RAPID RESPONSE PLAN FOR INVASIVE AQUATIC MUSSELS AND SNAILS IN ALASKA

UNITED STATES FISH AND WILDLIFE SERVICE
ALASKA REGION, ANCHORAGE ALASKA, MAY 2020

Contents

Photos on cover by Robert Aguilar, Smithsonian Environmental Research Center, New Zealand Mud Snail (left); USFWS, zebra mussels (right)

INTRODUCTION TO INVASIVE AQUATIC MUSSELS AND SNAILS

Zebra mussels *Dreissena polymorpha* and quagga mussels *D. bugensis* or *D. rostriformis* are closely related filter-feeding freshwater mussels in the genus *Dreissena* that have become problematic invasive species in the United States. These mussels produce free-swimming planktonic larvae, known as veligers, which eventually settle out of the water column (known as the settler stage) and attach to hard surfaces. Native to Eastern Europe, they were first discovered in North America in Lake Erie in 1988, and since have spread rapidly throughout North America. They are now found in all of the Great Lakes and many drainages in the Midwest, North Atlantic and Southwestern United States (excerpted and revised from Drahiem et al. 2013). Similarly, the New Zealand mudsnail (NZMS) *Potamopyrgus antipodarum* is an exotic aquatic snail species that is native to New Zealand, but has invaded brackish and freshwater habitats of Australia, Europe, Asia, and North America. In North America, the NZMS was first discovered in the middle Snake River, in Idaho, in 1987 (Bowler 1991). The NZMS has since become established in ten western states, six Great Lakes states and the Canadian provinces of British Columbia and Ontario (Benson 2015 in Poirier 2015).

Dreissenid mussels and NZMS can spread to new water bodies through natural and human-mediated transport. For dreissenid mussels, natural dispersal occurs by larval drift or the overland transport of all life stages attached to or within any object that can float in water. Natural dispersal of NZMS has been observed on the fur and/or feathers of terrestrial wildlife, livestock and waterfowl, or even in the excrement of local fish species (Poirier 2015). Long distance dispersal of dreissenid mussels and NZMS has been attributed to ballast water discharge (Zaranko et al. 1997; Gangloff 1998 in Drahiem et al. 2013), the movement of commercial aquaculture products such as fish, eggs, and ornamental plants (Bowler 1991; Bowler and Frest 1992), and on recreational watercraft, boat trailers, and personal gear such as boots and waders (Johnson et al. 2001, Karatayev et al. 2007 in Drahiem et al. 2013). Dreissenid mussels and NZMS are well adapted for long-distance dispersal. Adult dreissenid mussels are able to survive out of water up to five days in dry environments and for several weeks in wet areas, such as the compartments of boats, motors, trailers, and other conveyances, making overland transport by recreational boaters a high risk vector for the introduction of zebra and quagga mussels into Alaska waters (Johnson et al. 2001, Timar and Phaneuf 2009 in Drahiem et al. 2013). The small size, hardiness and exceptional adaptability of NZMS have likely contributed to the snail's spread within the US. The NZMS shell has a retractable operculum that allows the snail to seal off the shell opening making it highly resistant to desiccation and some pollutants (Richards et al. 2004; Schisler et al. 2008). Larger snails can survive up to 24 hours without water and for several weeks on damp surfaces (Cheng and LeClair 2011 in Poirier 2015).

Many factors contribute to the risk of dreissenid introduction and establishment, including environmental parameters of the waters (e.g., dissolved calcium, pH), and the extent and types of public usage (e.g., total day use, presence of boat ramps and marinas, proximity to transportation corridors, motorized boating, fishing) (Lucy et al. 1999, Frischer et al. 2005, Johnson et al. 2001, Karatayev et al. 2007). Once introduced, pH and calcium concentrations are likely to determine the success of the dreissenid mussels to establish, as these factors are considered critical environmental parameters for dreissenid mussel survival and growth (Hincks and Mackie 1997). Invasive zebra mussel populations in North America require 10 mg Ca^{2+}/l to initiate shell growth and 25 mg Ca^{2+}/l to maintain shell growth. Larval development is inhibited below a pH of 7 (Drahiem et al. 2013). New Zealand mudsnails may inhabit a broad range of natural aquatic ecosystems such as estuaries, rivers, lakes, and reservoirs, as well as man-made systems like hatcheries. They can also tolerate a broad range of temperatures, salinity, turbidity, water velocity, stream productivity and substrate types (excerpted and revised from Poirier 2015 et al. 2013; ANSTF 2007 and references therein). This flexibility has allowed NZMS to successfully colonize and thrive in a wide array of aquatic habitats.

Once established, dreissenid mussels and NZMS can dramatically alter the ecology of a water body and associated fish and wildlife populations. As filter feeders, mussels remove phytoplankton and other particles from the water column and thus shift production from the pelagic to the benthic portion of the water column (Sousa et al. 2009). Native mussels are significantly threatened by the presence of invasive mussels, as invasive mussels will attach themselves to the surface of native mussels, preventing other bivalves from filtering water. This starves out native mussels and can lead to localized extinctions (Drahiem 2013). Dreissenid mussels can also affect dissolved oxygen and calcium carbonate concentrations in waters where they are invasive (Strayer 2009). Similarly, once NZMS establish in a new habitat, lack of natural predators, in addition to high reproductive potential, allow the snail to reach extraordinary densities in some locations. NZMS can form large colonies comprising up to 95% of the total invertebrate biomass, and consume up to 75% of the food resources in a stream (Hall et al. 2003; Hall et al. 2006). Similar to invasive mussels, New Zealand mudsnails often outcompete or displace native snails, mussels, and aquatic insects which native fish species depend on for food. This disruption to the food chain may ultimately result in reduced growth rates and lower populations of economically and culturally important fish species (Poirier 2015). In Alaska, introduction of invasive aquatic mussels or snails could negatively impact the ecology of freshwater systems, displace the three native mussel species in Alaska, and degrade aquatic habitat of important cultural, subsistence, and economic resources such as salmon.

In the contiguous US, dreissenid mussels annually cause substantial economic damage by infesting municipal, industrial, and agricultural water systems and attaching themselves to the hard substrates of pipes, dams, and diversion pathways. This restricts the flow of water through the systems impacting component service life, system performance, and maintenance activities. The annual cost to power plants and municipal drinking water systems in North America has been estimated between $267 million and $1 billion (Connelly et al. 2007, Pimentel 2005). This could be problematic if these species were introduced to Alaska, where 21% of the state's power is generated from hydropower facilities. Understanding the risks associated with introduction of invasive mussels to hydropower facilities is needed. Furthermore, dressenid mussels can have significant impacts on waterfront recreation as well and watercraft recreation, a $587 million industry in Alaska (Dept. of Admin. Division of Motor Vehicles, 2018, National Marine Manufacturers Association report, 2018).

At the time of this report, no known infestations of either dreissenid mussels or NZMS exist in Alaska. However, recent boat inspections conducted by the United States Fish and Wildlife Service (Service) at the Alaska/Canada port of entry (Port of AlCan) during the years 2017-2019 found that of the 226 watercraft inspected at the border, 70% had not been previously inspected in route, and ~38% of these watercraft originated from states with known zebra/quagga infestations. Although work is being done to increase capacity for inspection and decontamination efforts at critical control points, currently most watercraft entering the state go uninspected. This risk, combined with the severe impacts that dreissenid and NZMS could have on ecological, economic, cultural, and subsistence resources in Alaska, underscores the importance taking rapid action if invasive mussels or snails are detected on watercraft or in water bodies of Alaska.

Introduction

This plan will serve as a framework to facilitate quick and effective management response to reports of invasive mussels or snails across Alaska. We emphasize that rapid response refers specifically to urgent actions taken to eradicate founding populations while these populations are still isolated (Department of the Interior 2016). However, in some cases, rapid eradication may not be possible, and rapid response actions may also include urgent actions taken to limit the spread of isolated populations of these invasive species. This document primarily references the mollusks species: *Dreissena sp.* and New Zealand mudsnails, which are thought to be the most likely to invade Alaska waters. However these steps are relevant to responding to any invasive aquatic mussel or snail species detected in Alaska.

The goal of this document is to consolidate information and facilitate communication within the Service, as well as among Service partners. Some actions outlined in this document are specific to the Service and may not be relevant for other agencies or organizations. However, the specific tasks outlined within each step can be modified to reflect the mandates, authorities, and jurisdictions of other agencies or organizations.

The text above is excerpted and revised from:

Drahiem et al. 2013. Oregon Dreissenid Mussel Rapid Response Plan, Center for Lakes and Reservoirs, Portland State University, Oregon Department of Fish and Wildlife, Oregon State Marine Board

Poirier J. 2015. New Zealand Mudsnail Surveys at Lower Columbia River Basin National Fish Hatcheries 2015. Columbia River Fisheries Program Office Annual Report.

☐ STEP 1: ADVANCE PREPARATION FOR INVASIVE AQUATIC MUSSEL OR SNAIL RESPONSE

This step outlines actions that entities should take immediately to increase capacity to respond to a report of dreissenid mussels or NZMS in Alaska. While some of these tasks are specific to federal agencies and the Service, any entity can modify these actions as appropriate to be prepared to respond to invasive mussels and snails in Alaska.

Step 1 Strategic Tasks

1) Familiarize oneself with Federal laws and regulations regarding authorities of the Service to respond to and manage invasive species (Tool 1.1)
    a. The Lacey Act (18 U.S.C 42) authorizes the Service to regulate the importation of species into the US that may be injurious to the welfare and survival of fish and wildlife resources, the interests of agriculture, horticulture or forestry, and the health and welfare of humans. The Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) assigned the Service and other federal agencies responsibility to work with partners, in part, to prevent the introduction and dispersal of aquatic invasive species in waters of the U.S. The Alaska National Interest Lands Conservation Act mandates the Service to maintain the natural diversity of fish and wildlife and their habitats on Service lands in Alaska, and to ensure necessary water quality. In addition, Executive Order 13751 directs Federal agencies to prevent the spread of invasive species in any work they authorize, fund, or carry out.
    b. At the time of this plan, zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis or D. bugensis*) are listed as Injurious Wildlife under the Lacey Act. New Zealand mudsnails are classified as an aquatic nuisance species by the Aquatic Nuisance Species Task Force (Task Force), which is co-chaired by the Service. The Task Force is a formal working group developed through NANPCA as amended by the National Invasive Species Act.
    c. The importation of injurious species is punishable under the Lacey Act (18 USC 42(b)). The corresponding regulations can be found under 50 CFR Part 16.
2) Designate individuals to receive Hazard Analysis and Critical Control Point (HACCP) training. Develop a HACCP plan for Rapid Response to invasive aquatic mussels and snails (Tool 1.2).
    a) HACCP planning is a management tool that provides a structured method to identify risks and focus procedures, and is being successfully used in natural resource pathway activities.
    b) Understanding pathways and developing plans to reduce non-target species and prevent biological contamination is necessary to avoid unintended spread of species.
3) Designate individuals to acquire watercraft inspection and decontamination training.
    a) Several levels of training exist, see Tool 1.2 for additional information.
    b) This is particularly important for National Wildlife Refuges (Refuges) and Fish and Wildlife Conservation Offices (FWCO) located near areas of high concern for an introduction (e.g., those located on the road system). At least one individual from each Refuge/FWCO, including biologists and/or office of law enforcement staff should receive training.
4) Become familiar with the **Clean, Drain, Dry** initiative and ensure that correct decontamination protocols are followed when working in aquatic environments (Tool 1.3).

5) Learn about native Alaska mollusk species as well as identification of invasive snails and mussels (Tool 1.4).
6) Pursue collaborations with local dive shops/SCUBA training programs, as these organizations may be able to provide volunteer divers to assist with survey efforts.

Step 1 Roles and Responsibilities

- Regional funding may be available to support HAACP trainings and Watercraft Inspection and Decontamination trainings for Service staff. Contact the Alaska Region's Regional Invasive Species Program Coordinator, or the Sub-Regional Strike Team Coordinators for further information (Tool 1.5)

Step 1 Tools

Tool 1.1. Regulations and policy relating to invasive species

A compilation of resources regarding regulations of invasive species can be found here

A list of injurious species, which includes zebra and quagga mussels can be found here

Tool 1.2. Training information links

HACCP training information

Link to HACCP template

Information regarding types of watercraft inspection and decontamination programs, with links to trainings can be found here

Tool 1.3. Decontamination protocols

Guidelines for preventing the spread of aquatic invasive species, US Fish and Wildlife Service, Alaska Region, 2018.

Uniform minimum protocols and standards for watercraft interception programs for dreissenid mussels

Tool 1.4. Information to facilitate identification of native and non-native mollusks

Alaska Freshwater Mussel Project

USGS Nonindigenous Aquatic Species Fact Sheet for quagga mussels, zebra mussels, and New Zealand mudsnails

Tool 1.5. Service contacts		
Role	**Name**	**Contact Info**
Regional Invasive Species Program Coordinator	Aaron Martin	aaron_e_martin@fws.gov Cell: (907) 378-0568 Office: (907) 786-3510
Sub-Regional EDRR Projec Manager (interior/northern Alaska)	Lisa Dlugolecki	lisa_dlugolecki@fws.gov Office: (907) 455-1840 Cell: (907) 251-5959
Sub-Regional EDRR Project Manager (southcentral/southwestern Alaska)	Ben Wishnek	benyamin_wishnek@fws.gov Cell: (907)-251-0692

☐ STEP 2: REPORT AND VERIFY SIGHTING

This step outlines the process to report a sighting of suspected invasive mussels or snails and to verify whether the sighting is a known invasive species. Report a suspected invasive mussel or snail as soon as it is observed. If suspected invasive mussels or snails are found on watercraft or floatplanes, immediately decontaminate the craft, even if uncertain of the species. This step provides guidance for sightings made by Service and non-Service employees on and off Service lands.

Step 2A: Take immediate decontamination steps and report sighting within agency

Step 2A Strategic Tasks

1) Decontaminate any watercraft/floatplane with suspected mussels or snails.
   a) Watercraft include non-motorized watercraft (canoes, rafts, kayaks, rowboats, paddleboats, etc.), sailboats, motorized watercraft, jet boats and personal watercraft.
   b) If a watercraft or floatplane is found to have **live or dead** animals suspected to be an adult or juvenile dreissenid mussel or NZMS, ensure that all equipment has been properly decontaminated. Follow procedures outlined in Tool 1.3.
2) Provide initial report to appropriate local and regional contact immediately.
   a) If a sample suspected to be either a dreissenid mussel or NZMS is detected by a Service employee or on Service managed land (or adjacent): report to your local supervisor or their designated alternate (e.g., Field Office Project Leader or Refuge Manager) with initial information AND contact the Service Regional Invasive Species Program Coordinator, or the Sub-Regional EDRR Project Managers. See Tool 1.5.
   b) All detections should also be reported to the Alaska Department of Fish and Game (ADF&G) through: 1-877-INVASIV (468-2748). For reports off of Service lands, also contact the appropriate agency representative. Details Tool 2A.1.
   c) Report any suspected invasive snail or mussel, whether dead or alive. Even the presence of dead animals can compromise future efforts, such as environmental DNA (eDNA) based early detection programs.
3) Collect relevant initial details to help direct additional verification and response stages.
   a) Complete a screening interview to determine the home location of the owner/ operator, the locations where the watercraft was previously used, the date of last use, and if the watercraft has been cleaned, drained, and dried and/or previously inspected in another state or province.
   b) Additional detail to direct the screening interview can be found in Tool 2A.2 and Tool 1.3.

Step 2A Roles and Responsibilities

- The Regional Invasive Species Program Coordinator will ensure the Assistant Regional Directors (ARDs) and appropriate support staff are aware of the situation. The Regional Invasive Species Program Coordinator will also provide an initial notification to the ADF&G Invasive Species Program Coordinator for mussels/snails located on Service lands or for those reported by Service staff.

Step 2A Tools

Tool 2A.1. Non-Service contact information

Agency	Role	Name	Contact Info
Alaska Department of Fish and Game	Invasive Species Program Coordinator	Tammy Davis	tammy.davis@alaska.gov (907) 465-6183
US Customs and Border Protection	Agriculture/Training Supervisor	Kara Cornum	kara.k.cornum@cbp.dhs.gov (907) 271-6313 ext 201
National Parks Service	Regional Wildlife Biologist	David Payer	david_payer@nps.gov (907) 644- 3578
Bureau of Land Management, Alaska State Office	Regional Aquatics Program Coordinator	Matt Varner	mvarner@blm.gov (907) 271-3348
US Forest Service	Alaska Region Fisheries Program Manager	Don Martin	donald.martin2@usda.gov (907) 586-8712
Bureau of Indian Affairs	Natural Resource Manager	Keith Kahklen	keith.kahklen@bia.gov (907) 586-7618
Bureau of Reclamation (Columbia-Pacific Northwest Region)	Regional Hazmat and IPM Coordinator	Heidi McMaster	HMcMaster@usbr.gov Office: 208-378-6209 Cell: 208-860-9649
Department of Defense (Fort Wainwright)	Natural Resource Manager	Dan Rees	dan.c.rees.civ@mail.mil (907) 361- 9318
Department of Defense (Joint Base Elmendorf-Richardson)	Ecologist	Charlene Johnson	charlene.johnson.3@us.af.mil (907) 384-3913

Tool 2A.2. Initial reporting information

1. The initial recipient and reporter should ensure the following information is collected when a report is first made.
2. Date and time of the report.
3. Name and contact information of the report recipient.
4. Date and time of the sighting(s).
5. Name, agency and contact information for the person making the report.
6. Name, agency/entity and contact information of identifying biologist (if any).
7. Details of the location of the snail/mussel sighting (name of the affected water body, landmarks, highway mile, and other identifying details, GPS coordinates, if possible).
8. Description of the surface the organism was attached to or substrate found on/in if appropriate.

Step 2: Report and Verify

9. Other relevant conditions (draw down, low tide, etc.).
10. An estimate of the number, density, extent of the population, number of populations, other organisms in the community.
11. Digital or other photographs (with scale indicator) of an individual, ideally images shot from multiple angles, and images of the population. When possible, include the habitat and/or community in which it was observed.
12. A sample of the live organism if possible
13. Comments (These might include notes about the condition the specimen was in when found, how reporter came across organism, if it had been observed before, access limitation to site, etc.).

Step 2B: Verify sighting

Step 2B Strategic Tasks

1) Verify the species following established protocols from the 100th Meridian Initiative and the Western Regional Panel.
    a) If initial reports are that *Dreissena sp.* veligers are present, then at least two replicate samples should be analyzed with polymerase chain reaction (PCR) techniques to identify and confirm species (see Tool 2B.1)
    b) If one PCR analysis results in a positive identification for dreissenid mussels, at least one other replicate sample should be analyzed to confirm the finding and eliminate the possibility of contamination or laboratory error.
    c) Note that veligers are not present in water bodies year round, and are likely only to be present in Alaska waters during summer months.
2) If the initial discovery is of *Dreissena* sp. or NZMS adults or juveniles, the Regional Invasive Species Program Coordinator should contact a recognized taxonomic expert for species identification. A list of experts can be found at this link; more detail in Tool 2B.1.
    a) NZMS, unlike dreissenid mussels and many other gastropods, produce fully formed juveniles and lack larval forms specialized for dispersal (New Zealand Mudsnail Management and Control Plan Working Group, 2007). Thus, verification of NZMS will only require identification of the adult/juveniles through visual identification or DNA based methods.
    b) Suspect dreissenids/NZMS can be preserved in 90-100% ethanol, which can be used for DNA extraction. If only shells are found, these can be placed into 5-10% formalin solution.
3) Designate the water body status following established protocols outlined in Tool 2B.2 Work with relevant state and federal partners to develop a consensus on water body status designations. This step may need to be completed following Step 4 if additional information is needed prior to making designations.

Step 2B Roles and Responsibilities

- The Service's Regional Invasive Species Program Coordinator, or their alternate, will direct the confirmation process for dreissenid mussels and NZMS on Service lands. The goal is to minimize the possibility of a false positive.
- Service, state, and other federal agencies and Alaska Native groups will work together to make formal water body designations.

Step 2B Tools.

Tool 2B.1. Laboratories performing dreissenid mussel/NZMS identification

The Service Conservation Genetics Laboratory is developing capacity to run PCR based verification of dreissenid mussel/NZMS samples. Contact them for additional information about sending samples for verification:
Service Conservation Genetics Laboratory
1011 E. Tudor Road Anchorage, Alaska 99503 (907) 786-3858

A list of additional laboratories in the United States with the capacity for PCR and cross-polarized light microscopy (CPLM) based verification of dreissenid mussels can be found here:

Laboratories in the United States and Canada that process dreissenid mussel samples (Compiled by the Aquatic Invasive Species Network).
These same laboratories can also be contacted for genetic based identification of NZMS.

Tool 2B.2. Water body designations based on verification outcomes

The following table is drawn from*:* Province of British Columbia. 2015. British Columbia Zebra and Quagga Mussel Early Detection and Rapid Response Plan. This is the classification system established by the Western Regional Panel. An Alaska-specific system is currently under development by the Alaska Invasive Species Partnership.

Table 2B.2. Definitions of water body status and subsequent actions.

Water body designation	Definition and Actions
Unknown	Waters have not been monitored.
Undetected	Sampling/testing is ongoing and nothing has been detected.
Inconclusive – Genetic sample (cross- polarized light microscopy (CPLM) and/or PCR) has only one positive test result	Temporary status of *Inconclusive* is assigned until further lab tests are completed. Further samples are collected if feasible.
Suspect – Positive identification through at least two genetic samples (CPLM and/or PCR)	The water body is given a status of *Suspect;* further samples are collected if required and /or feasible to determine the extent of the colonization and life stages present.
Positive	Multiple subsequent samples meet minimum criteria for positive identification. Moves through rapid response process.
Infested	Water body has an established (i.e., reproducing and recruiting) population of zebra or quagga mussels or NZMS. Moves through rapid response process.

Step 2C: Report verified sighting as appropriate

Step 2C. Strategic Tasks

1) Communicate verified sighting among partners and the public. Communication guidelines provided by the Western Regional Panel are in Tool 2C.1. These are example guidelines only, and final communication decisions should be made by the Response Team.
2) If a water body is confirmed positive or infested, notify the US Geological Survey's (USGS) Nonindigenous Aquatic Species Alert System. See Tool 2C.2. If additional information is needed prior to reporting, report after Step 4 has been completed. Ensure that initial reporting to the Service and ADF&G has been completed (Step 2A) prior to reporting through the USGS System.

Step 2C Tools

Tool 2C.1. Direction for communicating with others based on water body status

Table 2C.1. Agencies and individuals that should be notified under different scenarios.

Water body status	Communication outcome
Unknown	As necessary, communications about which water bodies are not monitored
Undetected	As necessary, communications about which water bodies are monitored
Inconclusive	AIS coordinator notifies key individuals within region (need to know basis, AIS coordinators)
Suspect	Informal or Formal notification within region (western AIS coordinators, public)
Positive	Formal notification system (AIS coordinators, USGS, public)
Infested	Formal notification system (AIS coordinators, USGS, public)

Tool 2C.2. Information to include in the USGS Sighting Report

Based on the information requirements from USGS's NAS alert system, the individual reporting should prepare a briefing statement including answers to the following questions.
Submit HERE.

What are you reporting? Common name, genus, species and an estimate of the number of organisms observed.
When was it found? Date of observation (MM/DD/YYYY)
Where was the observation made? State, county, latitude, longitude, specific location detail where the observation occurred
Who made the observation? Name, email, telephone number, address
Additional comments.
Upload images of the sighting.

☐ STEP 3: FORM INCIDENT RESPONSE TEAM

Due to the risk posed by invasive mussels and snails, any verified sighting of these species will initiate the rapid response process. Upon verification, a designated Incident Response Team will be assembled to determine the appropriate course of action and enact the response. This step provides guidance for assembling this team. Due to overlapping jurisdictions and limited capacity for any one agency to address invasive species efforts statewide, a successful response will benefit from including multiple partners.

Step 3 Strategic Tasks

1) Identify key partners to form the incident response team.
    a) Whenever possible, the response team should be made up of and directed by partners such as Refuge or FWCO biologists local to the area where mussels/snails were sighted, as they have the connections and local knowledge that will best ensure a rapid response.
    b) The team should include private land owners as consulting members to help foster support from affected stakeholders and to serve as liaisons with adjacent landowners.
    c) Identify experts that can provide insight into the response. Experts from other regions that have responded to mussel/snail infestations may be particularly helpful to include. The Service and ADF&G Regional Invasive Species Program Coordinators should both be included on the response team, and can help identify these experts.
    d) Ensure that the response team includes individuals with relevant trainings.
2) Assign leadership, define roles and responsibilities.
    a) Guidance for the minimum leadership roles that should be identified are listed in Tool 3.1.
    b) Other partners may be involved but may not have defined roles or additional roles can be identified to reflect specific circumstances.

Step 3 Roles and Responsibilities

- Alaska Department of Environmental Conservation (ADEC) will need to be involved to issue permits if pesticides will be used.
- Depending on the location of the *suspect*, *positive*, or *infested* water body, private landowners and other parties (Alaska Native organizations, other federal and state agencies) may or may not be directly involved in the response process. However, if mussels/snails or associated response actions could have impacts on lands managed by these agencies or individuals, they should always be included in regular communication.
- Refuge or FWCO staff may still want to engage in a response off of a Refuge if the incident threatens Refuge lands or Refuge resources.

Step 3 Tools

Tool 3.1. Definitions and duties for key leadership roles

1. Response Plan Implementation Coordinator

Tasked with determining the status of the rapid response and monitoring the situation to determine the need for seeking additional involvement and directing the roles of other participating agencies. This individual will direct the situation assessment (Step 4), lead the decision of the response options (Step 5) and the implementation of the response plan (Step 6).

Name: **Agency:** **Contact Information:**

For verified reports on Service lands, this position may be filled by:

Refuge Biologist or Manager/FWCO Biologist or Project Leader

For verified reports not on Service lands, this position may be filled by:

ADF&G Invasive Species Coordinator or
Natural Resource Specialist from appropriate federal/state/local/Alaska Native groups

2. Central Communication Coordinator

Tasked with contacting and informing all of the primary points of contact for local, state, federal agencies, and Alaska Native organizations. Communication with the broader public and the media should go through the Public Communication Coordinator unless the response team decides otherwise.

Name: **Agency:** **Contact Information:**

For verified reports on Service lands, this position may be filled by:

Service Regional Invasive Species Coordinator/EDRR Project Manager, or
Refuge Manager/FWCO Project Leader (or their alternate)

For verified reports not on Service lands, this position may be filled by:

ADF&G Invasive Species Coordinator, or
Natural Resource Specialist from appropriate federal/state/Alaska Native group
(see Tool 2A.1 for contact information)

3. Public Communication Coordinator

The Public Communication Coordinator(s) should deliver timely and consistent messaging to the public and to the media. They should coordinate among agencies, as it is essential to use consistent messages when dealing with the public. Contradictory or conflicting messages weaken public confidence in response actions and decision making.

Name: **Agency:** **Contact Information**

This position may be filled by:

Service External Affairs or respective program outreach staff from the agency leading the response

☐ STEP 4: TAKE RISK REDUCTION ACTIONS AND COMPLETE SITUATION ASSESSMENT

The assembled team should now work together to implement immediate actions that will reduce the risk of spread while the situation is further assessed. This step provides resources to inform risk reduction actions, and also provides a framework for gathering information needed to carry out the actions outlined in Steps 5 – 7.

Step 4A: Risk reduction

Step 4 Strategic Tasks

1) Take risk reduction actions.
    a) The area containing the dreissenid mussels/NZMS should be quarantined as soon as possible. If possible, the best option is to temporarily close the affected area until methods are in place to prevent further spread or eradication.
    b) If it not within an agencies' authority to entirely close a water body, restricting access may be feasible.
    c) See Tool 4A.1 for example risk reduction actions that may be taken (not an exhaustive list). Also note, if the water body is in federally designated Wilderness, some restrictions may apply (outlined in Tool 5.3).
2) Alert the public of the issue.
    a) Making the public aware of the severity of impacts that mussel/snail infestation(s) could have on Alaska waterways, as well as informing them of actions to reduce their spread, is key to minimizing any damage that may be caused.
    b) Tool 2C.1 can provide insight into the appropriate time to inform the general public.
3) Follow best management practices when completing any risk reduction actions (refer to Tool 1.3).

Step 4 Roles and Responsibilities

- The Public Communication Coordinator should facilitate the public outreach campaign that will be necessary to alert and educate the broader public of the issue.

Step 4 Tools

Tool 4A.1. Example risk reduction actions

- All watercraft, floatplanes and other equipment leaving an infested or suspect water body must be decontaminated. Place decontamination stations on site (see Tool 1.3 for further information on decontamination stations).
- Quarantine any hatcheries or aquaculture operations that are likely to spread mussels/snails or their larvae via transfers outside the affected watershed(s). Coordinate with appropriate resource management agencies to pursue access closures of public watercraft, floatplanes, or recreational opportunities if possible. This may be a short-term action until the initial report is verified.
    - Pursue voluntary agreements from floatplane operators to not use affected water bodies.
    - Watercraft and floatplane users using the affected system will need to be identified and interviewed, to determine what their movements were prior to the detection and therefore any potential sites to where the mussels/snails may have also been

spread.

- Install educational information where all visitors will see it. Given concerns with transportation vectors, post signs at all marinas, launch ramps, parking lots.
- Stop or slow water release to potentially uninfested sites.
- If water is needed for irrigation or power generation, draw water from below the thermocline.
- Determine feasibility of using silt curtains or other barriers to close an area or restrict flow.
  - Detail regarding types of physical barriers that may be used can be found in the Columbia River Basin Dreissenid Incident Response Toolkit.
  - Installing such barriers may require additional permits, see Tool 6.1 for detail.
- Mass produce and then widely distribute brochures, pamphlets, signage, install wayside exhibits, and distribute other educational information.

Further detail regarding risk reduction actions that can be taken are also outlined in several Rapid Response Plans developed from other regions. The particular actions that are feasible will depend on the authorities of the agency leading the response, and the particulars of the water bodies affected.

- Zebra and Quagga Mussel Early Detection and Rapid Response Plan for British Columbia
- Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other Dreissenid Species
- Oregon Dreissenid Mussel Rapid Response Plan
- National Management and Control Plan for the New Zealand Mud Snail

Step 4B: Field survey and situation assessment

Step 4B Strategic Tasks

1) Complete field survey to determine the extent of the infestation and understand the non-target species that could be impacted (Tool 4B.1).
   a) The field survey should focus on the water body where the mussels/snails were found, but should also include surveys of adjacent water bodies.
   b) Implement best management practices when completing field survey (Tool 1.3)
   c) Ensure that the survey identifies native mollusks, invertebrates, fish, and other resources that may be impacted by the infestation and any potential treatment actions.
2) Collate information from the field survey and other sources to complete the situation assessment. The situation assessment provides a general outline of all known information about the infestation, and will facilitate the communication and decision making actions in Steps 5-7 (Tool 4B.2).
3) Report verified sighting to local partners, stakeholders, and to the USGS Invasive Species Reporting Database if not previously completed in Step 2, and is relevant.
4) Identify additional partners to include in the response.

Step 4B Roles and Responsibilities

Within response team communication

- The Response Plan Implementation Coordinator will lead the field survey and situation assessment and report back to the Central Communication Coordinator (CCC). The CCC will facilitate disseminating information to the other members of the team.
- Additional agencies may need to be included once the extent of the situation is understood.

Communication with the public

- The Public Communication Coordinator should work with the lead agencies' External Affairs Program to develop a press release and/or hold a public meeting outlining the information that is known. At this step, a full response plan need not be developed, but the public should be aware that actions are being considered.

Step 4B Tools

Tool 4B.1. Direction for field survey for dreissenid mussels/NZMS

See this link for a list of response resources that can facilitate surveys and risk reduction actions.

If a water body is classified as any of the following categories: suspect, positive, or infested with dreissenid mussels it will be necessary to determine the extent of the colonization and the life- stage(s) of dreissenid mussel present in the water body. Assess maturity and spawning condition of mussels at the infestation site(s). See The Western Regional Panel Dreissenid Mussel Sampling and Monitoring Protocol (10/2018)**,** for additional detail.

- The sampling methods used will depend on the season, the location and size/depth of the infested water body. Plankton sampling will be used to verify the presence of veligers, whereas shoreline, substrate and dive surveys can be used to sample for adult dreissenid mussels. Similar protocols to the substrate and diver sampling methods for dreissenid mussels will be effective to detect NZMS. Shoreline surveys can also be effective for NZMS water body assessment.

- Plankton sampling for veligers usually requires the use of a boat. High sampling frequency throughout a water body increases the likelihood of collecting veligers. Sampling should focus on boat launches and marinas, in areas where plankton tend to collect (downstream/downwind), near inflows and outflows, and in nearshore and open water areas.
- Substrate sampling is desirable because it requires minimal cost and effort and can easily be done by private land owners and community groups. A substrate sampler can be deployed in areas of high watercraft or floatplane traffic use, in approximately 8 meters of water. The substrate sampler should then be checked once a month during the growing season (May-October) (see example protocol here).
- SCUBA divers can conduct underwater searches to confirm the location of adult dreissenid mussels. Procedures can be found here.
- Determine dispersal routes of mussles and snails via water flow. Potential methodologies include use of topography/hydrography, hodamine dye studies, interview field personnel.
- Identify the native mussels, snails, fish, invertebrate, bird, and other species that may be impacted by the infestation and any treatment actions. Gaining a thorough understanding of species that could be impacted by response actions is necessary to limit non-target effects.

Tool 4B.2. Situation assessment

The following situation assessment provides a framework to condense information from field surveys. Completing this assessment will facilitate communication among partners and the completion of Steps 5-7. The following information is minimal amount of data needed to inform an effective response plan.

Obtain a detailed bathymetric map of the suspect/positive/infested water body.

ADF&G maintains bathymetric maps for select lakes.

The Service does not have a database of bathymetry data. The Kenai Peninsula is the only region where systematic bathymetry has been done. On Refuge lands, contact the Refuge Supervisory Biologist to determine if any bathymetric data has been collected in association with a specific project.

If no bathymetric data exists, contact ADNR, the Alaska Division of Geological and Geophysical Surveys and/or the Service water resources department to determine capacity to acquire the information.

Identify the size and depth of the infested water body.

Wetland Mapper: https://www.fws.gov/wetlands/data/mapper.html

Google Earth: https://www.google.com/earth/versions/

Identify the distribution of the *invasive* mussels/snails within a water body.

Identify the presence and distribution of *native* mussels/snails within a water body.

Identify other native aquatic species and bird species present.

Identify the life stage(s) of invasive mollusks present. Determine if the population is

breeding.

Assess connectivity of waterway, hydrology, and survey downstream/upstream waterways. Note sources of water inputs, the waterway's drainage area, and any receiving streams or rivers. Determine how frequently the water body fills with new water (i.e., the turnover rate).

Determine the extent of public access.

Note the presence of watercraft access points, floatplane use, other points of public access, and any other obvious pathways for potential spread.

Assess the ability to establish decontamination stations.

Identify facilities that could be affected by an infestation (e.g., hydropower, marinas, fish hatcheries, irrigation systems, etc.).

Determine whether there is a need for law enforcement action or if any additional form of investigation is needed.

Determine additional location specific factors or impacts that should be considered in this location (drinking water wells, surface drinking water intakes, species listed under the Endangered Species Act, subsistence use, presence of other invasive species or species of concern, is the affected area in federally designated Wilderness?).

☐ STEP 5: EVALUATE RESPONSE OPTIONS

In this section we outline the treatment options available to eradicate or control dreissenid mussels and NZMS, and emphasize that an adaptive Integrated Pest Management approach is the preferred strategy for response. At present, there are few options available that have proven successful for eradication. In some instances, risk reduction actions taken to contain the infestation may be the only feasible option. The response team should carefully weigh the information gathered in the previous steps to determine the actions that will most likely lead to eradication and/or most effectively reduce risk of further spread.

Step 5 Strategic Tasks

1) Continue to contain the affected area. See Step 4B for directions on how to establish a quarantine.
2) Select among response options to control/eradicate the infestation (Tool 5.1, Tool 5.2 , and Appendices A and B).
3) Consider any special circumstances of the infestation. For example, if an infestation is located in federally designated Wilderness, additional steps are required (Tool 5.3).

Step 5 Roles and Responsibilities

- Continue to re-affirm roles and responsibilities – who is in charge of each component of the response (e.g., environmental analyses, state and/or federal Pesticide Use Permit/Proposal applications, logistics, etc.). Further detail about permitting can be found in Step 6.
    - The selection of the response option(s) should be led by the Response Plan Implementation Coordinator, but will be made together with the response team. The Central Communication Coordinator will communicate the final decision among members of the team and partners.
    - The Public Communication Coordinator should direct the outreach actions and is in charge of sharing decisions with the public as appropriate.

Step 5 Tools

Tool 5.1. Invasive mussel & snail response options

Dreissenid mussels

Treatment suggestions for dreissenid mussels under differing infestation scenarios can be found in the Columbia River Basin Rapid Response Plan Control Options Appendix. Refer to that document for additional insight into conditions under which particular options may be pursued. Further information about mussel management and control can be found here and in Appendix A of this document.

Options for eradicating or controlling dressenid mussels include physical treatment options (manual removal, engineering options such as water drawdowns, and other tools such as benthic mats and UVB radiation) as well as chemical treatment options. Many of the chemical treatment options available for mussels are appropriate solely for hydropower facilities and water delivery systems, in which fish and other species are not present. Other chemical treatments, which may have lower toxicity to fish and living organisms, are more appropriate for open water situations. An overview of the various options available are included in Appendix A, though only the less toxic chemical treatments that are appropriate for use in open water systems are included. It is the Service's policy that an Integrated Pest Management approach should be used when considering treatment of invasive species. As such, treatment options will likely include risk reduction actions, as well as physical and chemical approaches. At this time, biological approaches for mussel control are relatively untested, and unlikely to be included in a rapid response program.

New Zealand mudsnails
Fewer options exist for NZMS control and eradication. Nearly all responses to NZMS infestations have focused on efforts to limit spreaD. To our knowledge, successful eradication of invasive NZMS populations has not been documenteD. In Appendix B we also present the suite of physical and chemical options that have been used to control NZMS in other states. It is the Service's policy that an Integrated Pest Management approach should be used when considering treatment of invasive species. As such, treatment options will likely include risk reduction actions, as well as physical and chemical approaches. At this time, biological approaches for snail control are relatively untested, and unlikely to be included in a rapid response program.

NOTE: other than manual removal options, none of the treatment options included in Appendix A and Appendix B are species-specific, and non-target native aquatic mussel or snail species are likely to be impacted.
This template provides a framework for evaluating response options and determining the most appropriate options for a given scenario**.**

Tool 5.2. Response options decision template

1. Examine all feasible response options
Based on the information gathered in the site specific assessment, list possible response actions that may be feasible to address this situation:

Examples of potential actions to consider include, but are not limited to:
- Chemical controls
- Containment and other risk reduction actions
- Mechanical controls
- Outreach to user groups
- Targeted signage

2. Decision making: comparing options
Take the response options that were determined to be feasible from the above table, and complete the following table for each option to compare and contrast the best possible action for this infestation. Add more pages as necessary.

	Response Option 1	Response Option 2	Response Option 3	Response Option 4

Step 5: Evaluate response options

What resources would be needed to implement this strategy?	☐ Personnel ☐ Boats ☐ SCUBA ☐ Barriers ☐ Pesticides and applicators ☐ Transportation ☐ Funding	☐ Personnel ☐ Boats ☐ SCUBA ☐ Barriers ☐ Pesticides and applicators ☐ Transportation ☐ Funding	☐ Personnel ☐ Boats ☐ SCUBA ☐ Barriers ☐ Pesticides and applicators ☐ Transportation ☐ Funding	☐ Personnel ☐ Boats ☐ SCUBA ☐ Barriers ☐ Pesticides and applicators ☐ Transportation ☐ Funding
List any other resources that may be needed to address this situation				
Of the needed resources, which are readily available?				
What is the cost estimate for this response option?				
Do any regulations or permitting restrictions apply to this action?				
How feasible is it to meet your response objectives using this response option?				
What precedents exist for using this eradication/control methodology?				

Potential sources of response project resources may include:

Internal

- Fisheries and Conservation Program's Aquatic Invasive Species Allocation
- National Wildlife Refuge System's Invasive Species Base Allocation
- National Fish Habitat Partnership Allocations
- Tribal Wildlife Grant for projects occurring on federally recognized tribal lands
- Wildlife and Sportfish Restoration Allocation

External

- Other US Department of Interior and Department of Agriculture agencies
- State of Alaska agencies such as ADNR, ADF&G, or ADEC
- Alaska Sustainable Salmon Initiative
- National Fish and Wildlife Fund
- Borough Assemblies
- Local governments
- Corporate donations

Tool 5.3. Specific direction for federally designated Wilderness

The Wilderness Act of 1964 established the National Wilderness Preservation System (Wilderness), which today has grown to more than 104 million acres, approximately half of which (~57 million acres) are located in Alaska. The Service manages 21 designated Wilderness areas totaling approximately 18.6 million acres on 10 Refuges units in Alaska.

Table 5.3 Wilderness areas managed by the Service in the Alaska Region.

WILDERNESS AREA	SIZE (ACRES)	REFUGE UNIT
Aleutian Islands (1980)	1,300,000.00	Alaska Maritime NWR
Bering Sea (1970)	81,340.00	Alaska Maritime NWR
Bogoslof (1970)	175.00	Alaska Maritime NWR
Chamisso (1975)	455.00	Alaska Maritime NWR
Forrester Island (1970)	2,832.00	Alaska Maritime NWR
Hazy Islands (1970)	32.00	Alaska Maritime NWR
Semidi (1980)	250,000.00	Alaska Maritime NWR
Simeonof (1976)	25,855.00	Alaska Maritime NWR
St. Lazaria (1970)	65.00	Alaska Maritime NWR
Tuxedni (1970)	5,566.00	Alaska Maritime NWR
Unimak (1980)	910,000.00	Alaska Maritime NWR
Mollie Beattie (1980)	8,000,000.00	Arctic NWR
Becharof (1980)	400,000.00	Becharof NWR
Innoko (1980)	1,240,000.00	Innoko NWR
Izembek (1980)	307,981.76	Izembek NWR
Kenai (1980)	1,354,247.00	Kenai NWR
Koyukuk (1980)	400,000.00	Koyukuk NWR
Selawik (1980)	240,000.00	Selawik NWR
Togiak (1980)	2,270,799.00	Togiak NWR
Andreafsky (1980)	1,300,000.00	Yukon Delta NWR
Nunivak (1980)	600,000.00	Yukon Delta NWR

Step 5: Evaluate response options

The Service has developed guidelines for addressing invasive species in Wilderness areas. **Section 2.19** of the guidelines states the following:

"May the Service control invasive species, pests, and diseases in Wilderness?

The Service will follow an IPM approach to prevent, control, or eradicate invasive species, pests, and diseases subject to the criteria in section 2.16 (also see the Refuge program's biological integrity policy at 601 FW 3.16 for detail about managing non-native species to maintain and restore biological integrity, diversity, and environmental health). The Service will determine appropriate IPM procedures through a Minimum Requirements Analysis (MRA) and document them in the Refuge's Wilderness Stewardship Plan (WSP). If the approved IPM plan determines that chemical or biological treatments are necessary, we will only use agents that have the least impact on nontarget species and on the wilderness environment in compliance with current Service policy. We may make an exception to introducing species (see section 2.17) for Service-approved, nonnative biological control agents."

- In Alaska, all actions taken in Wilderness require an MRA. A short-form MRA has been developed for use only in Alaska. Contact the Service Alaska Wilderness Coordinator for this form and instructions: **Roger Kaye, roger_kaye@fws.gov**.
- If the short-form MRA is not appropriate, particularly if managers are considering a use prohibited by Section 4(c) of the Wilderness Act of 1964, use the Arthur Carhart National Wilderness Training Center's Minimum Requirements Decision Guide (Carhart standard form).
    - The Minimum Requirements Decision Guide can facilitate the completion of the MRA. This guide can help to identify if actions are warranted in Wilderness. Things to consider include whether or not options outside of Wilderness can be taken to address a situation, and if actions are necessary by meeting the following criteria:
        1) Is action necessary to satisfy valid existing rights or a special provision in Wilderness legislation?
        2) Is action necessary to meet the requirements of other federal laws?
        3) Is action necessary to preserve one or more of the qualities of wilderness character: Untrammeled, Undeveloped, Natural, Solitude or Primitive and Unconfined Recreation, or Other Features of Value that reflect the character of this area?

An example Minimum Requirements Analysis case study for non-native invasive plants can be found here, with additional detail. This Alaska Supplement provides assistance in adapting the use of the Minimum Requirements Decision Guide to Alaska's Wilderness units with respect to the Wilderness Act of 1964 and the Alaska National Interest Lands Conservation Act.

☐ STEP 6: DEVELOP AND IMPLEMENT INCIDENT RESPONSE

This step provides the framework to develop an incident response plan, which is a systematic process to direct and enact response actions while ensuring that all involved entities work together and all regulatory permitting needs are met. Several agencies and organizations will likely be involved in implementing the incident response plan.

Step 6 Strategic Tasks

1) Define a clear management goal.
    a. The goal of rapid response efforts should be eradication. In some cases this may not be feasible and alternative goals may be pursued.
    b. At this step it is critical that all members of the response team are aware of and are in agreement with the management goal for the rapid response plan.
2) Draw from existing management plans and eradication projects to inform further actions.
    a. The Aquatic Invasive Species Network has put together a broad suite of resources to inform and facilitate responding to invasive mussels and snails.
    b. Drawing from these established resources to direct response actions will increase efficiency (see Tool 6.1).
3) Review existing environmental documents and acquire regulatory permits (see Tool 6.2 – 6.5). Moving quickly through this step is integral to rapid response.
    a. Identify a qualified individual to oversee all permitting.
    b. If relevant, compliance under the National Environmental Policy Act (NEPA) can take several months to undergo review and approval. Pursue NEPA compliance as soon as possible. In some cases, the Responsible Official (see definition below) may determine that an emergency exists that makes it necessary to take urgently needed actions before preparing an analysis and documentation under NEPA, see Tool 6.3 for detail.
    c. Pesticide Use Permits from ADEC take a minimum of 100 days to complete unless special conditions apply, and Pesticide Use Proposals from the Service may also be needed (Tool 6.4).
    d. Endangered Species Act (ESA) Section 7 may also be required (Tool 6.5).
4) Use the framework provided in Tool 6.6 to develop a response plan. This will include defining a timeline for response, identifying the best qualified individuals to complete each on-the-ground response action, as well as identifying/confirming available resources, among other considerations.

Step 6 Roles and Responsibilities

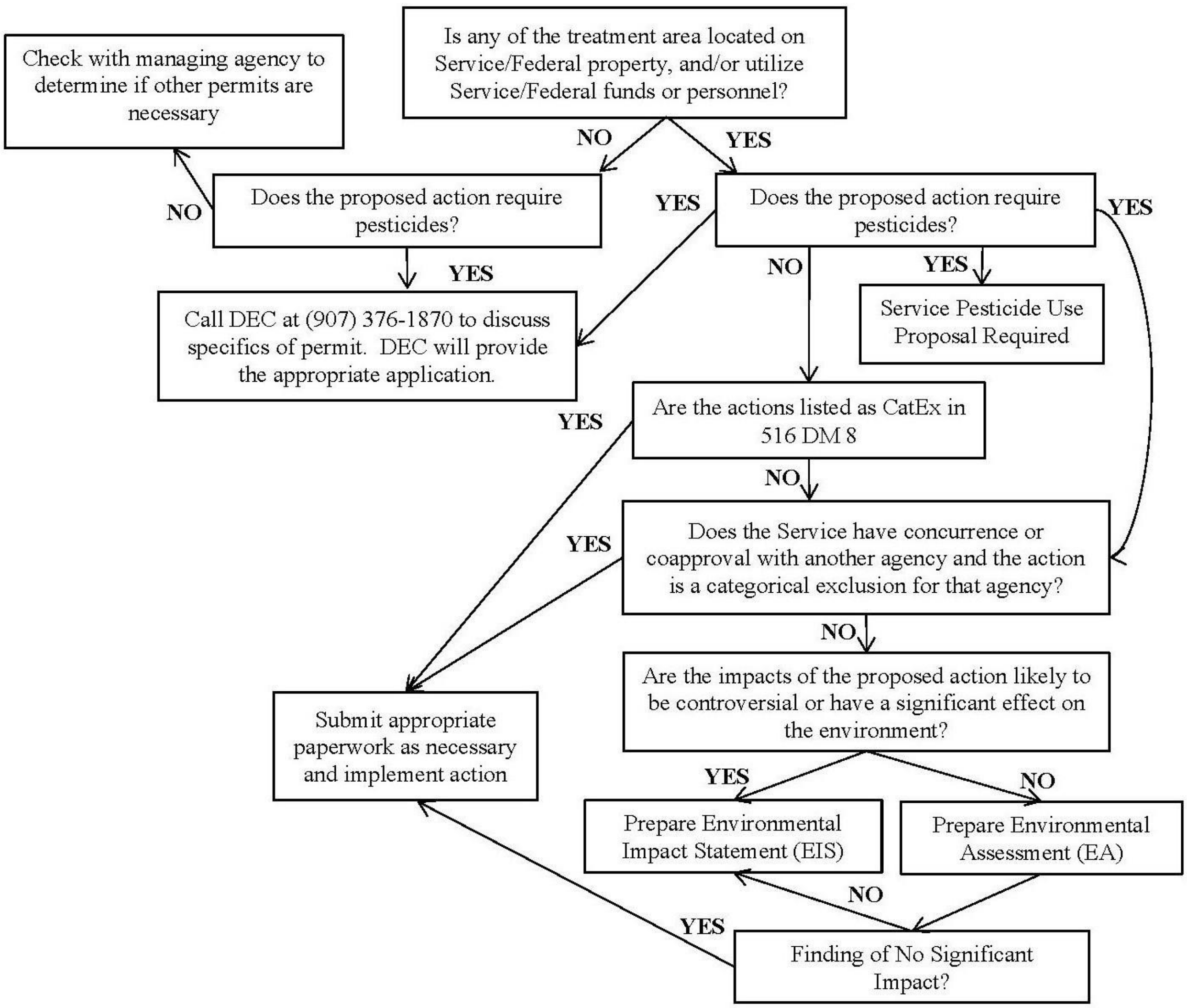
- If needed, the NEPA process should be completed by the managing office (Refuge or FWCO). Relevant documents should be submitted to the Regional Invasive Species Program Coordinator and the Regional IPM Coordinator for review.
- The Regional IPM Coordinator can provide insight into the Service's Pesticide Use Permit process if needed (when the Service funds or applies pesticides, whether on or off Service lands).

Step 6 Tools

Tool 6.1. Existing mussel and snail response plans

A compilation of existing Response Plans for invasive aquatic mussels and snails can be found on the Aquatic Invasive Species Network website under the *Rapid Response* tab. Refer to these plans for additional insight when completing the incident response framework and preparing future integrated pest management plans.

Tool 6.2. Regulatory permitting flowchart



Tool 6.3. National Environmental Policy Act (NEPA)

General Guidance
The National Environmental Policy Act (NEPA) applies when a Federal action would result in an effect on the environment, even when the effect would be beneficial, when a federal agency responds to an outside request for a permit or license, or when federal funds are useD. Prior to completing the following tool, review existing environmental documents. In some cases existing documents can be modified to use for response efforts. The level of environmental analysis required to comply with the NEPA will differ depending on the action proposed and the anticipated impacts. There are three different levels of NEPA documentation. These include:

- **Categorical Exclusion (CatEx)**. If the proposed action is covered by one of the listed categorical exclusions and no extraordinary circumstances apply, no further analysis under the NEPA is requireD. The Department of the Interior and the Service have established a list of categorical exclusions that may cover the proposed action. The Department publishes the list of actions that are categorically excluded in 43 CFR 46.205 and 46.210. The Service's CatEx list is in 516 DM 8. It is not necessary to document that an action qualifies as a CatEx before implementing the action, but in certain circumstances it may be prudent to do so.
  - **NOTE**: For an action where there may be some question about whether it qualifies as a CatEx, we recommend that you create a record that shows how the action qualifies as a CatEx—called an Environmental Action Statement (EAS). An EAS format can be found in: 550 FW 3
  - **NOTE**: If pesticide/herbicide treatment is the proposed action, then CatEX will not apply, and an EA or EIS will need to be pursued.
- **Environmental Assessment (EA).** If the proposed action is not covered by a CatEx, and the impacts of the proposed action are not likely to be controversial or to have a significant effect on the human environment, than you should prepare an EA. If during preparation of the EA you find no significant impacts or impacts can be mitigated below a level of significance through mitigation commitments, then the NEPA review process ends with preparation of a Finding of No Significant Impact (FONSI), and you can implement the action. However, if analyses in an EA indicate that there will be significant or controversial impacts, then you must prepare an Environmental Impact Statement (EIS). If significant or controversial impacts from the proposed action are anticipated, doing an EIS from the beginning (and skipping the EA) may save time and resources.
- **Environmental Impact Statement (EIS).** If the action will have a significant impact on the human environment or will be controversial, an EIS is requireD. Once you complete the EIS, you must develop and issue a Record of Decision that describes the alternative selected for implementation.

Additional detail regarding the NEPA (specific to Service Refuges) can be found here The Service Draft NEPA Reference Handbook can be found here

NEPA guidance for working in cooperation with other agencies
In the Departmental Manual for the Service: 516 DM 8, Section 8.5 (C) (8) states [A Categorical Exclusion Applies for]:

> "Actions where the Service has concurrence or coapproval with another agency and the action is a categorical exclusion for that agency. This would normally involve one Federal action or connected actions where the Service is a cooperating agency."

Contact the Council for Environmental Quality or other NEPA professional for additional questions.

NEPA guidance in emergency situations (§ 46.150 Emergency responses).
This section applies only if the **Responsible Official*** determines that an emergency exists that makes it necessary to take urgently needed actions before preparing an analysis and documentation in accordance with the provisions in subparts D and E of this part.

(a) The Responsible Official may take those actions necessary to control the immediate impacts of the emergency that are urgently needed to mitigate harm to life, property, or important natural, cultural, or historic resources. When taking such actions, the Responsible Official shall take into account the probable environmental consequences of these actions and mitigate foreseeable adverse environmental effects to the extent practical.

(b) The Responsible Official shall document in writing the determination that an emergency exists and describe the responsive action(s) taken at the time the emergency exists. The form of that documentation is within the discretion of the Responsible Official.

(c) If the Responsible Official determines that proposed actions taken in response to an emergency, beyond actions noted in paragraph (a) of this section, are not likely to have significant environmental impacts, the Responsible Official shall document that determination in an environmental assessment and a finding of no significant impact prepared in accordance with this part, unless categorically excluded (see subpart C of this part). If the Responsible Official finds that the nature and scope of the subsequent actions related to the emergency require taking such proposed actions prior to completing an environmental assessment and a finding of no significant impact, the Responsible Official shall consult with the Office of Environmental Policy and Compliance about alternative arrangements for the NEPA compliance. The Assistant Secretary, Policy Management and Budget or his/her designee may grant an alternative arrangement. Any alternative arrangement must be documenteD. Consultation with the Department must be coordinated through the appropriate bureau headquarters.

(d) The Department shall consult with Council on Environmental Quality (CEQ) about alternative arrangements as soon as possible if the Responsible Official determines that proposed actions, taken in response to an emergency, beyond actions noted in paragraph (a) of this section, are likely to have significant environmental impacts. The Responsible Official shall consult with appropriate bureau headquarters and the Department, about alternative arrangements as soon as the Responsible Official determines that the proposed action is likely to have a significant environmental effect. Such alternative arrangements will apply only to the proposed actions necessary to control the immediate impacts of the emergency. Other proposed actions remain subject to NEPA analysis and documentation in accordance with this part.

***Responsible Official** is the bureau employee who is delegated the authority to make and implement a decision on a proposed action and is responsible for ensuring compliance.

Step 6: Develop and implement response

Additionally, the Executive Office of the President's CEQ, has issued the following information regarding Emergency Actions under the NEPA:

In the case of an emergency:

1. Do not delay immediate actions necessary to secure lives and safety of citizens or to protect valuable resources. Consult with CEQ as soon as feasible – Please coordinate any communications with your agency Federal NEPA contacts. (see http://ceq.doe.gov/nepa_contacts/federal.html).
2. Determine if the NEPA is triggered, and the appropriate level of NEPA analysis:
   a. Determine if the proposed action is being taken by a Federal agency (e.g., city or state action does not trigger NEPA; Federal decisions to fund city or state action do trigger NEPA) or is statutorily exempt from NEPA (certain FEMA response actions under the Stafford Act are exempt from NEPA, information is available at: http://www.fema.gov/media-librarydata/20130726-1748-25045-1063/stafford_act_nepa_fact_sheet_072409.pdf).
   b. If the Federal agency proposed emergency response activity is not statutorily exempt from NEPA and the agency has a categorical exclusion (CE) that includes that type of activity, then apply the CE, unless there are extraordinary circumstances that indicate using the CE in this particular case is not appropriate. Agency NEPA personnel should be contacted regarding agency-specific definitions of actions that are "categorically excluded."
   c. If the proposed Federal agency emergency response activity is not statutorily exempt from NEPA a categorical exclusion is not available, and the potential impacts of the proposed response activity are not expected to be "significant" environmental impacts, then an Environmental Assessment (EA) is appropriate. Prepare a focused, concise EA as described in Attachment 2. Alternative arrangements as outlined at 40 C.F.R. §1506.11 do not apply because the environmental impacts are not expected to be significant. Agency NEPA personnel should be contacted regarding agency-specific definitions of "significant" actions.
   d. If the proposed emergency response activity is not statutorily exempt from NEPA, is expected to have "significant" environmental impacts, the agency should determine whether it is covered by an existing NEPA analysis. (e.g., implementing pre-existing spill response plans).
   e. If the proposed emergency response activity is not statutorily exempt from NEPA and is expected to have "significant" environmental impacts, and is not already covered by an existing NEPA analysis, then the agency should consult with CEQ to determine whether "alternative arrangements" can take the place of an Environmental Impact Statement. Contact Ted Boling, Associate Director, 202-395-0827, eboling@ceq.eop.gov to develop alternative arrangements under 40 C.F.R.§1506.11.

Factors to address when requesting and crafting "alternative arrangements" include:

- nature, scope, and duration of the emergency;
- actions necessary to control the immediate impacts of the emergency;
- potential adverse effects of the proposed action;
- components of the NEPA process that can be followed and provide value to decision making (e.g., coordination with affected agencies and the public)

Tool 6.4. Pesticide Use Permits and Proposals

If the proposed action for treating mussel/snail infestations includes the use of pesticides, permits must be obtained from the appropriate state and federal agencies.

Service Pesticide Use Proposals

If pesticides are used on Service property, purchased with Service funds, or applied by Service personnel, a Service employee must complete a Service Pesticide Use Proposal (PUP). Completion of this PUP can be done through the online portal system. Within the portal, users can select to create a new PUP or modify an existing PUP. A Service PUP requires an Endangered Species Act (ESA) consultation. See this link for additional information and instructions for completing the Service Pesticide Use Proposal. Or, for additional information, contact the Service Regional Integrated Pest Management Coordinator:

State of Alaska Pesticide Use Permits

The following are the conditions under which a Pesticide Use Permit from ADEC are required: if pesticides are going to be applied by aircraft, to water, or are being carried out by a state, borough or city agency. Note, additional federal regulations would apply if aerial chemical treatments are pursued, but are not included in this document. These can take up to 100 days to complete, so the application process should be started as soon as possible.

Also note, that any individuals physically carrying out the application of pesticides must have undergone the ADEC Certified Pesticide Applicator Training and have the appropriate relevant endorsement. A list of ADEC approved pesticides can be found here. This list is searchable by pest. Pesticides approved for quagga/zebra mussels as well as aquatic snails are includeD. To obtain an ADEC Pesticide Use Permit, follow the instructions outlined on the ADEC website. Prior to submitting an application, contact ADEC Division of Environmental Health to discuss permitting needs. For questions about permitting, products, or to submit registration for new products, contact:

Role	Name	Contact
Product Registration Specialist	Karen Davidson	karen.davidson@alaska.gov (907) 376-1863
Pesticide Program Manager	Karin Hendrickson	karin.hendrickson@alaska.gov (907) 376-1856

Tool 6.5. Endangered Species Act Section 7 Consultation

The Endangered Species Act (ESA) directs all Federal agencies to work to conserve endangered and threatened species and to use their authorities to further the purposes of the ESA. Section 7 of the ESA, called "Interagency Cooperation," is the mechanism by which Federal agencies ensure the actions they take, including those they fund or authorize, do not jeopardize the existence of any listed species.

The following information was excerpted and revised from:
https://www.fws.gov/endangered/laws-policies/section-7.html
https://www.fws.gov/midwest/endangered/section7/section7.html

Informal Consultation

Under Section 7, Federal agencies must consult with the Service when any action the agency carries out, funds, or authorizes (such as through a permit) *may affect* a listed endangered or threatened species. This process usually begins as informal consultation. A Federal agency, in the early stages of project planning, approaches the Service and requests informal consultation. Discussions between the two agencies may include what types of listed species may occur in the proposed action area, and what effect the proposed action may have on those species.

If the Federal agency, after discussions with the Service, determines that the proposed action is not likely to affect any listed species in the project area, and if the Service concurs, the informal consultation is complete and the proposed project moves ahead. If it appears that the agency's action may affect a listed species, that agency may then prepare a biological assessment to assist in its determination of the project's effect on a species.

Formal Consultation and the Biological Opinion

When a Federal agency determines, through a biological assessment or other review, that its action is *likely to adversely affect* a listed species, the agency submits to the Service a request for formal consultation. During formal consultation, the Service and the agency share information about the proposed project and the species likely to be affected. Formal consultation may last up to 90 days, after which the Service will prepare a biological opinion on whether the proposed activity will *jeopardize* the continued existence of a listed species. The Service has 45 days after completion of formal consultation to write the opinion.

In making a determination on whether an action will result in jeopardy, the Service begins by looking at the current status of the species, or "baseline." Added to the baseline are the various effects – direct, indirect, interrelated, and interdependent – of the proposed Federal action. The Service also examines the cumulative effects of other non-Federal actions that may occur in the action area, including state, Alaska Native, local, or private activities that are reasonably certain to occur in the project area. Contact the Service Endangered Species Coordinator for the Alaska Region for additional help or direction regarding Section 7 consultation.

Role	Name	Contact Information
Regional Endangered Species Program Coordinator	Drew Crane	drew_crane@fws.gov (907) 786-3323

Tool 6.6. Incident response plan framework

The goals and objectives for the response to this infestation. Objectives should be achievable, measurable, and flexible.

The primary objective of rapid response actions should be eradication whenever possible. However, in some cases eradication may not be feasible. In such cases, alternative objectives could include: preventing further spread; containing invasive species in known areas of infestation; protecting human safety. Note, however, ongoing management for chronic infestations is not a rapid response action and should not be listed above as a goal.

Infestation location

Water body name:
Nearest town/city:
GPS Coordinates of water body:

Extent of infestation

What is the approximate size of the impacted area?
Is the water body connected to any other body of water by in/out flows, canals, tributaries, etc.?
Is the body of water used for recreational activities? List activities (e.g., fishing, float planes, etc.)
Are there impediments to accessing the site?

Current Actions

Are there any response actions currently taking place at the infestation site? (Ex: treatment for other invasive species, containment, control activities).

Planned actions

What response action was chosen for this infestation?
What resources are needed for the response?
What resources are readily available?
For resources not readily available, how can they be obtained? What actions are needed to limit non-target impacts?

Permitting and regulations (select those that apply)

- ☐ ADEC PUP required
- ☐ Service PUP required
- ☐ CatEx
- ☐ EA
- ☐ EIS

Step 6: Develop and implement response

- ☐ Section 7 Consultation
- ☐ Minimum Requirements Analysis (for infestations in Wilderness)
- ☐ Other:

Personnel

Who will be the responsible lead(s) in charge of overseeing the entire response action (should be Response Plan Implementation Coordinator established in Step 3)?

Name	Agency	Contact Info.	Role
1)			
2)			

Who will be responsible for acquiring the needed resources?

Name	Agency	Contact Info.	Role
1)			
2)			

Who will be responsible for overseeing outreach and communication to shareholders, partners and the public (should be Public Communication Coordinator established in Step 3)?

Name	Agency	Contact Info.	Role
1)			
2)			

If necessary, who will be responsible for obtaining permits?

Name	Agency	Contact Info.	Role
1)			
2)			

List other individuals directly involved in the response and their roles:

Name	Agency	Contact Info.	Role
1)			
2)			

Funding

What is the estimated level of funding needed to implement this rapid response? What funding sources can be used to support this response effort? Who will be responsible for securing funding for this response effort?

Timeline

When will permits be applied for?
When are permits anticipated to be obtained?
Goal date for implementing action(s)?

☐ STEP 7: EFFECTIVENESS MONITORING

After the response actions have been taken, continued monitoring of the affected and surrounding areas will be necessary to determine efficacy of the response and to observe any non-target effects. Other long-term actions, such as maintaining decontamination stations, may also be required. This step directs these actions.

Step 7 Strategic Tasks

1) Assign leadership to direct long-term monitoring efforts.
    a. The Response Plan Implementation Coordinator may or may not be the individual in charge of long-term monitoring efforts.
    b. The incident response team should identify individual(s) to direct ongoing monitoring and control. Turning over leadership of these efforts to new individuals should occur as applicable.
2) Establish a long-term monitoring plan for areas that have undergone response actions (see Tool 7.1 for example).
    a. This information can be outlined in a larger Integrated Pest Management Plan if one is developed or already exists for the affected area. This plan should include monitoring of efficacy, as well as estimates of non-target effects of treatment.
    b. Monitoring efforts should focus on areas that have undergone response actions, but may also include monitoring or early detection efforts in surrounding areas to verify if the infestation has spread to adjacent locations.
3) Develop a communication plan for long-term monitoring efforts.
    a. Established guidelines exist for determining when an eradication of mussels is considered successful or not. These guidelines are outlined in Tool 7.2.
    b. Similarly, guidelines for long-term monitoring actions required to re-classify a water body as negative, based on the original water body status, are defined in Tool 7.3. These same guidelines can be followed for NZMS infested/positive water bodies.
    c. The guidelines provided in Tools 7.2 and 7.3 should be seen as suggestions and decisions should be made among the Response Team and other state and federal agencies to determine de-listing criteria specific to Alaska waters.

Step 7 Roles and Responsibilities

- The leadership in charge of long-term monitoring efforts should also establish a plan for continued communication with partners and the Service Regional Office, as appropriate. Long-term monitoring efforts may not be directed by the Service.
- Ongoing communication to keep the public apprised of efforts and outcomes will likely be necessary. A Public Communication Coordinator may continue to be assigned to this task.
- Invasive Species Program Coordinators across agencies should work together when making water body classifications.

Step 7 Tools

Tool 7.1. Direction for ongoing monitoring

Several bioassays should be employed to determine the effectiveness of chemical or mechanical treatments. Below is an example bioassay suggested by the Pacific State Marine Fisheries Commission for monitoring treatment efforts in the Columbia River Basin.

Pacific States Marine Fisheries Commission, 2020. The Columbia River Basin Dreissenid Incident Response Toolkit.

Bioassay example

If adult dreissenid mussels are present in a water body, mussel mortality would be assessed via in-situ cage bioassays (Lund et al. 2017). Four cages of ~50–100 mussels per cage would be placed within the treatment area. Cages would be constructed of plastic canvas mesh sheets (1–2 mm openings), anchored to the lake bottom. If the water body is stratified (having a distinct epilimnion, metalimnion, and hypolimnion), additional bioassays representative of the different layers may be appropriate. Live, gaping, and dead mussels would be recorded daily until all mussels are dead or until no additional mussels die over three consecutive days.

Bioassays may need to be conducted with proxy species because some jurisdictions may not allow the use of adult dreissenids, particularly if the initial detection was a veliger detection, and no presence of adult mussels was detected.

Tool 7.2. Guidelines for long-term monitoring actions

Table 7.2. Actions and associated outcomes to direct long-term monitoring efforts.

Outcome	Actions
Eradication successful	Long-term monitoring for a minimum of 5 years will be required to ensure treatment success and no re-infestation has occurred.
Unsuccessful eradication; continued rapid response or enter long-term containment.	Adjust the objectives and treatments of the rapid response plan and continue to attempt eradication.
Unsuccessful eradication; focus on long-term containment.	Eradication is not considered feasible. Focus on containment of infestation to a limited number of water bodies.

Table 7.3. Duration of long-term monitoring efforts that must be completed before re-classifying a water body as negative, given the original water body status.

Original water body status	Actions for re- classification
Undetected/Negative	No long-term monitoring required.
Inconclusive	Minimum of one year of negative testing including a sample taken in the same month as the initial positive sample.
Suspect	Three years of negative testing
Positive	Five years of negative testing and final report is prepared.
Infested	Following a successful eradication event, a minimum of five years of testing with negative results.

Tools 7.2 and 7.3 were drawn directly from the Zebra and Quagga Mussel Early Detection and Rapid Response Plan for British Columbia and reflect guidelines developed by the Western Regional Panel on Aquatic Nuisance Species.

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APPENDICES

Appendix A. Control options for dreissenid mussels

PHYSICAL TREATMENT OPTIONS

Combinations of the following physical treatments may be used, and multiple treatments may be necessary.

Manual removal

Information in this section is from Culver et al. (2013) in the Pacific States Marine Fisheries Columbia River Basin Response Toolkit. Removal, either by hand or another mechanical method, can potentially eradicate dreissenid mussels when 1) the structure from which mussels are being removed lends itself to this technique, and 2) when mussels are concentrated within specific areas of a water body or on particular infrastructure within it. Mussel populations can successfully be eradicated using this strategy only if 1) no additional larval or juvenile/adult mussels enter the water body from infested waters (aqueduct or reservoir) and/or boat traffic, and if enough mussels are removed to reach the point where the population can no longer sustain itself. Removing enough mussels to limit population recruitment can be difficult, due to the mussels' ability to inhabit inaccessible places, limiting removal efforts and increasing chances that individuals will survive. In areas where most of a water body is inaccessible, a combination of manual and other tactics will likely be most effective. Likewise, if the infested area is large (>20,000 square feet), a combination of oxygen deprivation using tarps and manual/mechanical removal may be useful.

The steps taken during manual removal include organizing divers, training divers, determining the distribution of mussels, conducting pre-implementation surveys, preparing the target site, manually removing the mussels using hand-held tools, collecting the mussels, disposing of the mussels, decontaminating personnel and gear, and evaluating tactic success. For more information on the specific steps associated with manual and mechanical removal of aquatic invasive species, California Sea Grant has developed an information sheet (2013) for educational purposes.

Benthic mats

Benthic mats are large, dark tarps anchored to the bottom of a water body to control invasive mussels by restricting water flow, oxygen and food from the mussels beneath the mats, and blocking light to prevent photosynthesis from producing oxygen beneath the mats. In some cases they prevent veligers from spreading. Benthic mats were used by the Texas Parks and Wildlife Department to treat Zebra mussels in Lake Waco, Texas beginning in 2014 to address an isolated area of zebra mussel infestation. The tarping appears to have been mostly effective. A few animals were found upon tarp removal, but no DNA has been detected and no suspect veligers have been collected from the lake in the years following (Smith 2017).

Intense Ultraviolet-B and Ultraviolet-C Radiation

Ultraviolet (UV) radiation is an effective method for controlling zebra mussels in all life stages, although veligers are more sensitive than adults. Complete veliger mortality can be obtained within 4 hours of exposure to UV-B radiation, and adult mortalities can also be obtained if constant radiation is applieD. UV radiation can be harmful to other aquatic species, and its effectiveness may decrease with turbidity and high suspended solids loads (Wright et al. 1997).

Doses as low as 26.2 mJ/cm^2 and 79.6 mJ/cm^2 can decrease survival of pre-settlement stage larvae by nearly 50% and 80%, respectively, within 4 days of exposure (Stewart-Malone et al. 2015).

The use of UV light to control larval dreissenids in industrial cooling water systems is well documented (Pucherelli and Claudi 2017). To reduce environmental effects, lower costs, and avoid the need for discharge permitting, UV light irradiation can be used to prevent or limit mussel colonization in industrial facilities, and can be used in water bodies in combination with treatments targeted at adult *Dreissenid*s. Site-specific characteristics, such as the ability of the water to transmit UV light, suspended solids, and flow conditions, affect the efficacy of this treatment (Pucherelli and Claudi 2017). This technique requires continuous UV light application for up to 120 hours, and is considered only partially effective in killing larval dreissenids.

The UV light is applied using watercraft and submerged UV light panels, which are raised and lowered in the water column to target larval dreissenids.

Water Level Management

Sudden water-level drawdowns during winter conditions can temporarily reduce dreissenids in impounded river sections, although this type of control is a method to temporarily reduce large numbers of adults (Leuven et al. 2014). Freezing air temperatures are highly lethal to zebra mussels within a matter of hours (Grazio and Montz 2002). Water drawdowns occur when managers decrease the maximum depth in a water body that has adequate water level control structures (Grazio and Montz 2002). Winter water drawdowns were used to treat Lake Zumbro, Minnesota, and Edinboro Lake, Pennsylvania, in 2000 and 2001. Although complete mortality of invasive mussels was observed in drawdown areas (1.5-meter drawdowns), mussels successfully overwintered in water deeper than the maximum drawdown depth (Grazio and Montz 2002). A drawdown of Ed Zorinsky Reservoir (Zorinsky Lake), Nebraska, in the winter of 2010 resulted in the eradication of zebra mussels within the lake, and the lake was refilled and re-opened for recreation in 2012 (Hargrave and Jensen 2012). Zebra mussel veligers were detected in May 2016, however, adult mussels have not been observed.

Total elimination of dreissenids with this management technique is unlikely, and the potential costs and benefits before attempting fall/winter lake drawdowns for zebra mussel control should be evaluated on a site-by-site basis.

CHEMICAL TREATMENT OPTIONS

Some chemical treatments are appropriate solely for hydropower facilities and water delivery systems, in which fish are not present and the water can be treated before being releaseD. Other chemical treatments, which may have lower toxicity to fish and living organisms, are more appropriate for open water situations. This document includes the treatment options most likely to be used in open-water systems. For example, oxidizing biocides (i.e., chlorine, bromine, hydrogen peroxide, ozone, and potassium permanganate) and non-oxidizing compounds (proprietary molluscicides; i.e., Clam-Trol, Bulab, and Bayluscide) are potential chemical options for treating dreissenid mussels. Although these aforementioned chemical treatments may be effective, they are highly toxic to other aquatic species, including fishes, and are not included in the list of potential treatment options, as they do not represent likely treatment options in open-water situations.

Appendix A

Muriate of Potash

In areas where non-target species are present, the most likely product to be used, based on least toxicity to aquatic life as well as cost, is potash. Potash is a common plant fertilizer which is largely comprised of potassium salts. Forms used to treat dreissenids include potassium chloride (KCl), potassium hydroxide (KOH), and potassium sulfide (K2SO4). Potassium fertilizers used in agriculture have been shown to precipitate salts when applied in large quantities and/or through time, which can cause salinity problems in spoils (Magen 1996). There is little information on the effects of potassium applied directly to water, however, increased nutrient loading is the anticipated outcome. Irrigation systems cause compound leaching over time and allow precipitates to accumulate in soils (Burt and Isbell 2005).

Toxicity

Potassium ions interfere with the respiration of dreissenids at the gill surface (Fisher et al. 1991, Aquatic Sciences Inc. 1997). Acute lethal effects of potash on juvenile brook trout (*Salvelinus fontinalis*) and juvenile Chinook salmon (*Oncorhynchus tshawytscha*) are not expected at concentrations used to control dreissenids (Densmore et al. 2018). In fact, exposure concentrations of eight times greater than the dose of KCl used as a molluscide (800 mg/L) in a static system during a 96-hour period resulted in no mortality, and no behavioral, histological, or gross morphological effects on fish of either species (Densmore et al. 2018). Significant mortality among sensitive aquatic invertebrates, such as water fleas (Daphniidae), has been observed (Densmore et al. 2018). Other invertebrates, such as crayfish (*Procambarus* spp.), demonstrate some degree of sensitivity to KCl (Densmore et al. 2018). For example, crayfish exposed to KCl at higher concentrations (e.g., 800 mg/L–1,600 mg/L) for at least 24 hours experienced immobilization, but half were able to fully recover in fresh water within 24 hours (Densmore et al. 2018). Further analysis is needed to fully realize the threats to crayfish and other invertebrate species from KCl. It is important to note, however, that Alaska does not have any native species of crayfish. Native mussel species would be affected by this treatment. Liquid potash was successfully used, with 100% effectiveness, to eradicate zebra mussels from the Millbrook Quarry in Virginia, USA (Fernald and Watson 2014).

Potash Application

Potash consists primarily of potassium chloride (KCl). Potash is not a registered pesticide in the United States and requires a Section 18 FIFRA Pesticide Emergency Exemption from the EPA to allow its use. Target application rates are 95–115 mg/L (KCl), $\leq$ 10 mg/L (KOH), and 160 - 640 mg/L (K2SO4). Applications may be made at the surface, mid-depth, or deep waters to ensure appropriate mixing and to maintain the desired concentration throughout the treatment area. Potash can be applied up to 21 days after mixing to achieve desired effectiveness. Equipment includes High Density Polyethylene storage tanks with spill containment to protect against spills and ensure a constant supply of stock solution. A stock solution of about 12% potassium is mixed by a chemical supplier and delivered to the site on an as required basis where it is transferred to the storage tanks and kept in solution by an electric tank mixer. The quantity of metric tons of KCl required to treat the site is estimated in advance based on the size of the contained portion of the water body.

Water-based operations use a work boat outfitted with a specially designed diffuser assembly. Stock solution from the shore-based storage tanks continuously feed the diffuser through a floating 3.8 cm (1.5 in.) diameter supply line and shore-based centrifugal pump transfer system. Proper diffusion of potassium is a critical element of the treatment method.

Treatment proceeds on a systematic basis by separating the cordoned off areas into segments or treatment zones delineated by water depth. The work platform-based retractable diffuser assembly consists of perforated vertical flexible hoses having capped and weighted ends attached to the horizontal section. This allows for an enlarged mixing zone to be achieved while the flexible hose reduces damage due to submerged obstacles. An echo sounder is used to monitor water depth and the depth of the submerged diffuser assembly to maintain an optimum height above the bottom of the water body. This system also reduces the risk of entangling the diffuser assembly on bottom features.

To ensure the potassium diffusion system is operating efficiently and is attaining target potassium concentrations throughout the treatment zone, potassium spot monitoring is completed during each charge operation. This provides personnel with information on how quickly and how well the potassium is dispersing through the treatment zone. This information can be used to modify the treatment protocol, either by increasing or decreasing the dosing rate to achieve target concentrations. Following the "charge" activities, a final sampling exercise is conducted throughout each cordoned off area to characterize potassium concentrations at various depth profiles. Monitoring points at each enclosed area are spaced depending on the width of the enclosed area at each transect location. Sites are monitored along each transect to ensure feasible and maximum monitoring coverage of the treated transect area. Duplicate samples are collected and analyzed for every tenth sample for quality assurance and quality assurance/quality control (QA/QC) purposes.

To determine the potassium concentrations, water samples are obtained by two different methods. Surface grabs are conducted where water depths are less than 2 m and are collected at least 0.15 m below the surface. A peristaltic pump, or Kemmerer bottle, is used to collect samples from each thermocline present in the sectioned off area and at depths greater than 2 m. Samples are analyzed with a concentration meter, in combination with a potassium probe. Sample identification, location, depth, date, GPS coordinates for each monitoring point, and other pertinent information is recorded in a field logbook and on reporting log sheets. The field instruments are calibrated prior to use every day with standards of known value. Monitoring is conducted daily throughout a 12-hour shift.

EarthTec QZ™

EarthTec QZ™ is a copper-based algaecide/bactericide (a formulation of copper sulfate pentahydrate) labeled to control zebra and quagga mussels. EarthTec QZ™ is registered in all 50 states as an algaecide/bactericide and in Montana and Washington as a molluscide. EarthTec QZ™ is documented as achieving 100% mortality of mussels when exposed to the product for 96 hours (Watters et al. 2013). The product can be spread on the surface of a water body or pumped into a water body, and disperses rapidly. EarthTec QZ™ is a liquid formulation that is miscible in water and has ionic diffusion properties that cause it to readily disperse throughout the water column. The product's active ingredient is delivered in the cupric ion form—a biologically active form of copper (Watters et al. 2013). EarthTec QZ™ does not have any degradation byproducts, and no adjuvants or surfactants are used in the application.

Toxicity

Lethal dose and exposure time of zebra mussels to EarthTecQZ™ had been identified under laboratory conditions (Watters et al. 2013, Claudi et al. 2014). The cupric ion (Cu2+) form of copper is considered the most toxic form of copper to aquatic life because it is the most bioavailable (Eisler 2000, Solomon 2009). In addition, the cupric ion form of copper is more lethal in soft water compared to hard waters rich in cations because cations reduce its bioavailability (Pagenkopf 1983, Paquin et al. 2002). The toxicity of copper to fish and other aquatic life depends on its bioavailability, which is strongly dependent on pH, the presence of dissolved organic carbon (DOC), and water chemistry, such as the presence of calcium ions.

- Juvenile Rainbow Trout (*Oncorhynchus mykiss*) were exposed to either hard water or soft water spiked with copper for 30 days (Taylor et al. 2000). Fish in the hard-water, high dose (60 µg/L) treatment groups showed an increased sensitivity to copper.

- The mean 96-hour LC50 (with 95% confidence limits) for copper exposure in alevin, swim-up, parr and smolt steelhead (*Salmo gairdneri*) is 28 (27–30), 17 (15–19), 18 (15–22), and 29 (>20) µg/L of copper, respectively (Chen and Lin 2001). The mean 96-hour LC50 for copper exposure in alevin, swim-up, parr, and smolt Chinook Salmon (*Oncorhynchus tshawytscha*) is 26 (24–33), 19 (18–21), 38 (35–44), and 26 (23–35) µg/L of copper, respectively. The experiments were done by adding copper as copper sulfate.

- Aquatic snails (*Biomphalaria glabrata*) had a 24-hour and 48-hour LC50 (with 95% confidence intervals) of 1.868 (1.196–3.068) and 0.477 (0.297–0.706) mg/L Cu, respectively (de Oliveira-Filho et al. 2004).

- 1-day-old freshwater snail eggs (*Lymnaea luteda*) were exposed to copper at concentrations from 1 to 320 µg/L of copper for 14 days at 21 °C in a semi-static embryo toxicity test (Khangarot and Das 2010). Embryos exposed to copper at 100 to 320 µg/L died within 168 hours. At lower doses from 3.2–10 µg/L, significant delays in hatching and increased mortality were noted.

EarthTec QZ™ Application

Application methods vary depending on the scale of project. It is applied at a rate of up to 2 mg/L, not to exceed 0.1 mg/L total copper. Concentrations may be held constant up to 30 days (depending on dose) to achieve effective treatment for all dreissenid life stages. EarthTec QZ™ copper is highly water soluble and does not precipitate. The product remains suspended until uptake by bacteria and algae occurs (Master Label for EarthTec QZ™, EPA Reg. No. 64962-1). Dispersion into the water body quickly reduces concentrations to below effective levels outside of the isolated treatment area.

EarthTec QZ™ is applied near the water surface and allowed to disperse, or is delivered via hose and pump to the depths, sites, and surfaces of the area of infestation. When applying to large areas, it is dispensed along a route with gaps no greater than 200 feet. Generally, when fish are present, no more than one-half of the body of water is treated at a time, starting near one shore and moving outward in bands to allow fish to move away. When treating half of a body of water, the second half must not be treated within 14 days from the last treatment. For effective control of adult and juvenile mussels, it is applied at the recommended rate of 2–16 parts per million (i.e., 2–16 gallons of EarthTec QZ™ per million gallons of water) to yield a rate of 0.120–0.960 mg/L (ppm) metallic copper. A total of at least four days is required for mortality of dreissenids to occur. Colder water temperatures may require longer exposures and doses closer to the high end of the allowable range. Within the half of the water body being treated, repeat applications may be needed to maintain lethal concentrations of copper for a sufficient time period. The second half of the water body is not treated within 14 days of the last treatment of the first half. Effective control can also be achieved by longer exposures (e.g., 5–30 days) at lower doses (1–5 parts per million EarthTec QZ™, to yield a rate of 0.06–0.30 mg/L (ppm) metallic copper.) When reapplying, a concentration of 1.0 mg/L (ppm) metallic copper in the treated water is not exceeded.

Zequanox®

Zequanox® is a biopesticide consisting of the dead bacterial cells of *Pseudomonas fluorescens* strain CL145 A that, when ingested by zebra and quagga mussels, destroy the digestive lining (https://marronebioinnovations.com/molluscicide/zequanox/). Prior to beginning chemical treatment, the area to be treated is sealed off using non-permeable geotextile membranes, creating a contained open water body. Zequanox® is maintained at a rate of 100 mg/L for up to eight hours; treatments are often repeated, although the label recommends no more than four Zequanox® applications annually.

Toxicity

Zequanox® is a potential tool for controlling dreissenids in shallow water habitats in lakes without significant long-term effects on water quality (Whitledge et al. 2014). However, this biopesticide does cause temporary, but substantial, reductions in dissolved oxygen because of the barriers that prevent well-oxygenated water from circulating into treatment zones (Whitledge et al. 2014).

Exposure to Zequanox® caused no mortality to blue mussels (*Mytilus edulis*) or any of six native North American unionid clam species (*Pyganodon grandis, Lasmigona compressa, Strophitus undulatus*, *Lampsilis radiata, Pyganodon cataracta*, and *Elliptio complanata*) (Bureau of Reclamation 2011). Exposure of duck mussel (*Anodonta* spp.), non-biting midge (*Chironomus plumosus*), and white-clawed crayfish (*Austropotamobius pallipes*) to Zequanox® in a 72-hour static renewal toxicity test at concentrations of 100–750mg active ingredient/liter resulted in LC50 values for Anodonta: >500mg active ingredient/liter, *C. plumosus*: 1075mg active ingredient/liter, and *A. pallipes*: >750mg active ingredient/liter, demonstrating that Zequanox ® does not negatively affect these species at concentrations required for greater than 80% zebra mussel mortality (i.e., 150mg active ingredient/liter) (Meehan et al. 2014).

Nicholson (2018) conducted a replicated aquatic mesocosm experiment using open-water applications of Zequanox® (100 mg/L of the active ingredient) to determine the responses of primary producers, zooplankton, and macroinvertebrates to Zequanox® exposure in a complex aquatic environment. Short-term increases occurred in phytoplankton and periphyton biomass (250–350% of controls), abundance of large cladoceran grazers (700% of controls), and insect emergence (490% of controls). Large declines initially occurred among small cladoceran zooplankton (88–94% reductions in *Chydorus sphaericus, Ceriodaphnia lacustris,* and *Scapheloberis mucronata*), but abundances generally rebounded within three weeks. Declines also occurred in amphipods (*Hyalella azteca* - mean abundance 77% less than controls) and gastropods (*Viviparus georgianus* - survival 73 ±16%), which did not recover during the experiment. Short-term impacts to water quality included a decrease in dissolved oxygen (minimum 1.2 mg/L), despite aeration of the mesocosms.

Zequanox® Application

Products are mixed in tanks and injected at the water surface. Following treatment, monitoring occurs every 1–2 days for 14 days post-treatment. Monitoring consists of collecting surface water samples at various locations inside the treatment area. Samples are submitted for analysis by mass spectroscopy, with results reported within 1–2 days. Portable meters are used to inform bump applications in the field.

During the Zequanox® application, concentrations are estimated using turbidity measurements, on the first and last day of treatment application. Monitoring of concentrations is of limited utility because the active agent in Zequanox® is degraded within 24 hours after it is added to water (Molloy et al. 2013).

Rhodomine Dye

There are water tracers that are carcinogenic, genotoxic, or ectoxic (carcinogenic substances have the potential to cause cancer; genotoxic substances have the potential to damage genetic information within a cell, causing mutations, which may lead to cancer; ecotoxic substances have the potential to place biological, chemical, or physical stressors on an ecosystem). Fluorescent dyes that demonstrate no effect on genotoxicity or ecotoxicity are classified as safe for use in water tracing (Behrens et al. 2001). Rhodamine dyes (aminoxanthenes) are used as hydrologic tracers in surface water systems (Runkel 2015). Rhodamine dyes are synthesized by reacting 3-dialkylaminophenols with phthalic anhydride (Ismael et al. 2013). Rhodamine WT is water soluble, highly detectable, and fluorescent in a part of the spectrum not common to materials commonly found in water, harmless in low concentrations, and reasonably stable in aquatic environments (USGS 1986). Domenico and Schwartz (1990) described rhodamine WT as a conservative, ideal tracer because it does not react with other ions or the geologic medium to any appreciable extent.

Toxicity

Molinari and Rochat (1978) concluded there is relatively low ecotoxicological risk from rhodamine; WT. Smart (1984) concluded rhodamine WT is a severe irritant to the eye and moderately irritating to the skin. Nestmann and Kowbel (1979) documented rhodamine WT was mutagenic in the Salmonella typhum/mammalian microsome Ames test. Douglas et al. (1983) concluded rhodamine WT does not represent a major genotoxic hazard because it was weak in vitro mutagenicity using very high dye concentrations.

In aquatic ecosystems, larval stages of shellfish and algae are most sensitive to fluorescent dyes (Smart 1984). However, Rhodamine WT does not affect development nor cause mortality in shellfish eggs and larvae after 48 hours exposure, and dye concentrations as high as 1 mg/l can be tolerated for two days without damage to aquatic organisms (Smart 1984). Fairy shrimp, *Thamnocephalus platyurus*, had a toxicity of EC50 24 hours: 1,698 mg/L-1. A total of 48-hour exposures at 24° C of 11,000 Pacific oyster (*Crassostrea gigas*) eggs per liter and 6,000 12-day-old larvae per liter, in sea water with concentrations of rhodamine WT ranging from 1 μg/l to 10 mg/l, resulted in development of the eggs to normal straight-hinge larvae and no abnormalities in the larvae development (Parker 1973). Coho salmon (*Oncorhynchus kisutch*) and Donaldson rainbow trout (*Oncorhynchus mykiss*) held for 17.5 hours in a tankfull of sea water with a dye concentration of 10 mg/l at 22°C showed no mortalities or respiratory problems (Parker 1973). A concentration of 375 mg/l, and extended time of an additional 3.2 hours resulted in no mortalities or abnormalities (Parker 1973). The fish remained healthy in dye-free water when last checked one month after the test. Researchers exposed a number of freshwater and brackish water invertebrates, including water flea (Daphnia magna), shrimp (*Gammarus zadIlachl*), log louse (*Asellus aquaticus*), may fly (*Cloeon dipterum*), and pea mussel (*Visidium* spp.), to water containing up to 2,000,000 μg/L of rhodamine WT for periods of up to 1 week. No significant differences in mortality between the test and control animals were observed (Smart and Laidlaw 1977).

Dye concentrations for water tracing purposes are low enough to exert almost no toxic impacts on water fauna, including fairy shrimp, water fleas (*Daphnia magna*), horned planorbis snail (*Planorbis corneus*), and guppy fish (*Poecilla reticulata*) (Rowinski and Chrzanowski 2011).

The lethal dose of rhodamine WT in rats is 25,000 mg kg-1 (Field et al. 1995). The oral lethal dose for humans is estimated to be 25,000 mg kg -1 d-1, which would require an adult to ingest 875,000 mg l-1 of rhodamine WT for a dose of 25,000 mg kg-1 d-1 to be achieved (Field et al. 1995). Field et al. (1995) tested the possible ecotoxicity effects of 12 water tracer dyes, including rhodamine WT, on human health. They concluded rhodamine WT has no skin absorption, has limited oral uptake, has inadequate data on carcinogenicity, and poses little concern for both oncogenic and mutagenic effects as well as little concern for chronic toxicity, including liver and kidney effects.

Ecological toxicity structure-activity relationship (SAR) concerns for rhodamine WT are as follows: Fish (96 hours LC50) > 320 mg 1-1a; Cladocera (48 hours LC50) 170 mg l-1a; Green algae (96 hours EC50) 20 mg l -1. The high LC50 demonstrated for aquatic organisms indicate unlikely serious effects on groundwater fauna from 1-2 mg 1-1 dye concentrations in the water (Field et al. 1995).

When used at recommended dosages, rhodamine WT does not constitute an environmental hazard associated with manmade nitrosamines in the environment (Steinheimer and Johnson 1986). However, it should be noted that Field et al. (1995) emphasized their focus on acute toxicity relative to lethal doses, noting that other toxicological effects, such as developmental toxicity, were not calculated.

Rhodamine WT Application and Best Management Practices (from Field et al. 1995)
The maximum recommended concentration of rhodamine WT is 2 mg 1-1. Individuals using tracers should be experienced or well trained in their use, and tracer concentrations should not exceed 1–2 mg 1-1 persisting for a period in excess of 24 hours in groundwater at the point of groundwater withdrawal, or discharge. Such concentrations are well below toxicity levels, allows for easy recognition by the naked eye, and is above persistent dye concentrations traditionally recommended for tracer tests.

The information in this section was excerpted and revised from the Columbia River Basin Dreissenid Incident Response Toolkit, published by the Pacific States Marine Fisheries Commission, 2020.

Appendix B. Control options for New Zealand mudsnails

Nearly all efforts to control New Zealand mud snails focus on efforts to limit spreaD. To our knowledge, successful eradication of invasive New Zealand mud snail populations has not been documented.

PHYSICAL TREATMENT OPTIONS

Control of NZMS is possible in certain isolated locations such as small lakes, ponds, irrigation canals, and fish hatcheries. Draining waters and allowing substrate to heat and dry completely in the summer or freeze in the winter can kill NZMS (Richards et al. 2004). Irrigation canals are routinely shut down for vegetation control and may be treated for invasive snails as well. However, such actions would likely also have negative consequences for native gastropods and other species. In contained areas such as fish hatcheries, the use of flame throwers on the walls and raceways has been effectively employed to rid these areas of NZMS (Richards *et al*, 2004; Dwyer *et al*, 2003).

CHEMICAL TREATMENT OPTIONS

Chemical treatment of aquatic systems poses risks to surrounding drainages and native species. Small lakes and ponds may be isolated from drainages for chemical treatment. Chemical methods used to eradicate NZMS include: Bayer 73 copper sulfate, and 4-nitro-3-trifluoromethylphenol sodium salt (TFM). The only molluscicide known to have been tested against NZMS is Bayluscide (niclosamide). Near complete mortality was observed when treated in a concrete-lined irrigation canal and exposed to concentrations of ~1mg/L for 17 hours (McMillin and Trumbo, 2009). Potassium permanganate has been experimentally examined to control NZMS, but was found ineffective (Oplinger and Wagner 2010). Copper-based substrates have also been found to be somewhat effective and may deter upstream movement, though these tests were focused on movement in water discharge facilities (Myrick and Conlin,2011 and Hoyer and Myrick, 2012).

BIOLOGICAL TREATMENT OPTIONS

Parasites of NZMS are another potential method of control. Studies of the efficacy and specificity of a trematode parasite from its native range as a biological control have demonstrated some potential for this option (Dybdahl *et al.* 2005, Dybdahl and Lively, 1998).

Integrated pest management

An integrated pest management and control plan for NZMS should be implemented in locations that are colonized and those that may potentially be invadeD. This plan should include preventive measures, public education, monitoring, and appropriate treatment to slow its spread and eradicate where possible and practical. Plans should account for the specific needs of individual locations and follow the guidelines provided by the Aquatic Nuisance Species Task Force.

The information from the previous section was excerpted and modified from:
New Zealand Mudsnail management and control plan working group, for the Aquatic Nuisance Species Task Force. 2007. National Management and Control Plan for the New Zealand mudsnail (*Potamopyrgus antipodarum*).