Quagga-Zebra Mussel Action Plan
for Western U.S. Waters

Submitted to the
Aquatic Nuisance Species Task Force
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by the
Western Regional Panel
on Aquatic Nuisance Species

Zebra mussels (*Dreissena polymorpha*)

Quagga mussels (*Dreissena bugensis*)

Acknowledgements

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Executive Summary

The quagga mussel (*Dreissena rostriformis bugensis*) and zebra mussel (*Dreissena polymorpha*, collectively referred to as Dreissenids) are among the most devastating aquatic nuisance species (ANS) to invade North American fresh waters. In January 2007, the first population of Dreissenid mussels west of the 100th Meridian was discovered in Lake Mead. The arrival of quagga and zebra mussels in the West extends their significant ecological and economic impacts to a region already challenged with water management issues. Once established, these mussels can clog water intake and delivery pipes, infest hydropower infrastructure, adhere to boats and pilings, foul recreational beaches, and cause many other costly problems. Their ecological legacy in the Eastern U.S. has included competition with native mussels, disruption of food webs, and bioaccumulation of toxins. It is almost certain that they will pose similar threats in the West, putting the long list of imperiled fish and other aquatic life at an even greater risk. Invasive mussels have not been detected in the vast majority of Western waters, presenting tremendous opportunities to prevent significant damage if coordinated and extensive action is taken immediately. **Without increased and immediate action, quagga and zebra mussels will cause irreparable ecological damage to western waters and long-term costs will be in the billions.** In Idaho, the conservative estimate of state-wide direct and indirect costs from establishment of Dreissenid mussels is $94,474,000.

Effective, decisive actions and support are needed from water management entities at all levels, including state and federal agencies, tribes, private water districts and concessionaires to prevent the introduction or spread of or to respond to an infestation of quagga or zebra mussels. Federal actions and coordination must complement and support State efforts. Water management jurisdictions and authorities in the West are varied and complex, emphasizing the need for comprehensive and effective coordinated action.

Efforts to prevent the further spread and introduction of ANS in the West do exist; however, they are extremely varied across state, tribal, federal and local agency jurisdictions. Most States within the West have limited ANS programs. Five of the nineteen States in the region have well developed and funded programs, although even these five programs have limitations and challenges. With water conveyance systems and a mobile recreating society, all water management entities throughout the West need effective programs to prevent the introduction and control the spread of aquatic invasive species.

The goal of this document is to summarize current strategies to address the invasion of zebra and quagga mussels in the West, and to identify and prioritize the specific actions that are needed to comprehensively prevent the further spread of these mussels, respond to new infestations, and manage existing infestations. This *Quagga-Zebra Mussel Action Plan for Western U.S. Waters* (QZAP) is intended to serve as a common 'road map' of priorities for any water or recreational management entity and their partners for the next five years and is not intended as a budget request.

Highest Priority Actions Needed

Actions to address this growing problem fall under seven major categories: Increasing Capacity to Address Invasive Mussels, Prevention, Early-Detection Monitoring, Rapid Response, Containment and Control, Outreach and Education, and Research. While research action items are not included in the "highest priority action" list, research is a critical need that cuts across the various categories, and is included in section G. The highest priority actions that are

immediately needed to prevent and control the spread of quagga and zebra mussels throughout the West are:

Increasing Capacity to Address Invasive Mussels

- State and Interstate ANS Management Plan funding and QZAP implementation (A.1.). *Implemented at the state and federal level; estimated annual funding need is $31,140,000.*

Prevention

- Implement mandatory inspection and decontamination at infested waters (B.1.). *Implemented at the state, federal and local level; estimated annual funding need is $19,432,090; Initial estimated cost is $25,320,090.*
- Continue the development of effective watercraft inspection and decontamination protocols and standards (B.2.). *Implemented at the state and federal level; estimated one-time funding need is $200,000.*
- Develop standard and effective equipment inspection and decontamination protocols (B.3.). *Implemented at the federal and state level; estimated one-time funding need is $200,000.*
- Adopt standard watercraft and equipment inspection and decontamination protocols in Western States (B.4.). *Implemented at the federal, state and local level; estimated one-time funding need is $270,000.*
- Establish and implement strong, consistent law enforcement programs in each Western State (B.5.). *Implemented at the federal, state and local level; estimated annual funding need is $11,400,000; estimated initial need is $380,000.*
- Develop a standardized model and strategy for risk assessment model for water bodies (B.6.). *Implemented at the state and federal level; estimated initial funding need is $250,000.*

Early-Detection Monitoring

- Expand early-detection monitoring programs to all Western water jurisdictions (C.1.). *Implemented at the federal, state and local levels; estimated annual funding need is $2,561,200.*
- Develop standard field protocols for early-detection monitoring (C.2.). *Implemented at the federal and state levels; estimated one-time funding need is $504,000.*

Rapid Response

- Create and maintain a rapid response fund (D.1.). *Implemented at the federal level; estimated initial funding need is $20 million; estimated annual funding need is $5 million.*
- Finalize the rapid response notification database (D.2.). *Implemented at the federal level; estimated annual funding need is $25,000.*

Containment and Control of Existing Populations

- Develop tools and best management practices for preventing and minimizing mussel movement and settlement within water distribution systems and other infrastructure (E.1.). *Implemented at the federal, state and local levels; estimated one-time funding need is $5,000,000.*

Outreach and Education

- Adopt consistent outreach messaging and enhance coordination of efforts (F.1.). *Implemented at the federal and state level; estimated annual funding need is $250,000.*

I. Introduction and Background

Quagga and zebra mussels (often referred to as Dreissenids) are among the most devastating aquatic species to invade North American fresh waters. Quagga mussels were found in January 2007 in Lake Mead and since then quagga or zebra mussels have been found in Arizona, California, Colorado, Nevada, Texas and Utah (see Appendix B for a distribution map). Quagga and zebra mussels are native to the Black and Caspian Sea drainages. Dreissenid mussels were introduced to the Great Lakes region of the U.S. in the late 1980s via ballast water discharge from ocean-going vessels and have spread throughout the central and Northeastern U.S., via a number of pathways. The arrival of quagga and zebra mussels to Western waters brings the potential to extend devastating impacts into a geographical area already challenged with water-related issues. The arrival of these mussels poses ecological ramifications including negatively impacting aquatic biodiversity and water quality and reducing food sources for native mussels, fish larvae, and zooplankton. Once established, these mussels can clog water intake and delivery pipes, foul dam intake gates and pipes, and adhere to boats, pilings, and most hard and some soft substrates. Mussels will impact public water delivery systems, fire protection, and irrigation systems and require costly removal maintenance. For example, a recent assessment of the potential economic impacts to the hydroelectric facilities of the Columbia River Basin suggest that costs to install chlorination systems could be as high as $2 million for some facilities with recurring operation costs of $100,000 per year.

In response to a request by the National Aquatic Nuisance Species Task Force (ANSTF), the Western Regional Panel (WRP) developed this plan to reflect the rising threat of invasive quagga and zebra mussels in the West. The WRP includes 19 western states, federal agencies, tribes and other invasive species stakeholders. The goal of this document is to summarize current strategies to address the invasion of zebra and quagga mussels in the West, and to identify and prioritize the specific actions that are needed to comprehensively prevent the further spread of quagga and zebra mussels, respond to new infestations, and manage existing infestations. The *Quagga-Zebra Mussel Action Plan for Western U.S. Waters* (QZAP) is intended to serve as a common 'road map' of priorities for agencies and their partners for the next five years. The concerted effort to address quagga and zebra mussels fits into the larger battle against aquatic nuisance species (ANS) that threaten Western waters.

History of Quagga and Zebra Mussel Coordination

Effective and decisive actions and support are needed from water management entities at all levels, including state and federal agencies, tribes, private water districts and concessionaires to prevent the introduction or spread of, or respond to an infestation of quagga or zebra mussels. Federal actions and coordination must complement and support State efforts. Water management jurisdictions and authorities in the West are varied and complex, emphasizing the need for comprehensive and effective coordinated action.

The primary coordinating body by which ANS prevention efforts have been carried out in the West is the 100th Meridian Initiative. This partnership of stakeholders, federal and state agencies was developed in the mid-1990s by the U.S. Fish and Wildlife Service (FWS) with the goal to stop the westward spread of ANS. Efforts are aimed primarily at recreational pathways, and include boater education and outreach, watercraft inspection training, coordination of early-

detection monitoring, assessment of watercraft use, and evaluation of inter-state routes of trailered watercraft movement. Level of participation in the 100th Meridian Initiative varies among groups; some federal and state agencies, tribes and local groups are strongly engaged but there are also significant gaps in participation at the local, regional, and national level. While the threats posed by ANS are widely recognized, the degree to which individual states are prepared to respond to them is variable. Under the Nonindigenous Aquatic Nuisance Prevention & Control Act (NANCPA) of 1990, state and interstate ANS management plans can be developed that are eligible for federal cost-share funding once approved by the ANSTF. Thirteen (AK, CA, HI, ID, KS, MT, NM, ND, OK, OR, SD, UT, and WA) of the 19 Western States currently have approved ANS management plans, and several other state plans are under development. The *Lake Tahoe Region Aquatic Invasive Species Management Plan* has also been approved by the ANSTF. Many western states also have designated a State ANS Coordinator to work on state priorities and coordinate with federal efforts. Prevention is fundamental to effective ANS management, but securing funding at the state level for such efforts has typically not fared well compared to programs to control existing ANS. Many western states have established ANS programs and laws to support prevention. Appendix A briefly summarizes each western state's, and British Columbia's, current level of activities to address the quagga and zebra mussel issue.

The Secretary of Interior has designated zebra mussels "injurious wildlife" under federal law and therefore the importation and interstate transport of zebra mussels are prohibited by the federal Lacey Act (18 U.S.C. 42). Although quagga mussels are not listed as injurious, various levels of prohibition (transport, possession, etc.) are in place in many western states. State prohibitions offer other opportunities under other provisions of the Lacey Act for coordination by state and federal law enforcement agents.

View of exposed zebra mussels at a Kansas reservoir after a lake drawdown.
(Photo: Jason Goeckler, KS Department of Wildlife & Parks)

Quagga and Zebra Mussel Biology

These invasive mussels are small, freshwater bivalves that attach to hard and soft substrates, including plants, rocks, man-made materials and structures including docks, dams, canals, aqueduct walls, watercraft hulls, and on other recreation or commercial equipment. A mature female Dreissenid mussel can produce over one million eggs per year. In the warmer waters of the Western U.S., there is the potential for year-round spawning. Eggs develop into microscopic larvae called veligers. Veligers float in the water column and can be transported within water distribution systems as well as in watercraft bilges, ballasts, and live wells, and in any other equipment that holds water. Juvenile and adult mussels secrete byssal threads (small, thin fibers) to attach themselves to substrates and can survive on substrate removed from one body of water and transferred to another. Dreissenid mussels often cluster in huge colonies from the surface of the water to more than 400 feet in depth.

How Quagga and Zebra Mussels Spread

As veligers grow, they settle out of the water and attach to a substrate where they may then crawl or float in search of a more suitable location. Adult mussels are hardy and can survive out of water for up to five days in warm, dry weather and up to 30 days in cool, moist weather. Adults can be easily spread between water bodies by watercraft, especially when protected in the crevices of trim tabs, keels, engines, propellers, and anchors. In addition, they may be moved with equipment, trailers, water tanks, construction equipment, fish for stocking, water-based aircraft, firefighting equipment, bait buckets, anglers, and other recreational water equipment. Survival out of water can be prolonged by proximity to damp objects, such as coiled rope, or in enclosed areas.

Ecological and Economic Impacts

In terms of ecological and economic impacts quagga and zebra mussels are two of the most devastating aquatic species to invade North American fresh waters. The arrival of these species to Western waters brings the potential to extend devastating impacts into an area already severely challenged with water-related issues. The spread of quagga and/or zebra mussels threatens the natural environment, water delivery systems, hydroelectric facilities, agriculture, and recreational boating and fishing.

Ecological Impacts

The ecological ramifications of these mussels include impacting aquatic biodiversity; reducing food sources for native mussels, fish larvae, and zooplankton; and changing water quality. Many other aquatic organisms rely on plankton for survival. The presence of quagga or zebra mussels in an environment can disrupt the food chain and out-compete other species. Therefore, food consumed by the mussels is detrimental to other species, and can result in the displacement of native, often threatened or endangered species, and recreationally important sportfish. Given their ability to filter large volumes of water, and in combination with extremely high densities, these mussels can significantly reduce the amount of nutrients and particles in the water, resulting in increased water clarity. This increased clarity allows for greater light penetration, resulting in increased algae and vegetation growth. Quagga and zebra mussels also selectively feed on green-algae and may increase the proportion of foul-smelling blue-green algae in water systems. As reported by the Government Accountability Office, zebra mussel invasions will reduce native mussel species by as much as 50 percent in the next

decade, causing the extinction of up to 140 species. Recovery efforts for razorback suckers, humpback chub, several salmon species, and other threatened and endangered western fish would be significantly hindered by the establishment of zebra and quagga mussels.

Due to the long-term negative ecological impacts that will occur from an established population of Dreissenids, response to a new infestation could be defined as an "emergency." That term may have implications for rapid response funding and environmental compliance, and its use can vary based on the definition within the state. For example, in Idaho when the Governor declares a state of emergency, that allows the use a deficiency warrant to fund prevention and response activities.

For more expansive Dreissenid Biology and Background, please see Appendix C.

Economic Impacts

Many analyses do not address the economic impact of invasive species on natural area ecosystems. Instead, they often reflect the impacts of invasive species on commercial activities. The true cost of invasive species is underestimated if estimates of damages do not include lost ecosystem function, such as water purification and aesthetic values. Some estimates of economic impacts of zebra and quagga mussels are included here to show the value of preventing the introduction of mussels and other aquatic invasive species.

U.S. Congressional researchers have estimated that Dreissenid mussel infestations in the Great Lakes area has cost the power industry $3.1 billion between 1993-1999, with an economic impact to industries, businesses and communities of more than $5 billion. Average costs from 1989-1994 for facilities with a Great Lakes basin water intake were over $4 million per respondent for zebra mussels. In the West, there is a vast infrastructure of water conveyance systems. Quagga and zebra mussels can clog water intake and delivery pipes, foul dam intake gates and pipes, and as a result impact water delivery systems. An infestation requires re-occurring, costly mechanical removal of mussels, and the decay of dead mussels can corrode steel and cast iron pipelines resulting in increased maintenance costs. Few economic studies projecting water delivery costs from a mussel invasion have been conducted, and projections omit the expense of lost ecosystem function.

A recent assessment of the potential economic impacts to the hydroelectric facilities of the Columbia River Basin, should it become infested, estimated that costs to install chlorination systems to manage an infestation could be as high as $2 million for some facilities, with recurring operation costs of $100,000 per year. In Idaho, the conservative estimate of state-wide direct and indirect costs from establishment of Dreissenid mussels, which does not include mussel impacts on irrigation systems (because there was no data) is $94,474,000. Bureau of Reclamation-wide appropriated costs attributable to zebra and quagga mussels since 2008 are on the order of $12.6 million. The American Recovery and Reinvestment Act provided $4.5 million of this total which enabled monthly sampling for larval detection through 2010 at more than 150 water bodies throughout the Western U.S. Control and management costs have been incurred primarily for initial implementation of control strategies at impacted Reclamation facilities along the lower reaches of the Colorado River (including Hoover, Davis, and Parker Dams). In addition, non-appropriated costs from power users for mussel mitigation at Reclamation facilities on the Lower Colorado River are estimated to be $250,000 in 2010 and will likely increase in future years.

Quagga and zebra mussels also negatively impact recreation and commercial fishing, and thus local economies. Attached mussels can increase drag on the bottom of watercraft, reducing speed, wasting fuel, and requiring scraping and repainting of the watercraft's hull. Mussels attached in and around the steering components can jam the equipment and can block the cooling system in engines causing them to overheat. Degraded habitats also reduce sport-fishing opportunities, which affect recreation opportunities and tourism. Many communities depend on an influx of tourism dollars, and even the presence of quagga and/or zebra mussels, let alone a full-blown infestation, may drive those dollars elsewhere.

Quagga mussel encrusted boat motor. (Photo: National Park Service)

II. Current Quagga and Zebra Mussel Efforts and Necessary Actions

Effective and decisive actions are needed from state and federal agencies, tribes, and water districts to prevent invasive mussels from spreading into additional waters. Despite efforts to protect the West from quagga and zebra mussels, invasions into new watersheds rapidly continue. Further invasions are expected to produce additional economic losses and irreversible ecological impacts. Additional funding is needed to properly address the management of quagga and zebra mussels throughout the West. However, the benefits of increased funding and coordination would go far beyond implications to quagga and zebra mussels and would improve all ANS prevention efforts throughout the region and possibly throughout the nation.

Similar to management of other ANS, efforts to address the invasion of quagga and zebra mussels in the West fall under seven major categories: increasing capacity to address invasive mussels, prevention, early-detection monitoring, rapid response, containment and control of existing populations, outreach and education, and research. The highest priority actions are indicated within each section (*****denotes a highest priority action item). See Appendix D for a summary table of all action items.

A. Increasing Capacity to Address Invasive Mussels

Effective and decisive actions are needed from state and federal agencies, tribes, and water districts to prevent the introduction and/or spread, or respond to or manage an infestation of quagga and/or zebra mussels. Federal actions and coordination must complement and support State efforts. Water management jurisdictions and authorities in the West are varied and complex, emphasizing the need for comprehensive and effective coordinated action. Unfortunately, a lack of communication channels can limit the speed and effectiveness of efforts to respond to a new invasion.

Action Items:

***A.1. State and Interstate ANS Management Plan Funding and Quagga-Zebra Mussel Plan Implementation (highest priority action item)**. *Implemented at the State level; estimated annual funding need is $31,140,000.*

The NANCPA authorizes $4 million for the implementation of State and Interstate ANS Management Plans (Plans). Through the FWS, $1.075 million is allocated each year to support ANSTF approved Plans. In 2009, there were 31 approved Plans, with each plan receiving $34,677 for implementation. As more state and interstate Plans are approved, the equal share for each Plan decreases. These Plans already define many needed actions to address quagga and zebra mussels and are complementary to the regional actions that are presented within QZAP. States are struggling to support plan implementation and associated staffing based on decreasing federal funds and state budgets.

Cost estimate: State ANS Coordinators play a critical role in ensuring plan implementation. Based on the implementation and coordination budgets associated with the existing approved plans, and those under development, an increase to $31,140,000 per year is recommended.

Nineteen states do not yet have approved Plans. From the annual funding amount $60,000 should be allocated to each State developing an ANS Management Plans. Therefore, with an allocation of $31,140,000, each approved Plan would receive $967,742 annually for implementation, and each state developing a plan would receive $60,000. When 50 States have their plans approved and if the current number of interstate Plans stays at three, each Plan would receive $587,547 for implementation. If a substantially less amount of funding is made available, specifically for Western States for QZAP implementation, then that funding should be equally divided among the 19 Western States and QZAP implementation.

A.2. Federal Coordination and Implementation of QZAP. *Implemented at the federal level; estimated annual funding need is $1,200,000.*

Federal coordination is necessary to ensure full implementation of QZAP. However, full support of State Management Plans is necessary prior to the addition of federal staff since the State agencies have primary jurisdiction and management authority. The USFWS has an ANS Coordinator in each USFWS Region and other federal agencies are starting to emphasize ANS more in their programs.

Cost estimate: Funding needs are for staff in each of the federal agencies involved with potentially infested waters in the West ($700,000 annually) and operations ($500,000 annually).

Flip-flop covered with quagga mussels at Lake Mead. (Photo: National Park Service)

B. Prevention

Prevention remains the most cost-effective and ecologically protective approach to managing ANS. The level at which prevention activities occur vary greatly among the Western States. Current prevention activities include outreach and education, law enforcement, watercraft inspection, decontamination and impoundment, watercraft exclusion, management of overland boat movement and permitting for movement of large water-based materials and equipment, and development of risk management/assessment plans.

A lack of resources and coordination has impeded full implementation of needed prevention efforts. Specifically, many of the water managers in the West that manage waters infested with quagga and/or zebra mussels are not ensuring watercraft and equipment exiting infested waters are free of mussels. In addition, inspections prior to entry of uninfested waters must be expanded. In some areas, various water managers are using different protocols and standards for inspecting and decontaminating watercraft and equipment. This lack of standard protocols is causing confusion and frustration among recreational users. The WRP has adopted *Recommended Uniform Minimum Protocols and Standards for Watercraft Interception Programs for Dreissenid Mussels in the Western United States*. Adoption of the standards was a unanimous decision among all member States, adopting the standards is a first step further work is to implement the standards in each of the Western States. In some cases, local water management districts restrict public access to particularly sensitive water bodies rather than risk contamination, which also confuses and frustrates recreational users.

While some Western States have specific laws granting legal authority to stop, inspect and decontaminate watercraft, many do not. In some areas management of a water body is contracted out and the terms of that contract cannot be simply changed to incorporate quagga and/or zebra mussel inspection or decontamination requirements. This means that a critical tool for containing the spread cannot be utilized when and where appropriate.

Action Items:

***B.1. Implement Mandatory Inspection and Decontamination at Infested Waters (highest priority action item).** *Implemented at the state, federal and local level; estimated annual funding need is $19,432,090; Initial estimated cost is $25,320,090.*

Infested waters can be a source for the further spread of quagga and zebra mussels. Containment of existing populations of mussels in the West must include inspection and decontamination so that watercraft do not leave carrying invasive mussels that can potentially infest other waters. Western States, tribes, federal agencies and others who have direct enforcement authority to stop, inspect, and decontaminate watercraft must increase their activities. Implementation would include establishment of inspection stations at marinas, reservoirs, and boat ramps were quagga and/or zebra mussels are known to occur. In addition to decontamination equipment, stations should have trained staff and educational materials.

Cost estimate: Sixty-four boater utilized waters within the WRP are infested with quagga or zebra mussels. It is estimated that each of these infested waters would require 5.6FTE ($46,969/FTE) for an effective decontamination program. Each infested water would require decontamination units (one mobile

unit @ $15,000 and one semi-permanent unit @ $100,000; replacement and maintenance costs are estimated at 20% per year). Operations (vehicles, fuel, supplies) costs per water body would be about $15,200 per season.

*B.2. Continue the Development of Effective Watercraft Inspection and Decontamination Protocols and Standards (highest priority action item).

Implemented at the state and federal level; estimated one-time funding need is $200,000.

Techniques currently being used for decontamination vary by location and need to be improved and tested for effectiveness at killing and removing quagga and/or zebra mussels from watercraft. "Recommended Uniform Minimum Protocols and Standards for Watercraft Interception Programs for Dreissenid Mussels in the Western United States" was adopted by the WRP at its annual meeting in September 2009. The WRP adopted the recommendations with the understanding that the document would be a "living document" and would need periodic updating. Further information is also required on effective and cost-efficient methods to decontaminate interior boat compartments.

Cost estimate: Costs are for the continued development and updating of the recommendations already adopted by the WRP. Personnel costs (0.3 FTE; $22,500) plus operation costs (travel, meetings, supplies; $18,500) are estimated at $40,000 per year or $200,000 over 5 years.

*B.3. Develop Standard and Effective Equipment Inspection and Decontamination Protocols (highest priority action item). *Implemented at the federal and state level; estimated one-time funding need is $200,000.*

Water-based equipment such as nets, heavy construction equipment, or fire-suppression equipment can spread mussels when moved overland to new watersheds. Techniques currently being used for decontamination vary by location and need to be improved and tested for effectiveness at killing and removing quagga and/or zebra mussels. Protocols should be designed specifically for audiences including resource managers, researchers, and consultants. The Bureau of Reclamation has developed an "Equipment Inspection and Cleaning Manual" which addresses inspection and decontamination of commonly used equipment, including construction equipment. The plan will require adoption by other agencies and annual updating, including evaluating additional specialized equipment such as floatplanes.

Cost estimate: Costs are for the continued development and updating of the manual. Personnel costs (0.25 FTE; $25,000) plus operation costs (travel, meetings, supplies; $15,000) are estimated at $40,000 per year or $200,000 over 5 years.

*B.4. Adopt Standard Watercraft and Equipment Inspection and Decontamination Protocols in the Western States (highest priority action item). *Implemented at the federal, state, and local level; estimated one-time funding need is $270,000.*

If watercraft and equipment inspections performed in one area were accepted by authorities in other areas, this would serve to streamline inspections and reduce frustration and confusion with the public. Standard protocols should include a standard training program and a quality control program to ensure protocols are followed. At the 2009 annual meeting of the WRP, the difficulty in adopting protocols regionally was recognized, especially as it would require multijurisdictional agreements and/or possible legislation/rulemaking. It was recognized that it may be easier to do basin-wide or state to state process agreements. Support for this action would involve personnel to guide the process, including developing a model agreement or legislation, further research on jurisdictional requirements, and convening meetings and workshops.

Cost estimate: Costs are for the adoption of standards among agencies/states/tribes. Personnel costs (1 FTE; $85,000) plus operation costs (travel, meetings, supplies; $180,000) over a 1.5 yr period, for a one-time cost of $270,000.

*B.5. Establish and Implement Strong, Consistent Law Enforcement Programs in Each Western State (highest priority action item). *Implemented at the federal, state and local level; estimated annual funding need is $11,400,000 with an estimated initial need of $380,000.*

Many States do not have laws or personnel to regulate quagga and/or zebra mussels. To effectively prevent the intentional or unintentional movement of invasive mussels or other ANS, appropriate authorities must be in place and matched by adequate enforcement personnel. Staffing is needed at all jurisdictional levels, including tribal, to enforce prohibited species laws, inspection requirements for watercraft and equipment, and other laws to contain the spread of ANS.

Cost estimate: For an estimated five law enforcement personnel per state, costs for each of the 19 States would include $600,000 (salary and operations annually) plus $20,000 (initial equipment).

*B.6. Develop a Standardized Model and Strategy for Risk Assessment Model for Water Bodies (highest priority action item). *Implemented at the state and federal level; estimated initial funding need is $250,000.*

A risk assessment model is needed for the West to identify the points most vulnerable to the introduction of quagga and zebra mussels. The most effective risk assessment would be based on a variety of parameters including, but not limited to, water quality, water temperatures, boater/angler use, proximity or connectivity to positive waters, and other vectors. A risk assessment model would be useful for prioritizing early-detection monitoring and prevention efforts. Although some initial work on ranking water body risk has occurred in the West, this work needs to be completed and expanded.

Cost estimate: A substantial amount of information has already been gathered to develop risk assessment models for water bodies in the west, however, additional support is necessary to complete the work. Personnel costs (1 FTE; $85,000) plus operation costs (travel, meetings, supplies; $165,000), for a one-time cost of $250,000.

B.7. Expand Mandatory Watercraft Inspection and Decontamination Capacity for Uninfested Regions. *Implemented at the state, federal and local level; estimated annual funding need is $19,000,000 to $1,102,215,150; estimated initial funding need is $21,850,000 to $320,000,000*

Sufficient inspection and decontamination resources need to be in place at the point-of-entry to uninfested States and/or water bodies in the West. This requires personnel, physical infrastructure, decontamination equipment and supplies, and associated training.

Cost estimate: Protection of uninfested areas can occur several ways. The more costly way to reach this goal is to have mandatory boat inspections at all major access points to uninfested waters and the estimated annual expense using this approach would be over $1.1 billion with an accompanied initial equipment and infrastructure cost of $320 million. These costs are estimated based on an estimate of 2,876 high-priority waters within each state needing protection with an average of two inspection sites at each water body with inspection stations operated for 16 hours per day, 7 days per week during an 8-month season (2.8 FTE per inspection site).

Each state within the region has a varying amount of water bodies needing protection; additionally, each water body is operated under varying jurisdictional authorities. A more cost-effective estimate for this action item would be to provide each state with an annual operating budget of $1 million (FTE and supplies) and an initial set up need of $21,850,000 (20 decontamination units per state @ $1,150,000 per state).

An alternative method to protect uninfested areas is to establish inspection stations at key border crossings instead of at each water body. In Idaho, the Department of Agriculture operates 17 mandatory watercraft check stations at key border crossings into the state. Crews work 12 hour days, 7 days a week, with an annual operating budget of $1.3 million, and 12,000 boats were inspected during 2009.

B.8. Develop and Implement Programs to Intercept Contaminated Equipment. *Implemented at the state and federal level; estimated annual funding need is $380,000 with one-time cost of $200,000.*

Interstate movement of equipment can be a pathway for the introduction of mussels in the West and would not be addressed by watercraft inspection programs. Existing state and federal programs should be funded to develop tools to close this gap.

Cost estimate: Industries and equipment operators need to be made aware of the potential to spread ANS through their operations. A program would have to be developed which would include an outreach component. Development through a contracted marketing group would be approximately $200,000. Implementation of the program would cost about $ 20,000 per state for a total of $380,000 in annual operating expenses.

B.9. Expand Use of ANS Hazard Analysis and Critical Control Point (HACCP) Planning. *Implemented at the state and federal level; estimated one-time funding need is $2,850,000.*

ANS HACCP planning is a proven method to analyze the potential invasive species introduction risks presented by an activity, and defines prevention and containment measures to minimize those risks. Support is needed to deliver additional HACCP training, provide staff resources for HACCP plan development, including Aquatic Wildlife Transfer Policies, plan implementation including supplies and equipment, and adapt regulatory programs, where appropriate, to incorporate HACCP plan submission and approval.

Cost estimate: Development of HACCP plans cost on average $1,000 in personnel time. Additional costs to implement plans and adapt programs (i.e. new supplies and/or equipment) would be $5,000 per plan. It is estimated that federal and state agencies would develop 25 HACCP plans at a total average cost of $6,000 per plan.

Pipe encrusted with zebra mussels. (Photo: California Department of Fish and Game)

C. Early-Detection Monitoring

Early-detection monitoring is critical to identify new infestations prompting a quick response necessary to prevent further spread and impact by maximizing the opportunity for controlling or eradicating an invasion at its earliest stage.

The level of effort and techniques utilized for early-detection monitoring for new populations of quagga and zebra mussels varies throughout the West. Several States and agencies operate early-detection monitoring for invasive mussels although in many places monitoring is limited or is not occurring due to staffing and budget shortfalls. The majority of Western waters are not sampled sufficiently to detect incipient populations of mussels. In addition, the best methods for early-detection monitoring have not yet been determined and analytical methods are still being improved. Because there are many Western waters vulnerable to quagga and zebra mussel infestations and many jurisdictions responsible for them, information must be centralized to ensure comprehensive and coordinated monitoring.

Action Items:

***C.1. Expand Early-Detection Monitoring Programs to all Western Water Jurisdictions (highest priority action).** *Implemented at the federal, state, and local levels; estimated annual funding need is $2,561,200.*

Widespread early-detection monitoring is needed throughout the West. To be effective, widespread sampling programs must be employed regularly and consistently between jurisdictions.

Cost estimate: The number of water bodies varies considerably among states, and it is not practical to monitor all water bodies. However, monitoring waters determined to be high-risk for Dreissenid invasion should be performed uniformly across the West. Assuming 50 water bodies per state will be sampled, with 10 samples per water body at a cost of about $230 per sample, processing costs per state would be $115,000 annually. Additional annual personnel costs would be 0.4 FTE per state ($18,800) and supplies at $1,000, for a total annual cost of $134,800 for each of the 19 western states.

***C.2. Develop Standard Field Protocols for Early-Detection Monitoring (highest priority action).** *Implemented at the federal and state levels; estimated one-time funding need is $504,000.*

Standard early-detection monitoring protocols are needed to improve and standardize detection of veligers and settled adult mussels. Standardization would enable comparison of monitoring efforts across jurisdictions and ensure the best methods are being utilized by everyone.

Cost estimate: Field protocols must be tested in a variety of conditions, requiring travel to field sites in various states (travel costs $20,000). Sample analysis is about $230 per sample. It will be necessary to process up to 200 samples for a total of $46,000. Other costs will include a research scientist annual salary for one year ($100,000), research labor costs ($50,000), equipment and supplies ($120,000) and overhead.

C.3. Improve Sample Analysis Methods. Implemented at the federal and state level; *estimated one-time funding need is $687,200.*

Sample analysis methods must be improved so that new infestations are detected quickly and appropriate containment actions can be implemented to prevent the spread. Further refinement of microscopy and PCR testing is needed to reduce processing time and improve accuracy of test results.

Cost estimate: Researchers and geneticists need to continue to develop more specific, timely and reliable testing methods. Costs are based on personnel time ($48,720 per laboratory) and supplies ($20,000 per laboratory) for 10 participating laboratories total cost would be $687,200.

C.4. Coordinate Early-Detection Monitoring Programs. *Implemented at the federal level; estimated initial funding need is $50,000.*

Completion of the centralized monitoring reporting database under development through the 100th Meridian Initiative would ensure monitoring efforts are not duplicated by multiple jurisdictions, and identify where there are gaps in monitoring. In addition, more formal coordination would ensure timely distribution of early-detection data.

Cost estimate: Completion of a centralized monitoring database under the 100th Meridian Initiative is necessary to coordinate early-detection monitoring programs across the Western United States. Costs include personnel ($20,000); equipment, software, and data services ($20,000); and travel to coordinate with states ($10,000); for a total initial cost of $50,000.

Quagga mussels on rock at Sentinel Island in the Boulder Basin. (Photo: National Park Service)

D. Rapid Response

In the event that prevention efforts are absent or fail, a rapid response may stop or limit the impacts of a quagga and/or zebra mussel introduction by providing for immediate containment of watercraft or other pathways of spread, and early mitigation of impacts. As with other ecological emergencies, successful response depends on adequate preparedness, planning, and funding. Tools currently exist to guide the development of ANS rapid response plans (i.e., WRP template, Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other Dreissenid Species (2008), and the National Park Service's Quagga/Zebra Mussel Infestation Prevention and Response Planning Guide (2007)). For greatest effectiveness, plans should incorporate the National Incident Management System within its organizational framework.

Only a small number of Western waters have comprehensive rapid response plans and the associated funding and personnel to implement those plans. Policy constraints, including unresolved questions about short-term environmental impacts associated with certain management techniques, also limits response preparedness in the West. At this time, the response infrastructure is informal and formal networks to notify the appropriate people of an incident are being developed. However, in many areas there are few individuals trained and available to support a rapid response. Currently, there are large gaps in availability of effective response methods and associated supplies and equipment. In locations where response plans are in place, the lack of guaranteed funding and staffing available for response significantly limits the likelihood that the plan can be implemented in a timely fashion.

Action Items:

***D.1. Create and Maintain a Rapid Response Fund (highest priority action item).** *Implemented at the federal level; estimated initial funding need is $20 million; estimated annual funding need thereafter is $5 million.*

A dedicated rapid response fund is necessary to rapidly implement containment at state, tribal or federal waters newly infested with quagga or zebra mussels. This fund would help jurisdictions organize and begin implementing immediate actions while they work with stakeholders and other partners to determine a long-term containment strategy and funding. Models exist for similar funding accounts that offer options for how the fund is financed and replenished. The rapid response fund would require an expedient transfer of funds to the lead jurisdictions in a manner that enables rapid response. The fund needs to be available year-round, regardless of a budget cycle.

Cost estimate: Estimated initial funding need is $20,000,000 with an annual recurring need of $5,000,000. This estimate is based on the anticipated costs of eradicating an incipient population of mussels, including associated environmental compliance, monitoring, and containment from at least one major water body in an infested sub-region in the West on an annual basis.

***D.2. Finalize the Rapid Response Notification Database (highest priority action item).** *Implemented at the federal level; estimated annual funding need is $25,000.*

Information must be quickly shared in order to initiate effective prevention and containment. The 100th Meridian Initiative has begun development of a database of principal contacts for communication about newly infested water bodies in Western States. Upon completion, this database will be useful for quickly contacting leads in jurisdictional areas when new infestations are discovered. This database would not be open to the public; it is shared only among the primary Western ANS contacts.

Cost estimate: This estimate is based on the anticipated need for consulting assistance to finalize the database structure and technical support in data acquisition/entry, based on similar database maintenance costs.

D.3. Complete and Maintain Rapid Response Plans for all Western States. *Implemented at the state level; estimated initial funding need is $975,000; estimated annual funding need is $325,000.*

Response plans should be tailored to types of water bodies within States and Tribes and at a minimum include: notification and verification procedures; response organizational structure; a communication plan; possible control or eradication methods; containment; protection of facilities and infrastructure; and post-response monitoring and evaluation. Plans must also address permits and pre-approvals needed to implement control or containment actions. Funding and contributions from all stakeholders should be clearly defined. Once plans are completed, they need to be maintained via periodic exercises designed to promote response readiness and evaluate plan adequacy.

Cost estimate: This estimate is based on the anticipated need for plan development and preparedness training efforts for the 19 Western States, Tribes and other jurisdictions (e.g., National Parks, Forest Service). Several States already have rapid response plans for zebra and quagga mussels. It is estimated that 15 States and Tribes need rapid response plans for a total of $975,000 ($65,000 per plan). If new infestations are found, water body specific plans may need to be created, coordinated and implemented. Plan development for 5 new waters per year would be an additional $325,000 per year.

D.4. Designate and Train Rapid Responders. *Implemented at the federal, state and local levels; estimated annual funding need is $4,950,000.*

At the state level, a dedicated ANS coordinator plays a critical role overseeing the statewide effort, developing site-specific plans, orchestrating the notification process and initiating rapid responses. The State ANS Coordinator should be able to attend regional meetings out of their home state and contribute to multi-state planning and implementation processes. In addition to staff at the state level, participation at the federal, local and private level is necessary. This coordination plays a key role in rapid response and can greatly increase the effectiveness of containment and control. Responders need to be sufficiently trained in relevant response plans, associated mussel response issues, and the Incident Command System.

Cost estimate: Rapid response is critical to containing a new infestation and preventing the infestation from spreading to other waters. It is imperative that once early-detection sampling finds a new population, staff is able to respond quickly to implement a field response. Assuming that the staffing is implemented in Action A, then first-line responders will be the permanent FTE in state and federal agencies.

The cost estimate includes $100,000/year in staffing, travel, and other costs for 19 Western States, for a total of $1,900,000 plus $50,000 annually for federal and other key jurisdictional entities to participate and contribute to rapid response efforts. Federal subdivisions in the West total 61, which equals a total sum of $3,050,000.

D.5. Planning for Short-Term Environmental Impacts Resulting from Rapid Responses. *Implementation at the federal and state level; estimated annual funding need is $5,000,000.*

Responding to an introduction may cause short-term environmental impacts. Developing processes and documents before an introduction occurs will enable a quicker and more effective response.

Cost estimate: This estimate is based on the anticipated need for staff or consulting assistance for environmental compliance tasks. Assuming 5 new infested waters each year at $1 million per water for environmental compliance, the total annual need would be $5 million. If QZAP is successfully implemented, it is estimated that this cost will significantly decrease because we will stop or slow the spread of mussels to new waters.

A boat being inspected and decontaminated.

E. Containment and Control of Existing Populations

Preventing the spread and introduction of quagga and zebra mussels is the ultimate goal, and containing existing infestations is a way to achieve that goal. Preventing the downstream dispersal of invasive mussels and the overland transport to new waters is critical and helps protect native fish and wildlife resources, recreation, and economic interests.

Controlling infestations in water distribution systems for municipal, agricultural and industrial supply enables continued operation of facilities and may contribute to reducing populations, which can also reduce the likelihood of a quagga or zebra mussel infestation spreading to new areas. A variety of management techniques are possible, including settlement prevention, desiccation, mechanical removal, oxidizing biocides, thermal, and biological control.

Tools for effective, cost-efficient, and ecologically sound quagga and zebra mussel control in the West are limited. Most containment and control technologies were developed for closed-water systems. It is very costly and difficult to prevent the spread through the large water distribution systems that exist in the West, including trans-mountain diversions that move water across the continental divide. Tools are needed to prevent invasive mussel movement through water delivery systems and for open water systems. Containment can be difficult as the volume of water to be treated is large, the environmental impacts of the treatment must be acceptable, and the costs must not be prohibitive. Development of options will benefit local governments, tribes, States, federal government and private industry to control infestations.

Action Items:

***E.1. Develop Tools and Best Management Practices for Preventing and Minimizing Mussel Movement and Settlement Within Water Distribution Systems and Other Infrastructure (highest priority action item).**
Implemented at the federal, state, and local levels; estimated one-time funding need is $5,000,000.

A toolbox is needed to prevent and control infestations in raw-water distribution systems. Researchers have been working on these control options for many years in the Eastern U.S., but further work is need to make tools applicable to the West distribution systems. Researchers will need to perform both laboratory and field trials, with extensive testing on products prior to recommending best management practices. These projects could likely be carried out by federal agencies such as the Bureau of Reclamation or the Army Corp of Engineers.

Cost estimate: Estimated costs are based on other similar research conducted in the Eastern U.S.

E.2. Implement Reliable and Cost-Efficient Control Tools for Water Distribution Systems. *Implemented at the federal, state, and local level; estimated one-time funding need is $5,000,000.*

Support is needed to implement reliable and cost-efficient control methods for distribution systems. Such efforts will prevent potentially rapid, widespread dispersal of quagga and zebra mussels throughout interconnected systems.

Cost estimate: Current research at the Bureau of Reclamation on mussel resistant coatings is demonstrating costs that are three times greater than previously used coatings. Mussel resistant coatings need to be replaced every 5 years versus the life-span of 20 years for previously developed products. It is estimated that the need for this action item would be $5,000,000.

E.3. Develop Open-Water Control Tools. *Implemented at the federal, state, and local level; estimated one-time funding need is $510,000.*

Research is needed to develop and implement a variety of mussel control options in open-water systems, investigate methods to minimize the impact of mussels on facilities and operations, and disseminate information.

Cost estimate: Annual costs include personnel ($82,000), travel, laboratory and supply costs ($100,000). Over a 5-year period for development, the total one-time funding need is $510,000.

E.4. Develop Closed-Water System Control Tools. *Implemented at the federal, state, and local level; one-time funding need is $510,000.*

Research is needed to develop and evaluate methods for mussel control in closed-water systems that reflect unique conditions and concerns in the West.

Cost estimate: Annual costs include personnel ($82,000), travel, laboratory and supply costs ($100,000). Over a 5-year period for development, the total one-time funding need is $510,000.

E.5. Support Designing Infrastructure for Long-Term Control. *Implemented at the federal, state, and local level; estimated one-time funding need is $4,000,000.*

As new systems that use raw-water are built, and existing systems are upgraded, research is needed to develop and implement new construction designs and modifications to existing structures that improve their ability to prevent and control mussel infestations.

Cost estimate: This action item would need to be broken out into several different projects, each focusing on a different component of the infrastructure and a suite of control options. Researchers will need to perform both laboratory and field trials, with extensive testing on products prior to recommending best management practices. These projects most likely would be carried out by federal agencies such as the Bureau of Reclamation or the Army Corp of Engineers. A one-time need of $4,000,000 is estimated.

E.6. Improved Understanding of Mussel Control. *Implemented at the federal and state level; estimated one-time funding need is $610,000.*

Research is needed to better understand the biology of quagga and zebra mussels in the West and apply this information for improved mussel control.

Cost estimate: Annual costs include personnel ($82,000), and an operations budget of $200,000 (travel to infested sites, laboratory costs and supplies). Over a 5 year period, the total estimated need is $610,000.

E.7. Develop Programmatic National Environmental Policy Act (NEPA) Guidance. *Implemented at the federal level; estimated one-time funding need is $230,000.*

Development of a programmatic NEPA document would evaluate various control options and identify appropriate action(s) prior to the need for control. See also D.5.

Cost estimate: Costs include personnel time ($130,000) and information gathering ($100,000). New control options may necessitate updating of this guidance.

F. Outreach and Education

Outreach and education remain critical tools in the fight against ANS such as quagga and zebra mussels. Lack of awareness is a major impediment to preventing the spread and minimizing impacts from invasive mussels. If people do not understand the impacts of invasive mussels, or learn how they can help prevent their spread, it will be difficult to gain their support toward solutions.

There are a number of outreach and education strategies in use within the West – some specifically address quagga and/or zebra mussels, while others address the larger ANS issue. The national "Stop Aquatic Hitchhikers!" campaign, used widely throughout the West, was designed to appeal to a broad range of interested parties and covers all ANS and actions to prevent their spread and introduction. Many States have also developed various quagga and/or zebra mussel specific messaging.

Current outreach strategies include informational brochures, stickers, videos, public service announcements, permanent and temporary exhibits and displays, billboards and highway signage, signage at boat access points, websites, presentations, agency training, information booths, and one-on-one outreach to the public. A collaboration of several Western state boating and fish and wildlife agencies under the "Western Mussel Accord" is working to enhance consistency among these various methods.

Despite significant investment in outreach and education programs, there are many relevant audiences still unfamiliar with the issue, many waters that lack basic signage and powerful media options that remain relatively unemployed. The rapid proliferation of local mussel outreach programs has led to an inconsistent mixture of messages and information that may confuse the public. In many cases, insufficient audience analysis and evaluation of outreach effectiveness limit the potential success of existing programs.

Action Items:

***F.1. Adopt Consistent Outreach Messaging and Enhance Coordination of Efforts (highest priority action).** *Implemented at the federal and state level; estimated annual funding need is $250,000.*

Consistent messaging is necessary for informing and educating the public. Many efforts are already underway that use a variety of messages. This increases the likelihood that target audiences will encounter divergent, sometimes conflicting messages. Without coordination and standardization of messaging, efforts may be ineffective. In addition, there is a growing demand for outreach materials in languages other than English. Support is needed to coordinate outreach programs, share lessons learned from individual projects, and provide new regional tools and templates. A consistent outreach program adopted throughout the West would greatly increase the effectiveness of all outreach efforts.

Cost estimate: This estimate is based on an extension of analogous efforts to build consistency in messaging for other regional environmental outreach programs, such as oil pollution prevention. It does not include the costs to print new outreach materials based on resulting common message standards. Costs include staff time for state and federal coordinators to participate in open forums to enhance coordination of efforts.

F.2. Conduct Social Science Research. *Implemented at the federal and state level; estimated initial funding need is $750,000; estimated annual need is $100,000.*

There are tremendous opportunities to enhance ANS education and outreach programs through social science research. Although some sectors of society have been addressed, more work is needed to characterize the information needs of target audiences, determine how to best meet those needs, and to identify those factors that constrain behavior changes even when information needs are met.

Cost estimate: Costs include initial costs for professional social marketing review for the 19 Western States, Tribes and Federal Agencies, coordinating consistent outreach messaging, annual review of the campaign, surveys of user groups, strategy updates and materials for increased effectiveness. Based on previously conducted projects, these costs are approximated at $750,000 for initial costs with a $100,000 annual cost for assessments and updating of materials.

F.3. Increase Audience Effectiveness Assessments. *Implemented at the federal and state level; estimated annual funding need is $950,000.*

Outreach to target audiences needs to be frequently evaluated to make sure efforts are effective in stimulating action, both for individual projects and to measure success at a regional scale.

Cost estimate: This estimate is based on $50,000 per state for comprehensive pre/post-project evaluation for an estimated 20 discrete major outreach projects per year.

F.4. Expand Availability of Existing Outreach Materials. *Implemented at the state level; estimated initial funding need is $1,710,000; estimated annual funding need is $4,750,000.*

Support is needed to produce more copies of materials that have already proven to be effective. Translation of those materials into other languages is also needed to reach all audiences.

Cost estimate: Estimate includes material production, updating and replenishment of materials (billboards ($200,000/jurisdiction for 30 billboards), signage (150 waters/state*2 ramps*3 signs per ramp*$100/sign=$1,710,000) and brochures (400,000 brochures/state at $0.25/brochure).

F.5. Make Better Use of Television and Radio. *Implemented at the federal and state level; estimated annual funding need is $10 million.*

Numerous studies point to television (TV) and radio as key sources of information for most Americans. However, the high cost of TV and radio advertising has limited the use of these media for ANS outreach. An investment in high quality, "catchy" TV or radio public service announcements may be an effective means of reaching the public. Such efforts should be guided by pre-assessment and post-evaluative data to determine the effectiveness of outreach and education efforts. Support is needed to develop a regionally-based TV and radio outreach strategy, produce associated materials in cooperation with media partners, and when necessary, purchase advertising time to reach critical audiences.

Cost estimate: This cost is based on advertising expenses for other major regional public health and commercial marketing campaigns.

F.6. Provide More Opportunities for Youth Education. *Implemented at the state level; estimated initial funding need is $150,000; estimated annual funding need is $1,425,000.*

Support is needed to develop new youth education materials, expand delivery of ANS education, and to help Western educators integrate ANS and invasive mussel issues into their curricula.

Cost estimate: Developing standardized curriculum for three different age groups would initially cost approximately $150,000. Annual printing and distribution of materials would cost approximately $75,000/state.

Example of a billboard near Lake Mead, Nevada.

G. Research

A vast amount of research has been conducted on quagga and zebra mussel biology in North America, primarily in the Eastern U.S., and Europe. However, the information often does not directly relate to Western water management systems. Information is still needed to improve prevention and control and to understand the unique attributes of managing quagga and zebra mussels for the unique chemical and temperature parameters in Western waters. As new options for control are developed, their effectiveness will need to be evaluated.

Action Items:

G.1. Determine Physiological Tolerances. *Implemented at the federal level; estimated one-time funding need is $405,000.*

Physiological tolerances are needed to estimate the potential range of Dreissenid species in the west. Specific waters may be deemed at high-risk or conclusions may be drawn that certain waters are not vulnerable to invasion. Physiological tolerances in Dreissenids have evolved since their initial introduction and it is important that these tolerances are known and monitored. Until the physiological tolerances of quagga and zebra mussels in the West are better understood, it will be difficult to determine their potential distribution and prepare an accurate water body susceptibility risk assessment.

Cost estimate: Retrieving live samples requires travel to field sites (travel costs $20,000), a full time research scientist ($100,000), research labor ($50,000), equipment and supplies ($120,000) and indirect costs will also be necessary for a total of $405,000.

G.2. Develop A Method to Track Dispersal Via Genetic Fingerprints. *Implemented at the federal level; estimated one-time funding need is $760,000.*

A method for genetically tracking the dispersal of mussels needs to be refined so that movement patterns can be analyzed and used to further hone risk assessments.

Cost estimate: Researcher salary costs ($82,000 annually) for a 5-year project would be $410,000. Travel to sample sites, laboratory costs and supplies are an estimated $350,000.

G.3. Develop Alternative Decontamination Methods. *Implemented at the federal and state level; estimated one-time funding need is $264,000.*

Many existing exterior decontamination programs rely on hot water pressurized spray applied by individuals who are prone to human error and the inherent challenges of removing all viable mussels. New methods are needed that can quickly, inexpensively, thoroughly, and consistently eliminate all viable mussels.

Cost estimate: Researcher salary costs ($82,000 annually) for a 2-year project would be $164,000. Travel to sample sites, laboratory costs and supplies are an estimated $100,000.

G.4. Develop Biological Control Methods. *Implemented at the federal and state level; estimated one-time funding need is $510,000.*

Several projects are looking at delivering bacteria, a parasite or a biochemical compound that is taken up by and harmful only to quagga and zebra mussels. More support is needed to study these potential controls. Research is also needed on quagga and zebra mussel parasites, an investigation of their effects on quagga or zebra mussel populations, and their host-specificity. It is unlikely that the release of parasites would eradicate Dreissenid populations, but it may provide an inexpensive and efficient tool to reduce population densities and the negative impacts associated with invasion.

Cost estimate: Researcher salary costs ($82,000 annually) for a 5-year project would be $410,000. Travel to sample sites, laboratory costs and supplies are an estimated $100,000.

G.5. Develop Eco-Friendly Chemical Control Methods. *Implemented at the federal and state level; estimated one-time funding need is $510,000.*

The development of environmentally friendly control methods needs to continue. Currently, the most widely used control method is chlorination. Chemical control methods are often not target specific and can persist in the environment following treatment or may be reactively converted to toxic chemicals. Any eco-friendly chemical controls will need to be competitively cost-effective if they are to compete with chlorination.

Cost estimate: Researcher salary costs ($82,000 annually) for a 5 year project would be $410,000. Travel to sample sites, laboratory costs and supplies are an estimated $100,000.

Zebra mussel shells along beach. (Photo:Watershed Council of Northern Michigan)

III. Conclusion

Dreissenid mussels have not been detected in the vast majority of Western waters, presenting tremendous opportunities to prevent significant damage if coordinated, extensive action is taken immediately. The longer it takes to put effective measures in place to prevent the spread of or contain these mussels, the greater the chances of irreparable ecological damage and long-term mitigation costs (that could reach in the billions of dollars annually). The estimated annual cost of implementing the highest priority actions in this plan is $117 million. Effective and decisive actions, coordination, and support are needed from water management entities at all levels, including state and federal agencies, tribes, private water districts and concessionaires to prevent the introduction and spread, or respond to an infestation of quagga or zebra mussels. In addition, actions taken to prevent the spread of these mussels will also complement and enhance general prevention strategies to minimize the spread of other aquatic invasive species.

Efforts to prevent the further spread and introduction of ANS in the West do exist; however, they are extremely varied across state, tribal, federal and local jurisdictions. Most states within the West have limited ANS programs (Appendix A). Five of the 19 States (California, Colorado, Idaho, Utah and Washington) in the region have well developed and funded programs, although even these five programs have limitations and challenges (see examples below). With water conveyance systems and a mobile recreating society, all water management entities throughout the West need effective programs to prevent the introduction and control the spread of ANS.

The spread of quagga and zebra mussels, if left unchecked could occur rapidly and while impossible to estimate an exact dollar figure, impacts to aquatic ecosystems would likely be severe in many locations. The costs to individuals, private businesses, and public agencies to control and mitigate fouling could likely be in the millions, perhaps billions, of dollars annually. If funded and implemented, the collective actions outlined in this plan by the WRP represents the best strategy toward minimizing future impacts of quagga and zebra mussels across the Western United States.

Idaho Example:
The Idaho Invasive Species Law was enacted in 2008. This law establishes the Idaho State Department of Agriculture (ISDA) as the lead agency for invasive species, authorizes the ISDA director to promulgate rules, conduct inspections, establish mandatory check stations, and access emergency funding. New legislation in 2009 required motorized and non-motorized boats to have an Invasive Species Sticker to launch and operate in Idaho. Revenue from this program is projected to be approximately $1.3 million/annually. The sticker program is administered by the Idaho Department of Parks and Recreation. Funding generated by this program is deposited in the Idaho Invasive Species Fund, which is administered by ISDA.

In 2009, ISDA used the boat sticker revenue to launch a comprehensive campaign to implement an operational inspection program targeting boats entering Idaho from other States. That same fund helped the department inform the public, increase existing monitoring efforts statewide, and purchase watercraft decontamination equipment.

The ISDA's 17 mandatory watercraft check stations were located where there was the highest likelihood of intercepting boats crossing into Idaho from states known to have infested water bodies. Crews worked 7 days a week, from 7am to 7pm. It is estimated that more than 12,000 boats were inspected during the July 4th – September 14th time period. Boats were

decontaminated at the inspection site if they were considered at high-risk of being infested. Several boats were decontaminated and two mussel-fouled boats were found before the check stations closed for the season.

The State of Idaho's new program has had tremendous initial success. Although there has been success at preventing infested boats entering the state more needs to be done to contain infested boats at their source. The State of Idaho declared an emergency in 2009 and instituted check stations at high-priority borders in an effort to prevent fouled boats from launching.

Colorado Example:
The Colorado State ANS Program is funded with severance tax dollars from oil and gas revenue. There are concerns that this funding will not be sustainable long-term and alternate sources of funding need to be identified. Beginning in March 2008, there has been a total of $12.1M allocated to the ANS Program which includes a rapid response grant of $1M from the Colorado Water Conservation Board for the Lake Pueblo Response, and the annual allocations of $7.1M in FY08-09 and $4M in FY09-10. In the 2008 boating season, there were over 130,000 boats inspected by Colorado Division of Wildlife (CDOW), State Parks and numerous public and private entities. Upon the conclusion of the 2009 boating season, we estimate that there will have been over 350,000 boats inspected in Colorado. In 2009, there were a total of 112 state certified inspection stations in Colorado. There are inspections at every infested and high-risk water body. Inspections are mandatory prior to exiting a known positive water for ANS or prior to entering any water of the state after boating in out of state waters. In 2008, there were 187 boats decontaminated and in 2009, we estimate that over 500 boats will have been decontaminated by the end of the season.

The majority of infested and high-risk waters with inspections are closed when inspectors are not present. However, there are waters that do not close at night or when inspectors are not present and are at risk for an introduction of mussels. Also, Colorado cannot fund programs on all waters, so mussels can get introduced upstream from the water with the inspection station, voiding the efficacy of said station by contaminating the upstream source. State crews have been sampling over 160 waters for ANS since 2005.

There are several areas where improvement is needed: dedicated full-time permanent staff, improved technology for decontamination of interior compartments on complex boats (ballast, live wells, etc.), a focus on large equipment and commercial operations (dam maintenance, water trucks, contractors, etc.), an educational campaign from the capital to the boat ramp and into the classroom, and lastly, all western state need funding to implement standardized programs.

Utah Example:
Utah's AIS program expends $1,875,761, supporting 66 personnel equating to 27.75 FTE (aquatic invasive species (AIS) Coordinator, 1 FTE; Outreach Specialist, 1 FTE; 5 AIS Biologists, 5 FTE; 5 Conservation Officers, 2.75 FTE; 54 seasonal Wildlife Technicians for boat inspections, 18 FTE). These funds were derived as $1,400,000 General Fund, $67,900 License Sales funds, and $407,861 contributed funds from 10 cooperative agreements from partner agencies (USFS, BLM, NRCS, 5 Water Conservancy Districts, 1 electric production company) seeking enhanced protection at specified waters.

The Utah Division of Wildlife Resources operates under authority of the Utah Aquatic Invasive Species Interdiction Act, which is facilitated by Rule R657-60. The act and rule do not have a "sunset clause." Also, there is no hiring freeze currently imposed due to the overall declining economy, as long as the program has sufficient funds for operation.

Utah has 150 boatable waters, supporting 355,000 boat launches per year; self decontamination certification is mandatory pre-launch at all waters as per Rule R657-60. Staffed AIS operations occurred at 40 of the highest priority waters (some with 16 hr/day coverage, 7 days per week), resulting in interdiction of 200,000 boat launches, where one-on-one AIS education occurred, and each boat was inspected for AIS, which led to 1,850 decontaminations, (two Dreissenid-affected waters require every departing boat to be decontaminated, which equals 1,000 of the aforementioned decontaminations).

Utah has an impressive program that interdicts 56% of the state's boat launches. If more funds were available, the hours of operation could be extended at the high-priority waters, and additional lower-priority waters could be covered.

Left: Zebra mussel; Right: Quagga mussel. (Photo: Pennsylvania Sea Grant)

Appendix A – State ANS and Quagga/Zebra Mussel Efforts

WRP States and Provinces	**ANS Coordinator?**	**Dedicated State Funding for ANS?**	**Approved Statewide ANS Management Plan?**	**Quagga/Zebra Mussel Infested Status** (as of Oct 1 2009)	**Authority for Quagga/Zebra Mussel Management or Other ANS?**	**Prevention Efforts?** (inspections or decontamination)	**Early-Detection Monitoring?**	**Other?**	**Cost for Development of State or Regional ANS Management Plan**
Alaska	Yes	Not in SFY10 ? for SFY11 Not q/z specific	Yes	No	No	Outreach only	Not yet	Outreach education	
Arizona	Yes	No	No - In Draft	Yes	Yes (but very new)	Inspection & Decontamination at Nat. Rec. Areas	Yes (minimal, Feds and Private)	Outreach, Education	$25,000 to date; $10,000 to finish
California	Yes	Yes	Yes	Yes	Yes	Inspection & Decontamination	Yes		
Colorado	Yes	Yes	No – In Draft	Yes	Yes	Inspection, Decontamination, Impound	Yes	Outreach, Education, Research	$60,000; plan in development
Hawaii	Yes	Yes	Yes	No	Yes	Inspection and Decontamination (focused on marine resources)	Yes (primary focus on marine systems)	Broad Invasives Outreach and Education (focus on marine algae)	$80,000
Idaho	Yes	Yes	Yes	No	Yes	Mandatory Inspection, Decontamination Hold Order, Impound, Emergency Funding	Yes	Comprehensive Statewide Outreach Campaign	$30,000
Kansas	Yes	Yes - salary	Yes	Yes	Yes	Inspection	Yes	Outreach, Education Programs, Research	$122,872

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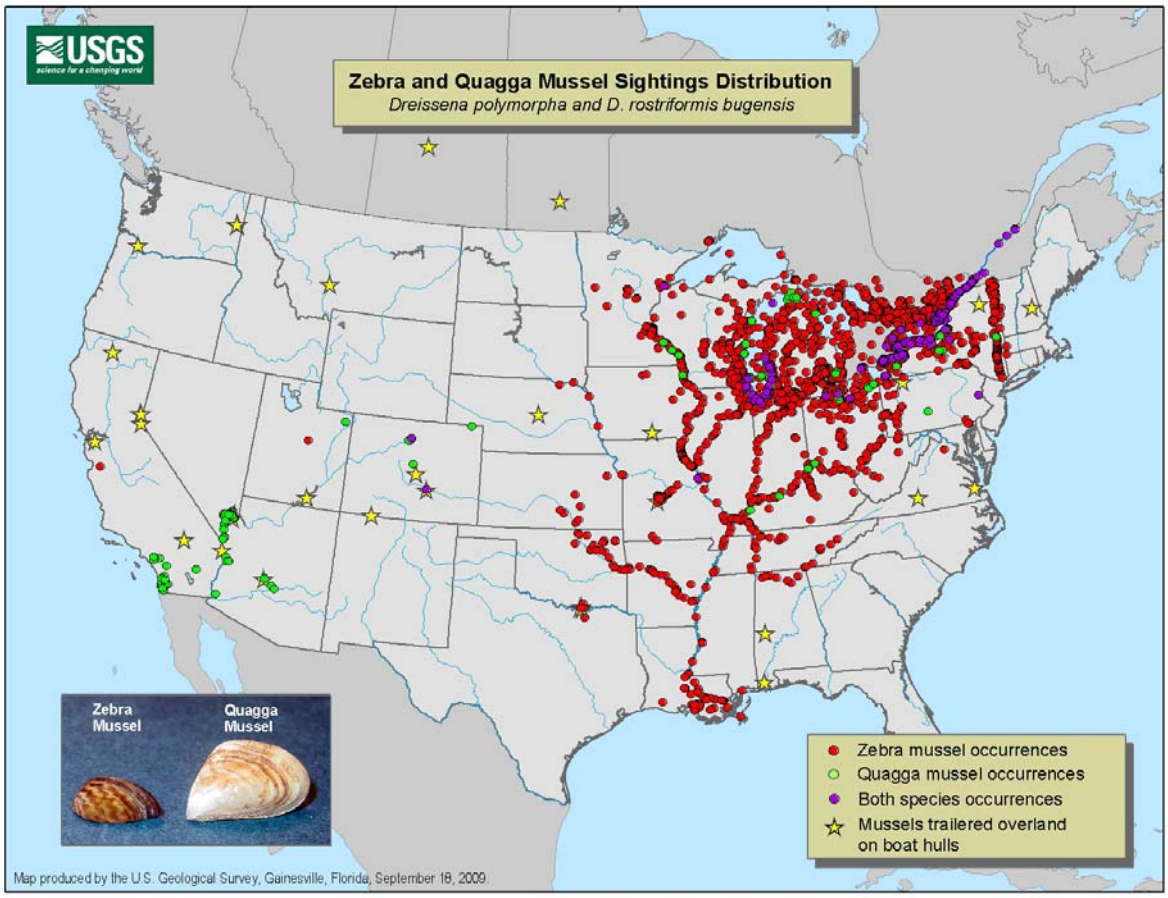
WRP States and Provinces	**ANS Coordinator?**	**Dedicated State Funding for ANS?**	**Approved Statewide ANS Management Plan?**	**Quagga/Zebra Mussel Infested Status** (as of Oct 1 2009)	**Authority for Quagga/Zebra Mussel Management or Other ANS?**	**Prevention Efforts?** (inspections or decontamination)	**Early-Detection Monitoring?**	**Other?**	**Cost for Development of State or Regional ANS Management Plan**
Montana	Yes	Yes	Yes	No	Yes	Inspection & Decontamination	Yes	Education, Outreach	$25,000
Nebraska	No	No	No	Yes	No	Monitoring	Yes	Education, Outreach	In development
Nevada	Yes (p/t, vacant)	No	Draft	Yes	Yes	Inspection & Decontamination	Yes	Education, Outreach	
New Mexico	Yes	Yes	Yes	No	Yes	Inspection & Decontamination	Yes	Outreach, Education, Research	
North Dakota	Yes	Yes	Yes	No	Yes	Yes	Yes	Education	$10,665
Oklahoma	Yes	Yes	Yes	Yes	Yes	Few Inspection & Decontamination	Yes	Education, Outreach, Research	$96,000
Oregon	Yes	$ for AIS prevention starting in Jan 2010 from boat registration fee	Yes	No	Yes, but more limited than other states	Complex (some limits on inspect, decont units throughout state, no visible ANS launch law 2010)	Yes	Education, Outreach, Drafting State ZMOMRRP	$15,000
South Dakota	No	Yes	Yes	No	No	Protocols for field staff decontamination	Yes	Education packet for K-12 and Outreach	$30,500
Texas	No	Yes, for aquatic plants	No (Draft complete)	Yes	Yes	No Inspection Program	Yes	Outreach	$20,000

Appendix A – State ANS and Quagga/Zebra Mussel Efforts

WRP States and Provinces	**ANS Coordinator?**	**Dedicated State Funding for ANS?**	**Approved Statewide ANS Management Plan?**	**Quagga/Zebra Mussel Infested Status** (as of Oct 1 2009)	**Authority for Quagga/Zebra Mussel Management or Other ANS?**	**Prevention Efforts?** (inspections or decontamination)	**Early-Detection Monitoring?**	**Other?**	**Cost for Development of State or Regional ANS Management Plan**
Utah	Yes	Yes	Yes	Yes (quagga & zebra)	Yes	On-Ramp Education, Inspection, Decontamination, Impound	Yes	Billboards, Outreach, Education, Research	$200,000
Washington	Yes	Yes	Yes	No	Yes	Inspection, Decontamination, Impoundment	Yes	Mandatory Check Stations; Integrated AIS Enforcement Program	$30-50,000
Wyoming	Yes – temporary	No	No – In Draft	No	Some AIS prohibited; No interdiction authority	No	Some, minimal	Outreach, Draft Legislation	$4000 spent to date
British Columbia	No	No	Under Development	No	No	No	Under Development		

Appendix B – USGS Quagga/Zebra Mussel Distribution Map (as of September 2009)

Check http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/ for additional options for maps.



Appendix C – Dreissenid Biology and Background

Density and Food Availability

Dreissenid mussel densities throughout the West could vary widely depending on water chemistry, food availability, and breeding population. After their initial introduction, Dreissenid mussel populations can rapidly increase by orders of magnitude, and then similarly decrease. Eurasian zebra mussel population densities range up to 40,000 mussels per square meter (Neumann et al. 1993). Under ideal conditions in the Laurentian Great Lakes, zebra mussel densities reach 700,000 – 800,000 per square meter (Kovalak et al. 1993). In the lower Mississippi River, where the zebra mussel has been introduced, densities of 400,000 per square meter have been reported (Kraft 1995). The Mississippi has an ideal environment for zebra mussels, in part because food resources are abundant (Kraft 1995).

Water Temperatures

Dreissenids can tolerate a wide range of water temperatures from roughly 32^0 to 86^0F ($0\ ^0$C to 30^0 C) (Ohio Sea Grant 1997). North American zebra mussel spawning (release of gametes into the water column) will not generally occur at temperatures below about 12^0 C (Claudi and Mackie 1994). There is evidence, however, that quagga mussels in deep waters of the Great Lakes are capable of spawning at temperatures near 5^0 C (Roe and MacIsaac 1997) and 9^0 C (Claxton and Mackie 1998).

Based on these parameters, a water temperature profile created from data recorded at the smolt monitoring facilities at Bonneville and John Day Dams shows the potential for quagga mussel egg release for approximately 7 months of the year (late March to late-November). However, peak spawning temperatures of 68 F (20^0 C) and above occur for 2 months during mid-July to mid-September (see Figure 1).

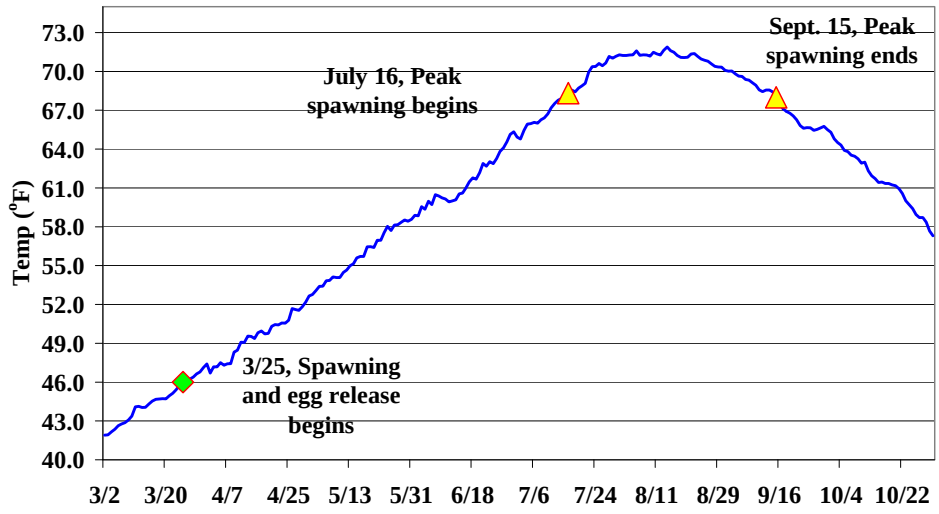


Figure 1. Daily average water temperatures at Bonneville Dam and John Day Dam Smolt Monitoring Facilities, 2000-2006 (Kovalchuk 2007).

Calcium Requirements

North American zebra mussel populations require 10 mg Ca^{2+}/l to initiate shell growth and 25 mg Ca^{2+}/l to maintain shell growth. Larval development is inhibited at pH of 7.4. Higher rates of adult survival occur at a pH of 7.0-7.5, but populations have been found in the hypolimnetic zone of lakes with a pH of 6.6-8.0, and in the epilimnetic zone with a pH of 7.7-8.5. Optimal larval survival occurs at a pH of 8.4, and optimal adult growth occurs at pH 7.4-8.0. (Benson and Raikow 2007).

Calcium concentrations could be a factor limiting Dreissenid densities in some parts of the West. Large populations of zebra mussels are not expected where calcium levels are less than 25 mg/l (Hincks and Mackie). Cohen and Weinstein (2001) found little evidence that zebra mussels can become established at ambient calcium concentrations below about 20mg/l. Calcium thresholds in the Columbia River West of the Cascades and in particular the Willamette River may be suboptimal for establishment of Dreissenid populations (Whittier et al. 2008).

It should be noted that calcium may be elevated near concrete structures (Cohen and Weinstein 2001). There are also cases where Dreissenid populations have become established in calcium-limited water bodies at locations that have input from other water sources with higher calcium levels (Cohen and Weinstein 2001).

History of Control Efforts

Although an attempt to eradicate a new Dreissenid mussel infestation presents significant challenges, there is at least one documented success story. In 2002, the first introduction of zebra mussels in Virginia was confirmed in Millbrook Quarry. The 12-acre quarry is located on property under private ownership. The Virginia Department of Game and Inland Fisheries led an effort to eradicate this population. Over a three-week period in early 2006, the water body was treated with 174,000 gallons of potassium chloride solution over a 3-week period from January 31 to February 17, 2006. Potassium concentrations were measured weekly throughout the quarry and in adjacent surface waters to ensure a target concentration of 100 milligrams of potassium per liter of water (below the level that would have human health or significant ecological impacts, but over twice the minimum concentration needed to kill zebra mussels). No potassium leakage from the quarry into adjacent waters was detected.

Monitoring results demonstrated that lethal potassium concentrations were achieved at various depths. Several weeks after treatment ended, four independent methods were also used to confirm zebra mussel eradication. First, more than 1,000 mussels were sampled from rocks at numerous sites around the quarry; none were alive. Divers also visually inspected the quarry and could not find live zebra mussels. Next, an extensive video survey also was conducted using a robotic camera system, documenting dead zebra mussels. Finally, 80 sets of live zebra mussels (100 per set) were placed at various locations and depths within the quarry. After one month of exposure to the treated quarry water, mortality of these test mussels was 100% (as opposed to zero mortality of a control set placed in untreated water). Other aquatic life in the quarry (including turtles, fish, and aquatic insects) appear to be thriving after the treatment. As of the date of this Plan, no additional zebra mussels have been found in the quarry. It is important to note that this case involved infestation in a small, contained water body. A similar example of an eradication effort in an isolated water body began. In September, 2008, on Offutt Air Force Base in Bellevue, Nebraska, using copper sulfate. However, attempting to eradicate zebra or quagga mussels in a large river system presents a very different set of challenges.

References

Benson, A. J. and D. Raikow. 2007. *Dreissena polymorpha*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. <http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=5> Revision Date: 1/10/2007

Claudi, R. and G. L. Mackie. 1994. Practical Manual for Zebra Mussel Monitoring and Control. Chapter 1. Biology of the Zebra Mussel. Lewis Publishers, CRC Press, Boca Raton, FL. 227 pp.

Claxton, W. T. and G. L. Mackie. 1998. Seasonal and depth variations in gametogenesis and spawning of *Dreissena polymorpha* and *Dreissena bugensis* in eastern Lake Erie. Can. J. Zool. 76:2010-2019.

Cohen, A.N., Weinstein, A. 2001. Zebra Mussel's Calcium Threshold and Implications for its Potential Distribution in North America. San Francisco Estuary Institute.

Cole, R. A. 2006. Freshwater aquatic nuisance species impacts and management costs and benefits at Federal Water resources projects. ANSRP Technical Notes Collection (ERDC/TN ANSRP-06-3), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *http://el.erdc.usace.army.mil/ansrp/ansrp.html*.

General Accounting Office (GAO). 2002. Invasive Species: Clearer Focus and Greater Commitment Needed to Effectively Manage the Problem. GAO-03-1.

Hushak, Leroy J. and Yuming Deng. January 28-31, 1997. Costs of Alternative Zebra Mussel Control Strategies: The Case of Great Lakes Surface Water Users. Ohio Sea Grant College Program. Proceedings Seventh International Zebra Mussel and Aquatic Nuisance Species Conference, New Orleans, LA. OHSU-TS-042 as a result of Ohio Sea Grant Project R/ZM-012.

Idaho Aquatic Nuisance Species Taskforce. 2009. Estimated Potential Economic Impact of Zebra and Quagga Mussel Introduction into Idaho. Prepared for the Idaho Invasive Species Council.

Kovalak, W, Longton G. and R. Smithee. 1993. Dispersal Mechanisms of the Zebra Mussel (*Dreissena polymorpha*), in *Zebra Mussels: Biology, Impacts, and Control*. Nalepa, T.F., and Schloesser, D.W., eds., Lewis Publishers, Boca Raton, FL, pgs 359-380.

Kraft, C. 1995. Zebra Mussel Update #24. University of Wisconsin-Madison, Wisconsin Sea Grant Institute.

Lovell, S. J., and Stone, S. F. 2005. The economic impacts of aquatic invasive species: A review of the literature. Working Paper # 05-02, U.S. Environmental Protection Agency, National Center for Environmental Economics, Washington, DC.

Neumann, Dietrich, Borcherding, Jost and Brigette Jantz. 1993. Growth and Seasonal Reproduction of *Dreissena polymorpha* in the Rhine River and Adjacent waters. in *Zebra Mussels: Biology, Impacts, and Control*. Nalepa, T.F., and Schloesser, D.W., eds., Lewis Publishers, Boca Raton, FL, pgs 95 - 109.

Ohio Sea Grant, 1997. Zebra Mussels in North America: The invasion and its implications. Fact Sheet 045. Columbus, Ohio.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52 pgs. 273– 288.

Roe, S.L., and MacIsaac, H.J. 1997. Deepwater population structure and reproductive state of quagga mussels (*Dreissena bugensis*) in Lake Erie. Can. J. Fish. Aquat. Sci. 54: 2428–2433.

Whittier, T., P. Ringold, A. Herlihy, and S. Pierson. 2008. A calcium-based invasion risk assessment for zebra and quagga mussels (*Dreissena* spp). Front Ecol Environ 2008; 6, doi:10.1890/070073.

Appendix D – QZAP Action Summary Table

*Highest priority action item

Subject to agency authorities, priorities, and appropriations of funding. The table does not include what is currently contributed by agencies.

	Title of Action	Implementation Level			Estimated Funding Need		
		Federal	State	Local	One-Time	Initial	Annual
A. Increasing Capacity to Address Invasive Mussels							
*A.1.	State and Interstate ANS Management Plan funding and QZAP implementation		X				$31,140,000 (divided by 53 = $587,547
A.2.	Federal coordination and implementation of QZAP	X					$1,200,000
B. Prevention							
*B.1.	Implement mandatory inspection and decontamination at infested waters	X	X	X		$25,320,090	$19,423,090
*B.2.	Continue the development of effective watercraft inspection and decontamination protocols and standards	X	X		$200,000		
*B.3.	Develop standard and effective equipment inspection and decontamination protocols	X	X		$200,000		
*B.4.	Adopt standard watercraft and equipment inspection and decontamination protocols in Western States	X	X	X	$270,000		
*B.5.	Establish and implement strong, consistent law enforcement programs in each Western state	X	X	X		$380,000	$11,400,000
*B.6.	Develop a standardized model and strategy for risk assessment model for water bodies	X	X			$250,000	

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*Highest priority action item

Subject to agency authorities, priorities, and appropriations of funding. The table does not include what is currently contributed by agencies.

	Title of Action	Implementation Level			Estimated Funding Need		
		Federal	State	Local	One-Time	Initial	Annual
B.7.	Expand mandatory watercraft inspection and decontamination capacity for uninfested regions	X	X	X		$21,850,000 - $320,000,000	$19,000,000 - $1,102,215,150
B.8.	Develop and implement programs to intercept contaminated equipment	X	X		$200,000		$380,000
B.9.	Expand Use of ANS HACCP Planning	X	X		$2,850,000		
C. Early-Detection Monitoring							
*C.1.	Expand early-detection monitoring programs to all western water jurisdictions	X	X	X			$2,561,200
*C.2.	Develop standard field protocols for early-detection monitoring	X	X				$504,000
C.3.	Improve sample analysis methods	X	X		$687,200		
C.4.	Coordinate early-detection monitoring programs	X				$50,000	
D. Rapid Response							
*D.1.	Create and maintain a rapid response fund	X				$20,000,000	$5,000,000

Appendix D – QZAP Action Summary Table

*Highest priority action item

Subject to agency authorities, priorities, and appropriations of funding. The table does not include what is currently contributed by agencies.

	Title of Action	Implementation Level			Estimated Funding Need		
		Federal	State	Local	One-Time	Initial	Annual
*D.2.	Finalize rapid response notification database	X					$25,000
D.3.	Complete and maintain rapid response plans for all Western States		X			$975,000	$325,000
D.4.	Designate and train rapid responders	X	X	X			$4,950,000
D.5.	Planning for short-term environmental impacts resulting from rapid response	X	X				$5,000,000
E. Containment of Management of Existing Populations							
*E.1.	Develop tools and best management practices for preventing and minimizing mussel movement and settlement within water distribution systems and other infrastructure	X	X	X	$5,000,000		
E.2.	Implement reliable and cost-efficient control tools for water distribution systems	X	X	X	$5,000,000		
E.3.	Develop open-water control tools	X	X	X	$510,000		
E.4.	Develop closed-water system control tools	X	X	X	$510,000		

Appendix D – QZAP Action Summary Table

*Highest priority action item

Subject to agency authorities, priorities, and appropriations of funding. The table does not include what is currently contributed by agencies.

	Title of Action	Implementation Level			Estimated Funding Need		
		Federal	State	Local	One-Time	Initial	Annual
E.5.	Support designing infrastructure for long-term control	X	X	X	$4,000,000		
E.6.	Improved understanding of mussel control	X	X		$610,000		
E.7.	Develop programmatic National Environmental Policy Act guidance	X			$230,000		
F. Outreach and Education							
***F.1.**	Adopt consistent outreach messaging and enhance coordination of efforts	X	X				$250,000
F.2.	Conduct social science research	X	X			$750,000	$100,000
F.3.	Increase audience effectiveness assessments	X	X				$950,000
F.4.	Expand availability of existing outreach material		X			$1,710,000	$4,750,000
F.5.	Make better use of television and radio	X	X				$10,000,000
F.6.	Provide more opportunities for youth education		X			$150,000	$1,425,000

Appendix D – QZAP Action Summary Table

*Highest priority action item

Subject to agency authorities, priorities, and appropriations of funding. The table does not include what is currently contributed by agencies.

	Title of Action	Implementation Level			Estimated Funding Need		
		Federal	State	Local	One-Time	Initial	Annual
G. Research							
G.1.	Determine physiological tolerances	X			$405,000		
G.2.	Develop method to track dispersal via genetic fingerprints	X			$760,000		
G.3.	Develop alternative decontamination methods	X	X		$264,000		
G.4.	Develop biological control methods	X	X		$510,000		
G.5.	Develop eco-friendly chemical control methods	X	X		$510,000		
TOTAL					**$22,716,200**	**$71,435,090 to $369,585,090**	**$117,304,290 to $1,200,519,440**