?
If no, then your lake or reservoir is at an even greater level of risk of an infestation. By putting prevention measures in place, you could significantly reduce the level of risk of an invasion occurring.

There are currently very few AIS prevention measures in place for Lake Whatcom, although signs have been posted at boat launches. (HIGH RISK)

6) What are the potential impacts that could result from an AIS infestation in your lake or reservoir?

Depending on the potential impacts and the mitigation costs, the level of risk associated with an infestation in your waterbody may increase.

Lake Whatcom would be severely impacted by an AIS infestation because it is a multiple-use watershed that provides drinking water to 95,000 people, habitat for fish and wildlife, recreational opportunities, and accommodates infrastructure for drinking water, fish hatcheries, and flood control. The costs of mitigating impacts to these designated uses would be substantial. (HIGH RISK)

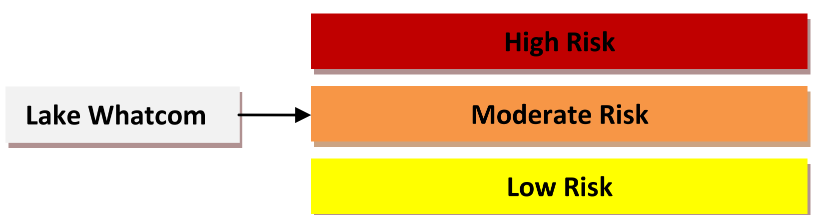
7) What is the proximity of AIS infestations relative to your lake or reservoir?

Near – If AIS infestations are near to your lake or reservoir, you should have a prevention program in place to reduce the risk of an infestation.

Far – If AIS infestations are far away, you need to know whether AIS are capable of surviving the journey from an infested waterbody to your waterbody using potential introduction pathways. If so, your waterbody is still at significant risk of an infestation.

Distribution of AIS are constantly changing as new infestations occur. Many top priority AIS are **Far** from Lake Whatcom but may move closer in coming years. There are also a number of species that are already **Near** Lake Whatcom and should be prevented from entering the reservoir. (MODERATE RISK)

Risk Designation:



Based on the above factors and questions, we have designated Lake Whatcom as a **Moderate Risk** waterbody for AIS invasions. **Note:** The designated risk level is expected to change over time based on a number of factors, including: changes in distribution of AIS, changes in water chemistry conditions in the lake, and changes in preparedness levels at Lake Whatcom as inspection and screening protocols are put in place. If action is not taken soon, Lake Whatcom may be designated as a High Risk waterbody as water chemistry conditions become more suitable and as more vectors for spread arrive over time. **We need to take action now to attain for Lake Whatcom designation as a Low Risk waterbody and actively prevent the spread of AIS to the Lake Whatcom Watershed.**

Prevention Strategies

Given the potential economic and ecological impacts that can result once AIS become established, the most effective management tool is the adoption of prevention strategies to stop aquatic invasive species from being introduced in the first place. Prevention strategies are used to address any AIS that are not yet present in a waterbody as well as to minimize the further spread of any AIS that are already present in a waterbody. Once AIS become widely established, the likelihood of eradicating them is dramatically reduced and the costs for control and mitigation efforts can become exorbitant.

Fortunately, preventing the introduction of AIS to new waterbodies is the most preferred outcome and is far more cost effective when compared to control efforts (**Figure 14**).

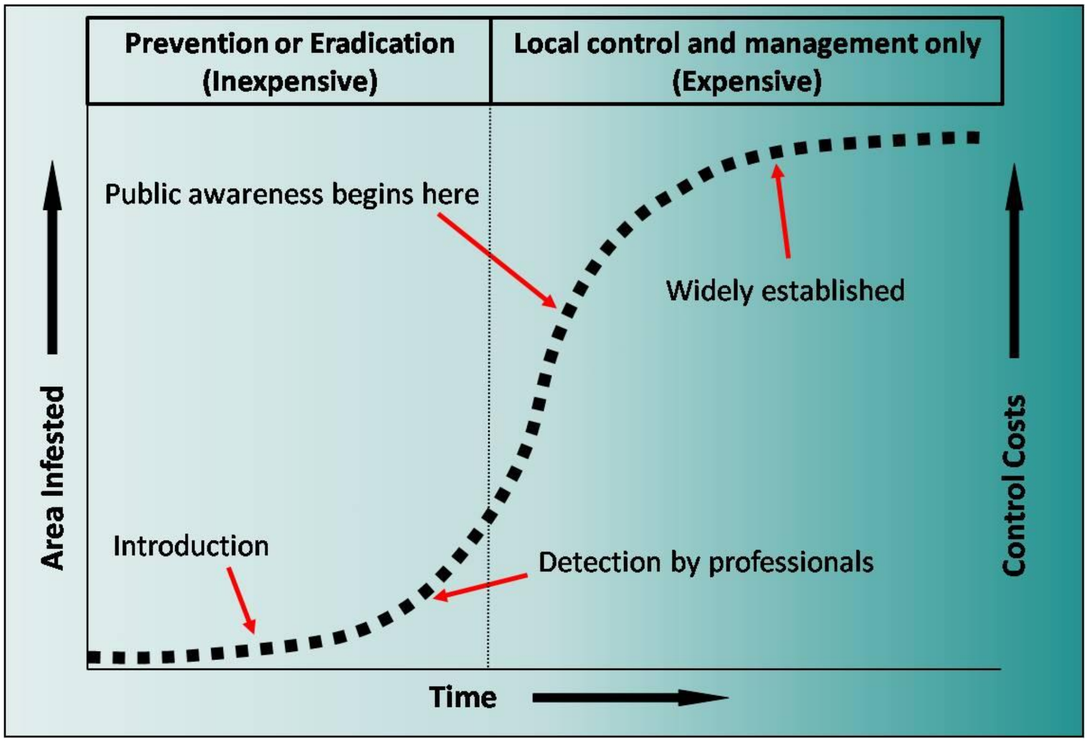


Figure 14: Invasion curve illustrating cost effectiveness of prevention and early detection over local control efforts as area infested increases over time (Adapted from R. Emanuel, Oregon Sea Grant/Oregon State University Extension, personal communication, December 8, 2010).

Prevention strategies include AIS education and outreach, inspecting and decontaminating watercraft and recreational equipment, and providing more stringent regulations and enforcement (Lodge et al., 2006).

Education and Outreach:

Education and outreach prevention strategies can include:

- Creating informational signage to be displayed at boat launches, beaches, waterfront parks, and along waterfront trails.
- Creating and disseminating outreach materials (brochures, fact sheets, online sources, etc) with consistent messaging that effectively communicate information on species of concern and preventative measures that residents and recreationists can take to stop AIS from being introduced into the waterbody.
- Conducting informational interviews with watercraft operators and recreationists to collect information on their most recently visited locations (infested vs. uninfested), current cleaning practices, and level of knowledge regarding AIS and prevention strategies.

Inspection and Decontamination:

Inspection and decontamination should be done both before and after watercraft and recreational equipment enter a waterbody. Not all AIS may be visible on the surface of a vessel or gear (e.g., zebra/quagga mussel larvae) so it is essential to **Clean, Drain, and Dry** watercraft and recreational equipment before entering other waters. Inspection and decontamination prevention strategies can include:

- Inspecting all watercraft (including boats, rafts, kayaks, float planes, and float tubes), fishing and field gear, clothing, waders, rope, cooling tanks and live wells for the presence of aquatic plants, animals, and mud.
- Cleaning, removing, and thoroughly washing all watercraft and recreational equipment with high-pressure hot water (>140°F) before launching into other waters.
- Draining all water from boats, trailers, pontoons, tackle, and gear before leaving a waterbody.
- Allowing sufficient time for boats and recreational equipment to dry before entering another waterbody (a minimum of 5 days depending on temperature and weather/humidity).
- If conducting field work in both infested and uninfested waterbodies, it is recommended to dedicate field gear and equipment to particular waterbodies to avoid contaminating uninfested waters (e.g., use dedicated pairs of waders and rubber boots).

Regulation and Enforcement:
Regulatory and enforcement prevention strategies at the local level may include:

- Adopting an ordinance that requires all watercraft to be inspected and decontaminated (if necessary) prior to launching into the designated waterbody.
- Adopting an ordinance that requires all watercraft to buy and display a permit stating that they have been inspected and decontaminated and are AIS-free. Watercraft launching or landing without a permit would be subject to costly fines.
- Establishing an enforcement presence at boat docks and recreational sites with a designated enforcement team available to educate watercraft operators and recreationists, inspect and decontaminate watercraft/equipment, and impose fines if necessary.

By using a combination of education/outreach, inspection/decontamination, and regulatory and enforcement strategies, agencies can increase their chances of preventing the introduction of AIS into their waterbodies. While prevention is the preferred outcome, there are some introduction pathways that are outside of our control. It is for this reason that it is also important to have strategies in place to ensure rapid detection and response in case an infestation does occur.

Response Strategies

It can take several years for some AIS to become established and for their impacts to become known. Once a species becomes established, however, it becomes increasingly difficult to eradicate the population (USACE, 2009). It is important to have an early detection protocol in place so that infestations can be reported, confirmed, and responded to as soon as possible. There are three main response strategies that need to be employed in order to effectively respond to an infestation, including: early detection, rapid response, and monitoring.

Early Detection:
Early detection is essential to prevent AIS from becoming established in a waterbody. The earlier an AIS is reported, the faster agencies can respond to the infestation. To detect species soon after their introduction, staff need to be monitoring the waterbody on a regular basis and need to be trained in AIS identification. One strategy that can aid in the prevention of and early detection and response to an AIS infestation is the **Aquatic Invasive Species Hazard Analysis and Critical Control Point (AIS-HACCP)**[G] process. The AIS-HACCP is a process to help identify and control the critical pathways for spread of AIS or other non-target aquatic species. The process involves self-monitoring, verification, and record-keeping systems to help ensure that watershed activities do not result in the spread of these AIS, or hazards. For example, if a scientist is monitoring two different streams and one is infested with New Zealand mudsnails and the other is not, doing an AIS-HACCP analysis before conducting the study could result in the prevention of an AIS infestation. Prior to going to the study sites, each step of the study is documented from start to finish (including study sites and equipment used, etc.) and steps that have the

potential to result in the spread of AIS are identified. By identifying these critical pathways ahead of time, extra precautions can be taken to avoid the spread of AIS. In the example above, field gear, including waders, may act as a vector for spreading New Zealand mudsnails from one stream to the next. Options to avoid spreading this AIS could include cleaning gear between sites, using different sets of gear for each site, or conducting the study of the uninfested site first. An example of an AIS-HACCP plan can be viewed in **Appendix K**. This process not only helps in the prevention of spread, but ensures that staff are aware of their actions at each step and can immediately detect potential points where an infestation may have occurred to launch a rapid response.

Rapid Response:

Once a suspicious organism is detected, protocols need to be put in place to ensure the rapid confirmation of the species in question. This may involve sending DNA or veliger samples to a lab for testing. Sometimes there is a lag time between when samples are taken and when they are actually analyzed for the presence of veligers or DNA. However, it is critical that these samples be analyzed quickly, as resource managers need this information in a timely manner to make effective management decisions. In some cases, lab results can be inconclusive, necessitating additional testing, which can also add to the response time. For this reason, it is important to communicate with testing facilities prior to an infestation to discuss the protocol for testing and distributing results to ensure that it is done in a consistent and timely manner.

Once an infestation has been confirmed, the next step involves assessing the extent of the infestation to determine whether eradication is a feasible option. **Eradication**[G] involves the complete removal of the species from the area. While this is the primary goal of rapid response, it is not always feasible due to the rapid spread and late detection of many AIS infestations. If eradication is not an option, efforts should focus on minimizing impacts associated with the infestation by containing the population to a given area in the waterbody, suppressing the population to slow its spread, or containing the population in the waterbody and preventing its spread to other locations (Glen Canyon National Recreation Area Plan, 2007). Once the extent of the infestation has been determined, the infested area should be quarantined, if possible, to contain the infestation. Whether the goal is to eradicate or contain the AIS in the given waterbody, ensure that the control options chosen will not result in additional harm to the aquatic ecosystem and its uses. Ultimately, the potential damage that may result from establishment of the invasive species should be weighed against the potential damage that could result from the control method. **Control**[G] options should be reviewed carefully to determine any adverse consequences that could result from the application of the control treatment. Some control options may also require special permits before they can be applied to a waterbody, so it is desirable to discuss these options with permitting agencies, such as the Washington State Department of Ecology, prior to an infestation.

Control refers to the act of eradicating, suppressing, reducing or managing invasive species populations, preventing spread of invasive species from areas where they are present and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions (USACE, 2009).

Some considerations for the development of control strategies include (Flathead Basin AIS Work Group, 2010):

- Control strategies should not create problems greater than those resulting from the AIS itself.
- Control strategies should not cause significant impacts to the environment or non-target organisms, nor have any negative consequence to human health or safety.

- Control strategies should only be implemented when the AIS is causing, or has the potential to cause, a significant adverse impact.
- Control strategies should not reduce the human utilization of the waterbody, unless it is determined that a reduction in certain utilizations would be an effective/appropriate method of control.
- Control strategies should be specific to the water body in question and be adaptable to other local waterbodies.
- Control strategies should have a reasonable likelihood of succeeding and be cost effective.

Monitoring:

The infested sites should be monitored continuously from the onset of the infestation to the application of control strategies to record progress over time as well as to allow for modifications to be made to the response and control strategies as needed. Control options are being updated on a regular basis as new information on AIS becomes available (**Appendix H**). For this reason, it is very important to continually update response and control protocols to ensure a rapid response that is able to effectively diminish the spread of AIS while minimizing any environmental, economic, or health impacts that may result from an infestation.

Case Study: Zebra and Quagga Mussels

Zebra Mussel (*Dreissena polymorpha)*
Quagga Mussel (*Dreissena rostriformis bugensis)*

Background

Figure 15: Zebra mussel. USGS

Zebra and quagga mussels are very small, invasive freshwater mussels that, since their detection in the Great Lakes in the late 1980s, have wreaked havoc throughout much of the eastern United States. Zebra and quagga mussel shells are elongated and are typically marked by alternating light- and dark-colored stripes; however, shell patterns and colors can vary to the point of being all dark, all light, or having no stripes at all (O'Neill and MacNeill, 1991). These mussels originate from the Black, Caspian, and Aral Seas of Eurasia. During the late 1700s, they were introduced to the rest of Europe, where they are now found in most inland waterways (O'Neill and MacNeill, 1991). It is believed that zebra and quagga mussels were introduced to the United States in the ballast water of transoceanic ships entering the Great Lakes Basin from European freshwater ports. These mussels were first detected in Lake St. Clair in June of 1988 (Benson and Raikow, 2010). By September of 1991, the mussels were found in all five of the Great Lakes (O'Neill and MacNeill, 1991).

Since the early 1990s, these thumbnail-sized mussels have spread rapidly throughout the St. Lawrence Seaway, the Mississippi River Basin, and the Missouri and Arkansas Rivers. The initial spread of zebra and quagga mussels occurred at an alarming rate due to the interconnectedness of the waterways throughout the Great Lakes Basin. The continued spread of these mussels to inland lakes and reservoirs occurred at a much slower rate due to their reliance on overland transportation by recreational boaters. The year 2007 marked the first time that quagga mussel colonies were discovered west of the 100th meridian with colonies located in Lake Mead, Lake Mohave, and Lake Havasu along the Colorado River and in several waterways in Southern California, to name a few (U.S. Geological Survey [USGS], 2009). To date, these invasive mussels have not been confirmed in the waterways of Washington, Oregon, Montana, or Idaho, but as boats continue to be transported via trailers across the country, the likelihood of an invasion in the Northwest has become more of a cause for concern.

Impacts

Figure 16: Native mussel covered in zebra mussels. Texas Parks and Wildlife

Zebra and quagga mussels can cause serious harm to native biodiversity and can initiate the collapse of entire food webs (Britton, 2007). These invasive mussels differ from native mussels due to their ability to attach to hard surfaces using **byssal threads**[G]. Where these mussels form dense aggregates in native mussel habitats, they are responsible for displacing, fouling and killing native freshwater mussels, resulting in decreased native biodiversity. Additionally, zebra and quagga mussels are capable of filtering substantial amounts of phytoplankton from the water, which decreases the amount of food available for zooplankton and can disrupt entire food chains (Britton, 2007). In the Northwest, there are fears that the introduction of zebra and/or quagga mussels could seriously threaten the viability of several endangered salmonid species (Bossenbroek et al., 2007). Once introduced, these mussels could colonize fish ladders and other transport structures resulting in serious damage to the fish as they pass through conveyance structures. Zebra and quagga mussels also have the ability to **bioaccumulate**[G] environmental contaminants, such as heavy metals and organochlorines that can cause serious harm to aquatic species at higher **trophic levels**[G] (MacIsaac, 1996; Ram and McMahon, 1996).

Due to their algae-filtering capabilities, zebra and quagga mussels are able to increase water clarity resulting in increased light transmittance and excessive growth of bottom-dwelling aquatic plants that would not normally be able to grow. Unfortunately, the mussels' preference for filtering out certain types of algae in preference to others can lead to uncontested growth of harmful blue-green algal blooms, or *Mycrocystis* spp.*,* that release a toxin capable of causing "skin rashes, liver damage, fish kills, and taste and odor issues in drinking water" (Science Daily, 2009; Fernald, Caraco, and Cole, 2007).

Figure 17: Quagga mussels clog pipe. ISDA

In addition to these biological and health impacts, zebra and quagga mussels also pose a substantial economic threat because of their ability to attach to infrastructure, such as piers and pilings, and to water conveyance structures, such as intake pipes and fish screens and ladders. These mussels, due to their high **fecundity**[G], have the ability to clog intake structures and impede the flow of water to municipal water supplies, irrigation operations, and power plants resulting in significant operation and maintenance costs. Between 1990 and 2000, the economic impact to industries, businesses and communities as a result of the zebra mussel infestation in the Great Lakes alone was estimated to be $5 billion (Lovell and Stone, 2005). Additionally, the cost of damage to intake pipes and power plants during this ten-year period was $3.1 billion (Lovell and Stone, 2005). Annual control costs nationwide are estimated to be at least $1 billion (Pimentel et al., 2005).

Figure 18: Mussels on boat motor. Utah Division of Wildlife Resources

Mussels also impact watercraft operators by fouling and causing damage to hulls, engines, rudders, anchors, and other watercraft equipment (**Figure 18**). Watercraft are the principal transporters of quagga and zebra mussels, either as free-floating **veligers**[G] or as adults, which are found attached to the vessel or in the bilge water. When watercraft operators visit out-of-state freshwater bodies and neglect to take the proper precautions, they are acting as a perfect vector for the spread of these aquatic hitchhikers. As a result of this neglect, zebra and quagga mussels have now spread throughout much of the eastern United States and are advancing westward (**Figure 19**).

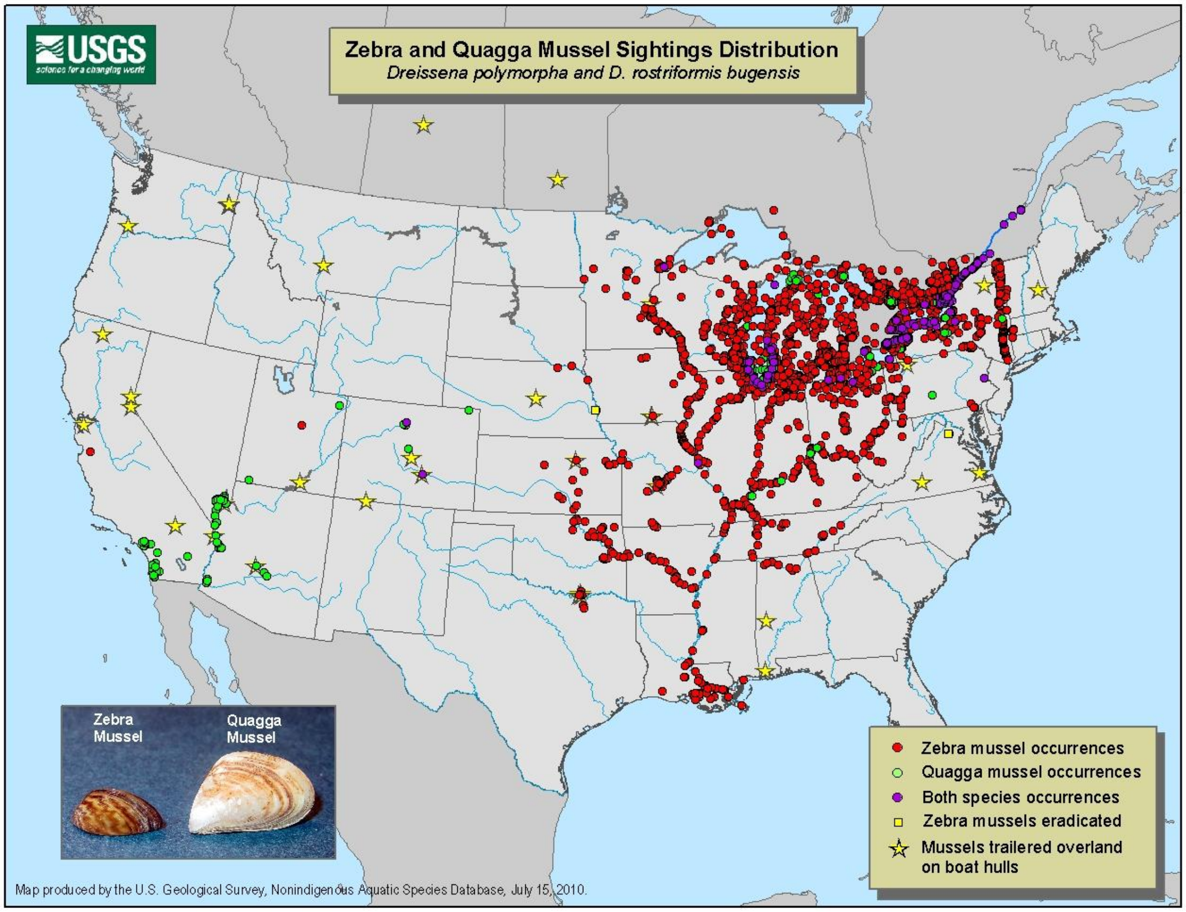


Figure 19: Map of zebra and quagga mussel distributions across the United States. Zebra mussel occurrences are highlighted in red and quagga mussel occurrences are highlighted in green. Yellow stars indicate locations where mussels were found on boat hulls being trailered overland. Note: The yellow star located in Spokane, WA, is from a boat carrying quagga mussels on its hull that was making its way from Lake Mead back to Canada (Source: USGS, Nonindigenous Aquatic Species Maps at: http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel Accessed on: 8/18/2010).

Environmental thresholds

Since the invasion of zebra and quagga mussels in the United States, many studies have been conducted to determine the environmental factors responsible for influencing their spread and survival. By knowing which factors influence the spread and survival of zebra and quagga mussels, scientists can then make predictions regarding which waterbodies are most at risk of an infestation and can advise managers accordingly. Several environmental factors that may be responsible for influencing the spread and survival of zebra and quagga mussels are temperature, relative humidity, dissolved oxygen, food availability (chlorophyll), calcium, water velocity, pH, salinity, **substrate**[G] composition, and depth. More information on these factors and how they may affect the survivability of these mussels can be found below and are summarized in **Table 4**.

Zebra and quagga mussels are highly adaptable to a variety of conditions, so while some of these factors are currently considered to be limiting, these ranges may expand as the species distributions change and as new information becomes available.

Temperature and Relative Humidity

Zebra and quagga mussels, while able to survive a wide range of water temperatures, require certain temperatures for optimal growth and reproduction. Zebra mussels can survive water temperatures as low as 6°C and as high as 32°C (Karatayev, Burlakova, and Padilla, 1998; Mackie and Claudi, 2010). Quagga mussels generally prefer cooler temperatures and can survive water temperatures as low as 5°C, but are known to rapidly die off at 30°C (Spindle, 1994; Mackie and Claudi, 2010). Reproductive capabilities of both zebra and quagga mussels are significantly reduced at water temperatures below 16°C (Britton, 2007). Zebra mussel **spawning**[G] generally occurs at water temperatures between 12-16°C (Claudi and Mackie, 1994; Benson and Raikow, 2010), whereas quagga mussels spawn at temperatures between 5-9°C (Roe and MacIsaac, 1997; Claxton and Mackie, 1998). Zebra and quagga mussels can survive long periods of time out of the water depending on the temperature and relative humidity, which facilitates their long-distance transport, and spread, via watercraft being trailered between waterbodies.

Dissolved Oxygen

Both zebra and quagga mussels can survive for only a short time in low oxygen environments. Adult zebra mussels need >25% dissolved oxygen (between 2 and 3 ppm at 10-25°C) to be able to grow and reproduce (Karatayev, Burlakova, and Padilla, 1998). While there is very little literature on the dissolved oxygen requirements of quagga mussels, it is likely that they have similar tolerance levels to zebra mussels. More recent literature by Cohen (2007) suggests that, while both of these mussels may be able to survive in low oxygen environments, the limiting dissolved oxygen level for both zebra and quagga mussels may be closer to 4 ppm and may be confounded by other factors such as food availability at depths with lower temperatures.

Food availability

Zebra and quagga mussels are filter feeders and primarily feed on phytoplankton but may also filter out other suspended materials from the water column, including bacteria, protozoans, microzooplankton, and silt (MacIsaac, 1996). Their filtering capabilities depend not only on the amount of food available, but also on other water conditions, such as temperature and dissolved oxygen (Noordhuis, Reeders, and Bij de Vaate, 1992). Extremes in temperature and the presence of low dissolved oxygen may result in a decline in filtration rates (Noordhuis, Reeders, and Bij de Vaate, 1992). Large amounts of phytoplankton in the waterbody are generally preferred for the survival and establishment of zebra and quagga mussels, which, once they have become established, have been known to significantly reduce phytoplankton populations and alter entire food webs (Caraco et al., 1997; Whittier et al., 2008).

Calcium

Zebra and quagga mussels prefer high dissolved calcium environments with concentrations >20 ppm required for basic metabolic function and for shell building (Whittier et al., 2008). Waterbodies with lower calcium levels (<12 ppm) are considered to be low-risk because they are less able to provide the environmental conditions necessary for mussel survival and shell production (Whittier et al., 2008). However, a recent study done to determine the likelihood of mussel survival in Lake Tahoe (a low-calcium environment) found that adult quagga mussels could survive for up to 51 days in Lake Tahoe waters with dissolved calcium concentrations of only 13.5 ppm (USACE, 2009). It seems plausible that the calcium range required for survival may actually be closer to previous estimates of 8-32 ppm with a slightly narrower range needed for veliger survival and shell production (Cohen and Weinstein, 2001; Mackie and Claudi, 2010).

Water velocity

High water velocities can affect the mussels' ability to attach to different substrates. For example, flow velocities greater than 2 meters/second can minimize mussel settlement in water intake structures as they may become detached from substrates under higher velocities (O'Neill, 1993; Britton, 2007). Areas with higher water velocities may be more suitable for the veliger stage of development but may impede mussel colony establishment.

pH

Zebra and quagga mussels prefer slightly alkaline waters with pH values in the range of 7.4 to 9.5 for optimal survival and reproduction (Britton, 2007).

Salinity

In North American waters, neither zebra nor quagga mussels can survive in waters with salinity levels greater than 5 ppt (Mills et al., 1996).

Substrate

Both mussels, during their adult stages, prefer to attach to hard surfaces, though quagga mussels have been known to tolerate living in soft sediments (Britton, 2007). Adult zebra and quagga mussels can attach to a variety of hard surfaces, including the shells of other wildlife species, infrastructure, rocks and woody debris, submersed plants, and other hard objects that have been submersed. During their free-floating veliger stage, their survival is not influenced by the type of substrate present.

Depth

In the United States zebra and quagga mussels have been found at depths of over 30 meters below the surface. Typically, these mussels can be found anywhere from just below the surface to depths of 12 to 55 meters, as long as there is sufficient oxygen present (Britton, 2007; California Resources Agency, 2008).

Table 4: Environmental conditions for zebra and quagga mussel survival

Conditions	Zebra mussel		Quagga mussel	
	Adult	Veliger	Adult	Veliger
Temperature (° C)	6-32° C[a]	10-25° C[b]	5-30° C[c]	10-25° C[b]
Dissolved Oxygen (ppm)	>3 ppm[i]	>3 ppm[i]	>3 ppm[i]	>3 ppm[i]
Food availability (chlorophyll a)	2.5-25 mg/m^3 [i]	2.5-25 mg/m^3 [i]	2-25 mg/m^3 [i]	2-25 mg/m^3 [i]
Calcium (mg/L)	8->32 mg/L[d,i]	>8 mg/L[i]	8->30 mg/L[i]	>10 mg/L[i]
Water velocity (m/sec)	<2 m/sec[e]	-	<2 m/sec[e]	-
pH	7.4-9.5[f]	7.4-9.5[f]	7.4-9.5[f]	7.4-9.5[f]
Salinity (ppt)	<5 ppt[g]	<5 ppt[g]	<5 ppt[g]	<5 ppt[g]
Substrate	Hard[f]	-	Hard[f]	-
Depth (m)	<12-55 m[h]	-	<12-55 m[h]	-

[a] Karatayev, Burlakova, and Padilla, 1998, [b] Claudi and Mackie, 1994; Karatayev, Burlakova, and Padilla, 1998, [c] Roe and MacIsaac, 1997; Spindle, 1994, [d] Cohen and Weinstein, 2001, [e] O'Neill, 1993; Britton, 2007, [f] Britton, 2007, [g] Mills et al., 1996, [h] California Resources Agency, 2008, [i] Mackie and Claudi, 2010.

Prevention Strategies

Since the rapid spread of zebra and quagga mussels was observed in the early 1990s, strategies have been developed to prevent the migration of these mussels to uninfested waters. These prevention strategies include regulatory, education, and outreach methods to encourage watercraft operators to take the necessary precautions when traveling between infested and uninfested waterbodies.

Figure 20: Road Sign. WDFW

To prevent the spread of zebra and quagga mussels, several states, including Washington, have adopted laws prohibiting the transport of zebra mussels and other AIS between waterbodies. The transport of AIS into Washington can result in fines of up to $5,000 and up to a year of jail time. Intentionally bringing AIS into Washington can result in even greater fines and jail time (WDFW, 2010).

Several regional agencies have also adopted ordinances prohibiting the launching of any watercraft contaminated with AIS, such as zebra and quagga mussels, into regional waters. Additional regulations have been adopted at several waterbodies, including Lake Tahoe, that require fees for mandatory watercraft inspections and decontamination, when watercraft are judged to be at high risk for carrying invasive species. By requiring mandatory watercraft inspections, agencies can limit the traffic entering the waterbody to boats that are certified as being AIS-free, thereby limiting the risk of AIS introduction.

Figure 21: Billboard. Tahoe Resource Conservation District

As zebra and quagga mussels move west, many states are taking extra precautions to prevent their waters from becoming infested. Lake Tahoe has just updated their program in 2010 to include a clean boating certificate and sticker. Fees for this program are collected annually and vary depending on the size and horsepower of the vessel, as well as whether the boat is permanently moored in Lake Tahoe or is used in other waters (Tahoe Resource Conservation District , 2010). Idaho has also recently passed a bill that requires all in- and out-of-state boats to buy a sticker for their boat to help fund the Idaho Invasive Species Fund which funds the state's invasive species prevention efforts, including boat inspection and decontamination stations. In 2010, Oregon also initiated a statewide boat permit program to raise funds for AIS prevention programs (**Appendix G**).

Washington and several other states have created Watercraft Interception Programs to stop boats at state borders and inspect and decontaminate them to prevent the spread of these invasive mussels. Since 2007, 12,500 watercraft have been inspected in Washington state through mandatory AIS check stations, boater surveys, integrated AIS/boater safety inspections, and Washington State Patrol (WSP) Port of Entry weigh station inspections (Pleus et al., 2010). Since 2006, the Washington Department of Fish and Wildlife (WDFW) has found zebra/quagga mussels on more than 20 boats that were stopped as they were entering Washington (WDFW, 2010). Each summer, thousands of boat inspections are completed in Washington State and this practice has helped prevent these invasive mussels from spreading to Washington waterways.

In addition to regulatory methods, education and outreach methods are also useful tools for encouraging boaters to adopt practices that will prevent the spread of AIS to uninfested waters. Boaters throughout the United States are being encouraged to **Clean, Drain, and Dry** their watercraft in an effort to prevent the spread of zebra and quagga mussels to new waters (**Figure 22**). Many states in the Northwest are now using billboards to share this message with drivers transporting trailered watercraft. This outreach message is also used in brochures that are distributed to boaters as well as on signs posted at boat launches (Zap the Zebra Brochure–**Appendix L**).

Response Strategies

While prevention is the recommended course of action, there are several response strategies that can be employed in the case of an infestation. These strategies can include the use of chemicals and **biocides**[G] at the site of intake pipes, using high pressure hot water (>140°F) to kill and remove mussels from infrastructure and watercraft, by physical/mechanical removal from sites, and by exposure to freezing air/water (**Appendix H**). However, once these mussels become established, the likelihood of eradicating them becomes greatly diminished and efforts must focus on minimizing the spread of the mussel colonies as well as on minimizing any environmental and economic impacts that result from mussel infestation (USACE, 2009).

Given the mussel's ability to clog intake pipes and impede flows to power plants and municipal water supplies, agencies have had to discover ways of clearing these sites in order to restore flows. Chlorine injection is the most common chemical used for on-site mussel eradication; however, it can be toxic to other aquatic organisms at certain concentrations and can form harmful byproducts (U.S. EPA, 1999; Thornton, 2000).

STOP AQUATIC HITCHHIKERS!™

www.ProtectYourWaters.net

Follow these simple steps:

☑ Clean

Remove all plants, animals, mud and thoroughly wash everything, especially all crevices and other hidden areas.

☑ Drain

Eliminate all water before leaving the area, including wells, ballast, and engine cooling water.

☑ Dry

Allow sufficient time for your boat to completely dry before launching in other waters.

If your boat has been in infested waters for an extended period of time, or if you cannot perform the required steps above, you should have your boat *professionally* cleaned with high-pressure scalding hot water (>140 °F) before transporting to any body of water.

Before launching and before leaving...

Inspect everything!

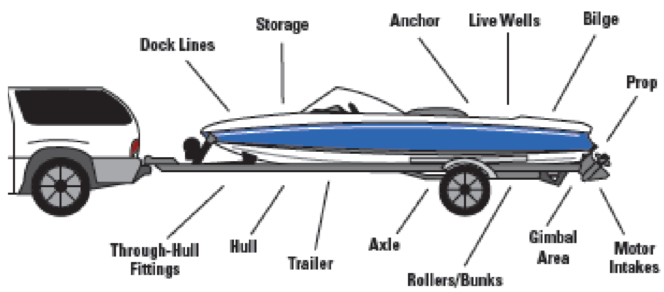


Figure 22: Stop Aquatic Hitchhikers! Example of Outreach Message for Watercraft

Some evidence also suggests that zebra and quagga mussels may have the ability to sense when chlorine has been added to the water and may close their shells resulting in a reduced mortality rate (Molloy and Mayer, 2007).

Physical and mechanical removal are the most often used strategies for removing isolated mussel colonies in intake pipes and in open waters. Unfortunately, physical removal can be very costly and time consuming and requires a long-term investment. If all of the mussels are not removed or killed, they can re-colonize sites and reach high densities again after only a few years. Even after mussel colonies have been killed using chemical treatments at the site of intake pipes, the debris from the dead mussels can build up resulting in obstructed water flows. In Buffalo, New York, divers have been sent down to the City's intake pipe in Lake Erie to remove a pile of dead mussels that has been accumulating since the early 1990s, as a result of chlorine treatment (Meyer, 2010). The pile of dead shells is approximately 12 feet long, 10 feet wide, and almost 8 feet high at one point – blocking almost two thirds of the pipe's opening (Meyer, 2010). The estimated cost for this clean-up operation is $396,000 (Meyer, 2010). The Buffalo Water Board is working to establish more regular, smaller-scale clean-ups that would be scheduled every few years at a much lower cost (Meyer, 2010). Unfortunately, eradicating zebra mussels from Lake Erie is not likely to occur anytime soon, so this costly clean-up operation is likely to continue well into the future.

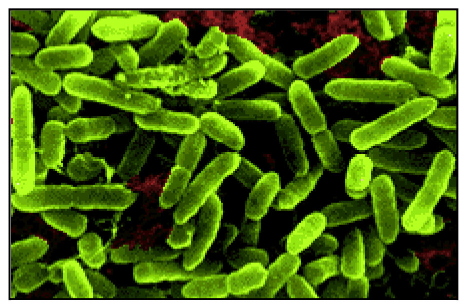


Figure 23: Zequanox, stained *Pseudomonas fluorescens.* Marrone Bio Innovations

A new approach that is currently being studied for the eradication of invasive mussels in North American waters is the use of a biocide, *Pseudomonas fluorescens*, a species of bacteria that appears to kill both zebra and quagga mussels without impacting native mussels, macroinvertebrates, or fish (Molloy and Mayer, 2007). By isolating the toxin responsible for killing these mussels, dead bacteria cells containing the toxin can be injected into the water without having any harmful effects on fish and other wildlife. A pilot *Pseudomonas* study was undertaken in Canada at the Decew Falls hydro plant owned by Ontario Power Generation to see if this would be an effective, safe, and affordable way of removing mussels from intake pipes and, potentially, from infested waterways (Molloy and Mayer, 2007). In late 2009, the U.S. Bureau of Reclamation (The Bureau) applied to the U.S. EPA for an exemption waiver that would allow it to use an experimental pesticide containing *Pseudomonas fluorescens* to treat quagga and zebra mussel infestations in their facilities along the Colorado River. The request was approved by the U.S. EPA and The Bureau hopes to begin full-scale open-water testing at Davis Dam in Spring of 2011. This will be the first time this particular pesticide has been used to treat these mussel infestations in the United States (Streater, 2009). While this biocide has only been tested at the site of facilities so far, it is hoped that it will also be effective at treating mussel infestations in open waters. In 2010, Marrone Bio Innovations was granted $500,000 from the National Science Foundation Grant to commercialize Zequanox, the product containing *Pseudomonas fluorescens*, as a mussel eradication tool (PSMFC, 2010).

AIS Management Plan

Introduction and Objectives

As stated earlier, the purpose of the *Aquatic Invasive Species Action Plan for Lake Whatcom Reservoir* (the Plan) is to act as a guide for the implementation of AIS prevention, monitoring, control, and education/outreach strategies in the Lake Whatcom Watershed.

Specifically, the goals of the Plan are to inform decision-makers and the public on ways to:

- Prevent the introduction and establishment of AIS to Lake Whatcom
- Effectively monitor for AIS to ensure early detection and rapid response
- Control and mitigate infestations in a timely manner in order to diminish any harmful ecological, economic, or public health impacts that could result from the introduction of AIS into the Lake
- Limit the spread of existing AIS populations from Lake Whatcom to other uninfested waterbodies in the area

This installment of the Plan summarizes specific actions and procedures for the prevention and control of AIS in Lake Whatcom.

These actions are organized around the following six objectives:

I. **Coordination and collaboration**–Improve the coordination and collaboration of people, resources and efforts involved in AIS prevention and control.
II. **Prevention**–Establish effective prevention programs to minimize introduction and spread of AIS into Lake Whatcom and nearby waterbodies.
III. **Early detection, rapid response and monitoring**–Establish effective programs for early detection, rapid response, and monitoring for new AIS infestations.
IV. **Control and mitigation**–Establish an effective plan for control and mitigation that can be enacted in a timely manner to minimize AIS impacts to society and the environment.
V. **Research and information sharing**–Continue to invest in AIS research and develop protocol for information sharing among appropriate parties.
VI. **Regulations**–Ensure that local regulations effectively promote the prevention and control of AIS.

Each section in this installment begins with an overview of the objective and is followed by a set of tasks and actions to be completed.

I. Coordination and Collaboration — Improve the coordination and collaboration of people, resources and efforts involved in AIS prevention and control.

The state of Washington has made significant strides in the fight against AIS by actively participating in the 100th Meridian Initiative Columbia River Basin Team, creating the Washington State Aquatic Nuisance Species (ANS) Management Plan, establishing the Washington Invasive Species Council, being a leader in conducting Watercraft Inspection Programs, and in creating and supporting tough noxious-weed laws. Despite these notable accomplishments at the state level, very little action is being taken at the local level to prevent AIS infestations. There is a need for more coordination and collaboration between local and state agencies to ensure that efforts are not duplicated, management gaps are addressed, and that local agencies have the resources and knowledge necessary to prevent the spread of AIS.

To address this need, staff from the City of Bellingham are working to form partnerships with representatives from both local and state agencies, local tribes, and NGOs to improve the coordination and collaboration of people, resources and efforts to address AIS issues. At the regional level, the City of Bellingham is coordinating with representatives from the U.S. Fish and Wildlife Service, the Washington Department of Fish and Wildlife, the Washington Invasive Species Council, and staff from the City of Seattle, the City of Everett, and the City of Tacoma. At the local level, the City of Bellingham is coordinating with the Whatcom County Noxious Weed Control Board to collaborate with staff on prevention and control strategies and to share resources and information. Whatcom County and City of Bellingham staff are becoming more aware of the threat that AIS pose to Lake Whatcom management efforts. While the AIS issue is becoming more recognized at the local level, staff are still in need of more resources, leadership, and coordination from the state level to effectively address this new threat. Actions laid out in this section of the Plan will aim to address these deficiencies at the local level in an effort to improve the coordination and collaboration of people, resources and efforts involved in AIS prevention and control.

Action I: Coordinate and collaborate with local, state and regional agencies on AIS issues
Task 1. Identify and coordinate with key AIS personnel at local, state, tribal, and regional levels
Task 2. Identify gaps in AIS coordination and develop strategies to improve coordination and collaboration
Task 3. Create a Lake Whatcom AIS Task Force who will be responsible for coordinating and collaborating with other agencies and personnel

Action II: Participate in and support state and regional AIS efforts
Task 1. Identify all AIS management efforts being implemented at the state and regional level
Task 2. Participate in and support the 100th Meridian Initiative Columbia River Basin Team
Task 3. Participate in and support the efforts of the Washington Invasive Species Council
Task 4. Participate in and support all other local, state, and regional efforts to increase awareness, collaboration, and coordination

Action III: Coordinate messaging to make consistent with regional efforts
Task 1. Identify all current AIS messages being disseminated across region
Task 2. Adopt the most consistent and effective AIS messages and dissemination techniques

Action IV: Identify funding needs and opportunities
Task 1. Identify funding/resource needs for an effective AIS program
Task 2. Identify potential sources of funding and resources to support implementation of AIS Plan
Task 3. Create and fund a Lake Whatcom AIS Coordinator position (1.0 FTE)

II. Prevention — Establish effective prevention programs to minimize introduction and spread of AIS into Lake Whatcom and nearby waterbodies.

Prevention strategies are used to address AIS that are not yet present as well as to reduce further spread of AIS to other uninfested waterbodies. Examples of prevention strategies include: outreach and education, watercraft inspection and decontamination, enforcement, and the development of more stringent regulations.

Most jurisdictions have difficulty justifying the allocation of funds for AIS prevention efforts and have a tendency to wait until the invader is already at their doorstep before taking action. However, once AIS become established, the likelihood of eradicating them is significantly reduced and the cost of controlling and mitigating an infestation becomes substantial. By investing in prevention efforts now, jurisdictions can stop the spread of invasive species to new waterbodies while also avoiding economic and environmental impacts associated with AIS infestations.

An additional step for preventing the spread of aquatic invasive species from watershed activities is the use of **Aquatic Invasive Species-Hazard Analysis and Critical Control Point (AIS-HACCP)**[G] plans. These plans can help to identify and control the potential pathways for spread that may result from activities in the watershed (**Appendix K**).

AIS-HACCP is a process to help identify and control the critical pathways for spread of AIS or other non-target aquatic species. The process provides for self-monitoring, verification, and record-keeping systems to help ensure that your activities do not spread these hazards.

The following actions laid out in this section offer a range of potential prevention strategies that could be implemented in the Lake Whatcom watershed to minimize introduction and spread of AIS into Lake Whatcom and nearby waterbodies:

Action I: Develop an education and outreach strategy for AIS prevention
Task 1. Identify effective AIS messaging and outreach strategies for Lake Whatcom residents/visitors
Task 2. Develop an AIS prevention campaign strategy for Lake Whatcom that is consistent with state, tribal, and regional efforts
Task 3. Develop and disseminate outreach materials and host AIS awareness events in the watershed

Action II: Identify watercraft, equipment, and field gear inspection and decontamination options
Task 1. Identify watercraft, equipment and field gear inspection and decontamination options
Task 2. Develop a range of options that could be implemented in the Lake Whatcom Watershed
Task 3. Conduct focus groups to determine which options might be most effective (e.g., what incentives/disincentives might work to get people to follow inspection and decontamination protocol?)

Action III: Develop a watercraft inspection program for Lake Whatcom
Task 1. Develop a tiered watercraft inspection program for Lake Whatcom (Phase I, Phase II, etc.)
Task 2. Pilot watercraft inspection program to gain feedback before widespread implementation

Action IV: Establish AIS-HACCP plans for preventing spread of AIS from watershed activities
Task 1. Establish AIS-HACCP plans for various activities in watershed that may result in AIS spread
Task 2. Train professionals working in watershed on new AIS-HACCP procedures
Task 3. The AIS Task Force shall go over reports and update procedure as needed

Action V: Develop more stringent local regulations to prevent spread of AIS

Task 1. Identify AIS regulations being enforced elsewhere on a local, state, tribal, and federal level

Task 2. Develop list of possible options for creating more stringent local regulations for AIS

Task 3. Meet with relevant staff to discuss regulatory options for AIS prevention

III. Early detection, rapid response and monitoring — Establish effective programs for early detection, rapid response, and monitoring for new AIS infestations.

If an AIS infestation occurs, it is important to have the protocols and resources in place to ensure that the infestation is detected early enough to allow for quick corrective action. Regular monitoring for new AIS infestations needs to be done to ensure that AIS are detected early. There are already many teams conducting regular water quality monitoring throughout the watershed. Teaching these teams to regularly monitor for and identify AIS while in the watershed will bring about a more rapid response to an infestation once it occurs.

While conducting regular watershed monitoring an Aquatic Invasive Species - Hazard Analysis and Critical Control Point (AIS-HACCP) plan must be in place to ensure that when monitoring is taking place, AIS or other non-target aquatic species are not spread during monitoring activities. These plans will also ensure that if an infestation does occur, there is a procedure in place to identify the hazard and to deal with it in a timely and efficient manner.

The following actions in this section aim to aid in the development of effective programs for early detection, rapid response, and regular monitoring for new AIS infestations:

Action I: Establish an AIS monitoring program for the Lake Whatcom Watershed
Task 1. Coordinate with staff already conducting monitoring in Lake Whatcom watershed to develop an AIS monitoring program
Task 2. Using AIS-HACCP, standardize field protocols for early-detection monitoring
Task 3. Establish effective, standardized sample-analysis methods with quick turnaround of results
Task 4. Develop a voluntary AIS monitoring and reporting program for Lake Whatcom residents

Action II: Create a rapid response protocol for Lake Whatcom in case of infestation
Task 1. Designate and train rapid responders
Task 2. Create a Rapid Response Notification Database (list of people you would contact/inform about infestation–1st responders, 2nd, etc.)
Task 3. Establish strategy for confirming infestation and disseminating information
Task 4. Establish an emergency rapid response fund
Task 5. Discuss options for quarantine procedure, control options and permit limitations

Action III: Coordinate with state and regional agencies for a collaborative rapid response system
Task 1. Coordinate with state and regional agencies on development of AIS rapid response procedures
Task 2. Include state, tribal, and regional personnel in Rapid Response Notification Database
Task 3. Discuss large-scale containment options and potential risk of spread to other waterbodies

IV. Control and mitigation — Establish an effective plan for control and mitigation that can be enacted in a timely manner to minimize AIS impacts to society and the environment.

The identification of new infestations often generates the most attention and demands immediate resources to control the invasive species.

> **Control** refers to the act of eradicating, suppressing, reducing or managing invasive species populations, preventing spread of invasive species from areas where they are present and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions (USACE, 2009).

It is nearly impossible to completely eradicate some AIS once they have become established. For this reason, it is important to be able to respond rapidly with appropriate control measures at the earliest signs of an infestation with appropriate control measures. In general, when deciding on control measures for AIS, the following factors should be considered:

- The size of the infestation
- Demonstrated history of eradication elsewhere (successes and failures)
- Knowledge of species life cycle
- Potential environmental impacts of both the AIS and control measures
- Financial support for initial and follow-up management
- Likelihood of re-introduction
- Opportunities for public comment
- Current policy restrictions

Given how difficult it is to eradicate populations, the most effective control efforts typically focus on mitigating the impacts of the established population and on stopping that population from spreading to and colonizing other locations. The following actions aim to aid in the establishment of an effective control and mitigation plan for AIS should they be discovered in Lake Whatcom:

Action I: Identify control and mitigation options for AIS in Lake Whatcom
Task 1. Identify all current control and mitigation tools and BMPs for dealing with AIS
Task 2. Develop a range of control and mitigation tools and BMPs that could be implemented in Lake Whatcom for preventing AIS movement and settlement within the lake (including distribution systems and other infrastructure)
Task 3. Assess environmental impacts of control and mitigation strategies and choose those that are the most reliable and cost-efficient while having the least impact on the environment and society

Action II: Discuss control permit options/requirements with local and state representatives
Task 1. Identify control permit options/requirements/protocols for intake pipes vs. open waters
Task 2. Organize meeting with relevant local and state representatives to discuss permit options
Task 3. Discuss what qualifies as an emergency and how emergency status impacts the permit process

Action III: Identify and adopt protocols to minimize dispersal of established AIS into new waterbodies or to new areas of Lake Whatcom
Task 1. Follow mitigation measures determined in the AIS-HACCP plan to minimize the spread of established AIS
Task 2. Follow inspection/decontamination protocol to minimize the spread of established AIS

Task 3. Erect signs throughout the watershed to warn people of the presence of AIS and the possibility of spreading them to other waters

Action IV: Develop regulations to quarantine Lake Whatcom should it become infested
Task 1. Discuss quarantine options and protocol with local staff from Lake Whatcom jurisdictions
Task 2. Develop regulations to quarantine Lake Whatcom should it become infested
Task 3. Once a protocol is established, conduct quarantine simulations in watershed

Action V: Establish mechanisms to ensure that the control strategies developed and implemented are done so in coordination with state, regional agencies/organizations, and other stakeholders
Task 1. Coordinate and collaborate with staff from state, tribal, and regional agencies/organizations when developing and implementing control and mitigation strategies
Task 2. Establish a public comment procedure to ensure stakeholder involvement in control and mitigation strategy discussions

V. Research and information sharing — Continue to invest in AIS research and develop a protocol for information sharing among appropriate parties.

Research is a critical element of any AIS Plan given the amount of uncertainty surrounding many AIS, their possible effects on the environment, and the unknown environmental impacts that could result from the use of certain control measures. Particular research areas of interest include:

- Effects of AIS on native species, habitat, and infrastructure
- Most likely modes of AIS transport from one body of water to another
- Limiting environmental factors for AIS survival
- Environmental conditions present in an at-risk waterbody
- Most cost-effective, tested, low-risk control measures

Having a good understanding of these elements gives managers critical information needed to effectively prevent and combat an AIS infestation. Knowing the possible impacts that AIS might have on native species, habitat, and infrastructure can give managers an idea of the potential costs, both economic and to the environment, that these species would pose if they were to become established. Similarly, understanding the most likely vectors for transporting AIS to a particular waterbody enables managers to target prevention efforts where they will be most effective. Understanding what factors limit the survival of AIS and how they compare to the environmental conditions present in a particular waterbody can help managers to decide how at-risk their waterbody may be and how much to invest in a prevention strategy. Additionally, it is important to have up-to-date information on any tested, low-risk control measures that could be used in the case of a confirmed infestation.

In addition to having research on these particular elements, it is also important for an AIS Plan to have an information-sharing protocol in place in case of a reported infestation. Having an information-sharing protocol in place ensures that the designated personnel and authorities are informed in a timely manner and the infestation is not reported to the public until it has been confirmed (to avoid unnecessary losses to fishing/tourism industries). The following actions aim to emphasize the importance of investing in AIS research that will aid in AIS planning efforts as well as in the establishment of an information sharing protocol to be used in case an AIS infestation occurs.

Action I: Support research that will provide information on effective means of preventing, predicting, and combating AIS infestations

Task 1. Create a list of research topics that will aid in AIS prevention and management efforts

Task 2. Support research efforts in the Lake Whatcom watershed that will provide information on effective ways of preventing, predicting, and combating AIS infestations (including determination of physiological tolerances/limiting environmental factors, etc.—see specific topic examples above)

Action II: Facilitate the collection and dispersal of information, research, and data on AIS infestations

Task 1. Coordinate and collaborate with local, state, tribal, and regional AIS personnel and organizations to share information, resources, and data on AIS infestations

Task 2. Establish mechanism for sharing information, research, and data with AIS staff

Action III: Establish an information-sharing protocol to be initiated in the case of an infestation

Task 1. Establish information-sharing protocol with guidance from state, regional AIS personnel

Task 2. Incorporate use of Rapid Response Notification Database in information-sharing protocol

Task 3. Discuss information-sharing protocol with Public Information Officer

VI. Regulations — Ensure that local regulations effectively promote the prevention and control of AIS.

As awareness increases regarding the potential threat and impacts associated with AIS, new laws are going to have to be developed and existing laws adapted to address this threat. While some state laws have been enacted to aid in the prevention of AIS infestations, these laws are not adequately enforced. If Lake Whatcom is to be protected, local jurisdictions are going to have to take responsibility for ensuring that local regulations effectively promote the prevention and control of AIS and are adequately enforced.

The following actions aim to guide the establishment of a more effective regulatory framework for promoting the prevention and control of AIS:

Action I: Develop list of current legislation for regulating AIS
Task 1. Compile and maintain list of current local, state and federal laws, rules, and regulations pertaining to AIS
Task 2. Research examples where local jurisdictions have changed regulations for AIS prevention

Action II: Identify and address gaps for regulating and controlling AIS in local waters
Task 1. Identify gaps in local and state legislation that would limit the ability to prevent and/or control AIS in local waters
Task 2. Develop recommendations for addressing gaps in current regulations

Action III: Secure funding for personnel to enforce AIS regulations
Task 1. Determine funding and personnel needs for adequate enforcement of local and state AIS regulations
Task 2. Determine funding sources to meet personnel and enforcement needs

Action IV: Publicize AIS regulations and enforcement presence
Task 1. Develop outreach materials to educate the public on the importance of complying with legislation to prevent AIS introductions and spread

Program Evaluation and Reporting

The evaluation process of the *Aquatic Invasive Species Action Plan for Lake Whatcom Reservoir* will provide a means for monitoring progress, evaluating needs and concerns, and improving coordination of efforts. As information is gained from the evaluation process, it will then be incorporated into the Plan as warranted.

The AIS Task Force will be responsible for overseeing the implementation of the Plan. The committee will evaluate the success of each objective by examining the progress made under each of the tasks within each action.

The evaluation effort will not only look at the amount of progress made, but will also determine funding needed to successfully accomplish the goals and associated tasks. The evaluation effort will also consider information and feedback from management staff as well as resource user groups.

The implementation of the Plan will be guided by an annual work plan that highlights specific tasks from the Plan to be completed within a given timeframe. At the end of each year, an annual progress report will be prepared and disseminated, highlighting the management actions that were completed that year. This report will include information on the status of achieving the goals of prevention and control of AIS introductions and spread into, within, and from Lake Whatcom.

A program status report will be written every five years that ties the annual progress reports to the overall AIS management plan, as well as future plans and directions. Successes, failures, and new directions for Lake Whatcom will be evaluated in comparison to and in concert with neighboring cities/counties and state and regional planning efforts. All reports will be made available on the City's website.

Glossary

Aquatic Invasive Species — a nonnative species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters (National Invasive Species Act of 1996 P. L. 104-332; Fuller, 1999)

Aquatic Invasive Species-Hazard Analysis and Critical Control Point (AIS-HACCP) —a process to help identify and control the critical pathways for spread of aquatic invasive species or other non-target aquatic species. The process provides for self-monitoring, verification, and record-keeping systems to help ensure that your activities do not spread these hazards.

Asexual reproduction —a type of reproduction that involves only one parent and produces offspring that are genetically identical to the parent.

Ballast water—any water and associated sediments used onboard a ship to increase the draft, change the trim, regulate the stability or maintain the stress loads of the vessel.

Bioaccumulation—a process by which substances, such as pollutants or other organic chemicals, are taken up, retained, and become concentrated in the tissues of living organisms over time.

Biocide—a chemical that is used to kill selected living organisms; for example pesticides, herbicides, fungicides.

Bio-control—the use of living organisms, such as predators, parasites and pathogens, to control pest animals (e.g., insects), weeds or diseases.

Bio-fouling —the undesirable accumulation of living or dead organisms on submersed structures (pipes, boat hulls, piers, anchors, rocks, et cetera) or other organisms.

Bivalve—mollusks belonging to the class Bivalvia that are characterized by having a shell composed of two parts or valves.

Byssal threads—fibers produced by bivalves that function to anchor individuals to their substrate.

Catadromous—a species that reproduces in the ocean but spends the majority of its life in a freshwater environment (e.g. Chinese mitten crabs).

Control—eradicating, suppressing, reducing or managing invasive species populations, preventing spread of invasive species from areas where they are present and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions (USACE, 2009).

Critical Control Point—any point, step or procedure at which aquatic invasive species can be controlled.

Dreissenid—a family of small, often invasive, freshwater mussels in the phylum Mollusca.

Eradicate—the act or process of eliminating an aquatic nuisance species.

Established—an introduced organism with a permanent population(s), i.e., one that has the ability to reproduce and is not likely to be eliminated by humans or natural causes.

Exotic—organisms that are not native to the region in which they are found.

Fecundity—the number of offspring produced per unit of time per individual of any given age. Also referred to as birth rate, maternity rate, or fertility.

Fragmentation—a form of vegetative asexual reproduction that occurs in plants whereby the plant is split into fragments or pieces. Each fragment can grow into a mature, fully-grown clone of the original plant.

High-risk watercraft—any vessel or piece of equipment that operates on or in the water that has been used in any waterbody known or suspected of having zebra or quagga mussels (or other high-risk AIS) in the past 30 days or any watercraft or equipment that is not clean, and to the extent practical, drained and dry (Zook and Phillips, 2009).

Infested—the state of being invaded or overrun.

Introduction—the intentional or unintentional escape, release, dissemination or placement of a species into an ecosystem as a result of human activity.

Monoculture—a large area covered by a single plant species (or a single plant variety).

Native species—a species within its natural range or natural zone of dispersal, i.e., within the range it would or could occupy without direct or indirect introduction and/or care by humans.

Nonindigenous species—a species that enters an ecosystem beyond its historic geographic range. Also known as exotic or alien species. Other taxa can be considered nonnative or non-indigenous, such as families, genera, subspecies or varieties.

Pathogen—any organism or infectious agent, capable of causing disease or illness, such as bacteria, viruses, protozoa or fungi.

Pathway—mode by which a species establishes and continues to exist in a new environment; often synonymous with vector, dispersal mechanism, and mode. Natural and human connections that allow movement of species or their reproductive propagules from place to place (CDFG 2008).

Perennial—refers to plants that live for more than two years as a result of some form of vegetative reproductive structure. Some perennials die back to a storage organ during the winter while others retain their green leaves year round.

Rhizome—a horizontal, underground plant stem capable of producing the shoot and root systems of a new plant.

Rotenone—a naturally occurring substance found in the roots and stems of several tropical plants that is used as a broad-spectrum insecticide, piscicide, and pesticide.

Rotovation—the process of using a rotary tiller or plough (also known as a rotovator) to remove roots in the soil by means of rotating tines or blades.

Spawning—is the production or depositing of large quantities of eggs in the water.

Substrate—the base on which an organism lives and grows.

Total Maximum Daily Load (TMDL)— a regulatory term in the U.S. Clean Water Act (CWA), that describes a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

Trophic levels—energy levels or steps in a food chain or food web that are occupied by an organism: primary producer, primary consumer, secondary consumer, tertiary consumer, etc. A food chain represents a succession of organisms that eat another organism and are, in turn, eaten themselves.

Tuber—a specialized modified plant structure that is enlarged to store nutrients.

Vector—the physical means or agent by which a species is transported (e.g., boat hulls, live wells, fishing gear); often synonymous with pathway, dispersal mechanism, and mode (Carlton 2001).

Veligers—free-swimming larval stage of many kinds of marine and fresh-water mollusks (such as Dreissenids) prior to settlement or attachment to a substrate.

Watercraft—a vehicle, vessel, or craft that is designed to move across or through water (such as kayaks, motorized boats, sailboats, or float planes).

Watershed—the geographic area that drains to a single waterbody or hydrographic unit such as a lake, stream reach or estuary.

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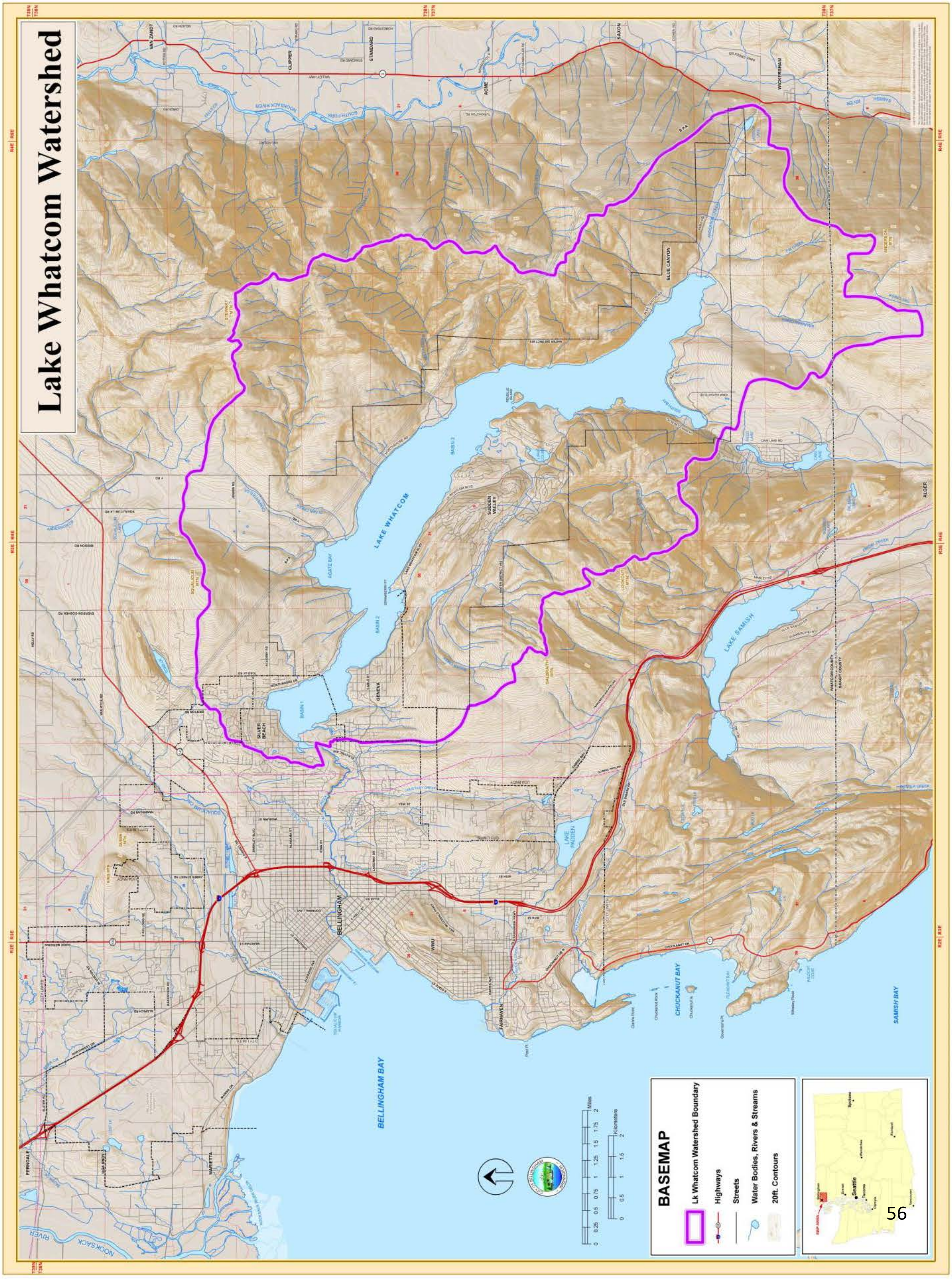
* The appendices included in this Plan are intended to act as reference documents for Lake Whatcom Management Program staff as they develop AIS prevention and management strategies for the Lake Whatcom Watershed. The information contained in these appendices should not be used to guide interpretation of any part of the AIS Management Plan or program recommendations.

Appendix A – Lake Whatcom Watershed



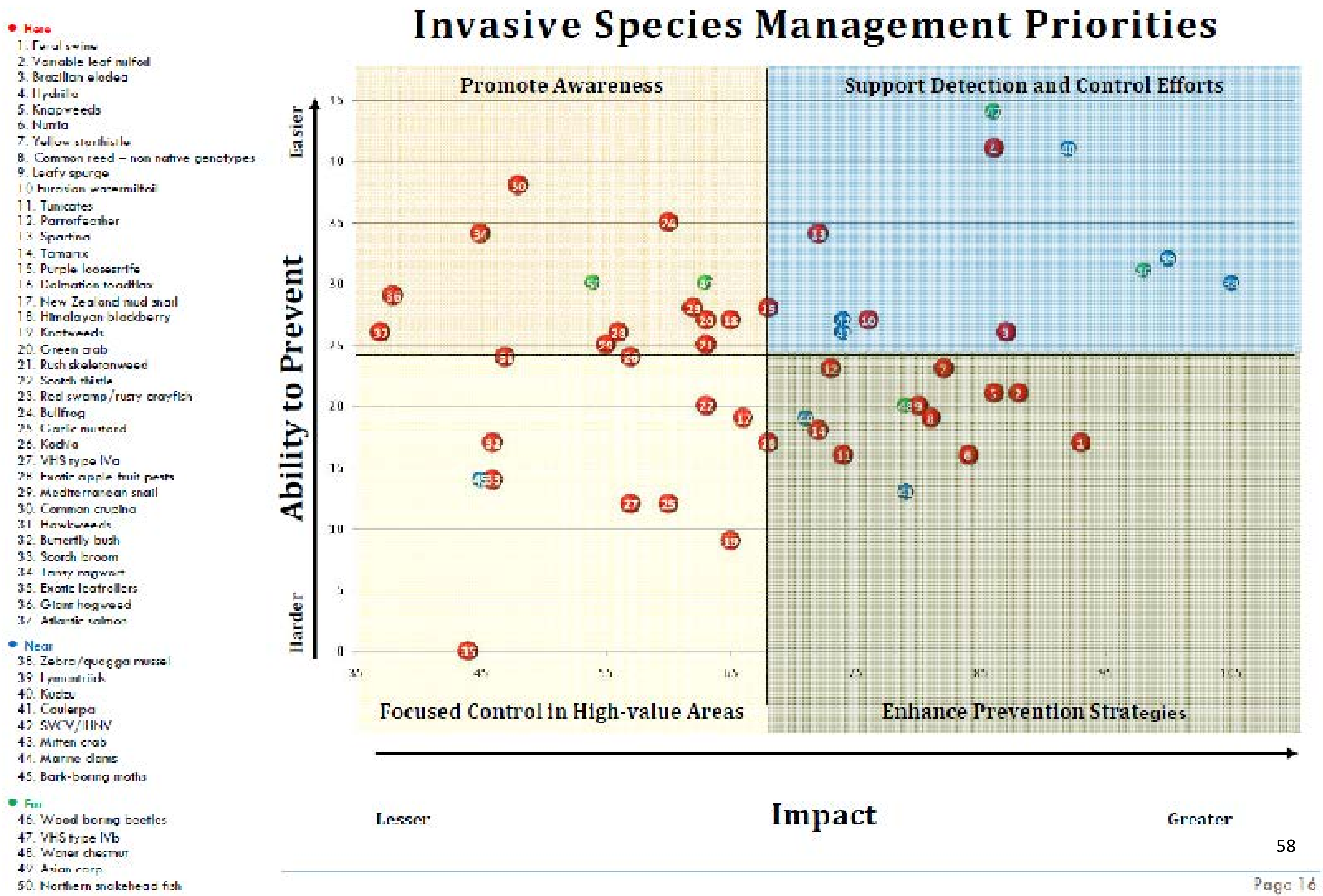
Appendix B – Environmental Conditions for AIS Survivability

Table 5: Environmental factors affecting survivability of several high-risk aquatic invasive species (includes conditions for Lake Whatcom – Basin 1)

Species or Environment		**Temp.** (° C)	**Dissolved Oxygen** (ppm)	**Chlorophyll a** (mg/m^3)	**Calcium** (mg/L)	**Water Velocity** (m/sec)	**pH**	**Salinity** (ppt)	**Substrate**	**Depth** (m)
Zebra mussel	Adult	6-32° C[a]	>3 ppm[b]	2.5-25 mg/m^3[b]	8->32 mg/L[b]	<2m/sec[c]	7.4-9.5[d]	<5 ppt[e]	Hard[d]	<12-55 m[f]
	Veliger	10-25° C[g]	>3 ppm[b]	2.5-25 mg/m^3[b]	>8 mg/L[b]	-	7.4-9.5[d]	<5 ppt[e]	-	<12-55 m[f]
Quagga mussel	Adult	5-30° C[h]	>3 ppm[b]	2-25 mg/m^3[b]	8->30 mg/L[b]	<2m/sec[c]	7.4-9.5[d]	<5 ppt[e]	Hard[d]	<12-55 m[f]
	Veliger	10-25° C[g]	>3 ppm[b]	2-25 mg/m^3[b]	>10 mg/L[b]	-	7.4-9.5[d]	<5 ppt[e]	-	<12-55 m[f]
Asian clam		2-36° C[b]	>1-3 ppm[i]	>4.3 mg/m^3[b]	>2.1 mg/L[b]	-	5-10[j]	<13 ppt[k]	Silt/Sand/Gravel[l]	1.5-76 m[m]
New Zealand mudsnail		0-32° C[n]	>6.7 ppm[o]	-	8-9 mg/L[p]	-	>6-8[b]	<5 ppt[q]	Variety[q]	-
Asian carp	Adult	0-30° C[r]	>0.5 ppm[s]	-	-	-	-	<4 ppt[s]	-	-
	Larvae	>18° C[r]	-	-	-	>0.3m/sec[r]	-	-	-	Shallow[r]
Conditions in Lake Whatcom[t]		**4.4-24.1° C**	**0.2-12.3 ppm**	**0.4-10.8 mg/m^3**	**7.36-11.72 mg/L**	**Low**	**6.3-9.3**	**<2 ppt**	**Variety**	**3-100 m**

[a]Karatayev, Burlakova, and Padilla, 1998, [b]Mackie and Claudi, 2010, [c]O'Neill, 1993; Britton, 2007, [d]Britton, 2007, [e]Mills et al., 1996, [f]California Resources Agency, 2008, [g]Claudi and Mackie, 1994, [h]Roe and MacIsaac, 1997; Spindle, 1994, [i]Sprung, 1987, [j]Wittman et al., 2008, [k]Aguirre and Poss, 1999, [l]USACE, 2009, [m]TERC, 2010, [n]Hylleberg and Siegismund, 1987; Quinn et al., 1994, [o]Alonso and Camargo, 2003, [p]Kolosovich and Chandra, 2008, [q]Zaranko et al., 1997, [r]Nico et al., 2005, [s]Oregon Sea Grant, 2008, [t]Matthews et al., 2010.

Appendix C – AIS Priority Management Grid



Appendix D – AIS Sighting Report Form

Hotline: 1-877-9-INFEST
Email: invasivespecies@rco.wa.gov
Online: www.invasivespecies.wa.gov

Need to report a sighting?

1) **Take a picture of the organism** (be sure to include an object for scale in your photo such as a coin, key, or pencil)
2) **Collect a specimen and freeze it** (place a sample in a freezer bag or container with some water and freeze it)
3) **Provide as much of the information below as possible**
4) **Call the hotline, send an email, or fill out a sighting report form online**

Photo: New Zealand mudsnails
www.putahcreektrout.org

What did you find?

Common Name: e.g. New Zealand mudsnail
Genus/Species: e.g. *Potamopyrgus antipodarum*
Or, describe what you found: Type, size, features, etc.
Type: What sort of plant/animal/organism is it (aquatic invertebrate, aquatic plant, aquatic vertebrate, bird, fish, insect, land mollusk, mammal, microorganism, reptile, other)?
Size: How big is it (if you can't measure it, give an approximate size, e.g. as big as a…)?
Features: Describe the color(s) and any other distinguishing features
Familiarity: Have you seen this species in this location before? Is this an invasive species you've seen identified elsewhere?

Where did you find it?

State and County where collected: e.g. Whatcom County, Washington
Waterbody and location: Include the name of the waterbody and the access point (or the nearest road or address, landmark, or driving directions to the location).
Latitude and longitude: If you have a GPS unit, these can be decimal degrees, degrees and decimal minutes, or degrees, minutes and decimal seconds.
Date of observation: Include the month, day, year, and time of day.
Field observer: Include the name of the person or people who made the observation.
Estimated density: Is it sparse, moderate or abundant in density?
Comments: Include any other notes on the location of the species and the conditions present when the observation was made.

Appendix E – Watercraft Inspection Protocol

In 2009, Zook and Phillips of the Pacific States Marine Fisheries Commission prepared a document for the Western Regional Panel on Aquatic Nuisance Species that defined recommended uniform minimum protocols and standards for watercraft inspection programs in the western U.S. Three levels of inspection programs are discussed by Zook and Phillips (2009) and are distinguished based upon risk level and individual agency/organization capacity.

Level 1 - Self-inspection
Level 2 - Screening out high risk watercraft and equipment
Level 3 - Comprehensive

Level 3 Comprehensive inspection programs offer the most protection from AIS infestations and are recommended by Zook and Phillips (2009). These programs include screening interviews at the point of entry; a comprehensive watercraft/equipment inspection performed by trained inspectors of all high risk watercraft/equipment; decontamination and/or quarantine or exclusion of suspect watercraft, and vessel certification using bands (Anderson, 2010).

1. **Self-Inspection (Voluntary/Mandatory)**
   Self-inspection programs involve either requesting (voluntary) or requiring (mandatory) watercraft operators to complete an inspection of their vessel before launching. For a self-inspection program, instructions and checklists are provided at boat launches for use by watercraft operators.
2. **Screening Interview**
   Screening interviews involve asking watercraft operators a series of questions before launching their vessel in order to determine the level of risk associated with the vessel based on the recent history of use.
3. **Watercraft/Equipment Inspection**
   Watercraft/equipment inspections involve a close visual and tactile inspection of watercraft and equipment focused on exterior and interior surfaces, areas of standing/trapped water, trailers and other equipment to determine the presence of AIS.
4. **Decontamination**
   Decontamination is the process of killing and removing any AIS (including veligers) from every area of the watercraft, trailer and equipment.
5. **Quarantine/Drying Time**
   Quarantine/drying time is the amount of time out of the water required to assure that all AIS are killed through desiccation (if possible). This requirement can vary depending on the temperature and relative humidity.
6. **Exclusion**
   Exclusion involves not allowing the watercraft or equipment to be launched. In most cases, this is only applied to watercraft or equipment that has been deemed **high-risk** based on the recent history of use or inspection results.
7. **Certification**
   Certification is a process whereby watercraft and equipment are determined to present only minimal risk to the waterbody based on inspection, decontamination or quarantine/drying time. Vessels and equipment that meet this determination receive some form of certification to show that they are "AIS-free" (or low risk).

While many watercraft interception programs only utilize a few of the elements outlined above, it is recommended that all of these steps be considered during the design phase of a watercraft inspection program.

High Risk Watercraft/Equipment[G] **–** Any vessel or piece of equipment that operates on or in the water that has been used in any waterbody known or suspected of having zebra or quagga mussels (or other high-risk AIS) in the past 30 days or any watercraft or equipment that is not clean, and to the extent practical, drained and dry.

Watercraft/equipment that have been moored or been in the water for several days or longer pose the highest level of risk for attached mussels and other AIS, while all watercraft with on-board raw water systems present some elevated level of risk for veliger contamination regardless of the length of exposure. Generally speaking, the longer the period of exposure, the higher the risk (Zook and Phillips, 2009).

Three Program Levels for Watercraft/Equipment Inspection Programs:

Text describing the three program levels and the protocols and standards is excerpted below (Zook and Phillips, 2009):

Level 1: Self-Inspection (<$1000/waterbody/year)

A relatively low cost program to be used for low risk waters or on higher risk waters where organization or physical capacity prevents a more aggressive approach.

Mandatory programs work best if the authority to enforce provisions of the program are in place. In the absence of that authority, a voluntary program should be implemented.

This type of program involves the dissemination of an inspection form which can be made available at either an entry station, kiosk or message board with boldly printed instructions for the watercraft/equipment operator to answer all the questions and inspect all designated areas and equipment. The form is then placed in or on the transport vehicle where it can be easily seen. If the program is mandatory, spot checks by enforcement personnel can reinforce compliance.

Example: Utah Division of Wildlife Resources (http://wildlife.utah.gov/mussels/decontaminate.php)

Level 2: Screening out high risk watercraft and equipment ($5,000-$50,000/waterbody/year)

To be used for moderate to high risk waters where budget or other issues prevent a more comprehensive (Level 3) program.

All programs should include a screening interview to identify high risk watercraft and/or equipment, an inspection to verify interview information and exclusion of any watercraft/equipment that remain high risk following screening and inspection.

This type of program can often be incorporated into an existing entry station operation that is set-up to collect access fees, confirm reservations or provide use information and regulations. Current entry station staff can be easily trained to conduct verifying inspections and the number of watercraft excluded would normally be expected to be low on waters where this type of program would be implemented. Because a rigorous inspection is not required and no decontamination or quarantine facilities are required, this is a relatively low cost option for some agencies/organizations.

Level 3: Comprehensive ($50,000-$250,000/waterbody/season)

To be used for high risk waters and wherever possible.

This type of program is recommended for all high risk waters. A Level 3 program should include screening interviews at the point of entry; a comprehensive watercraft/equipment inspection performed by trained inspectors of all high risk watercraft/equipment; the decontamination and/or quarantine or exclusion of suspect watercraft, and may also include vessel certification.

This type of program may require construction or modification of entry facilities, purchase of a hot water powerwash and wastewater containment system, hiring trained inspectors and decontamination operators and provision of a quarantine facility, along with a set of policies and rules that allow all of the above actions.

Programs like this can cost between $50,000 and $250,000 per waterbody per season to operate depending on the size of waterbody involved, type of equipment and facilities used, hours of operation and the number of access points.

Protocols and Standards for Watercraft/Equipment Inspection:

Text excerpted from Zook and Phillips (2009):

Self-inspection:

Self-inspection programs, whether voluntary or mandatory, offer a limited level of protection because compliance and effectiveness are not guaranteed. However, they are very effective boater education tools, provide some level of protection for waters where implemented, and are cost-effective.

<u>Protocols:</u>

1. Provide a self-inspection form with clear directions on how to complete the inspection and form at the point of entry, kiosk or dedicated check-in area.
2. Require (where a rule/law is in place) or request (when rules are not established) that the form be completed, signed, and posted in clear view on the watercraft/equipment transport vehicle prior to launching.

<u>Standards:</u>

Before launching, boaters must confirm that the following conditions have been met by signing and displaying a completed self-inspection form.

1. Watercraft, equipment, trailer have not been in any water known or suspected of having zebra-quagga mussels (or other high-risk AIS) in the past 30 days.
2. Watercraft, equipment, trailer are cleaned, and to the extent practical, drained and dried.
3. Watercraft, equipment, trailer have been visually inspected at the site prior to launching.

Screening interviews:

Screening interviews involve asking the vessel/equipment operator a series of questions prior to launching or entry that are designed to determine the level of risk posed by that watercraft based on its recent history of use. The screening interview should not rely totally on the responses given, but the person conducting the interview should be attentive enough to make sure that the responses given match the physical evidence available and are credible.

Protocols:

1. Develop and use a standard screening interview form that requests, at a minimum, the following information:
   - The home location of the owner/operator
   - The specific location (waterbody) where the watercraft or equipment was last used
   - The date of the last use
   - If the watercraft/equipment has been cleaned, drained and dried
2. Verify the responses by checking the license plate or registration (boat ID) number and doing a quick visual inspection to clarify any inconsistencies between the responses given and the physical evidence before clearing the watercraft or equipment for launch.
3. The screening interview provides all agencies and organizations implementing inspection programs the opportunity to explain the importance of prevention and to educate the boating public on ways they can take personal responsibility for "clean" boating.

Standards:

1. Watercraft that have been used in any infested or waterbodies suspected of being infested in the past 30 days should be subjected to a comprehensive inspection by a trained professional before being allowed to launch.
2. If there is reasonable suspicion of deception on the part of the owner/operator/transporter during the screening interview, the vessel should be subjected to a comprehensive inspection before being permitted to launch.

Watercraft/equipment inspection:

Conducting an effective inspection requires some knowledge of AIS identification, life history and biology, a good understanding of watercraft parts, as well as the cooperation of the boat/equipment operator. A checklist should always be used when conducting a watercraft or equipment inspection to ensure that all areas are inspected thoroughly.

Training resources for inspection programs: http://www.aquaticnuisance.org/wit

Note: the authority to stop, inspect, decontaminate and/or quarantine watercraft or equipment varies between jurisdictions. Make sure that you understand the authority that you have in your jurisdiction and exercise it accordingly with regard to search and seizure.

Protocols:

1. Use an inspection checklist and follow it. The inspection checklist should include (at a minimum) the following information:
   - The home state or area code where the watercraft or equipment is registered
   - The vessel ID number
   - The name and date of the last water visited
   - A checklist of areas to be inspected, including all of the following:
     - Exterior surfaces (at and below the waterline): hull, transducer, speed indicator, through-hull fittings, trim tabs, water intakes, zincs, centerboard box and keel (sailboats), foot-wells (PWCs)

- Propulsion system: lower unit, cavitation plate, cooling system intake, prop and prop shaft, bolt heads, gimbal area, engine housing, jet intake, paddles and oars
- Interior area: bait and live wells, storage areas, splash wells under floorboards, bilge areas, water lines, ballast tanks, drain plug
- Equipment: anchor, anchor and mooring lines, PFDs, swim platform, wetsuits and dive gear, inflatables, down-riggers and planning boards, water skis, wake boards and ropes, ice chests, fishing gear, bait buckets, stringers, etc
- Trailer: rollers and bunks, light brackets, cross-members, license plate bracket, fenders

2. Inspect all **high-risk watercraft**[G]
3. Have a systematic plan when conducting inspections to ensure complete coverage of every area of the watercraft
4. Use the opportunity to educate the boat owner/operator on the importance of pre-launch self-inspection, proper cleaning and drying and the reasons why all watercraft and equipment operators need to **clean, drain and dry** watercraft and equipment when moving between waters.

Standards:

1. If attached AIS or standing/trapped water are found on a high risk vessel, it should not be allowed to launch without first being decontaminated or subjected to the prescribed quarantine/drying time standard or both.
2. If water is found on exposed areas only (rain or wash-water), on an otherwise low-risk and clean watercraft, the watercraft should be thoroughly wiped dry first, but allowed to launch.
3. If no AIS or water are found following a thorough inspection of the watercraft that is considered high-risk because it has been in known infested waters within the last 30 days, but has been out of the water long enough to be considered safe by applying drying time standards, it should be allowed to launch, **except for watercraft that have ballast tanks or other water storage areas that are difficult to access and completely drain. Normal drying time standards do not apply when areas that cannot be completely drained are present. These areas need to be treated to kill any mussels or veligers that are present.**
4. Any watercraft or piece of equipment with attached vegetation (including algae growth) should not be allowed to launch without their complete removal and re-inspection, if necessary.

Watercraft/equipment decontamination:

If, following an inspection, a watercraft or piece of equipment transported from one waterbody to another is confirmed or believed to have AIS on board, three options are available: 1) decontamination, 2) quarantine/drying, or 3) exclusion. Decontamination is the only option that kills and removes mussels. Since we cannot be sure that all areas of the watercraft and/or equipment have been adequately treated, we recommend that a period of drying be used in conjunction with decontamination for all watercraft confirmed or suspected of having mussels (or other high-risk AIS) on board.

There are a number of ways to decontaminate watercraft, but with the current technology available, it is recommended that hot water (140° F or greater at the point of contact) and pressure washing equipment with various attachments be used to kill and remove all visible AIS (live and dead) and veligers from all areas of the watercraft, engine, trailer, and equipment. It is recommended that a combination of drying time and hot water decontamination be employed as the most effective means to assure that all AIS are killed and removed from the vessel/equipment.

The objective of decontamination is to KILL and REMOVE, to the extent possible, all visible mussels (and other high-risk AIS). Killing prevents establishment of new populations as a result of watercraft/equipment transfer, but, removing them is also important because finding pieces of shells/plant fragments or DNA can lead managers to falsely believe that a waterbody is infested and can result in unnecessary concern and expensive action.

Protocols:

1. Before commencing a decontamination procedure, explain the options and decontamination process in detail and get permission from the vessel owner.
2. Find a location for the decontamination that is away from the water where the run-off and solids from the cleaning process can be contained and will not re-enter any waterbody.
3. If possible, wastewater and solids should be totally contained and directed to an appropriate waste treatment or disposal facility.

Standards: These were written specifically for zebra-quagga mussel removal/decontamination but are also applicable for the removal and decontamination of other high-risk AIS found on vessels.

1. Use 140° F or hotter water (at the point of contact) to kill mussels, veligers, and other high-risk AIS. Water loses approximately 15-20° F per foot of distance when sprayed from a power nozzle, so initial temperature should be increased to account for this heat loss to the point of contact.
2. When using a hot water flushing attachment and/or pressure washer to kill and remove attached mussels from the surface of watercraft/equipment, allow at least 10 seconds to elapse from the leading edge of the spray to the tailing edge when moving the wand across the surface to maintain sufficient "lethal" contact time. If larger mussels are present, more time may be required to remove them from the surface.
3. Use a power wash unit capable of spraying at least 4 gallons/minute with a nozzle pressure of 3,000 psi or greater (not to exceed 3,500 psi) to remove attached visible mussels from all exposed surfaces of the watercraft, piece of equipment, trailer and engine.
4. Use a flushing attachment to rinse all hard to reach areas and those areas where pressure may damage the watercraft or equipment (such as the rubber-boot in the gimbal area). A brush may also be used in conjunction with flushing to remove mussels from hard to access areas.
5. When flushing hard-to-reach and sensitive areas, maintain a contact time of 60 seconds to assure that mussels receiving only indirect contact are killed since it may not be possible to remove them from these areas.
6. First drain and then use a flushing attachment and 140° water to flush the live well, bait well, storage compartments, bilge areas, ballast tanks, bladders, gear and equipment to kill any mussels and veligers that might be present.
7. Use appropriate attachment connected to the powerwash unit or other hot water source, start the engine and run for 1-2 minutes to kill mussels in the engine cooling system.

Quarantine or drying time:

If watercraft and/or equipment suspected of carrying zebra and quagga mussels (or other high-risk AIS) cannot be decontaminated for any reason, then they must be held out of water for a period of time to dry-out and kill all mussels, veligers, or other AIS located on-board through desiccation. The amount of time required to achieve complete desiccation varies depending on the species, the temperature and the relative humidity and can range from 3-30 days.

Quarantine/drying is probably the most effective way to assure that live mussels (and other AIS) are not transported between waterbodies on trailered watercraft or equipment. The problem with quarantine/drying is that it does not remove attached mussels. If mussels remain on the vessel, they will eventually drop off. If that occurs at a boat ramp or beach, the presence of mussel shells can raise concern of a new infestation, triggering alarm and resulting in expensive and unnecessary action. For that reason, it is recommended that all visible mussels be removed from quarantined/dried watercraft before they are allowed to launch.

See 100th Meridian Initiative Quarantine Time Calculator: http://www.100thmeridian.org/emersion.asp

Protocols:

1. Requiring quarantine, drying time or a waiting period should be applied to watercraft and equipment that meet the definition of high-risk; either in lieu of decontamination or in addition to decontamination as an "insurance policy."
2. Implementation of this option can take several forms:
    - Physically quarantining a watercraft or piece of equipment requires providing a safe and secure holding area where they can be "parked" for the amount of time required to kill all mussels on-board. A few agencies/organizations have used this option to take or oversee possession of suspect watercraft (with or without the owner's permission, depending on individual jurisdiction authority) until they remain out of the water long enough to be considered safe. Establishing and maintaining a dedicated quarantine facility can be expensive and comes with some potential liability issues.
    - When a quarantine facility is not available, then quarantine/drying time can be achieved by banding (secured connection between watercraft and trailer) the watercraft or equipment. The operator is advised not to launch into any freshwater area until the date indicated on the "band" or an accompanying paper certificate (this form of quarantine does not require a holding facility).
    - The final option is simply to require that all high risk watercraft serve a pre-determined drying/waiting period prior to launch (duration determined by risk level and current temperature and humidity conditions).
3. All visible mussels (and other AIS) should be removed from watercraft or equipment following the quarantine or drying period before being allowed to launch.

Standards:

1. Where practical, the 100th Meridian Initiative quarantine time "calculator" should be used to determine the length of quarantine/drying time required (provides the greatest precision but limited availability and predictability for boaters).
2. Watercraft with ballast or other internal water storage tanks that cannot be completely drained should be treated differently (See Zook and Phillips, 2009)

Watercraft/equipment exclusion:

High-risk watercraft[G] which are not decontaminated and/or quarantined should be excluded and not allowed to launch; whether the result of vessel owner refusal, or lack of available equipment, trained applicators or facilities. Exclusion should not be used as a long-term substitute for development of a more user-friendly inspection program that recognizes the legitimate interests of the boating public.

Protocols:

1. High risk watercraft and equipment that have not been or cannot be decontaminated or meet the quarantined/drying time standard should be excluded from launching.
2. The information obtained from the screening interview, used to determine risk level, should be shared with the watercraft owner/operator and made available on a real-time basis at all access points to prevent excluded watercraft/equipment from attempting to launch from any other access points.

Standards:

1. Watercraft or equipment that are coming from known zebra/quagga mussel areas in the last 30 days that have not been decontaminated and/or been out of the water for the required time (based on temperature and humidity conditions by either the quarantine time calculator or alternative method recommended here) should be decontaminated if approved facilities are available; placed in self or on-site quarantine for the required time frame; or excluded.
2. **Watercraft that are not clean** (having attached vegetation, debris or surface deposits that can mask the presence of small mussels)**, drained** (no visible water in any live well, bait well, bilge area, engine compartment, floor or cooler) **and dry** (no standing water in boat, equipment, trailer, engine) **should be decontaminated and/or quarantined or excluded.**

Watercraft certification/banding:

A number of boating and water management agencies and organizations currently offer some form of certification for watercraft or equipment that have passed inspection, been decontaminated or have remained out of the water long enough to satisfy quarantine/drying time standards. Certification of this type helps the operator avoid repeated time delays upon re-entry and makes it easier for the management agency/organization by reducing work load, processing time and by allowing them to concentrate limited resources on higher risk watercraft. Some groups currently offer a sticker or paper certificate, however, since there is no way to determine where that watercraft or equipment has been between inspections, this form of certification offers little benefit. Some agencies/organizations (e.g. California) have addressed this short-coming by applying “bands” that connect the watercraft/equipment to the trailer so that it cannot be used between inspections without detection. In some cases, a written certificate is also issued with the band.

If agencies and organizations choose to offer certification, it is recommended that the watercraft/equipment be banded in such a manner that it cannot be launched between interceptions without detection. If banding is coordinated between jurisdictions, further action can be expedited (at the discretion of the implementing agency/organization) at the next launch site anywhere in the western U.S. so long as the tag remains intact. Such a system will reduce the amount of staff and equipment time required at interception facilities region-wide; increasing resource protection, saving money, reducing waiting time and crowding and lowering the frustration level of staff and the boating public.

Protocols:

In order to implement a region-wide program that may be acceptable to most agencies and organizations in the western U.S., three conditions should be met:

1. The agency/organization placing the tag/band must implement all Uniform Minimum Protocols and Standards to insure that the best practical science and technology has been employed in certifying the watercraft or equipment.
2. All agencies and organizations participating in this certification program should use a banding system that attaches the watercraft to the trailer that cannot be tampered with or removed

without detection. The certification is no longer valid if the band has been tampered with, severed or removed.

3. While a variety of different "band" styles and materials may continue to be used, all tags should have the following: (This information can either be incorporated into the band (which may be difficult) or be provided on an accompanying paper receipt or certificate)
   - The name and contact telephone number of the agency/organization applying the tag.
   - Some way to indicate the basis for certification as one of the following three categories; inspection, decontamination or quarantine (several options are available including color-coding, pre-printed number or letter coding applied at the time of issue).
   - The banding date should be indicated on the tag (leaving a blank space for writing in the date of issue with permanent ink on the band or providing a dated "paper" certificate in addition to the banding appear to be the most practical options for this).

<u>Standards:</u>

1. Only watercraft or equipment that have passed inspection or have been decontaminated or quarantined in accordance with all of the Uniform Minimum Protocols and Standards as adopted, should receive certification banding.
2. Certification banding should only be applied by a trained inspector.
3. Watercraft and equipment that have been certified and banded by an agency or organization utilizing these Uniform Minimum Protocols and Standards may receive expedited processing at the discretion of the receiving agency/organization.

STOP AQUATIC HITCHHIKERS!

100th Meridian Initiative

100th Meridian Initiative

Interview/Inspection Form for Trailered Boats and Aquatic Invasive Species

Site Information

Interviewer:	Date: Time:
Water Body: State:	Survey Type: O Contact O Observation
Specific Location:	

Boater Information

Home State:	Zip:		
Was the boat commercially hauled?	O Yes	O No	
Do you always launch in the same water body?	O Yes	O No	
How many times have you launched this year?	O Yes	O No	
How often do you clean your boat? O After every launch O After a few launches O Ocassionally O Never	Boat cleaning method: O Car wash/High pressure O Home/Hand Wash O Professional Cleaning O Not Applicable		
Do you keep your boat moored or in a slip?	O Yes	O No	
If so, where?			
Boat direction:			

Boat Type:
O Angling
O Pleasure
O Pontoon
O Jetski/PWC
O Canoe/Kayak
O Houseboat
O Other

Boat/Trailer Condition:
O Clean & Dry
O Dirty or Wet

Knowledge/Action Information

Have you heard of zebra/quagga mussels?	O Yes	O No	How?
Have zebra/quagga mussels impacted you?	O Yes	O No	How?
Have you heard of other aquatic invasives?	O Yes	O No	How?
Have any AIS affected you?	O Yes	O No	How?
Did you inspect your boat for AIS today?	O Yes	O No	How?
Would you wash your boat if a public washing facility was available nearby?	O Yes	O No	
Has anyone asked you about zebra/quagga mussels before?	O Yes	O No	
If so, who?	If so, when?		
Have you ever considered changing destinations to avoid AIS issues?	O Yes	O No	

Destination Information

Where else fo you take the boat that you are using today?

Water Body:	State:	O Been There	O Going There
Water Body:	State:	O Been There	O Going There
Water Body:	State:	O Been There	O Going There
Water Body:	State:	O Been There	O Going There

Boat Inspection

AIS Found? O Yes O No

If yes, what species?

If yes, where was it found?

Comments

Please send copies of all completed forms to: David Britton, UT Arlington - Biology, UTA Box 19498, Arlington, TX 76019

Appendix F - Float Plane Guidelines*

As a watercraft that enters and exits the water, float planes may involuntarily transport aquatic invasive species from one waterbody to another. Any part of the plane that comes in contact with water may act as a vector for the spread of aquatic hitchhikers unless preventative measures are taken.

Before take-off:

- Remove aquatic plants and animals (e.g., zebra mussels and Eurasian watermilfoil) from floats, rudders, cables, transom, chine, wheel wells, and step area.
- Pump, remove, or otherwise treat water from floats (clean with 6% Bleach solution).
- Avoid taxiing through areas with heavy aquatic plant growth.
- Raise and lower rudders several times to free aquatic plants.

After take-off:

- Raise and lower rudders while over waters you are leaving or over land. If plants remain, return to that waterbody to remove.

Storage, mooring, and maintenance:

- Remove aircraft from the water whenever practical to better facilitate self inspection, drainage, removal, cleaning and drying.
    - Spray floats with hot or high-pressure water.
    - Dry floats by storing aircraft on land for at least 5 days.
    - Scrub or scrape undersides of floats (when spraying or drying is not possible) especially if moored for more than a day.
- Maintain pontoons, floats and hulls to make sure they remain water tight; including sealing seams, replacing gaskets on inspection covers and repairing any cracks.
- Aircraft moored for extended periods may have aquatic invasive species attached and should be cleaned regularly. If no cleaning equipment is available, the least prevention option is to hand-clean the submerged floats with a scrub brush and to physically remove any aquatic invasive species.

Plan ahead – in addition to the national guidelines we suggest that pilots consider the following options:

- Check the list of known infested waters and choose to moor your float plane on an uninfested lake for the season if possible (list available at http://www.100thmeridian.org/Seaplane_Critical_Species_Contast_List_2.pdf).
  Note: Lake Whatcom is listed as an infested water due to the presence of Eurasian watermilfoil.
- If you must use one of these infested waterways, you may be required by the regulating authority to move the aircraft out of the water for inspection and, if needed, for a professional decontamination.
- Plan flight paths to prevent the spread of invasives – visit uninfested lakes before infested lakes whenever possible.

For additional inspection and decontamination information, please view the **Seaplane Pilot/Owner Inspection and Decontamination Training Video** produced by the Pacific States Marine Fisheries Commission (http://www.aquaticnuisance.org/wit/seaplanes).

* *In 1998 the Great Lakes Panel of the national Aquatic Nuisance Species Task Force (ANSTF) developed "generic" voluntary guidelines for seaplanes that were adopted by the ANSTF as national guidelines in April of 1999. These guidelines (summarized above) still serve as the national standard even though some local jurisdictions have recently expanded on them, and in a couple of cases, made them mandatory.*

Appendix G – AIS Permit Programs for Watercraft

Many states now offer permit/sticker and/or banding programs to certify that a boat has been inspected and decontaminated before it can be launched into uninfested waters.

Benefits of a permit/sticker program include:

- Improving the regulation of boat traffic on public waterways by requiring AIS-free permits or stickers for all non-motorized and motorized watercraft before launching
- Helping boaters to avoid repeated time delays when re-entering waters
- Raising revenues to fund AIS prevention programs to protect our waters

Idaho and Oregon have already implemented statewide permit/sticker programs to regulate boat traffic in their waters and to fund their aquatic invasive species prevention efforts. A similar program may be implemented in Washington state in the near future. In the meantime, a permit program on a local scale could be used to regulate boat traffic on Lake Whatcom while funding aquatic invasive species prevention efforts for the Lake.

Oregon's Permit Program (Aquatic Invasive Species Prevention Permit (AISPP):
As of January 1, 2010, the Oregon State Marine Board now requires an Aquatic Invasive Species Prevention Permit to be carried for every boat when in use on Oregon's state waters. There are no restrictions on the name of the permit holder or on the transferability of the permit.

- Permits cost $5 and are automatically included in boating registration fees
- Out-of-state powerboat operators will pay $22 ($20+$2 agent fee)
- Operators of manually powered boats 10 feet or longer, such as canoes, kayaks, drift boats, rafts, small sailboats, will purchase and carry a $7 permit ($5+$2 service fee)
- Permits for manually powered boats are valid for one year and expire on December 31 of the year issued
- Permits can be transferred from one boat to another as well as among boaters
- Vessel operators must carry a permit when on a public waterway
- Boaters under 14 years old are not required to carry a permit when operating a non-motorized boat
- Non-motorized boats under 10 feet are exempt from the permit requirement

Fees from this program will be used to fund five regional inspection teams, pay for education and outreach materials, voluntary boat inspections and decontamination of infested boats. The fees will also be used to pay for training and decontamination equipment. Boaters found without a permit could face fines of $142 for a Class D Violation under the new law (http://www.boatoregon.com/).

Idaho's Sticker Program (Idaho Invasive Species Fund (IISF):
In 2009, Idaho passed legislation that requires all boaters, both motorized and non-motorized, to contribute to the Idaho Invasive Species Fund (IISF). Under the new law, all boaters are required to purchase and display IISF stickers in order to legally launch and operate in Idaho state waters. The sticker and fee are in addition to any registration fees already being paid.

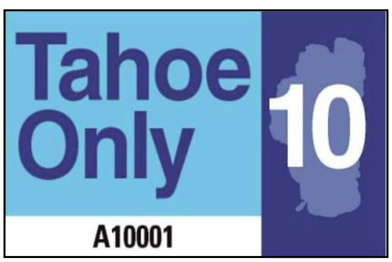
- Sticker prices are as follows: $10 for motorized vessels registered in Idaho, $20 for other motorized vessels (all out-of-state motorized vessels), and $5 for non-motorized vessels.
- Inflatable non-motorized vessels must be less than 10 feet in length in order to be exempt from this requirement.
- Boating on Idaho waters without displaying the required Invasive Species Sticker will be a violation of Idaho Code Chapter 70, Title 67, Section 67-7008(A), which has a fixed penalty of $57.

Fees generated from this program fund vessel inspections, washing stations and informational materials to assist in preventing the introduction of aquatic invasive species into Idaho state waters (http://parksandrecreation.idaho.gov/).

Lake Tahoe's Blue Boating Program:
A similar program is being used to protect Lake Tahoe through the use of mandatory watercraft inspections and certification requirements at all launch facilities. Boat inspections have been in effect at Lake Tahoe since 2008 and have recently been updated to include a clean boating certification and sticker. Watercraft inspections include checking for aquatic invasive species as well as reducing pollution from emissions, noise, and sewage discharges.

- A single annual fee includes Blue Boating certification plus unlimited inspection services
- Once your boat has been certified, you receive a Tahoe Blue Boat certification sticker
- There is a Tahoe-Only boat sticker for boating ONLY at Lake Tahoe ($20-$60/year)
- There is also a Tahoe In-and-Out sticker if you plan on visiting other lakes throughout the year ($30-$125/season)
- Cost for stickers depends on horsepower and vessel length
- Tahoe Regional Planning Agency (TRPA) has the authority to inspect all boats entering Lake Tahoe and may issue fines as high as $5,000 for any watercraft operator that attempts to evade inspections

Fees generated from this program are used to fund Lake Tahoe's Blue Boating Program and to invest in mitigation measures to protect the lake from aquatic invasive species and enhance water quality (http://www.trpa.org/default.aspx?tabindex=1&tabid=351).



Designing a permit system for Lake Whatcom:
While the state of Washington may soon have its own permit program modeled after Oregon and Idaho's efforts, Lake Tahoe has managed to implement a localized program for the lake that may act as a good example for Lake Whatcom (at least until a statewide permit program is in place). Before such a program can be implemented, research needs to be conducted to estimate the number of boats coming to Lake Whatcom from other lakes and potentially infested waters vs. the number of boats that are permanently moored on Lake Whatcom. A one-time fee and sticker system could be put in place to ensure that all boats entering Lake Whatcom have been **Cleaned, Drained, and Dried** and are AIS-free. Different fees would apply for Lake Whatcom Only vs. Lake Whatcom In-and-Out vessels, similarly to Lake Tahoe. Fees from this program could then be used to fund aquatic invasive species prevention efforts for Lake Whatcom. Permit design considerations:

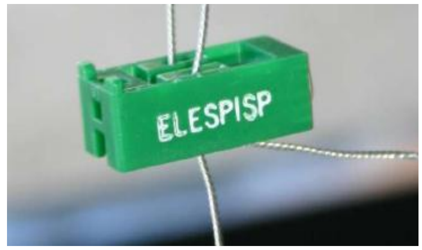
- Should the permit be transferable among boaters and between boats?
- Should the cost of the permit change depending on the horsepower, length, permanent mooring location?
- Should a permit be required for non-motorized boats?
- Should a permit be required for underage boaters?
- How often does the permit need to be renewed?
- Should the cost of the permit include unlimited inspection and decontamination services?

- What costs need to be covered by the permit?
- If the state of Washington implements a statewide program, should we still require our own separate Lake Whatcom AIS-free sticker in addition to state requirements?
- What should the penalty be for entering the Lake without a permit?

Banding Programs – California, Colorado, Utah

While permit/sticker programs are already in use in many northwestern states, Zook and Phillips (2009) suggest that a "band" be used instead of a paper/sticker permit to ensure that infested boats are not able to enter uninfested waters without detection. For a boat to launch into a waterbody, the band (or seal) must be broken. Unlike the permit/sticker programs, bands (or seals) guarantee that when boaters want to re-enter a body of water, inspectors can obviously see whether the boat has been launched since it was last inspected.

Banding programs are generally found in states that already have quagga-zebra mussel infestations in one or more waterbodies. Banding programs are now used in several western states including California, Colorado, and Utah. Different colored bands are used depending on the state, or agency doing the inspection. Bands are attached to the vessel between the winch hook of the trailer and the eyebolt of the bow of the vessel. Bands can be used to show that a boat has not been launched since it was last inspected.

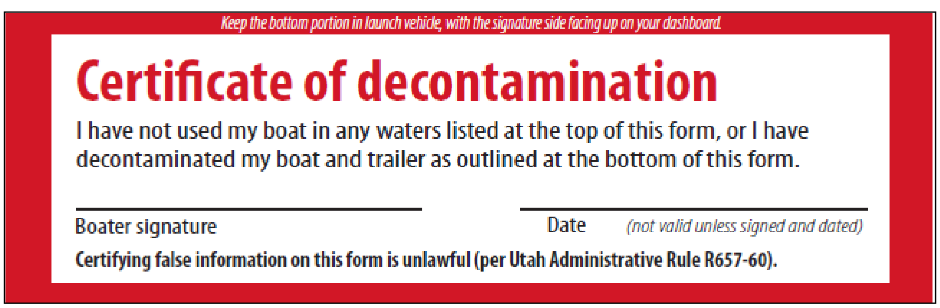


Bands are often used in conjunction with a written certificate or decontamination certification form that is signed and dated and has the band/seal number and boat identification information written on it. When watercraft operators attempt to re-launch their boat, they must show the signed certificate and the intact band/seal to boat-inspection personnel before launching. If the band/seal is broken upon re-entry to a waterbody, that vessel must be re-inspected before being launched.

When designing a permit program for Lake Whatcom, it may be worthwhile to consider implementing a banding program in addition to a permit/sticker program. In the case of Lake Whatcom, residents who use their boats solely on Lake Whatcom could have a seal placed on their boats upon leaving the Lake (after being inspected). If the seal is still intact upon re-entry, the vessels would be allowed to re-launch into Lake Whatcom without the time delays associated with screenings and inspections. The seal would ensure that the boat had not been launched into any other waterbody during that timeframe and would allow personnel to focus their energy on higher-risk vessels coming from other waterbodies.

Note: In Utah, Decontamination Seals are only given to boats that have been professionally decontaminated using scalding 140°F water. The seals must be accompanied by a decontamination certification form (See excerpt below or view entire certification form at: http://wildlife.utah.gov/mussels/PDF/self_certify.pdf).

For more information on Utah's Mussel Free Certification Program see: http://wildlife.utah.gov/mussels/decontaminate.php.



Keep the bottom portion in launch vehicle, with the signature side facing up on your dashboard.

Certificate of decontamination

I have not used my boat in any waters listed at the top of this form, or I have decontaminated my boat and trailer as outlined at the bottom of this form.

Boater signature Date *(not valid unless signed and dated)*

Certifying false information on this form is unlawful (per Utah Administrative Rule R657-60).

Appendix H – Control Options

Options to control the spread of aquatic invasive species include the use of chemicals, bio-control agents, and physical removal or the use of physical barriers to isolate populations. **Control options are going to vary depending on the species in question, the location of the infestation, the uses of the waterbody, and permitting requirements.** This appendix outlines some of the potential control options for the species illustrated earlier in this Plan. When complete eradication is deemed infeasible, efforts need to focus on: isolating the population, preventing its spread, and mitigating any impacts that may occur as a result of the infestation. Once an infestation has occurred, jurisdictions should also consider closing the waterbody (or the invaded area, if it can be isolated) to fishing and recreation to prevent the spread of the infestation.

Viral Hemorrhagic Septicemia (VHS) Virus *(Novirhabdovirus sp.)*
VHS is likely to result in a very high mortality rate at first, but over time it is expected that healthier fish will develop a natural immunity and the number of fish killed by the virus will decline. Due to the high initial mortality rate, efforts should be made to contain the virus to reduce its spread from locations where it is known to exist. To prevent the spread of the virus, fish should not be moved from the endemic area to areas outside the Great Lakes; all boats should be cleaned, drained, and dried; and bait minnows or other live bait from the endemic area should not be used in any uninfected waters (University of Wisconsin Sea Grant Institute [UWSGI], 2004). At fish hatcheries, efforts should focus on eliminating possible contact between the virus and the fish through hatchery disinfection, egg treatment with anti-viral agents, and using ultra-violet light to treat hatchery water (UWSGI, 2004).

New Zealand mudsnail *(Potamopyrgus antipodarium)*
Given the small size of New Zealand mudsnails, they are able to spread undetected by hitching a ride on fishing gear, sampling equipment, shoes, clothes, and animal fur. Complete eradication of this species is near impossible because they are able to reproduce asexually i.e. it would only take one surviving snail to repopulate an entire colony. Preventing the spread of this species is the best management option; however, control options have also been used at various locations with limited success. Control options for New Zealand mudsnails include (NZMMPWG, 2007):

- Periodic desiccation of the waterbody
- Periodic freezing of the waterbody
- Flooding the waterbody with brackish water
- Periodic molluscicide or biocide application
- Periodic introduction of a bio-control agent, such as a parasite
- Mechanical removal

It is also recommended that any gear used in waters infested with New Zealand mudsnails be cleaned and treated by freezing, hot water, drying, or by using physical or chemical treatments outlined here: http://seagrant.oregonstate.edu/sgpubs/onlinepubs/g10001.pdf.

Asian clam *(Corbicula fluminea)*
Once introduced into a waterbody, it is very unlikely that an Asian clam population will be eradicated. While the Asian clam is preyed upon by various predators including raccoons, birds, fish, and crabs, there are not enough of these predators to have a significant impact on an Asian clam population. Large-scale control options are limited to the following:

- Mechanical removal by labor intensive scraping
- Drying, high salinity, and exposure to low concentrations of chlorine or bromine
- Covering clam colonies with acres of thin rubber matting (or black bottom barriers made out of pond liners) to starve them of oxygen (TERC, 2010)

Asian clams were first discovered in Lake Tahoe in 2002. Earlier this year, a team of research scientists from the Tahoe Environmental Research Center (TERC) unveiled the first stage of an experiment designed to impede the spread of Asian clams in Lake Tahoe. In July, 2010, a team of scientists rolled out a series of 100 foot by 10 foot black bottom barriers in the south end of Lake Tahoe where Asian clam populations had become prevalent in recent years (Renda, 2010). The barriers were designed to deprive the clams of dissolved oxygen and limit their food availability which are both necessary for their survival. The barriers were scheduled to be removed in September. The goal of this experiment was to determine whether impermeable bottom barriers are an effective control option for limiting the spread of Asian clams throughout Lake Tahoe. To determine the effectiveness of this experiment, scientists will monitor treated areas for signs of recolonization after the barriers are removed (Renda, 2010).

Zebra and quagga mussels *(Dreissenid sp.)*
Once a waterbody has become infested with quagga-zebra mussels, it is impossible to eradicate them completely so management actions focus on controlling the mussels' attachment to surfaces and infrastructure and on preventing their spread (ENSR, International [ENSR], 2005). Potential control methods for quagga-zebra mussel infestations vary depending on the use of the waterbody, the extent of the infestation, the size of the waterbody, and the connectivity of the waterbody to other uninfested sites (ENSR, 2005). Several control methods are outlined below:

1. **Drawdown and Exposure**

If an infestation occurs in an impoundment or quarry in which jurisdictions have the ability to control water levels, drawdown can be an effective control technique that results in the mussels being exposed (ENSR, 2005). However, in most cases this is not a practical option and could have a deleterious impact to native fish and wildlife species. In some cases, lake or pond levels can be drawn down enough so that mussels established on the shoreline areas will be exposed. Mussels are extremely vulnerable to freezing temperatures and desiccation that may result when they are exposed during lake drawdown events (Heimowitz and Phillips, 2008).

2. **Physical Removal**

Physical removal can be a successful control method for quagga-zebra mussels in the case of small, isolated infestations (ENSR, 2005). Physical removal involves manual or mechanical scraping and suction, typically done by professional divers (Heimowitz and Phillips, 2008). While this method can be very effective for removing mussel colonies and results in fewer impacts to other fish and wildlife, it is impossible to completely eradicate the mussels unless removal is done before reproduction has occurred (Heimowitz and Phillips, 2008). However, this method is used as a continuous management tool (to be re-applied on a scheduled basis over time) in many lakes and reservoirs to control isolated quagga-zebra mussel colonies.

3. **Oxygen Starvation**

Given that quagga-zebra mussels need oxygen to survive, lowering oxygen levels below their lethal limit can be a successful control option. Oxygen starvation in open waters can be achieved using benthic mats or bottom barriers, similar to those being used to control Asian clam populations in Lake Tahoe. These mats cover the sediment and the mussels resulting in a low oxygen, low food, and high ammonia environment that can lead to high mussel mortality rates (Heimowitz and Phillips, 2008).

4. **Thermal Shock Treatment**

Treatment with hot water that is >100°F over several hours is an effective tool for killing quagga-zebra mussels (Heimowitz and Phillips, 2008). However, it can also be lethal to other aquatic organisms so should only be used on a localized scale and is not recommended for lakewide application (ENSR, 2005).

5. **Acoustic and Electrical Deterrents**

While the effectiveness of acoustic and electrical deterrents have not been proven, they may be a successful control option that can be used for certain structures. Acoustic deterrents include using cavitation (the formation and collapse of microbubbles), sound treatment (using low frequency energy), and vibration (Anderson, 2010; Heimowitz and Phillips, 2008). Electrical deterrents include using continuous low-voltage electrical fields (has been successfully used on boat hulls) and plasma pulse technology (which has been effectively used to control mussels in intake pipes) (Heimowitz and Phillips, 2008).

6. **Biological Control**

Zebra and quagga mussels are both vulnerable to predation by carp, catfish, bullhead, sucker, sunfish, sturgeon, crayfish, certain wading birds and muskrats (Heimowitz and Phillips, 2008). However, due to their large numbers, this is not an effective control method for established mussel colonies. Another bio-control method is the natural bacterium, *Psuedomonas fluorescens*, that carries a toxin that is fatal to these mussels without resulting in negative impacts to other fish and wildlife species. The biocide, now labeled as Zequanox, was recently approved to be commercialized by Marrone Bio Innovations as a mussel eradication tool. It has not yet been tested in open waters in the United States (PSMFC, 2010).

7. **Chemical Control**

There are also a variety of chemical control agents that have been developed for mussel control and eradication, primarily to be used to manage infestations at facilities. Chemical controls include oxidizing biocides, such as chlorine, bromine, hydrogen peroxide, ozone, and potassium permanganate (Heimowitz and Phillips, 2008). Chlorination is the most frequently used method of mussel control but is used on non-open water situations only due to its high toxicity to other aquatic species. Other effective chemical controls include non-oxidizing biocides, such as molluscicides, or metallic salts, such as potassium salts, "BioBullets", and chloride salts (Heimowitz and Phillips, 2008).

More detailed information on non-chemical and chemical mussel control treatments can be found in Tables 5-7 on pages 32-36 of the U.S. Bureau of Reclamation's Upper Colorado Region Prevention and Rapid Response Plan for Dreissenid Mussels (2010):
http://www.usbr.gov/uc/envdocs/rp/UCDreissenidRapidResponsePlanv.pdf.

Chinese mitten crab *(Eriocheir sinensis)*

Chinese mitten crabs are very difficult to completely eradicate due to their sheer numbers and their ability to migrate long distances over land. Control options can include the use of physical controls such as capture methods (traps/sinks, and trawls) or barriers (electric or others). Traps as well as traveling screens and trash racks are often used at the site of dams and other structures to capture juvenile crabs as they migrate upstream (Crosier, Molloy, Rudnick, and Veldhuizen, 2006). Bounty and harvest programs have also been used to try to minimize the spread of populations. More research is currently being done to assess the feasibility of using bio-controls or chemical inhibitors/disrupters to control the spread of Chinese mitten crabs (Chinese Mitten Crab Control Committee [CMCCC], 2002). Chinese mitten crabs are also potential prey for predatory fish, wading birds, river otters, and raccoons, though predator numbers are likely too small to significantly curtail Chinese mitten crab population growth (CMCCC, 2002).

Asian carp *(Hypophthalmichthys molitrix)*

Once Asian carp become established, they are near impossible to eradicate and remain very difficult to control. Several control methods are currently being used in the Great Lakes region to minimize the spread of Asian carp from the Mississippi River basin to the Great Lakes. These methods include erecting electric barriers, using poison, and hosting fishing tournaments. In 2002, an electric dispersal barrier was erected in the Chicago Sanitary and Ship Canal to prevent bighead and silver carp from entering Lake Michigan. In 2007, the Army Corps of Engineers were authorized to upgrade the initial barrier and install a second barrier on the Canal. These barriers pass electric currents through the water that act as barricades to deter the fish from passing through to the other side (Asian Carp Regional Coordinating Committee [ACRCC], 2008). While it is very unlikely that the carp are able to swim past the electric barriers, the barriers are not always fully operational due to lightning strikes, flooding, and maintenance so it is possible that carp could swim through the barriers when they are shut off. Other possible control options include poisoning sections of the Canal using **Rotenone**[G] (ACRCC, 2008). While Rotenone does not accumulate in the water, it poisons all species of fish making it an unfeasible option for large-scale control (ACRCC, 2008). Other options being considered include erecting a permanent barrier between the Great Lakes and the Mississippi River basins, using acoustic bubble barriers, hosting Asian carp fishing tournaments, and increasing the food market for Asian carp (UWSGI-AIS, 2010).

Hydrilla *(Hydrilla verticillata)*
Managing hydrilla infestations can be a very expensive and time consuming process. Common control options include (Oklahoma State University [OSU], 2011):

- Physical removal (raking, seining, and blocking sunlight)
- Bio-control agents (primarily grass carp)
- Chemical applications (herbicides)

In some cases, lake drawdowns can also help to control hydrilla populations by allowing any exposed plants to die and decompose (Ramey, 2001). While physical removal is generally a less expensive process, the use of mechanical harvesters and chopping machines can often fragment the hydrilla plants which may increase their distribution. Bio-control fish and insects, such as the Chinese grass carp, tuber-feeding weevils and leaf-eating flies, have also been used to control hydrilla populations (Ramey, 2001). However, the most effective way to control hydrilla is through the use of registered aquatic herbicides such as copper, diquat, endothall, or fluridone (Ramey, 2001). Unfortunately, the application of these herbicides often requires expensive permits and may also result in negative impacts to native fish and wildlife species.

Purple loosestrife *(Lythrum salicaria)*
Options for managing purple loosestrife infestations include manual, biological, and chemical control. Manual removal is only effective when the infestation is small or isolated to a single area and should be conducted in late June, July and early August, when it is in flower. When removing by digging or hand-pulling, the entire root system must be removed as any broken roots may sprout new plants (Minnesota Sea Grant, 2010). With less isolated infestations, it is recommended that the flowering heads be cut off to prevent the plant from releasing this year's seeds (a mature plant can produce up to 2 million seeds per year). It is also recommended that the stems be cut off at the ground to inhibit growth (although the roots will sprout new plants) (Minnesota Sea Grant, 2010).

In areas of severe purple loosestrife infestation, bio-control methods are recommended over manual or chemical control. Bio-control methods for purple loosestrife include using specially selected insects that feed on purple loosestrife to keep the infestation under control. Insects that have been approved for purple loosestrife control in the United States include: two leaf-eating beetles, one root-boring weevil, and two flower-eating beetles. Only four of these control agents have been released in the United States so far and it is expected to take a number of years before we see a long-term reduction in purple loosestrife populations (Minnesota Sea Grant, 2010). Alternatively, chemical control methods, such as the application of herbicides e.g. Roundup, can be used to manage the spread of purple loosestrife (although a permit is required to spray herbicides near waterbodies in the United States) (Minnesota Sea Grant, 2010).

Garden loosestrife *(Lysimachia vulgaris)*
Options for managing garden loosestrife infestations include manual, mechanical, and chemical control. Small infestations can be removed by hand, if care is taken to dig down to remove all of the roots (Whatcom County Noxious Weed Control Board, 2011). However, hand digging is only recommended for very young plants that are not yet established as it is nearly impossible to remove all of the root fragments from older plants that have extensive rhizome networks. If the plants are in seed, it is

important to cut off and bag all of the seed heads before removing the plants. Removed plants should be bagged, removed from the site, and discarded in the trash. To minimize spread from the site, garden loosestrife should not be composted or placed in yard waste. Repeated mowing or cutting of garden loosestrife are not effective control methods and may increase their spread if rhizomes and root fragments are left behind. For dense seedling infestations, covering the seedlings in black plastic may aid in slowing growth and seed dispersal. For larger infestations, herbicide treatment may be necessary. Some herbicides that have been effective at controlling garden loosestrife infestations include: Glyphosate, Imazapyr, and Triclopyr (King County Noxious Weed Control Program, 2007).

Eurasian watermilfoil *(Myriophyllum spicatum)*
Millions of dollars have been spent in recent years in the United States and Canada to manage Eurasian watermilfoil infestations (Melchior, 1997). Options to control Eurasian watermilfoil include mechanical, chemical, and biological methods. It is near impossible to completely eradicate Eurasian watermilfoil through mechanical means (such as cutting, harvesting, and rotovation) as these methods may result in fragmentation and increased spread (Washington State Department of Ecology, 2011). **Rotovation**[G] involves using a rotovator (or rotary tiller) to remove Eurasian watermilfoil roots (Washington State Department of Ecology, 2011). Any roots that are then found to be floating on the water's surface are collected. Harvesting is similar to underwater lawn mowing. Plants are cut five feet below the water's surface and are then collected by a conveyer and disposed of on land (Washington State Department of Ecology, 2011). Cutting of plants is similar to harvesting except cut plants are not picked up by the cutting machine and must be removed manually from the water. Lake drawdowns and the use of bottom barriers are also used in some locations to control Eurasian watermilfoil populations (Melchior, 1997).

Herbicides have also been used to control Eurasian watermilfoil since the 1960s (Melchior, 1997). Similarly to hydrilla, registered aquatic herbicides such as copper, diquat, endothall, or fluridone appear to be the most effective at eliminating Eurasian watermilfoil in lakes (Washington State Department of Ecology, 2011). Copper herbicides can only be used in irrigation ditches while the other herbicides listed are permitted for aquatic use in Washington state waters (Washington State Department of Ecology, 2011).

Bio-control options for Eurasian watermilfoil are limited but there is some research currently being done in Washington to evaluate whether the milfoil-weevil might be a good bio-control agent for the control of Eurasian watermilfoil in Washington state waters (Washington State Department of Ecology, 2011). Grass carp are not generally recommended for the control of Eurasian watermilfoil because they prefer other aquatic plant species as food (Melchior, 1997). However, when milfoil is the only plant species present in the waterbody, this is considered an acceptable control method (Washington State Department of Ecology, 2011). The Army Corps of Engineers is also currently conducting research on the use of plant pathogens as a control method for Eurasian watermilfoil. A fungus, *Mycoleptodiscus terrestris,* has been observed to significantly reduce Eurasian watermilfoil biomass in laboratory studies and may act as a successful bio-control agent (Washington State Department of Ecology, 2011).

Appendix I – Washington State and Federal AIS Laws and Regulations*

Statute	Agency	Description
Lacey Act, 18 U.S.C. 42 (1900, amended in 1998)	USFWS	Regulate - Trade
Fish and Wildlife Coordination Act	NMFS, USFWS	Reviews development projects, issues grants
National Environmental Policy Act (1970)	All Federal Agencies	Environmental Impact Assessment
Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990, 16 U.S.C. 4701-4751	NOAA – NSGO	Research, prevention, control, management, restoration
Federal Noxious Weed Act, 7 U.S.C. 2814 (1974)	Federal Land Management Agencies	Requires cooperative agreements
Anadromous Fish Conservation Act, 16 U.S.C. 757a-757g; 79 Stat. 1125	USDA, DOI, USFWS	May conduct studies and make recommendations to EPA about reducing or eliminating substances detrimental to fish and wildlife in interstate or navigable waters or tributaries
Puget Sound Water Quality Protection, RCW 90.71	Puget Sound Partnership	Coordination
Aquatic Invasive Species Enforcement Account – Aquatic Invasive Species Enforcement Program for Recreational and Commercial Watercraft, RCW 43.43.400	WSP	Regulate at port of entry weight stations; ex officio enforcement of aquatic nuisance species laws, education
Prohibited Aquatic Animal Species – Infested Waters, RCW 77.12.875, WAC 23-212-016	WDFW	Designate infested waters, provide education
Unlawful Avoidance of Aquatic Invasive Species, Invasive Species Check Stations, RCW 77.15.293	WDFW	Regulate, penalty
Inspection Authority, RCW 77.15.080(2)	WDFW	Inspection of transported watercraft
Rapid Response Plan, RCW 77.12.878	WDFW	Develop, implement, enforce, rule making, signage
Aquaculture Disease Control, RCW 77.115	WDFW	Regulate, inspection
Aquatic Invasive Species Prevention Account, RCW 77.12.879	WDFW	Educate, inspect, check stations research, monitoring, prevention, management, develop early detection-rapid response plan
Aquatic Invasive Species Inspection, RCW 77.12.882	WDFW	Inspection, rule making, signage
Removal or Control of Aquatic Noxious Weeds, RCW 77.55.081	WDFW	Rule making for removal project methods, pamphlets

Unlawful Transport of Fish and Wildlife or Aquatic Plants, RCW 77.15.290, WAC 232-12-016	WDFW	Inspection, regulation, enforcement, penalty
Water Pollution Control, RCW 90.48, WAC 173-201A, WAC 173-270	Ecology	Regulation, control, prevention
Freshwater Aquatic Algae Control Account – Freshwater Aquatic Algae Control Program, RCW 43.21A.667	Ecology	Educate, financial assistance, survey
Aquatic Nuisance Species Committee, RCW 77.60.130 Washington Invasive Species Council Created, RCW 79A.25.310	WSDA, WDFW, DNR, Ecology, PSAT, DOH, WSP, PSP, NWCB, and WSG Core Members, Tribes, Federal Agencies, Affected Industry Invited	Plan, coordinate, report, recommend potential regulations
Noxious Weed Control Boards, RCW 17.10, WAC 16-750, 2 WAC 16-75	WSDA, Noxious Weed Control Board, Local Weed Boards	Survey, educate, report, regulate
Unlawful Use of Prohibited Aquatic Animal Species, RCW 77.15.253, WAC 232-12-016	WDFW	Check station inspections, regulate, transport, possession or release, enforce penalty
Control of *Spartina* and Purple Loosestrife, RCW 17.26	WSDA, Ecology, DNR, WDFW, and State Parks	Control, survey, eradicate, and restore on agency owned lands
Control of *Spartina* and Purple Loosestrife, RCW 77.55.051	WDFW	Control, survey, eradicate, and restore on agency owned lands
Area of District, RCW 17.04	Weed Boards	Survey, educate, regulate, tax, fund
Unlawful Release of Deleterious Exotic Wildlife, RCW 77.15.250	WDFW	Regulate, enforce – unlawful release of Zebra Mussel, European Green Crab, and Chinese Mitten Crab
Imported Oyster Seed – Inspection, RCW 77.60.090	WDFW	Regulate, inspection – Zebra Mussels and European Green Crabs
Zebra Mussels and European Green Crabs, RCW 77.60.110, WAC 232-12-01701 (1998)	WDFW	Educate; prepare draft rules for legislature, establish aquatic nuisance species phone number monitoring and control programs, abatement
Zebra Mussel and European Green Crab Infested Waters, RCW 77.60.120	WDFW	Publish list of infested waters, participate in regional or national groups

*Adapted from WISC, 2008

State Regulations: more details can be found at http://www.leg.wa.gov/pages/search.aspx
Federal Regulations: more details can be found at http://thomas.loc.gov/

Acronyms: DOH – Washington Department of Health, DOI – U.S. Department of Interior, DNR – Washington Department of Natural Resources, Ecology – Washington Department of Ecology, EPA – U.S. Environmental Protection Agency, USFWS – U.S. Fish and Wildlife Service, NMFS – National Marine Fisheries Service, NOAA – National Oceanic and Atmospheric Administration, NSGO – National Sea Grant Office, NWCB – Washington State Noxious Weed Control Board, PSAT – Puget Sound Action Team, PSP – Puget Sound Partnership, RCW – Revised Code of Washington, St. Parks – Washington Parks and Recreation Commission, USDA – U.S. Department of Agriculture, WAC – Washington Administrative Code, WDFW – Washington Department of Fish and Wildlife, WSDA – Washington State Department of Agriculture, WSG – Washington Sea Grant, WSP – Washington State Patrol

Appendix J – Links to AIS Fact Sheets

AIS Information Databases:

Washington Invasive Species Council - Fact Sheets for Washington's Priority Species:
http://www.invasivespecies.wa.gov/priorities.shtml

USGS - Nonindigenous Aquatic Species (NAS) Database – Fact Sheets:
http://nas.er.usgs.gov/default.aspx

Washington Department of Fish and Wildlife – Aquatic Invasive Species Fact Sheets:
http://wdfw.wa.gov/ais/species.html

Whatcom County Noxious Weed Control Board – Noxious Weed Fact Sheets:
http://www.co.whatcom.wa.us/publicworks/weeds/factsheets.jsp

Washington State Department of Ecology – Invasive Freshwater Plants Fact Sheets:
http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua011.html

Links to Fact Sheets for AIS of concern:

Asian carp (silver carp) *(Hypophthalmichthys molitrix)*
http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=549
Nearest location: Sunset Park Pond, Las Vegas, NV and Mississippi River

Asian clam (*Corbicula fluminea)*
http://www.iisgcp.org/exoticsp/asianclam.htm
Nearest locations: Lake Washington; Columbia, Snake, Chehalis, and Willapa rivers; Hood Canal; Aberdeen Lake, WA

Brazilian elodea *(Egeria densa)*
http://www.invasivespecies.wa.gov/documents/priorities/BrazilianElodeaFactsheet.pdf
Nearest locations: Big Lake, Skagit County and Private Pond, Whatcom County, WA

Chinese mitten crab *(Eriocheir sinensis)*
http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=182
Nearest location: Columbia River at the Port of Ilwaco, WA

Curly-leaf pondweed *(Potamogeton crispus)*
http://www.co.whatcom.wa.us/publicworks/weeds/pdf/Curly-leafPondweed2.pdf
Nearest location: Lake Whatcom, WA

Eurasian watermilfoil *(Myriophyllum spicatum)*
http://www.co.whatcom.wa.us/publicworks/pdf/weeds/aquatic/eurasianwatermilfoil.pdf
Nearest location: Lake Whatcom, WA

European green crab *(Carcinus maenas)*
http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=190
Nearest location: Grays Harbor and Willapa Bay, WA

Flowering rush *(Butomus umbellatus)*
http://www.co.whatcom.wa.us/publicworks/weeds/pdf/FloweringRush2.pdf
Nearest location: Silver Lake, Whatcom County, WA

Fragrant water lily *(Nymphaea odorata)*
http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua005.html
Nearest location: Lake Whatcom, WA

Garden loosestrife *(Lysimachia vulgaris)*
http://www.co.whatcom.wa.us/publicworks/pdf/weeds/aquatic/gardenloosestrife2.pdf
Nearest location: Lake Whatcom, WA

Hairy willow-herb *(Epilobium hirsutum)*
http://www.co.whatcom.wa.us/publicworks/pdf/weeds/aquatic/hairy_willow_herb.pdf
Nearest location: Lake Whatcom, WA

Hydrilla *(Hydrilla verticillata)*
http://www.invasivespecies.wa.gov/documents/priorities/HydrillaFactsheet.pdf
Nearest location: Confirmed in Lake Lucerne and Pipe Lake, WA (Now eradicated in WA)

New Zealand mudsnail *(Potamopyrgus antipodarium)*
http://www.invasivespecies.wa.gov/documents/priorities/NewZealandMudsnailFactsheet.pdf
Nearest locations: Thornton Creek, Seattle and Capitol Lake, Olympia, WA

Parrotfeather *(Myriophyllum aquaticum)*
http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua003.html
Nearest location: Private pond in Whatcom County, WA

Purple loosestrife *(Lythrum salicaria)*
http://www.co.whatcom.wa.us/publicworks/pdf/weeds/aquatic/purple_loosestrife2.pdf
Nearest location: Lake Whatcom, WA

Quagga mussel *(Dreissena bugensis)* **and Zebra mussel** *(Dreissena polymorpha)*
http://www.invasivespecies.wa.gov/documents/priorities/ZebraQuaggaMusselFactSheet.pdf
Nearest locations: Electric Lake, UT and Copper Basin Reservoir, CA (Zebra) and Rye Patch Reservoir, Lahontan Reservoir, and Lake Mead, NV (Quagga)

Reed canarygrass *(Phalaris arundinacea)*
http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua011.html
Nearest location: Lake Whatcom, WA

Variable-leaf milfoil *(Myriophyllum heterophyllum)*
http://www.invasivespecies.wa.gov/documents/priorities/VariableLeafMilfoilFactsheet.pdf
Nearest location: Florence Lake, Pierce County, WA

Viral Hemorrhagic Septicemia Virus *(VHS IVb strain)*
http://www.invasivespecies.wa.gov/documents/priorities/VHSFactSheet.pdf
Nearest location: Great Lakes

Yellow flag iris *(Iris pseudacorus)*
http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/BMPs/yellow-flag-iris-control.pdf
Nearest location: Lake Whatcom, WA

Yellow floating heart *(Nymphoides peltata)*
http://www.co.whatcom.wa.us/publicworks/pdf/weeds/aquatic/yellow_floating_heart2.pdf
Nearest location: Geneva Pond, Whatcom County, WA

Appendix K – AIS-HACCP Plan Example

Do your activities pose a risk for spreading AIS?

Resource managers, researchers, students, technicians, consultants, waterfront property managers, and enforcement officers engage in activities that can result in the spread of aquatic invasive species.

AIS-HACCP is a process designed to help identify and control the critical pathways for spread of aquatic invasive species or other non-target aquatic species. The process provides for self-monitoring, verification, and record-keeping systems to help ensure that your activities do not spread these hazards.

Who should be using AIS-HACCP Plans to manage their activities to prevent the spread of AIS?

- Resource managers
- Researchers
- Graduate students
- Monitoring staff/Technicians
- Consultants
- Enforcement officers

Steps for developing an AIS-HACCP Plan:

- Describe all of the steps involved in the activity from start to finish
- Identify potential AIS-related hazards (Hazard Analysis Worksheet)
- Identify **critical control points**[G] (any point, step or procedure at which aquatic invasive species can be controlled)
- If critical control points are found, complete the AIS-HACCP Plan Form and establish monitoring procedures and corrective actions to prevent the spread of AIS hazards (AIS-HACCP Plan Form)

What are some corrective actions or procedures that can help to eliminate AIS hazards:

- Avoiding infested waters
- Choosing when, where, and how to sample or harvest
- Tagging management, research, and enforcement equipment used in infested waters for use *only* in infested waters
- Treating all equipment used in infested waters with chemicals, dehydration, freezing or other appropriate measures to kill AIS

Developing AIS-HACCP Plans:

Preliminary Steps

1. Document general information
2. Describe the harvest, production, management, research, or enforcement activity
3. Describe the method of transportation, distribution and storage of fish, gear, boats, etc.
4. Identify the intended use and consumer (if applicable)
5. Develop a flow diagram

Hazard Analysis Worksheet

6. Set up the Hazard Analysis Worksheet
7. Identify the potential AIS-related hazards
8. Complete the Hazard Analysis Worksheet
   - Understand the potential hazard
   - Determine if the potential hazard is significant
   - Identify the critical control points (CCP)

AIS-HACCP Plan Form

9. Complete the AIS-HACCP Plan Form
   - Set the critical limits (CL)
   - Establish monitoring procedures: What, How, Frequency, Who
   - Establish corrective action procedures
   - Establish verification procedures
   - Establish a record-keeping system

(Minnesota Sea Grant, 2001*)

See AIS-HACCP Sample Plan Two for an example of how AIS-HACCP can help prevent the spread of AIS (Minnesota Sea Grant, 2001*).

Blank Forms and other resources: http://www.seagrant.umn.edu/ais/haccp

AIS-HACCP Planning Wizard available at: http://www.haccp-nrm.org/

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AIS-HACCP SAMPLE PLAN TWO

Aquatic Invasive Species – Hazard Analysis and Critical Control Point

Product/Procedure Form

Product/Procedure Description

Organization info	Organization name: Department of Resource Enforcement
	Address: 123 Main Street City: Outlaw City State: MT Zip: 11111
(if applicable):	Fish species: N/A
Harvest, production, management, research or enforcement activity:	Activity: Checking for violations by boat on several area lakes
Method of transportation, distribution and storage of fish, gear, boats, etc.:	Methods: Moored boat is taken from lake and trailered to other lakes for enforcement activities.
(if applicable):	Intended use and consumer: N/A

Product/Procedure Flow

List the steps involved in the research, management, enforcement, or fish production activity. Only a simple, but complete, description of the procedure is needed. It is important to include all the steps within the control of the agency or business, but use only as many steps as necessary to define your procedure.

①	Conservation Officers (COs) depart office trailering boat. COs retrieve moored boat at Lake Woo and trailer it into water at landing at Lake Zoo for safety checks and fishing enforcement.
②	COs patrol the lake. While patrolling, COs come upon an illegally set net. They anchor, inspect and pull the net, and bring it aboard.
③	COs return to landing. Boat is driven onto trailer. Trailer is driven out of water. Net is stored in rear of vehicle.
④	After the 2 sampling sessions, the boat is driven back to the original on-land secure storage facility.
⑤	COs continue to Lake Yoo. COs arrive at Lake Yoo for routine patrol. Boat and trailer are backed into water at boat landing.
⑥	While patrolling, COs come upon a suspicious float in adjacent wetland. COs anchor, don waders and inspect float. Float is not attached to anything. COs return to boat, remove waders, pull-up anchor and continue circuit of lake.
⑦	COs complete circuit of Lake Yoo and return to landing and boat is driven onto trailer. Trailer is driven out of water. COs return to office, store illegally-set net for future destruction.
⑧	Next morning, COs depart office in vehicle with same boat trailered behind. COs arrive at Lake Poo for routine patrol. COs back boat and trailer into water at boat landing.
⑨	
⑩	
⑪	
⑫	

Next Steps...
Once you have defined your procedure, determine potential hazards by completing the potential hazards worksheet.

Upon completion of your AIS-HACCP plan, sign to signify that the plan has been accepted for implementation.

Name: Andy Haccip

Signature: X Andy Haccip Date: 1/31/05

Potential AIS Hazards

List all relevant species

Examples: round goby, tubenose goby, non-native amphibians, etc.	AIS Fish and Other Vertebrates N/A
Examples: Dreissenid mussels, spiny waterfleas, etc.	AIS Invertebrates Zebra mussels are present in lakes Woo and Yoo.
Examples: Eurasian watermilfoil, water chestnut, etc.	AIS Plants Eurasian watermilfoil is present in Lake Zoo.
Examples: whirling disease, heterosporis, spring viremia of carp, etc.	AIS Pathogens N/A

Next Step...
Once you've identified potential hazards, complete a hazard analysis form.

AIS-HACCP SAMPLE PLAN TWO

Aquatic Invasive Species · Hazard Analysis and Critical Control Point

Hazard Analysis Worksheet

1 Activity Activity, Harvest or Aquaculture Step (from flow diagram)	2 Hazards Potential AIS hazards introduced or controlled at this step (from potential hazards worksheet)	3 Are AIS hazards significant? (Yes/No)	4 Justification Justify your decisions for column 3.	5 Control What control measures can be applied to prevent the significant hazards?	6 CCP Is this step a critical control point? (Yes/No)
Work Flow Step (1) In morning, COs depart office in vehicle with boat trailer behind. COs retrieve moored boat at Lake Woo and load onto trailer. COs arrive at Lake Zoo for safety checks and fishing enforcement. Boat and trailer are backed into water at boat landing.	Fish/Other Vert.	No	AIS Fish not present	Nets and equipment should be inspected and fish removed before sampling as a precaution.	No
	Invertebrate Zebra mussels	Yes	Woo is infested with z.m. & could be moved as adults on boat or plants and as larvae in any standing water.		Yes
	Plant	No	AIS Plants not present in Lake Woo.		No
	Pathogens	No	None present		No
Work Flow Step (2) COs patrol the lake. While patrolling, COs come upon an illegally set net. They anchor, inspect and pull the net, and bring it aboard.	Fish/Other Vert.	No	AIS fish not present in Lake Woo.		No
	Invertebrate Zebra mussels	Yes	Zebra mussels from Lake Woo could be present on the boat.	Hazard controlled at previous step.	No
	Plant	No	AIS Plants not present in Lake Woo.		No
	Pathogens	No	None present		No

Next Step...

Once you have determined the critical control points of your procedure, you may enter them in row 1 of the HACCP plan form.

AIS-HACCP SAMPLE PLAN TWO

Aquatic Invasive Species – Hazard Analysis and Critical Control Point

Hazard Analysis Worksheet

1 Activity Activity, Harvest or Aquaculture Step (from flow diagram)	2 Hazards Potential AIS hazards introduced or controlled at this step (from potential hazards worksheet)	3 Are AIS hazards significant? (Yes/No)	4 Justification Justify your decisions for column 3.	5 Control What control measures can be applied to prevent the significant hazards?	6 CCP Is this step a critical control point? (Yes/No)
Work Flow Step (3) COs return to landing. Vehicle and trailer are retrieved. Trailer is backed into water at boat landing. Boat is driven onto trailer. Trailer is driven out of water. Net is stored in rear of vehicle.	Fish/Other Vert.	No	AIS Fish not present		No
	Invertebrate	No	AIS invertebrates not present in Lake Zoo		No
	Plant Eurasian water-milfoil	Yes	Lake Zoo infested with EWM and could be moved to another lake on equipment.	Before leaving boat landing, remove all weeds from equipment (trailer, motor, anchor, etc.)	Yes
	Pathogens	No	None present		No
Work Flow Step (4) COs continue to Lake Yoo. COs arrive at Lake Yoo for routine patrol. Boat and trailer are backed into water at boat landing.	Fish/Other Vert.	No	AIS fish not present in Lake Woo.		No
	Invertebrate	No	None Present		No
	Plant Eurasian water-milfoil	Yes	EWM present and could be introduced into Yoo on boat, trailer or equipment.	Hazard controlled in previous step.	No
	Pathogens	No	None present		No

Next Step…

Once you have determined the critical control points of your procedure, you may enter them in row 1 of the HACCP plan form.

AIS-HACCP SAMPLE PLAN TWO

Aquatic Invasive Species – Hazard Analysis and Critical Control Point

Hazard Analysis Worksheet

1 Activity Activity. Harvest or Aquaculture Step (from flow diagram)	**2 Hazards** Potential AIS hazards introduced or controlled at this step (from potential hazards worksheet)	**3** Are AIS hazards significant? (Yes/No)	**4 Justification** Justify your decisions for column 3.	**5 Control** What control measures can be applied to prevent the significant hazards?	**6 CCP** Is this step a critical control point? (Yes/No)
Work Flow Step (5) COs patrol the lake. While patrolling, COs come upon a suspicious float in adjacent wetland. COs anchor, don waders and inspect float. Float is not attached to anything. COs return to boat, remove waders, pull-up anchor and continue circuit of lake.	Fish/Other Vert.	No	AIS Fish not present		No
	Invertebrate	No	AIS invertebrates not present in Lake Zoo.		No
	Plant Eurasian water-milfoil	Yes	EWM entangled on boat anchor could be introduced into Lake Zoo.	Hazard controlled in previous step.	No
	Pathogens	No	None present		No
Work Flow Step (6) COs complete circuit of Lake Yoo and return to landing. Vehicle and trailer are retrieved. Trailer is backed into water at boat landing. Boat is driven onto trailer. Trailer is driven out of water. COs return to office and store illegally-set net for future destruction.	Fish/Other Vert.	No	AIS fish not present in Lake Woo.		No
	Invertebrate Zebra mussels	Yes	Z.M. could be introduced into next lake as adults on weeds ensnared on equipment, and as larvae in any standing water or in coiled wet anchor rope.	At landing, remove weeds from equipment. Drain water, rinse equipment (including waders & anchor rope) with high-pressure sprayer or hot water. If net not disposed of, freeze or dry for 1week before use.	Yes
	Plant	No	AIS Plants not present in Lake Woo.		No
	Pathogens	No	None present		No

Next Step...

Once you have determined the critical control points of your procedure, you may enter them in row 1 of the HACCP plan form.

AIS-HACCP SAMPLE PLAN TWO

Aquatic Invasive Species – Hazard Analysis and Critical Control Point

Hazard Analysis Worksheet

1 Activity Activity, Harvest or Aquaculture Step (from flow diagram)	2 Hazards Potential AIS hazards introduced or controlled at this step (from potential hazards worksheet)	3 Are AIS hazards significant? (Yes/No)	4 Justification Justify your decisions for column 3.	5 Control What control measures can be applied to prevent the significant hazards?	6 CCP Is this step a critical control point? (Yes/No)
Work Flow Step (7) Next morning, COs depart office in vehicle with same boat trailered behind. COs arrive at Lake Poo for routine patrol. COs back boat and trailer into water at boat landing.	Fish/Other Vert.	No	AIS Fish not present in Lake Yoo.		No
	Invertebrate Zebra mussels	Yes	Zebra mussels present in Lake Yoo.	Hazard controlled at previous step.	No
	Plant	No	AIS plants not present in Lake Yoo.		No
	Pathogens	No	None present in Lake Yoo		No
Work Flow Step ( )	Fish/Other Vert.				
	Invertebrate				
	Plant				
	Pathogens				

Next Step...

Once you have determined the critical control points of your procedure, you may enter them in row 1 of the HACCP plan form.

AIS-HACCP SAMPLE PLAN TWO

Aquatic Invasive Species – Hazard Analysis and Critical Control Point

AIS-HAACP Plan Form

Critical Control Point Each row answered "yes" in column 6 on the Hazard Analysis Form	1	In morning, COs depart office in vehicle with boat trailer and retrieve moored boat at Lake Woo and load onto trailer. COs arrive at Lake Zoo for safety checks and fishing enforcement.	COs return to landing for trailer. Trailer is backed into water at landing. Boat is driven onto trailer. Net is stored in rear of vehicle.
Significant Hazards as determined in column 3 of the Hazard Analysis Form	2	Zebra mussels could be moved to Lake Zoo as adults on boat or plants and as larvae in any standing water.	EWM and could be moved to another lake on equipment.
Limits for each control measure	3	Before leaving landing, all organisms (e.g., weeds and adult mussels) are removed from equipment & water is drained. All equipment is rinsed with a high-pressure sprayer or hot water.	Before leaving boat landing, remove all weeds from equipment (trailer, motor, anchor, etc.)
Monitoring Describe what is being monitored	4	Presence of adult mussels or plant fragments.	Presence of plant fragments.
Explain how the monitoring will take place	5	Visual inspection. High pressure rinsing.	Visual inspection.
Frequency of monitoring	6	Each time equipment leaves Lake Woo.	Each time boat leaves Lake Zoo.
Person or position responsible for monitoring	7	Driver	Driver
Corrective Actions Actions taken when limits of control mesaures are not met	8	If adults or plant fragments found on equipment, remove before going to uninfested waters.	If plant fragments found on equipment, remove before going to uninfested waters.
Verification Method of Verification	9	Records review.	Records review.
Records List what is recorded at each critical control point	10	Record time of rinsing and visual inspection.	Record time of visual inspection.

Final Step...

Once you have completed your HACCP plan, attach it to the signed product/procedure form with the hazard analysis worksheets.

AIS-HACCP SAMPLE PLAN TWO

Aquatic Invasive Species – Hazard Analysis and Critical Control Point

AIS-HAACP Plan Form

Critical Control Point Each row answered "yes" in column 6 on the Hazard Analysis Form	1	COs complete circuit of Lake Yoo and return to landing for trailer. Boat is loaded on Trailer then driven out of water. COs return to office, store illegally-set net for future destruction.	
Significant Hazards as determined in column 3 of the Hazard Analysis Form	2	Zebra mussels present in Lake Yoo could be introduced into next lake as adults on weeds ensnared on net, trailer, waders or propeller, and as larvae in any standing water.	
Limits for each control measure	3	At landing, remove weeds from equipment & drain water. Rinse equipment (including waders) with high-pressure sprayer/hot water. If net not disposed of, freeze or dry for 10 days before use.	
Monitoring Describe what is being monitored	4	Presence of adult or juvenile mussels or plant fragments. Freezing/ drying of net. Rinse or dry all equipment.	
Explain how the monitoring will take place	5	Visual inspection for plant fragments. Length of time net is frozen or dried. Record of rinsing method or length of time of drying.	
Frequency of monitoring	6	Each time equipment leaves Lake Yoo. Each time a net is confiscated from Lake Yoo.	
Person or position responsible for monitoring	7	Driver	
Corrective Actions Actions taken when limits of control mesaures are not met	8	If adults or plant fragments found on equipment, remove before going to uninfested waters. If equipment not properly dried use a hot water or high pressure rinse.	
Verification Method of Verification	9	Records review.	
Records List what is recorded at each critical control point	10	Record time of rinsing and visual inspection. Record length of time of freezing or drying activities	

Final Step...

Once you have completed your HACCP plan, attach it to the signed product/procedure form with the hazard analysis worksheets.

Appendix L – Zap the Zebra Brochure

STOP AQUATIC HITCHHIKERS!™

www.ProtectYourWaters.net

Follow these simple steps:

☑ Clean

Remove all plants, animals, mud and thoroughly wash everything, especially all crevices and other hidden areas.

☑ Drain

Eliminate all water before leaving the area, including wells, ballast, and engine cooling water.

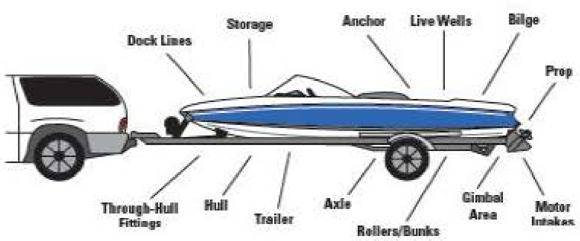
☑ Dry

Allow sufficient time for your boat to completely dry before launching in other waters.

If your boat has been in infested waters for an extended period of time, or if you cannot perform the required steps above, you should have your boat *professionally* cleaned with high-pressure scalding hot water (>140 °F) before transporting to any body of water.

Before launching and before leaving...

Inspect everything!



Quagga mussels encrusting a boat motor

Zebra and quagga mussels are a nuisance for anglers and boaters. They can ruin your equipment, clog motor cooling systems, foul hulls, and jam the centerboard wells under sailboats.

100th Meridian Initiative

ZAP THE ZEBRA

www.100thMeridian.org

Please report any sighting by calling our National Hotline:

1-877-STOP-ANS

1-877-786-7267

100th Meridian Initiative

Image Credits: *Zebra Mussels on a Fishing Lure* by Marc Murrell, Kansas Department of Wildlife and Parks • *Zebra Mussels, Zebra Mussels on a Beer Can, Zebra Mussels on a Native Mussel, Bait Bucket, Quagga Mussels, Zebra/Quagga Mussel Distribution January 2009* by David Britton, U.S. Fish & Wildlife Service • *Zebra Mussels in a Cut-Away Pipe* by Don Schlosser, Great Lakes Science Center • *Zebra Mussels in a Pipe* by Craig Czarnecki, Michigan Sea Grant • *Quagga Mussels Encrusting a Boat Motor* by Matt Watson, The University of Texas at Arlington • The distribution map is based on data compiled by the U.S. Geological Survey's Nonindigenous Aquatic Species Program (http://nas.er.usgs.gov).

Invasive Mussels: Expensive Damage!

When zebra and/or quagga mussels invade our local waters they clog power-plant and public-water intakes and pipes. Routine treatment is necessary and very expensive. This leads to increased utility bills. If you use water and electricity, you do not want these mussels.


Zebra mussels in a cut away pipe

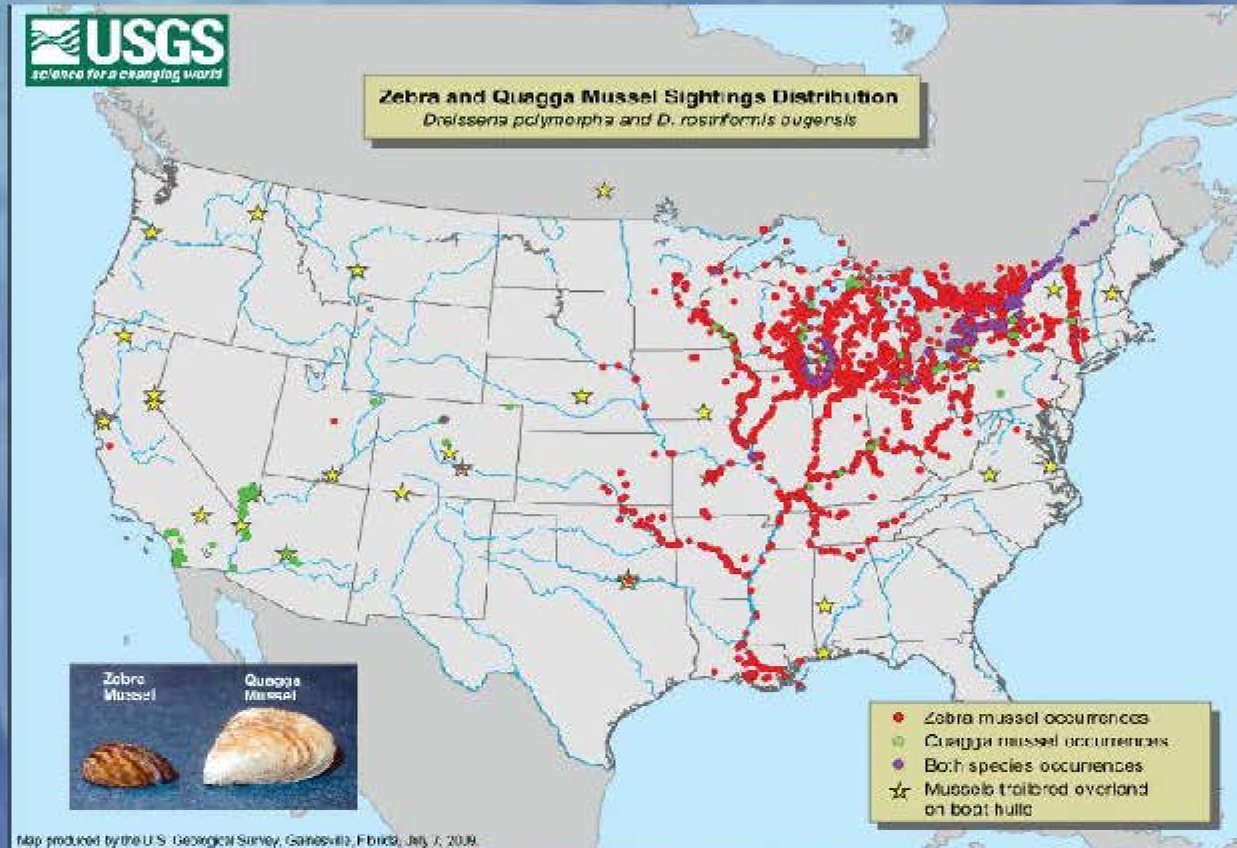

Zebra mussels blocking a pipe

Zebra/Quagga Mussels May Use Your Boat to Invade Additional Waters!

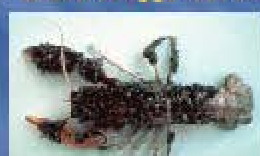
Once a boat has been in infested waters, it could carry invasive mussels. These mussels can spread to new habitats on boats trailered by commercial haulers or the public. Zebra and quagga mussels attach to boats and aquatic plants carried by boats. These mussels also commonly attach to bait buckets and other aquatic recreational equipment. An adult female zebra mussel can release up to a million eggs in a year. Please take precautions outlined in this brochure to help reduce the chance that zebra or quagga mussels will spread from your boat or equipment to uninfested areas.


Before zebra mussels


After zebra mussels



Zebra/Quagga Mussels Harm Native Aquatic Life


Zebra mussels on a crayfish


Zebra mussels on a native mussel

Zebra/Quagga Mussels Encrust Any Hard Surface


Zebra mussels on a beer can


Zebra mussels on a fishing lure

Zebra Mussels / Quagga Mussels

What are they?

Both are closely related, invasive, freshwater bivalve (mollusk) species that encrust hard surfaces.

Where do they come from?

These species came from the Black and Caspian Sea Drainages in Eurasia.

What size are they?

Larvae are microscopic and adults may be up to two inches long. They are usually found in clusters.

Why "Zebra" mussels?

Both species are sometimes referred to as "zebra" mussels because they both have light and dark alternating stripes. Quagga mussels are actually a distinct (but similar) species named after an extinct animal related to zebras.

Appendix M – AIS Contacts and Resources

National and Regional AIS Resources:

Nationwide:
The Aquatic Nuisance Species (ANS) Task Force
http://www.anstaskforce.gov/default.php

The National Invasive Species Council
http://www.invasivespecies.gov/

National Invasive Species Information Center – U.S. Department of Agriculture
http://www.invasivespeciesinfo.gov/index.shtml

USGS – Nonindigenous Aquatic Species Information Resource
http://nas.er.usgs.gov/

Stop Aquatic Hitchhikers!
http://www.protectyourwaters.net

The 100th Meridian Initiative
http://www.100thmeridian.org

Great Lakes:
Great Lakes Information Network – Invasive Species in the Great Lakes Region
http://www.great-lakes.net/envt/flora-fauna/invasive/invasive.html

Western States:
Quagga-Zebra Mussel Action Plan for Western U.S. Waters (2010)
http://www.anstaskforce.gov/QZAP/QZAP_FINAL_Feb2010.pdf

The Western Regional Panel on Aquatic Nuisance Species
http://www.fws.gov/answest/resources.htm

Aquatic Nuisance Species Project – Pacific States Marine Fisheries Commission
http://www.aquaticnuisance.org/

State AIS Resources:

Arizona:
Arizona Game and Fish Department – Aquatic Invasive Species
http://www.azgfd.gov/h_f/aquatic_invasive_species.shtml

Arizona State Aquatic Invasive Species Management Plan – Draft (2010)
http://www.azgfd.gov/h_f/documents/AISMP-DRAFT-B-Nov2010.pdf

Arizona Invasive Species Management Plan (2008)
http://www.governor.state.az.us/ais/Documents/AISMP2008.pdf

California:
California Aquatic Invasive Species Management Plan (2008)
http://www.dfg.ca.gov/invasives/plan/

California Department of Fish and Game – Invasive Species Program
http://www.dfg.ca.gov/invasives/quaggamussel/

California Department of Boating and Waterways
http://www.dbw.ca.gov/BoaterInfo/QuaggaLoc.aspx

Lake Tahoe, California/Nevada:
Lake Tahoe Region Aquatic Invasive Species Management Plan – California/Nevada (2009)
http://www.trpa.org/documents/docdwnlds/AIS/LTAIS_Magmt_Plan_Final_11-2009.pdf

Tahoe Resource Conservation District - Tahoe Boat Inspection Program
http://www.tahoercd.org/index.php/boat

Tahoe Regional Planning Agency – Invasive Species/Boat Certification Information
http://www.trpa.org/default.aspx?tabid=351

Colorado:
Colorado State Parks – Aquatic Nuisance Species
http://parks.state.co.us/NaturalResources/ParksResourceStewardship/AquaticNuisanceSpecies/Pages/AquaticNuisanceSpeciesHome.aspx

Colorado Department of Natural Resources
Aquatic Nuisance Species (ANS) Watercraft Inspection Handbook (2009)
http://parks.state.co.us/SiteCollectionImages/parks/Programs/ParksResourceStewardship/ANS%20Inspect%20HBook%20V12.pdf

Colorado Division of Wildlife – Watercraft Cleaning
http://wildlife.state.co.us/WildlifeSpecies/Profiles/InvasiveSpecies/WatercraftCleaning.htm

Idaho:
Idaho Aquatic Nuisance Species Plan (2007)
http://www.agri.state.id.us/Categories/Environment/InvasiveSpeciesCouncil/documents/Idaho%20Aquatic%20Nuisance%20Species%20Plan.pdf

State of Idaho Parks and Recreation
Invasive Species Prevention Program and Idaho Invasive Species Fund
http://parksandrecreation.idaho.gov/idahoinvasivespeciesfund.aspx

Idaho Department of Agriculture – Idaho Invasive Species Council
http://www.agri.state.id.us/Categories/Environment/InvasiveSpeciesCouncil/indexInvSpCouncil.php

Minnesota:
Minnesota Sea Grant
http://www.seagrant.umn.edu/ais/index

Minnesota Department of Natural Resources – Invasive Species Program
http://www.dnr.state.mn.us/eco/invasives/index.html

Minnesota Invasive Species Advisory Council – Minnesota Department of Agriculture
http://www.mda.state.mn.us/misac

Minnesota Waters – Citizens protecting and improving our lakes and rivers
http://www.minnesotawaters.org

Montana:
Montana Aquatic Nuisance Species (ANS) Management Plan (2002)
http://fwpiis.mt.gov/content/getItem.aspx?id=3258

Montana Fish, Wildlife and Parks – Aquatic Invasive Species Identification and Distribution
http://fwp.mt.gov/fishing/guide/ANS/default.html

Flathead Basin Aquatic Invasive Species Strategic Prevention Plan (2010)
http://www.flatheadlakers.org/uploads/pdfs/Flathead%20Basin%20AIS%20Plan%202010.pdf

Oregon:
Oregon Aquatic Nuisance Species Management Plan (2001)
http://www.clr.pdx.edu/publications/files/OR_ANS_Plan.pdf

Oregon State Marine Board – Aquatic Invasive Species Prevention Program
http://www.boatoregon.com/OSMB/Clean/AISPPmain.shtml

Utah:
Utah Aquatic Invasive Species Management Plan (2009)
http://wildlife.utah.gov/pdf/AIS_plans_2010/AIS_mgt_plan_full.pdf

Utah Division of Wildlife Resources – Aquatic Invasive Species Threats and Prevention Efforts
http://wildlife.utah.gov/mussels/

Washington:
Washington State Aquatic Nuisance Species Management Plan (2001)
http://wdfw.wa.gov/publications/00809/wdfw00809.pdf

Washington Invasive Species Council
http://www.invasivespecies.wa.gov

Washington Invasive Species Education
http://www.wise.wa.gov

Washington Department of Fish and Wildlife – Aquatic Invasive Species
http://wdfw.wa.gov/ais/

Wisconsin:
Wisconsin Sea Grant – Aquatic Invasive Species
http://seagrant.wisc.edu/ais/

Wisconsin Department of Natural Resources – Invasive Species
http://dnr.wi.gov/invasives/

Clean Boats, Clean Waters – University of Wisconsin Extension - Lakes
http://www.uwsp.edu/cnr/uwexlakes/cbcw/

Wisconsin's Citizen-Based Water Monitoring Network
http://watermonitoring.uwex.edu/level1/monitoring.html

Wyoming:
Wyoming Aquatic Invasive Species Management Plan – Draft (2010)
http://gf.state.wy.us/downloads/pdf/Wyoming%20AIS%20Management%20Plan_revised%20051810_reduced.pdf

Wyoming Game and Fish Department
http://gf.state.wy.us/fish/AIS/index.asp

AIS Contacts:

U.S. Fish and Wildlife Service: Kevin Aitkin, Fish Biologist Western Washington Fish and Wildlife Office Kevin_Aitkin@fws.gov (360) 753-9508 Paul Heimowitz, Aquatic Invasive Species Coordinator U. S. Fish and Wildlife Service, Pacific Region Paul_Heimowitz@fws.gov (503) 736-4722 **Washington Invasive Species Council:** Wendy Brown, Executive Coordinator Wendy.Brown@invasivespecies.wa.gov (360) 902-3088 **Washington Department of Fish and Wildlife:** Allen Pleus, ANS Coordinator Allen.Pleus@dfw.wa.gov (360) 902-2724 Steve Sherlock, WDFW Public Boating Access Areas Stephen.Sherlock@dfw.wa.gov (360) 902-2375 **Washington Sea Grant:** Jeff Adams, Marine Water Quality Specialist jaws@u.washington.edu (360) 337-4619	**Washington State ANS Coordinator:** Allen Pleus, ANS Coordinator Allen.Pleus@dfw.wa.gov (360) 902-2724 **The Pacific States Marine Fisheries Commission:** Stephen Phillips, Aquatic Nuisance Species and Invasive Species Program Manager Stephen_Phillips@psmfc.org (503) 595-3100 Bill Zook, Contractor – Watercraft Inspection Training bjzook2@msn.com **Washington Department of Fish and Wildlife Enforcement: Aquatic Invasive Species/Boating Safety** Sgt. Carl Klein, AIS Enforcement Coordinator Carl.Klein@dfw.wa.gov (360) 902-2346 **Washington State Department of Ecology:** Kathy Hamel Water Quality Program kham461@ecy.wa.gov (360) 407-6562 **Minnesota Sea Grant – AIS-HACCP Training:** Doug Jensen, AIS Program Coordinator Djensen1@umn.edu (218) 726-8712
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Whatcom County Noxious Weed Control Board:	**City of Everett:**
Laurel Baldwin LBaldwin@co.whatcom.wa.us (360) 715-7470	Julie Sklare, Senior Environmental Specialist jsklare@ci.everett.wa.us (425) 257-7208
WSU Whatcom County Extension/ Washington Sea Grant:	Jenni Lamarca, Public Education Programs Coordinator Snohomish County PUD education@snopud.com (425) 783-8292
Sue Blake, Water Resources Educator sgblake@wsu.edu (360) 676-6736	

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