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*)

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I. *Introduction*

In terms of ecological and economic impacts, quagga and zebra mussels are among the most devastating aquatic species to invade North American fresh waters. Zebra mussels (*Dreissena polymorpha*) were introduced into the Great Lakes by international ocean-going vessels in the late 1980s. The related quagga mussel (*Dreissena bugensis*) was also introduced around the same time, likely via ballast water. Quagga mussels were found in January 2007 in Lake Mead and since then quagga or zebra mussels have been found in Arizona, California, Colorado, and Texas and Utah. The arrival of quagga and zebra mussels (often referred to as Dreissenids) to Western waters brings the potential to extend devastating impacts into a geographical area already challenged with water-related problems. Once established, these mussels can clog water intake and delivery pipes, dam intake gates and pipes, adhere to boats, pilings, and most hard and some soft substrates. This impacts water delivery systems, fire protection, and irrigation systems and requires costly removal maintenance. 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.

The primary program by which ANS prevention and coordination efforts have been carried out in the West is through 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 spread of ANS via recreational pathways. Boater education and outreach combined with assessments of routes by which trailered boats move across North America were conducted to increase our understanding and to allow rudimentary risk assessment for western waters. A few major 100th Meridian Initiative activities and accomplishments include:

- Coordination of outreach and monitoring programs via implementation teams for the Arkansas, Colorado, Columbia, Missouri, and Rio Grande river basins;
- Expansion of a National Hotline for ANS Reporting (1-877-STOP-ANS);
- Initiation and support of a Watercraft Inspection Training program which has enhanced the capacity to detect and manage infested boats by hundreds of law enforcement officers in the West;
- Management of a comprehensive informational website, including the trailered boat movement database with over 14,000 entries and development of a new notification database;

The Western Regional Panel (WRP) to the federal Aquatic Nuisance Species Task Force (ANSTF) includes 19 western states, federal agencies, tribes and other invasive species stakeholders. In response to a request by the ANSTF, the WRP has developed this action plan to reflect the rising threat of invasive mussels in the West. The primary objective of the WRP's Quagga/Zebra Mussel Action Plan (QZAP) is to underscore the highest priority actions and resources needed to minimize impacts of these invasive shellfish to native species, water delivery infrastructure, and other vulnerable resources in the West. The concerted effort to address quagga and zebra mussels fits into a larger battle against aquatic invasive species that threaten Western waters. A summary table of the priority actions needed is located at the end of the document.

II. *Highest Priority Actions Needed to Address Quagga and Zebra Mussels in Western Waters*

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/zebra mussels, invasions into new watersheds rapidly continue. Further invasions are expected to produce additional economic losses and irreversible ecological impacts. Regional coordination and timely actions are necessary to minimize the further spread and inevitable impacts. States have jurisdiction, regulatory authority, and expertise that are critical for an effective plan to combat invasive mussels in the West. State agencies are often the first line of defense against aquatic invasive species, unfortunately existing resources are limiting the effectiveness of such efforts. Additional funding to support an immediate coordinated response to the quagga/zebra mussel invasion is essential. Listed below are the highest priority actions needed to immediately address the quagga/zebra mussel invasion. Additional funding is needed to properly address the priority action items. The benefits to the increase in funding and coordination would go far beyond implications to quagga and zebra mussels and would improve all aquatic invasive species prevention efforts throughout the region and possibly throughout the nation. The highest priorities are captured below under three broad areas and are embedded under the broader categories of Section III in the summary table found at the end of the plan.

Increase Funding for ANS Management Plans and Quagga/Zebra Mussel Plan Implementation

The Nonindigenous Aquatic Nuisance Prevention and Control Act (NANCPA) of 1990, Section 1204(b) authorized $4 million for the implementation of State ANS Management Plans. Through the U.S. Fish and Wildlife Service, $1.075 million is allocated each year to support ANS Task Force approved State or Interstate ANS Management Plans. In 2009, there were 31 approved plans, with each plan receiving $34,677 for implementation. As more state plans become approved the share for each state declines. These plans already define many needed actions to address zebra and quagga mussels and states are best suited due to their jurisdictional authority to implement these activities. To help implement these high priority action items an increase to $30 million for approved plans is recommended. The remaining QZAP high priority needs fall outside the scope of implementing individual plans.

- **Implementation of Inspection and Decontamination Stations at Infested Waters** – Inspections and decontamination are useful tools for containing infestations at their source by preventing spread via watercraft and water based equipment. Inspections also serve a valuable educational role.
- **Dedicated State ANS Law Enforcement** – Law enforcement is a necessary component of any ANS Program. Although many states have ANS rules they are often unenforced because of a lack in enforcement personnel. High profile prosecutions can reinforce the significance of the ANS infestations.
- **Create and Maintain a Rapid Response Fund** – A dedicated fund is necessary to rapidly implement containment at waters found to be positive with zebra or quagga mussels. Rapid response is necessary to contain infestations and limit impacts.
- **Detection and Monitoring Actions** – Early detection and monitoring programs are necessary to detect an infestation early so as a response can be implemented soon after infestation.

Inspection and Decontamination

Inspections and decontaminations are a useful tool to prevent the overland transport of ANS by watercraft or other water based equipment. Many western states operate some kind of inspections, decontaminations or both. However, there are a variety of techniques used in each state which can lead to questions on which technique is most appropriate. Additionally, more consistency with inspections and decontaminations would lead to less confusion by the public.

- **Develop Consistent and Reliable Boat and Equipment Decontamination Protocols** – Varying techniques for decontamination need to be evaluated for their effectiveness on both zebra and quagga mussels. Field-based evidence is lacking and should be obtained to support and improve recommended practices.
- **Develop Consistent Equipment Inspection Protocols** – Reliable protocols for equipment inspections are lacking and should be developed and implemented. Water-based equipment may include nets, heavy construction equipment, or fire-suppression equipment.
- **Streamline Inspection Protocols Across States** – If watercraft inspections performed in one area were accepted by authorities in other areas, this would serve to streamline inspections and reduce frustration and confusion to the public. Streamlining protocols could include a standardized training program and a quality control program to ensure protocols are effective.

Development and Research

Several high priority gaps exist to effectively manage and control quagga/zebra mussels.

- **Develop Best Management Practices for Early Detection and Monitoring** – Detection and monitoring typically involves detection of the planktonic larval stage or the settled adult stage. Best management practices have not been developed for detection of either mussel stage.
- **Research and Identify Best Management Practices for Water Managers to Prevent and Minimize Larvae Movement and Settlement Within Water Delivery Systems and Other Water Infrastructure** – A toolbox of prevention techniques, specifically for water providers, is needed to engage implementation of tools to prevent further introductions of mussels and their larvae into currently uninfested systems.
- **Standardized Model for Risk Assessment of Water Bodies** – Water body susceptibility and risk assessment is necessary to prioritize the use of limited funds to target sampling, inspection, and decontamination stations. Several models exist, but a consistent and effective method for assessing water body risk needs further improvement.
- **Finalize Notification Database** – A database of principal contacts for communication about newly infested water bodies in Western states is under development. This database will be useful for quickly contacting the jurisdictional leads when new infestations are discovered and information needs to be shared in order to initiate prevention and containment.
- **Adopt Consistent Outreach Message** – A consistent message should be adopted and incorporated into all prevention and control programs and through marinas, boat dealers and others.

III. *Addressing the Issue*

This section includes needs that are not on the highest priority list but are also important to address for Prevention and Containment, Early Detection and Monitoring, Rapid Response, Control of Established Populations, Outreach and Education, and Research.

A. Prevention and Containment

Current Approach

Prevention remains the most cost-effective and ecologically protective approach to minimize damage from quagga and zebra mussels. Movement of quagga/zebra mussels can be prevented if their pathways are intercepted. Overland transport is easier to intercept and prevent than downstream dispersal or movement in water conveyance systems. Transport pathways include boat transport, angling and other recreational activities, movement of water tanks, construction equipment, fish stocking, trans-basin water diversions, water-based aircraft, and wildlife. Prevention has been a focus within the western region for several years. Current prevention activities in place include outreach and education, watercraft inspections and decontaminations, watercraft exclusion, law enforcement, "green" certification programs for boat hauling services, permits for movement of large water-based materials, use of Hazard Analysis and Critical Control Point (HACCP) plans and similar risk management/assessment methods, reward programs, and stiff penalties for intentional introductions of these invasive mussels. The level at which these activities occur vary greatly among the Western states. In order to provide consistency for watercraft inspections, the FWS and Bonneville Power Administration supported the development and ongoing delivery of the Pacific States Marine Fisheries Commissions' Watercraft Inspection Training Program, but not all jurisdictions are trained or implementing this approach. While it is most cost-effective and ecologically protective to devote most effort to keeping quagga and zebra mussels out of water bodies, a closely related element is the need to contain infestations to where they already occur.

Challenges with Current Approach

The Western states use varying standards for inspection and decontamination; even within a state, standards can vary among agencies and organizations conducting the inspections and decontaminations. This can lead to confusion and frustration for recreational users. Development of BMPs that could be easily adopted by the states, may be a way to streamline inspections and decontaminations across the West and additionally could reduce some of the frustration within the public.

Although importation and interstate transport of zebra mussels is prohibited by the federal Lacey Act (18 USC 42), the federal government's role has been to encourage and foster coordinated state efforts to prevent further invasions by providing technical assistance, tools and forums for exchange of information among all stakeholders, especially through the 100th Meridian Initiative. Quagga mussels are not currently listed as injurious wildlife under the Lacey Act. Though a number of federal agencies have authority to intercept mussel pathways in certain situations, states are better suited to lead regulatory prevention programs that are focused on watercraft and other equipment. Some states have broad authority to stop and inspect all vulnerable watercraft, matched with substantial enforcement personnel resources, while others still lack clear authority to detain watercraft. States need support to develop comprehensive, and ideally consistent, regulations that would prevent aquatic invasive species introductions through the various pathways of introduction.

Regulatory programs to prevent introductions via other pathways, like water-based construction equipment, are much less developed. In some cases, local water management districts are restricting public access to particularly sensitive water bodies rather than risk contamination. The FWS strongly promotes the use of HACCP planning to reduce inadvertent introduction of aquatic invasive species into western watersheds via fish stocking programs and other natural resource activities.

PREVENTION AND CONTAINMENT NEEDED ACTIONS

The following actions must be addressed to prevent introductions in new areas and maximize containment of existing populations:

ACTION A1: Implementation of Mandatory Inspection and Decontamination Stations at Infested Water Bodies – Containment of quagga and zebra mussels must include sufficient inspection and decontamination at water bodies so that boats traveling to new areas are not carrying invasive species. Western states, tribes, federal agencies and others who have direct enforcement authority to stop, inspect, and disinfect contaminated watercraft must increase their activities. This would include inspection stations, training, and boat washing decontamination units that can be used at marinas, reservoirs and boat ramps where quagga and zebra mussels are found and medium-to-high risk sites where mussels could be introduced through recreational and commercial boat launches. Staffing, educational materials, cleaning of incoming and containment of out-going vessels at infested reservoirs are also needed. *Estimated annual funding need is $20 million*.

ACTION A2: Expand Mandatory Watercraft Inspection and Decontamination Capacity for Uninfested Regions – Given that containment is not fool-proof, sufficient inspection and decontamination resources need to be in place at the point-of-entry to uninfested states and/or watersheds in the West. This includes personnel, physical infrastructure, decontamination equipment and supplies, and associated training. In many cases, support is needed to establish necessary legal authorities for mandatory inspections. The broad overlap of regulatory jurisdiction among states, tribes, federal agencies, local water districts, and other jurisdictions requires new efforts to coordinate inspection and decontamination procedures. *Estimated annual funding need is $50 million*.

ACTION A3: Establish and Implement Strong, Consistent Law Enforcement Programs in Each Western State – Strengthening inspection and decontamination capacity must be matched by enhanced law enforcement authority and capacity. Many states do not have regulations that allow inspection and decontamination and need to pursue having the appropriate authorities in place. Staffing is needed at all jurisdictional levels to enforce inspection requirements for watercraft and equipment, existing prohibited species laws, public access closures, and thwart intentional mussel releases. *Estimated annual funding need is $20 million*.

ACTION A4: Develop Programs to Intercept Contaminated Materials and Equipment – Even in the relatively few cases where states and other jurisdictions regulate movement of water-based construction equipment and other vulnerable materials, those regulatory programs rarely address mussel inspection and decontamination. However, this pathway has been associated with at least one zebra mussel introduction in the West, and is not likely to be addressed by

watercraft inspection programs. Existing state and federal programs need additional funding to develop tools to close this gap. *Estimated annual funding need is $5 million.*

ACTION A5: Expand Use of HACCP Planning – Hazard Analysis and Critical Control Point (HACCP) is a proven method to analyze the potential invasive species introduction risks presented by an activity and define 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, pay for the costs of plan implementation, and adapt regulatory programs where appropriate to incorporate HACCP plan submission and approval. *Estimated annual funding need is $3 million.*

ACTION A6: Develop a Valid and Consistent Risk Assessment Strategy – There are inconsistent models for assessing invasion risk and different levels of risk have been concluded for the same water body. This has led to difficulties in developing and implementing consistent prevention strategies. Although risk assessment models may continue to differ across jurisdictions, there should be some attempt at developing a standard model using a prioritized list of the most important parameters that should be considered. *Initial need is $1 million.*

What is at risk without action?

With the existing level of investment in prevention and containment of existing quagga and zebra mussel populations, the spread of these invaders to new areas is almost certain and with it significant economic impacts to the public, and ecological impacts to western waters and wildlife. Many of the prevention and containment efforts already in place are part of a broader approach to address pathways for all species. However, efforts are implemented to varying degrees across states and private and federally managed water bodies. The potential veliger loads that may be seen in downstream waters from reproductively active adults upstream will likely increase. This will subsequently increase the need for additional containment and control efforts and costs.

Zebra mussels on a trailered boat (view under the trim tab) intercepted while entering California in 2002. (Photo: U.S. Fish and Wildlife Service)

B. Early Detection and Monitoring

Current Approach

Early detection is critical to containing new infestations as quickly as possible in order to prevent spread to new water bodies. Many states and other water managers have been monitoring for early detection of quagga and zebra mussels for years. Some states do not yet have monitoring programs in place due to limited resources. However, if populations are detected early, rapidly coordinated responses provide an opportunity to eradicate or contain the unwanted species before the species is spread to other waters. For those states with active early detection and monitoring programs a wide variety of techniques are employed and there is a general lack of understanding as to which techniques are best. However, it is clearly understood that lack of participation in these efforts could lead to further invasions. Monitoring should also include a variety of techniques to increase the chance of detections. Corroboration and confirmation of results is also necessary.

Challenges with Current Approach

Current early detection and monitoring efforts are limited by two major factors. First, the availability of resources necessary to implement regular sampling programs in all western waters is insufficient. Second, the existing laboratories qualified to process samples are extremely limited in their processing capacity which can lead to a delay in results. Samples need to be processed in a timely manner to allow for any rapid response.

EARLY DETECTION AND MONITORING NEEDED ACTIONS

ACTION B1: Expand Early Detection and Monitoring Programs to All Western Jurisdictions – Early detection and monitoring could be improved considerably if all western states and jurisdictions employed regular, widespread sampling programs at their highest risk waters. *Funding need is included in other action items, though an annual funding need for coordination is $40,000.*

ACTION B2: Coordinate Monitoring Programs– A centralized monitoring reporting database is under development through the 100th Meridian Initiative. Development of this coordination tool should be completed so that all jurisdictions may benefit from timely distribution of early detection data. *Initial need is $50,000.*

What is at risk without action?

Without increasing the capabilities of early detection and monitoring programs in the West, quagga and zebra mussels will undoubtedly continue to spread to new waters without notice. Historically, quagga and zebra mussel populations have not been discovered until it was too late to eradicate or stop the population from growing and spreading to additional waters. Invasive species in general are more easily controlled when populations are incipient and small. An effective early detection and monitoring program should be tied to a rapid response program designed to minimize the impacts of invasive species as swiftly as possible, and the primary goal should seek eradication if possible and feasible. As research continues to develop technologies to fight quagga and zebra mussel invasions, these new technologies will be most efficiently employed and should be most effective if they are aimed at populations detected early.

C. Rapid Response

Current Approach

Capacity to conduct a rapid and effective response to an incipient introduction is gaining emphasis in the West. In the event that prevention efforts fail, rapid response is an opportunity to stop or limit the effects of an invasion. As with other environmental emergencies, successful rapid response depends on adequate preparedness and planning. A variety of guidance materials now exist to guide the development of aquatic invasive species rapid response plans, such as the template developed by the Western Regional Panel and many rapid response plans exist at various levels. The Columbia Basin Team of the 100th Meridian Initiative completed a rapid response plan for the entire Columbia/Snake River watershed. This plan incorporates the National Incident Management System within its organizational framework. Similarly, the National Park Service has developed a broad mussel response plan at the national scale.

Planning is only the first step in rapid response preparedness. There are additional efforts in the West to enhance the ability to respond via training and other strategies, including:

- Identifying and securing emergency response funding pools
- Defining internal and external notification lists and processes
- Providing Incident Command System training to aquatic invasive species specialists and others likely to participate in response activities
- Developing advance intergovernmental cooperative agreements
- Defining federal, state and local agency roles and responsibilities
- Developing systems to quickly hire personnel to complete response tasks
- Holding drills and exercises to test and enhance ability to implement plans

Challenges with Current Approach

Only a small number of Western waters are adequately covered by comprehensive rapid response plans and the associated capacity to implement those plans. If quagga/zebra mussels were detected in the majority of currently uninfested watersheds in the West, the associated jurisdictions would have no clear strategy or defined roles and responsibilities to guide response. As a result, response is unlikely to be rapid and any eradication efforts would be ineffective. In locations where response plans are in place, the lack of guaranteed funding available for response significantly limits the likelihood that the plan can be implemented in a timely fashion. Policy constraints, including unresolved questions about short-term environmental impacts associated with certain eradication techniques, also limit the existing state of response preparedness in the West. There is an overall lack of response infrastructure. There are few individuals trained and available to support a rapid response. Similarly, there are large gaps in availability of effective response methods and associated supplies and equipment. Rapid response requires a multitude of entities that are each individually responsible for managing a subset of distribution vectors and control. Roles and responsibilities need to be defined, funded and supported at the agency level in advance, versus at the ground level during an incident response.

RAPID RESPONSE NEEDED ACTIONS

ACTION C1: Create and Maintain a Rapid Response Fund – A dedicated fund is necessary to rapidly implement containment at waters found to be positive with zebra or quagga mussels. This fund will help states and other jurisdictions organize and begin implementing immediate

actions while they work with stakeholders and other partners to determine the long-term containment strategy and how those efforts would be funded. This fund would have to be set up for fast turnaround and processing to transfer dollars to the states and other lead jurisdictions in a manner that enables rapid response. The lack of a fund that is available year-round, regardless of a budget cycle, is a primary limitation on response to a new infestation. *Estimated one-time funding need is $20 million.*

ACTION C2: Finalize Notification Database – A database of principal contacts for communication about newly infested water bodies in Western states is under development through the 100th Meridian Initiative. This database will be useful for quickly contacting leads in jurisdictional areas when information needs to be transmitted quickly. Each key contact should have a notification process defined for their specific jurisdiction to disseminate information quickly and efficiently. This database is not open to the public; it is shared only among the primary Western contacts. *Estimated annual funding need is $20,000.*

ACTION C3: Complete Rapid Response Plans for all Major Western Water Bodies – Site specific rapid response plans are critical to ensuring actions are implemented immediately upon notification of a positive detection of mussels. Response plans should address, at a minimum: 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 any permits and/or pre-approval needed to implement control or containment actions. Funding and contributions from all stakeholders should be clearly defined. *Estimated annual funding need is $2 million.*

ACTION C4: Establish Effective Response Personnel Infrastructure – In order to effectively implement rapid response, properly trained personnel must be in place in advance. At the state level, a dedicated ANS coordinator position plays a critical role overseeing the statewide effort, developing site-specific plans, orchestrating the notification process and initiating rapid response. The State ANS Coordinator must be enabled to attend regional meetings out of their home state, and contribute to multi-state planning and implementation processes. Currently, not all western states have full-time State ANS Coordinators.

In addition to staff being necessary at the state level to achieve the goal of a coordinated rapid response, an increase in participation at the federal, local and private level is also necessary. Many water bodies are managed by a federal agency such as the Army Corp of Engineers, Bureau of Land Management, Bureau of Reclamation, National Park Service or the U.S. Forest Service. Local governments, water providers, marina operators, marine dealers and other private industries all play a key role in rapid response and can greatly increase the effectiveness of containment and control. *Estimated annual funding need is $3 million.*

ACTION C5: Develop Processes and Documents to Expedite Approval of Response Tactics That May Have Short-Term Environmental Impacts – Completion of rapid response plans, and the establishment of associated response networks, provide an important foundation for decision-making. However, these efforts are not enough. Written delegation of authority for all lead agency representatives is needed to streamline internal decision-making. Further, state and

federal agencies with environmental compliance oversight responsibilities need to be engaged in all phases of planning and implementation. *Estimated annual funding need is $2 million.*

What is at risk without action?
If a comprehensive rapid response system is not in place, response to new introductions will be slow and inefficient, resulting in the further spread of mussels and perpetual high costs of mitigation.


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

D. Control of Established Populations

Current Approach

Although preventing the spread to new areas remains the priority, there is still a need to focus attention on control and management of quagga and zebra mussels for the protection of native fish and wildlife resources and recreational and economic benefits. Controlling infestations and reducing the population size also helps prevent spread to new areas. Control can be difficult as the volume of water to be treated is usually large, the environmental impacts of the treatment must be acceptable, and the costs may be prohibitive. For established populations of quagga and zebra mussels, there are a variety of control techniques that range in effectiveness, including settling prevention, dessication, mechanical removal, oxidizing biocides, thermal, and biological control.

Challenges with Current Approach

Ongoing control of these mussels once they are introduced to a water body is more costly than prevention and containment measures. Information on current control options for Western waters is poorly summarized and can be time consuming for water managers to track down. A decision tree, summarizing information about what can be done today and on what scale, including reducing the risk of spread and permit information, could expedite many control efforts. Additionally, the tools that are currently available need to be expanded to provide more opportunities for effective, cost-efficient, and environmentally sound control.

CONTROL OF ESTABLISHED POPULATIONS NEEDED ACTIONS

ACTION D1: Open Water Control Tools – Tools that control populations in open water systems are needed for federal, state and private water facilities, irrigators, and others. Since many water systems in the Midwest and East are not open water, many of these tools have not yet been developed. Support is needed to develop and implement protocols for 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. *Initial need $5 million.*

ACTION D2: Closed Water System Control Tools – Improved tools that control populations in closed water systems are also needed. Control methods that work for one system may not work for other systems. Support is needed to develop, evaluate, and implement methods for mussel control in closed water systems that reflect unique conditions and concerns in the West via a coordinated research effort. *Initial need $5 million.*

ACTION D3: Infrastructure Upgrade for Long-term Control of Invasive Mussels – Much has been learned about the construction of systems that are better able to prevent settlement of veligers and easier to clean if infested. However, older infrastructure systems were not built with the control of ANS in mind. As new systems are built, support is needed to implement construction designs to better prevent and control infestations. *Initial need $10 million.*

ACTION D4: Improved Application of Mussel Control Options – In many ways, quagga and zebra mussels in the West are behaving differently than populations in the eastern United States. For example, they are thriving at deeper depths and in warmer waters than predicted. Support is needed to better understand the biology of invasive mussels in the West and to apply this

information through decision support tools to improve application of invasive mussel control options in water-related infrastructure. *Initial need $500,000.*

ACTION D5: Develop Programmatic National Environmental Policy Act Guidance – Control options need to be analyzed for regulatory and environmental compliance, particularly for species that are Threatened or Endangered (state or federal). Quagga and zebra mussel mitigation at water projects may require numerous environmental assessment documents (NEPA, CWA, ESA and others), as current technologies all have biocidal properties. A programmatic NEPA document could allow evaluation of the various treatments or other alternatives and identify appropriate action(s) prior to need for control. *Initial need $500,000.*

What is at risk without action?
Affordable, effective control options must be developed or improved or the number of sites that are infested with this species will increase. Preventing new introductions is the primary goal, but even delaying the spread of these species delays the economic costs and ecological impacts. Without better tools to control quagga and zebra mussel infestations, water delivery costs will certainly increase in the near future and ecological impacts could be significant.


A boat being decontaminated.

E. Outreach and Education

Current Approach

Outreach and education remain critical tools in the fight against invaders such as quagga and zebra mussels. Ignorance is a major impediment to minimizing the spread and impacts from quagga and zebra 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 entire aquatic invasive species issue. Outreach campaigns have been targeted at numerous geographical or jurisdictional levels. The national "Stop Aquatic Hitchhikers!" campaign, that has been used widely throughout the West, was designed to appeal to a broad range of interested parties and covers all aquatic invasive species and actions to prevent their spread and introduction. Current outreach and education strategies in the West include:

- Written materials, e.g. *Zap the Zebra* brochure
- Videos, e.g. *Don't Move A Mussel*
- Audio public service announcements, e.g. *Clark and Lewis – the Wrong Zebra*
- Permanent exhibits and displays
- Billboards and highway signage
- Temporary exhibits and displays, including boat and outdoor show booths
- Signage at boat ramps, marinas, and other access points
- *Stop Aquatic Hitchhikers!* stickers, paperweights, and similar items
- Web sites, e.g. ProtectYourWaters.net and other agency websites
- Slide shows and presentations
- Agency training courses
- One-on-one outreach with individual boaters and other water users

Challenges with Current Approach

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 unexploited. 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 reach of existing programs.

OUTREACH AND EDUCATION NEEDED ACTIONS

ACTION E1: Adopt Consistent Outreach Messaging and Enhance Coordination of Efforts – A consistent message is necessary for informing and educating the public to reduce confusion and increase effectiveness. However, many efforts are already underway that use a variety of messages. This increases the likelihood that boaters and other target audiences encounter divergent, sometimes conflicting messages. Social marketing theories emphasize the need for consistency and repetition. 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. Without coordination and standardization of messaging we risk confusing the public further. *Estimated annual funding need is $250,000.*

ACTION E2: Expand Availability of Existing Outreach Tools – Agencies are struggling to keep up with the increased demand for outreach materials. Additionally, most publications are only printed in English, missing large groups of water users who require access to information in other languages. Support is needed to produce more copies of materials that have already proven to be popular and effective, and translation of those materials so they can be read by all relevant audiences. *Estimated annual funding need is $500,000.*

ACTION E3: Make Better Use of Television and Radio – Numerous studies point to TV and radio as key sources of information for most American residents. However, the high cost of TV and radio advertising has limited the use of these media. Significant gains in awareness about public health and environmental issues have been demonstrated after major TV/radio campaigns. If an investment is made in a high quality, "catchy" TV or radio public service announcement, subsequent air play can be achieved at greatly reduced costs through partnership with media outlets. 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. *Estimated annual funding need is $10 million.*

ACTION E4: Provide More Opportunities for Youth Education – Quagga and zebra mussels are now a permanent problem in the West. 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. *Estimated annual funding need is $2 million.*

ACTION E5: Increase Audience and Effectiveness Assessments – Despite broad recognition that education and outreach are best guided by strong pre-assessment and post-evaluative data, limited budgets rarely support those activities. As the zebra and quagga mussels begin to change the Western landscape, outreach target audiences need to be frequently evaluated to make sure that efforts are effective in stimulating action, both for individual projects, and to measure success at a regional scale. *Estimated annual funding need is $1 million.*

What is at risk without action?
Education and outreach will remain critical components of any effective prevention and detection program. If boaters, anglers, and others associated with mussel introduction pathways lack the information, awareness, and motivation to help stop the spread, regulatory programs alone will not prevent further introductions.

Example of a billboard near Lake Mead, Nevada.

IV. *Research Needs*

A vast amount of research has been conducted on quagga/zebra mussels in North America and Europe. Despite the number of published research findings there are several areas that need to be further developed. The majority of research on Dreissenid mussel control techniques has concentrated on the treatment of mussels in raw water intake systems. There has been little published research of mussel control in open waters. Control of quagga/zebra mussels in large bodies of interconnected waters, which are widespread in the West, is difficult with existing knowledge and technologies. Development of new technologies and methods may be capable of overcoming these difficulties.

Prevention of Spread and Containment of Current Infestations

- Decontamination Efficacy – The effectiveness of various watercraft decontamination procedures needs to be evaluated and recommendations developed.
- Physiological Tolerances – Until the Western water physiological tolerances of quagga and zebra mussels are better understood it will be difficult to know their potential distribution and prepare an accurate water body susceptibility risk assessment.
- Genetic Fingerprinting – 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.

Early Detection and Monitoring

- Early Detection Methodologies – Early detection methods must be improved so that newly infested bodies of water can be quarantined to limit spread to new areas.
- Research for PCR Assays – Further refinement of PCR testing is needed to improve accuracy of test results. Improvements in these technologies, especially in increasing effectiveness and processing time will provide natural resource managers more time to make decisions and possibly offer better opportunities to minimize the spread of new populations to other water bodies.

Rapid Response

- Fast and Reliable Testing for Detection – Rapid, reliable processing of samples and test results is needed to enable a rapid response. Currently, various sample processing methods can take months and techniques need to be refined to handle complex samples.
- Proven Methods for Watercraft Decontamination – It is not known how long microscopic veligers can live and grow in the interior compartments of the boats and there is currently no efficient method for decontaminating those interior boat compartments that carry large volumes of water. None of the current options have been field tested and approved nationally. Exterior boat decontamination methods also need to be tested and proven.
- Reliable and Cost-efficient Control Mechanisms for Water Distribution Systems – Best Management Practices for reliable and cost-efficient control methods for distribution systems must be developed and implemented quickly to avoid the same exponential rate of spread witnessed by eastern states over the last 20 years from happening to the west.

Control of Established Populations

- Research Biological Control – 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 research this potential control.
- Host-specific Parasites – Research focus should be in the discovery of 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.
- Eco-friendly Chemical Control – The development of environmentally friendly control methods needs to continue. Currently, the most widely used control strategy for water users 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. Chlorination is cost-effective and any eco-friendly chemical controls will need to be equally cost-effective if they are to compete with chlorination.

Outreach and Education

- Social Science Research – 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.

V. Concluding Remarks

Failure to act comprehensively against the proliferation of quagga and zebra mussels will result in the eventual infestation of a majority of the freshwater bodies in the Western United States. The spread of invasive mussels, if left unchecked, could occur rapidly, as occurred throughout the Eastern and Mid-Western United States. The costs for control and mitigation of fouling by water users could likely be in the millions, perhaps billions, of dollars every year if mussels become established throughout the West. The ecological impact on aquatic ecosystems is difficult to assess economically, however the damage would likely be severe in many locations. Despite the economic impact of the quagga and zebra mussel invasion, little funding has been appropriated to develop and implement ANS action and management plans and other preventative programs. The Western Regional Panel proposes that if funded and implemented, this plan represents the best strategy toward minimizing future impacts of quagga and zebra mussels across the Western United States.

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

Summary Table of Actions Necessary to Address Quagga-Zebra Mussels in Western Waters (* Indicates a Highest Priority Action).

Prevention of New Infestations and Containment of Existing Infestations	
*Develop Consistent and Reliable Boat and Equipment Decontamination Protocols	Estimated one-time funding need is $1 million
*Develop Consistent Equipment Inspection Protocols	Estimated one-time funding need is $500,000
*Streamline Inspection Protocols Across States	Estimated one-time funding need is $1 million
*Implementation of Mandatory Inspection and Decontamination Stations at Infested Water Bodies	Estimated annual funding need is $20 million
Expand Mandatory Watercraft Inspection and Decontamination Capacity for Uninfested Regions	Estimated annual funding need is $50 million
*Establish and Implement Strong, Consistent Law Enforcement Programs in Each Western State	Estimated annual funding need is $20 million
Develop Programs to Intercept Contaminated Materials and Equipment	Estimated annual funding need is $5 million
Expand Use of HACCP Planning	Estimated annual funding need is $3 million
*Develop a Standardized Model and Strategy for Risk Assessment of Water Bodies	Initial need is $1 million
Early Detection and Monitoring	
*Develop Best Management Practices for Early Detection and Monitoring	Estimated one-time funding need is $500,000
*Expand Early Detection and Monitoring Programs to All Western Jurisdictions	Estimated annual funding need is $40,000
Coordinate Monitoring Programs through the 100th Meridian Initiative	Initial need is $50,000
Rapid Response	
*Create and Maintain a Rapid Response Fund	Estimated one-time funding need is $20 million
*Finalize Notification Database	Estimated annual funding need is $20,000
Complete Rapid Response Plans for all Major Western Water Bodies	Estimated annual funding need is $2 million
Establish Effective Response Personnel Infrastructure	Estimated annual funding need is $3 million
Develop Processes to Expedite Approval of Response Tactics with Short-Term Environmental Impacts	Estimated annual funding need is $2 million

Control of Established Populations	
Open Water Control Tools	Initial need $5 million
Closed Water System Control Tools	Initial need $5 million
Infrastructure Upgrade for Long-term Control of Invasive Mussels	Initial need $10 million
Improved Application of Mussel Control Options	Initial need $500,000
Develop Programmatic National Environmental Policy Act Guidance	Initial need $500,000
Outreach and Education	
*Adopt Consistent Outreach Message	Estimated annual funding need is $50,000
Enhance coordination of outreach and consistency of messaging	Estimated annual funding need is $200,000
Expand availability of existing outreach tools	Estimated annual funding need is $500,000
Make better use of TV and radio	Estimated annual funding need is $10 million
Provide more opportunities for youth education	Estimated annual funding need is $2 million
Increase audience and effectiveness assessments	Estimated annual funding need is $1 million
Development and Research	
Prevention and Containment - *Research and Identify Best Management Practices for Water Managers to Prevent and Minimize Larvae Movement and Settlement Within Water Delivery Systems and Other Water Infrastructure - Decontamination Efficacy - Physiological Tolerances - Genetic Fingerprinting	
Early Detection and Monitoring - Detection Methodologies - Research for PCR Assays	
Rapid Response - Fast and Reliable Testing for Detection - Proven Methods for Decontamination - Reliable and Cost-efficient Control Mechanisms	
Control of Established Populations - Research Biological Control - Host-specific Parasites - Eco-friendly Chemical Control	
Outreach and Education - Social Science Research	