



Non-Project Environmental Impact Statement

Aquatic Invasive Species Control

Final



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Cover Photo: Nonnative northern crayfish (*Orconectes virilis*) from Lake Patterson, Methow River Basin. Photograph courtesy of Washington Fish and Wildlife, Guy Wiest photographer

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Non-Project Environmental Impact Statement

Aquatic Invasive Species Control Final

*by
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Olympia, Washington

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Fact Sheet

Project Title: Final Non-Project Environmental Impact Statement for the Washington State Department of Ecology (Ecology) Aquatic Invasive Species Management Permitting Program.

Project Description: Ecology developed an Environmental Impact Statement for the chemical control of:

- Nonnative, invasive freshwater animals.
- Nonnative, invasive marine animals.
- Nonnative, invasive marine algae.

This action is a non-project proposal under State Environmental Policy Act (SEPA) rules and Ecology integrated the Environmental Impact Statement (EIS) with a National Pollutant Discharge Elimination System (NPDES) permit and fact sheet for the control of these species. This document analyzes reasonable alternatives for their management, the probable significant adverse and beneficial environmental impacts of these alternatives, and their relation to existing policies, rules, and regulations. The EIS does not include alternatives for removing aquatic invasive species from infrastructure such as dams or water intakes to keep them operational.

The recommended alternative is an integrated approach that uses the most effective and environmentally protective mix of management methods and includes adaptive management elements. Control methods may include biological, physical, mechanical, and chemical control technologies. Other alternatives analyzed include chemical use only, physical/mechanical use only, biological use only, and taking no action.

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Licenses, Permits:

This list reflects permits and licenses required for various nonnative invasive freshwater and marine animal and marine algae control alternatives discussed in this document including the use of chemical, physical, mechanical, and biological control methods. Not all permits/licenses listed below are required for all activities discussed in this document. Requirements may change. Check with state resource agencies and local and federal governments to determine permit requirements for a particular project. This EIS provides an overview of local, state, and federal programs for aquatic pesticide regulation and other management methods in Section I.

Washington State Department of Ecology:	<ul style="list-style-type: none">• NPDES/State Waste Discharge Permit• 401 Water Quality Certification
Washington State Department of Fish and Wildlife:	<ul style="list-style-type: none">• Hydraulic Project Approval• Fish Planting Permit• Sport Fishing Rules
Washington State Department of Agriculture:	<ul style="list-style-type: none">• Applicator’s license for aquatic application of registered pesticides• Experimental Use Permit
Washington State Department of Natural Resources:	State Aquatic Land Use Authorization for projects on state-owned aquatic lands
Local Government:	<ul style="list-style-type: none">• Shoreline Master Program• Substantial Development Permit• Conditional Use Permit• Variance Permit
Federal Government:	<ul style="list-style-type: none">• National Environmental Policy Act reviews (NEPA)• Section 404 Permit from the U.S. Army Corps of Engineers• U.S. Army Corps of Engineers

- Section 10 permit
- Endangered Species Act Section 7 Consultation

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Location of Reference Material : Water Quality Program
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Availability: Digital copies of the FEIS are available at the Washington Department of Ecology's website at:
<http://www.ecy.wa.gov/biblio/1010010.html>

Executive Summary

Ecology developed a Final Environmental Impact Statement (FEIS) for its Aquatic Invasive Species Management Permitting Program for the chemical control of:

- Nonnative, invasive freshwater animals
- Nonnative, invasive marine animals
- Nonnative, invasive marine algae

Invasive species are nonnative organisms that cause economic or environmental harm and are capable of spreading to new areas of the state (RCW 79A.25.310). Aquatic invasive species also threaten the diversity or abundance of native species, the ecological stability of infested waters, or commercial, agricultural, or recreational activities dependent on such waters (RCW 77.60). Some examples of invasive freshwater animals include, but are not limited to, zebra and quagga mussels, Asian carp, snakeheads (invasive freshwater fish), rusty crayfish, red swamp crayfish, New Zealand mud snails, spiny water fleas, fishhook water fleas, and round gobies. Invasive marine animals include, but are not limited to, mitten crabs, green crabs, Atlantic salmon (when escaped), tunicates, and bamboo worm. Examples of invasive marine algae include *Caulerpa taxifolia* and *Sargassum* Spp. Not all of the invasive species listed above are currently present in Washington.

The introduction of invasive species into marine and fresh waters of Washington not only threatens the ecological integrity of the state's water resources, but also the economic, social, and public health conditions within the state. While the effects of individual organisms may vary by species, aquatic invasive species often have few predators, diseases, or competitors outside of their native range. This can allow their populations to explode at the expense of native organisms and existing ecosystems. Invasive single-species populations reduce native species biodiversity and may lead to native species extirpation or extinction. Invasive aquatic species can degrade water quality, impair fisheries, block intakes that supply water for domestic and agricultural purposes, and interfere with navigation, recreation, and aesthetics.

Washington has an abundance of surface water resources, including approximately 7,800 lakes, ponds, and reservoirs, 40,492 miles of rivers and streams, 2,337 miles of saltwater shorelines, and many acres of associated wetlands. Washingtonians depend on the states abundant surface water resources for recreation, fish and wildlife habitat, commercial and sport fishing, water supply (drinking water and agriculture), navigation, transportation, aquaculture, flood control, fire fighting, power generation, and aesthetics. Nonnative invasive species often degrade aquatic systems to such a degree that is desirable to eradicate or aggressively manage their populations to protect and maintain the beneficial uses of the affected water bodies. With its abundant aquatic resources, Washington has much to lose with the introduction of new aquatic invaders and the expansion of existing populations of invasive species into uninfested waters. Therefore, Washington must make the prevention, eradication, and control of these species high priority.

Although Ecology currently issues permits that allow the chemical treatment of invasive freshwater and marine plants and freshwater algae, there are no permits available for the chemical management of invasive freshwater and marine animals (with a few exceptions) or marine algae. Ecology's Water Quality Program received a request for a National Pollutant Discharge Elimination System (NPDES) permit from the Washington State Department of Fish and Wildlife to use chemicals and other control products to manage invasive aquatic animal species and marine algae in surface waters of the state of Washington. The Aquatic Invasive Species NPDES permit for Washington State developed in conjunction with this FEIS will help limit the spread and reduce the impacts of these species by allowing for their management with chemical control technologies. The permit also allows for rapid emergency response for early invasions of these organisms.

In response to this request for an NPDES permit, and in accordance with the provisions of the State Environmental Policy Act (SEPA), Ecology determined that invasive aquatic species management by chemical treatment may have significant adverse environmental impacts, and that an Environmental Impact Statement was necessary. The preparation of this FEIS was a non-project proposal under SEPA rules. Ecology integrated the FEIS with a NPDES permit and fact sheet for the control of these species.

The FEIS document analyzes reasonable alternatives for aquatic invasive species management, the probable significant adverse and beneficial environmental impacts of these alternatives, and their relation to existing policies, rules, and regulations. The FEIS does not include alternatives for removing aquatic invasive species from infrastructure such as dams or water intakes to keep them operational. This FEIS analyzes five possible alternatives. The FEIS discusses the principle features and mitigation measures for each alternative in their respective sections. The information provided will aid decision-makers in assessing available alternatives and their appropriate application. The alternatives evaluated are:

1. The use of an integrated pest management approach that incorporates adaptive management principles.
2. The "no action" alternative – continuing current practices.
3. The use of physical removal/mechanical methods only.
4. The use of biological methods only.
5. The use of chemical methods only (the proposed action).

This FEIS is limited in part by lack of information on methods and their impacts, because there is simply little information available.

The recommended alternative is an integrated approach that uses the most effective and environmentally protective mix of management methods and includes adaptive management elements. Control methods may include biological, physical, mechanical, and chemical control technologies. Other alternatives analyzed include chemical use only, physical/mechanical use only, biological use only, and taking no action.

Introduction to Aquatic Invasive Species Control

Background

What are aquatic invasive species?

Federal Executive Order 13112 defines an invasive species to mean “an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.” Washington’s RCW 79A.25.310 defines invasive species as “nonnative organisms that cause economic or environmental harm and are capable of spreading to new areas of the state. Invasive species does not include domestic livestock, intentionally planted agronomic crops, or non-harmful exotic organisms.” RCW 77.60 defines an aquatic nuisance species as “a nonnative aquatic plant or animal species that threatens the diversity or abundance of native species, the ecological stability of infested waters, or commercial, agricultural, or recreational activities dependent on such waters.”

The Draft Environmental Impact Statement focuses only on control activities for nonnative invasive freshwater and marine animals and nonnative invasive marine algae. The term “aquatic invasive species” in this document will hereafter refer only to these organisms.¹ Some examples of invasive freshwater animals include, but are not limited to, zebra and quagga mussels, Asian carp, snakeheads (invasive freshwater fish), rusty crayfish, red swamp crayfish, New Zealand mud snails, spiny water fleas, fishhook water fleas, and round gobies. Invasive marine animals include, but are not limited to, mitten crabs, green crabs, Atlantic salmon (when escaped), tunicates, and bamboo worm. Examples of invasive marine algae include *Caulerpa taxifolia* and *Sargassum* Spp. Not all of the invasive species listed above are currently present in Washington.

Why are we concerned about aquatic invasive species?

The introduction of invasive species into marine and fresh waters of Washington not only threatens the ecological integrity of the state's water resources, but also the economic, social, and public health conditions within the state. While the effects of individual organisms may vary by species, aquatic invasive species often have few predators, diseases, or competitors outside of their native range. This can allow their populations to explode at the expense of native organisms and existing ecosystems. Invasive single-species populations reduce native species biodiversity and may lead to native species extirpation or extinction. Invasive aquatic species can degrade water quality, impair fisheries, block intakes that supply water for domestic and agricultural purposes, and interfere with navigation, recreation, and aesthetics.

¹ A separate document - the *Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management* (February 2001) covers the control of nonnative invasive aquatic plants such as Eurasian watermilfoil and Brazilian elodea. The *Final Environmental Impact Statement for Noxious Emergent Plant Management* (November 1993) covers control of noxious emergent plants e.g., purple loosestrife and spartina.

The economic and environmental impacts of invasive species can be especially devastating. In a 2004 journal article, Cornell University scientists Pimentel et al. estimated that the costs associated with ecological damage and control of all terrestrial and aquatic invasive species in the United States were \$120 *billion* per year and increasing.

Invasive species are one of the leading threats to the world's biodiversity. Pimentel et al. (2004) referencing Wilcove et al. (1998), also estimated that invasive species impact nearly half of the plants and animals currently listed as Threatened or Endangered under the United States Federal Endangered Species Act.² Wilson (1992) states that the spread of invasive species is second only to habitat destruction as a cause for creating threatened and endangered species.

Molnar et al. (*Assessing the Global Threat of Invasive Species to Marine Biodiversity*) concluded that marine invasive species are a major threat to biodiversity, and have had profound ecological and economic impacts. They also found that there were high levels of invasion in the temperate regions of Europe, North America, and Australia.

Table 1- Examples of the economic impacts of invasive estuarine and marine species.
From Williams and Groholz (2008)³

Table 1 Examples of economic impacts of introduced estuarine and marine species

Introduced Species	Economic Impact	Estimated Cost	Reference
Seaweeds			
<i>Caulerpa taxifolia</i> killer algae	Eradication	>US\$6M (6 year)	Authors
<i>Codium fragile</i> v. <i>tomentosoides</i> oyster thief, deadman's fingers	Cultured oyster mortality, kelp valuation	CS\$1,500,000 /yr	Colautti et al. 2006
<i>Hypnea musciformis</i>	Removal from native seaweed farm	Bankruptcy	Neill et al. 2006
<i>Undaria pinnatifida</i> Wakame	Reduced property values Eradication	US\$55,000 NZ\$2,923,500 (total)	Van Beukering and Cesar 2004 Wotton et al. 2004
Invertebrates			
<i>Carcinus maenas</i> European green crab	Reduces bivalve aquaculture	US \$22M/yr	Grosholz et al. 2000, Lovell et al. 2007
<i>Eriocheir sinensis</i> Chinese mitten crab	Invasion of fish salvage facility	US\$1M (2000)	Aquatic Nuisance Species Task Force 2003
<i>Mnemiopsis leidyi</i> Ctenophore	Correlated loss of anchovy fishery	US\$250M/yr	Zaitsev 1992
<i>Mytilopsis sallei</i> black striped mussel	Eradication	A\$2.2M	Bax et al. 2002
<i>Phyllorhiza punctata</i> Scyphomedusa	Potential loss in shrimp landings	US\$10M (2000)	Graham et al. 2003
<i>Terebrasabella heterouncinata</i> Sabellid polychaete	Reduced cultured abalone product quality Eradication	Bankruptcy Several US\$K	Culver and Kuris 2000 Kuris 2003
<i>Teredo navalis</i> Shipworm	Structural damage (ships, docks)	US\$200M/yr	Cohen and Carlton 1995

At a regional level, preliminary research by Lodge (University of Notre Dame) and Finnoff (University of Wyoming) on the impacts of invasive aquatic animals on the Great Lakes regions,

² See http://ipm.ifas.ufl.edu/pdf/EconomicCosts_invasives.pdf to read Dr. Pimentel's article -

³ Susan L. Williams and Edwin D. Groholz. 2008. *The Invasive Species Challenge in Estuarine and Coastal Environments: Marrying Management and Science*. Estuaries and Coasts.

estimates a loss of \$200 million per year. Damaged sectors of the economy include sport fishing (\$123 million in 2006); wildlife viewing (\$47.6 million loss); raw water use by municipalities, power plants, and industry (\$27 million); and commercial fishing (2.1 million).⁴

In 2009, Idaho estimated a potential annual economic impact from the introduction of zebra and quagga mussels at \$94 million. This analysis included impacts to hydropower, drinking water, golf courses, boat facilities, hatcheries/aquaculture, boat maintenance, and reduction in angler days. The cost-estimate did not include impacts to irrigated agriculture. However, the report concluded that it is likely that zebra and quagga mussels would increase maintenance costs for operations that rely on surface water for irrigation.⁵

According to a joint report from Oregon State University and the EPA⁶, the authors consider Washington and Oregon to have the least infested streams and rivers among 12 western states. Based on a sample of 51 sites, the authors estimate that only 20 percent of Washington stream and river miles have nonnative fish and amphibian species. The report noted that many of the recent introductions are aquarium fish species.

This does not mean that Washington is trouble free. Although Washington's geography provides some protection from invasion with many of its waters being located in high mountain lakes and streams, there are growing populations of invasive species in both eastern and western Washington interfering with native species and damaging habitat. Aquarium species such as Chinese mystery snails and goldfish are well established in several lakes, and reports of anglers catching other aquarium species such as pacu, piranha, and arrowana are increasing. Washington's 2003 Natural Heritage Plan identifies invasive species as a principal risk to the natural heritage in seven of the state's nine eco-regions.

Sanderson et al. in their paper titled *Nonindigenous Species of the Pacific Northwest: An Overlooked Risk to Endangered Salmon?* concluded that nonindigenous species are a major threat to global diversity (Figure 1). The taxonomic groups represent plants, birds, fishes, amphibians, reptiles, mollusks, crustaceans, and mammals. Although Figure 1 includes terrestrial as well as aquatic plants and animals, it is apparent that nonnative species have significantly invaded Washington. However, some of the most significant economically and environmentally damaging freshwater animal invaders, like the zebra and quagga mussel, are not yet found in the Pacific Northwest.

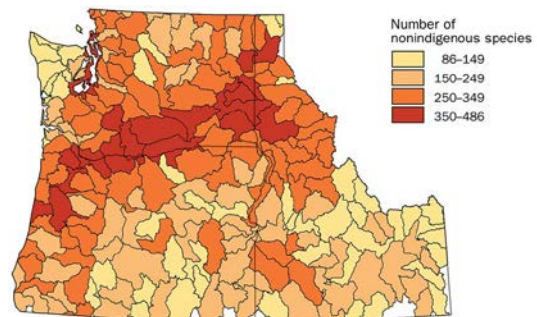


Figure 1 -The number of nonindigenous species already present in watersheds in the Pacific Northwest. From Sanderson et al.

⁴ http://www.glu.org/english/invasive_species/economy/lodge_factsheet.pdf.

⁵ (From: *Estimated Potential Economic Impact of Zebra and Quagga Mussel Introduction into Idaho* – prepared by the Idaho Aquatic Nuisance Species Taskforce 2009).

⁶ Lomnický et al., 2007

Why develop an EIS for the management of nonnative aquatic invasive species

Washington has an abundance of surface water resources, including approximately 7,800 lakes, ponds, and reservoirs, 40,492 miles of rivers and streams, 2,337 miles of saltwater shorelines, and many acres of associated wetlands. Washingtonians depend on the states abundant surface water resources for recreation, fish and wildlife habitat, commercial and sport fishing, water supply (drinking water and agriculture), navigation, transportation, aquaculture, flood control, fire fighting, power generation, and aesthetics. Nonnative invasive species often degrade aquatic systems to such a degree that is desirable to eradicate or aggressively manage their populations to protect and maintain the beneficial uses of the affected water bodies. With its abundant aquatic resources, Washington has much to lose with the introduction of new aquatic invaders and the expansion of existing populations of invasive species into uninfested waters. Therefore, Washington must make the prevention, eradication, and control of these species high priority.

Although Ecology currently issues permits that allow the chemical treatment of invasive freshwater and marine plants and freshwater algae, there are no permits available for the chemical management of invasive freshwater and marine animals (with a few exceptions) or marine algae. Ecology's Water Quality Program received a request for a National Pollutant Discharge Elimination System (NPDES) permit from the Washington State Department of Fish and Wildlife to use chemicals and other control products to manage invasive aquatic animal species and marine algae in surface waters of the state of Washington. The Aquatic Invasive Species NPDES permit for Washington State developed in conjunction with this FEIS will help limit the spread and reduce the impacts of these species by allowing for their management with chemical control technologies. The permit also allows for rapid emergency response for early invasions of these organisms.

In response to this request for an NPDES permit, and in accordance with the provisions of the State Environmental Policy Act (SEPA), Ecology determined that invasive aquatic species management by chemical treatment may have significant adverse environmental impacts, and that an Environmental Impact Statement was necessary.

Goals of the aquatic invasive species environmental impact statement

There are many aquatic invasive species already present in Washington's fresh and marine waters (e.g., New Zealand mud snails, tunicates). Other species, such as zebra or quagga mussels are present in nearby states and chances are high that they will spread to Washington waters via boating activities. This FEIS and accompanying NPDES permit for Aquatic Invasive Species will provide Washington state agencies with additional management tools to manage the infestations of these organisms.

The primary goal of developing a chemical program for the control of aquatic invasive species is to allow for their effective removal from Washington's surface waters while minimizing harm to the environment from chemical use. The permitting program will regulate the use of appropriate

chemicals and other control products while maintaining a balance between environmental harm from their use and the environmental harm from the invasion and establishment of aquatic invasive aquatic organisms. The permit will allow both for rapid response when surveyors first detect potentially devastating organisms in Washington waters and for the treatment of invasive species that are already present where physical, mechanical, or biological control methods are not the entire solution to managing the invasion.

This FEIS also includes an analysis of harm to human health from chemical use. The degree of risk may vary depending on the perceived threat of the invading species to the water body or the state, the chemical proposed for use, and any mitigation. For example, it may be appropriate to treat an entire water body for zebra or quagga mussels if the water body is isolated. It may not be appropriate or even possible to treat a water body such as the Columbia River.

This FEIS and accompanying documents -the NPDES permit, and the permit Fact Sheet- allows Ecology, other resource agencies, tribes, and the public to review current and potential control technologies for the management of aquatic invasive species. Ecology used the draft EIS as a guidance document to decide which chemicals, conditions, and mitigations were appropriate to include in an Aquatic Invasive Species NPDES permit.

Addressing the potential loss of habitat or habitat disruption from aquatic invasive species invasion and the control strategies used to manage them is also a goal in the development and implementation of any management program. This is especially important because the federal government lists species of salmon, trout, char, or steelhead runs in nearly every county in Washington as candidates for a threatened or endangered species under the Endangered Species Act (ESA).

Aquatic Invasive Species Control Regulation

Introduction

Ecology is the primary lead for regulating pesticides or chemicals used in aquatic environments under Washington State's Water Pollution Control Law, Chapter 90.48 RCW. However, the Washington State Departments of Agriculture, Fish and Wildlife, and Natural Resources may also play a role in managing aquatic invasive species or in regulating potential control methods such as physical or mechanical removal of these organisms.

Any proposal that requires a state or local agency decision to license, fund, or undertake a project, or the proposed adoption of a policy, plan, or program can trigger environmental review under the State Environmental Policy Act (SEPA). See WAC 197-11-704 for a complete definition of agency action.

The broad scope of planning for the control of aquatic invasive species makes it difficult to develop a permitting program that will cover all eventualities or will include all the appropriate chemicals or tools needed for each organism should it invade. The suite of potentially invasive

species includes many different organisms. The list includes species that are not here but that have potential to invade and become problematic (known invasion history elsewhere); to species whose invasion potential is unknown, but may become a problem should they be introduced; to species that are already here and are causing problems. The NPDES permit covers many taxa of invasive animals in both fresh and marine waters including aquatic invertebrates, fish, and amphibians. It also covers the control of nonnative invasive marine algae. The management of aquatic invasive species under their respective jurisdictional authorities can be generally categorized by the control method used.

Regulatory requirements for physical, mechanical, and biological control methods

State regulatory requirements

Washington State Department of Fish and Wildlife

The Washington State Department of Fish and Wildlife (WDFW) requires a permit called a [Hydraulic Project Approval](#) (HPA) for any activity in or near the water that has the potential to directly kill fish or shellfish or alter the habitat that fish or shellfish require ([Chapter 77.55 RCW](#)). For additional information regarding HPA permits, see the WDFW website (<http://wdfw.wa.gov/hab/hpapage.htm>).

Some of the methods proposed for aquatic invasive species control, such as the installation of bottom barriers, physical removal, and diver dredging have the potential to alter habitat. Project proponents using these methods may need HPA permits from WDFW.

Washington State Department of Natural Resources

The Washington Department of Natural Resources (DNR) may require state aquatic land use authorization for projects that occur on aquatic state-owned lands. Project proponents should contact the DNR Aquatics District Office for the area in which the project is proposed and forward information related to environmental review and permitting for the project to the DNR SEPA Center. An invasive species removal project on tidelands, for example, may trigger the need for state aquatic land use authorization.

Local regulatory requirements

Depending on the proposed management activity to remove aquatic invasive species, local jurisdictions (city or county governments) may require shoreline permits for activities in or near the water under the Shoreline Management Act ([Chapter 173-27 WAC](#)). Each local government has established a system of permitting for shoreline management and these permitting programs vary by government. Project proponents may need Substantial Development permits for projects costing over \$2,500 or those that materially interfere with the public's use of the waters. Under special circumstances, local governments may also issue Conditional Use or Variance permits; Ecology must review and approve these permits. Ecology also reviews the more common Substantial Development permits, but does not have direct approval authority of those permits.

Federal regulatory requirements

Project proponents may need federal permits and/or federal environmental review when the project takes place on federal lands or uses federal funding. Permits and environmental reviews may include:

- National Environmental Policy Act reviews (NEPA). NEPA applies to all major federal actions, any project requiring a federal permit, receiving federal funding, or that is located on federal land. NEPA is similar to Washington's SEPA process.
- Endangered Species Act (ESA) Section 7 consultation by U.S. Fish and Wildlife Service and/or National Oceanic and Atmospheric Administration. Project proponents need to consult with these agencies when endangered species are present and they are using federal funding or the project takes place on federal lands.
- U.S. Army Corps of Engineers Section 10 permit for discharge of dredge/fill material.
- Clean Water Act Section 404 permit for work in navigable waters from the U.S. Army Corps of Engineers.
- Ecology-issued 401 Water Quality Certification. This requirement triggers when a project proponent applies for a federal permit or license to conduct an activity that might result in a discharge of dredge or fill material into water, non-isolated wetlands, or excavation in water or non-isolated wetlands.

Regulatory requirements for aquatic chemical applications

State regulatory requirements

Washington State Department of Ecology

Under the Aquatic Invasive Species Permit, the state has made a tentative decision to allow the use of chemicals in Washington's surface waters for the purpose of eradicating or controlling aquatic invasive species. Ecology intends to issue coverage under this general NPDES permit to WDFW and any other Washington state agency that requests coverage under the permit. The permit Fact Sheet, a companion document to the Aquatic Invasive Species NPDES General Permit, provides the legal and technical basis for permit issuance (WAC 173-226-110). The Aquatic Invasive Species NPDES General Permit and the Fact Sheet accompany this FEIS and are incorporated by reference into the EIS.

Washington State Department of Agriculture

Except for fish, mosquito larvae, ballast water treatments, and burrowing shrimp, there are few products labeled by the United States Environmental Protection Agency (EPA) for aquatic animal control in aquatic ecosystems. Because of this, and in addition to NPDES permit coverage from Ecology, entities applying chemicals or other EPA-registered products under the Aquatic Invasive Species Permit may also be required to pursue:

- Experimental Use Permit (EUP). An EUP is required for all experiments involving unregistered pesticides, and for all experiments involving uses not allowed by the pesticide label. See <http://agr.wa.gov/PESTFERT/Pesticides/docs/4350-PesticideRegistrationInWA%20.pdf> for more details.
- Special Local Needs label (24 (c)). A “special local need” means an existing or imminent pest problem within a state for which the state lead agency, based on satisfactory supporting information, has determined that an appropriate federally registered pesticide product is not sufficiently available (<http://www.epa.gov/opprd001/24c/#General%20Overview>). A special local need could include a new application method or timing, different rate, new crop, new pest, less hazardous formulation, prevention of pesticide resistance or application to a different soil type (<http://agr.wa.gov/PESTFERT/Pesticides/docs/4350-PesticideRegistrationInWA%20.pdf>)
- Emergency Exemption – EPA also calls this a crisis exemption. Section 18 of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) authorizes EPA to allow an unregistered use of a pesticide for a limited time if EPA determines that an emergency condition exists. WSDA can request an emergency exemption from registration from EPA. An emergency could include an outbreak of a new pest (<http://agr.wa.gov/PESTFERT/Pesticides/docs/4350-PesticideRegistrationInWA%20.pdf>).

Entities will need to coordinate these additional pesticide label or permitting requirements with the Washington State Department of Agriculture (WSDA) staff. WSDA is Washington’s lead agency that regulates pesticides.

Laws and Codes Several sections of the State Water Pollution Control Law and Washington’s Administrative Code apply directly to the use of aquatic chemicals, including:

- Chapter 15.58 RCW - Washington Pesticide Control Act
- Chapter 17.21 RCW - Washington Pesticide Application Act
- Chapter 17.15.010 RCW- Integrated pest management
- Chapter 17.15.020 RCW - Implementation of integrated pest management practices
- Chapter 90.48.010 RCW- Water Pollution Control Policy enunciated
- Chapter 90.48.260 RCW - Federal Clean Water Act -- Department designated as state agency, authority -- Powers, duties and functions.

Local regulatory requirements

A few local jurisdictions (city or county governments) may require shoreline permits for chemical application in or near the water under the Shoreline Management Act ([Chapter 173-27 WAC](#)). Each local government has established a system of permitting for shoreline management and these permitting programs vary by government. The project proponent should check with the local jurisdiction before starting a chemical treatment for aquatic invasive species.

Federal regulatory requirements

Project proponents may need federal permits and/or federal environmental review when the project takes place on federal lands or uses federal funding. Permits and environmental reviews may include:

- National Environmental Policy Act reviews (NEPA). NEPA applies to all major federal actions, any project requiring a federal permit, receiving federal funding, or located on federal land.
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) provides the basis for regulation, sale, distribution, and use of pesticides in the U.S. FIFRA authorizes EPA to review and register pesticides for specified uses. WSDA coordinates with EPA if an applicant applies for an EUP, Section 24(c) or a Section 18 emergency exemption.
- The federal Clean Water Act [FCWA, 1972, and later modifications (1977, 1981, and 1987)], established water quality goals for navigable (surface) waters of the United States. One of the mechanisms for achieving the goals of the Clean Water Act is the NPDES system of permits. The EPA delegated responsibility for administering Washington’s NPDES permit program to the State of Washington based on Chapter 90.48 RCW. This statute defines Ecology's authority and obligations in administering the Wastewater Discharge Permit Program. See also the Aquatic Invasive Species Permit Fact Sheet for more information about regulations and authorities supporting aquatic pesticide application to state waters.
- EPA allows for a crisis exemption (Section 18) for pesticide use in dire situations when an emergency exists, the time period for pesticide application is critical, and there is insufficient time to request another type of exemption. This allows for the use of an unregistered pesticide for up to 15 days. The crisis exemption request may be issued by the head of a federal or state agency, the Governor of a state, or their official designee. Whenever feasible, the federal or state agency issuing the crisis exemption must notify EPA of this action at least 36 hours prior to using the crisis provision (http://www.epa.gov/owow/invasive_species/invasives_management/pdf/AquaticInvasiveSpecies-final.pdf). Crisis exemptions may not be used for suspended pesticides, pesticides containing a new active ingredient, or the first food use of a pesticide.
- Endangered Species Act (ESA) - Section 7 consultation by U.S. Fish and Wildlife Service and/or National Oceanic and Atmospheric Administration. The ESA lists many salmon, steelhead, and bull trout populations and other aquatic biota for special protection in Washington waters. These listings may affect aquatic invasive species management projects in Washington. Project proponents may obtain information regarding potential listings of endangered species in particular water bodies from the local office of WDFW or on their website at <http://wdfw.wa.gov/wildlife/management/endangered.html> . *Obtaining coverage under the Aquatic Invasive Species NPDES permit from Ecology does not exempt a permit holder from “take” liability under ESA. “Take” means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in such conduct with respect to a species listed under ESA (16 U.S. C. Section 1532 (19)).*

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Alternative Aquatic Invasive Species Control Methods

Introduction to alternatives

Ecology defined the alternatives in terms of actions that an agency or agencies may take for the eradication or control of aquatic invasive species. The actions required to implement various alternatives include activities such as Ecology's issuance of an NPDES permit to allow the application of chemicals to waters of the state. Actions may also include WDFW's issuance of HPA's for hand removal, diver dredging, or bottom barrier installation to manage aquatic invasive species or DNR's issuing State Aquatic Land Use Authorization for projects on state-owned aquatic lands. Local governments may require shoreline permits for manual, mechanical, or chemical treatment projects costing over \$2,500. The U.S. Army Corps of Engineers may also require Section 404 permits for suction dredging or sediment removal projects. For simplicity, Ecology uses the term "permits" when referring collectively to all of these permits.

The action that triggered this SEPA documentation is Ecology's proposed issuance of an NPDES permit for the chemical management of aquatic invasive species. Ecology determined that applications of chemicals or products to water to manage these species have the potential to result in significant environmental impacts, creating a need to develop an Environmental Impact Statement. Ecology plans to issue the new NPDES permit for the management of aquatic invasive species for a five-year period.

This SEPA process will identify and analyze reasonable alternatives to chemical control, probable adverse environmental impacts, and potential mitigation for each alternative, including chemicals. The draft EIS and accompanying NPDES permit and Fact Sheet provided for public participation in developing and analyzing information, improving the proposals through mitigation of identified environmental impacts, and development of reasonable alternatives.

Most current management actions focus on preventing introductions of aquatic invasive species by trying to close introduction pathways. Once an invasive animal enters a waterway, no action is the most often used management alternative. This may be because there are few effective and environmentally safe management tools. Managers simply do not have effective feasible control methods available to remove established animal populations. This made the analysis of control alternatives in this FEIS more difficult.

Although it may be comparatively simple to hand-pull early infestations of invasive plants like Eurasian water milfoil, it is not generally possible to remove some invasive animal species from a water body using hand removal techniques. As an example - in reporting a new water body infested with the spiny water flea, a Wisconsin water resource specialist said, "No effective strategy is available to control the spiny water fleas once they are introduced to lakes." Some invasive animals have life cycles that may preclude any control method except widespread chemical use or perhaps biological control should a biocontrol agent be available.

With invasive aquatic plants, there are a number of EPA-registered herbicides with proven effectiveness in killing the targeted species. These herbicides have undergone extensive review

to determine environmental and human health impacts. There is also a wide margin of safety for humans with aquatic herbicides because they target biochemical pathways that are present in plants but not in animals. However, there are few chemicals registered for aquatic invasive animal management, except for cleaning infrastructure (e.g., removing zebra or quagga mussels from water intakes) or ballast water treatment.

This FEIS analyses five possible alternatives for controlling aquatic invasive species. The FEIS discusses the principle features and mitigation measures for each alternative in their respective sections. The information provided will aid decision-makers in assessing available alternatives and their appropriate application. The alternatives evaluated are:

1. The use of an integrated pest management approach that incorporates adaptive management principles.
2. The “no action” alternative – continuing current practices.
3. The use of physical removal/mechanical methods only.
4. The use of biological methods only.
5. The use of chemical methods only (the proposed action).

This FEIS is limited in part by lack of information on methods and their impacts, because there is simply little information available.

Analysis and comparison of alternatives

State surface water quality regulations and standards (RCW 90.48; Chapter 173-201A WAC) provide authority to establish criteria for waters of the state and to regulate various activities. These standards protect public health and maintain the beneficial uses of surface waters, which include recreational activities such as swimming, SCUBA diving, water skiing, boating and fishing and aesthetic enjoyment; public water supply; stock watering; fish and shellfish rearing, spawning, and harvesting; wildlife habitat, and commerce and navigation.

Key to the analysis and comparison of approaches is the goal to maintain beneficial uses of state waters and protect the environment. Therefore, Ecology will analyze each method for aquatic invasive species management for:

- The extent that the approach detracts from the beneficial use of a water body.
- Potential adverse environmental impacts.
- Potential adverse human health impacts, particularly for chemical control methods.
- The effectiveness of the method in controlling aquatic invasive species.

Mitigation defined

As defined by SEPA, mitigation means, in the following order of preference:

1. Avoiding the impact altogether by not taking a certain action or part of an action.
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts.
3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action.
5. Compensation for the impact by replacing, enhancing, or providing substitute resources or environments.

Wetlands: Mitigation for all methods

For the most up to date wetland mitigation guidance – please see Ecology’s website <http://www.ecy.wa.gov/programs/sea/wetlands/mitigation/guidance/index.html>. Ecology has two wetland mitigation guidance documents: *Wetland Mitigation in Washington State: Part 1 – Agency Policies and Guidance* (Publication #06-06-011a) and *Wetland Mitigation in Washington State: Part 2 – Developing Mitigation Plans* (Publication #06-06-011b). The most current versions of these documents are always available on Ecology’s website.

Mitigation for sediment for all methods

The Sediment Management Standards, Chapter 173-204 WAC, have a narrative standard of *no effect*, which applies to all sediments (Washington 1995a). To the extent the chemicals or other control methods may have adverse effects on benthic organisms, permit writers can require a sediment mixing zone, i.e., a sediment impact zone or consider the proposed action unacceptable pursuant to antidegradation policy (Chapter 173-201A-070 WAC).

The antidegradation and designated use policies of the Sediment Management Standards state, in part, “existing beneficial uses must be maintained and that sediment must not be degraded to the point of becoming injurious to beneficial uses.” Additionally, sediment in waters considered outstanding natural resources must not be degraded; outstanding waters include those of national and state parks and scenic and recreation areas, wildlife refuges, and waters of exceptional recreational or ecological significance. The purpose of the standards is to manage pollutant discharges and sediment quality to protect beneficial uses and move towards attaining designated beneficial uses as specified in section 101(a)(2) of the Federal Clean Water Act and Chapter 173-201A WAC, the States’ surface water standards.

The sediment standards include specific marine sediment chemical criteria, but Ecology determines the criteria for low salinity and freshwater sediments on a case-by-case basis.

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The Preferred Alternative—an Integrated Pest Management Approach Incorporating Adaptive Management Principles

Description of the preferred alternative

An integrated pest management approach incorporating adaptive management principles

EPA defines integrated pest management (IPM) as an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. The information, in combination with available pest control methods, is used to manage pest damage by the most economical means with the least possible hazard to people, property, and the environment. IPM takes advantage of all appropriate pest management options, including, but not limited to the judicious use of pesticides (from EPA website <http://www.epa.gov/opp00001/factsheets/ipm.htm>).

Ecology based its recommendation for an integrated pest management approach for aquatic invasive species projects on the following guidance:

- Washington’s 1997 Integrated Pest Management Law (Chapter 17.15 RCW).
- Washington’s Water Quality Standards (WAC 173-201A-110).

The 1997 Integrated Pest Management Law requires all state agencies that have pest control responsibilities to follow the principles of integrated pest management. The draft Aquatic Invasive Species Permit limits coverage to Washington State agencies, such as WDFW, DNR, or WSDA. The pest management actions of these agencies fall under this law. Washington State law defines IPM to mean “a coordinated decision making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet agency programmatic pest management objectives.” The elements of integrated pest management as outlined in the state law include:

- Preventing pest problems.
- Monitoring for the presence of pests and pest damage.
- Setting action thresholds.
- Managing pest problems to reduce populations to below those levels established by the action threshold using strategies that may include biological, cultural, mechanical, and chemical control methods and that must consider human health, ecological impacts, feasibility, and cost-effectiveness.
- Evaluating the effects and efficacy of pest treatments.

Washington’s Water Quality Standards encourage entities to develop integrated pest plans, particularly for long-term or ongoing activities. Washington’s Water Quality Standards “may be

modified for a specific water body on a short-term basis... when necessary to accommodate essential activities, respond to emergencies, or otherwise protect the public interest, even though such activities may result in temporary reduction of water quality conditions...Ecology may authorize a longer duration where the activity is part of an...integrated pest or noxious weed management plan....”

Requiring IPM planning for invasive organisms is consistent with the planning requirements included in other Ecology NPDES permits for aquatic pesticide use. In the first issuance of the Noxious Weed NPDES permit, Ecology required WSDA (the permit holder) to develop an IPM plan for freshwater emergent noxious and quarantine listed weeds (revised July 2004). See the plan on Ecology’s website:

http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/noxious/Noxious%20Emergent%20IPM.pdf.

Under its Aquatic Weeds Financial Assistance Program, Ecology requires (and funds) integrated aquatic vegetation management plans before awarding grants for the management of widespread infestations of state-listed noxious weeds such as Eurasian watermilfoil. Ecology grant recipients have developed and implemented dozens of these plans for invasive freshwater plants. See examples of these plans on Ecology’s website at

<http://www.ecy.wa.gov/programs/wq/plants/planning.html>.

In keeping with other NPDES aquatic pesticide permit requirements and to facilitate an integrated planning approach to aquatic invasive species management, the draft Aquatic Invasive Species Permit requires the permit holder to develop an integrated plan no later than 18 months after starting initial chemical treatment for each organism or category of organism.

IPM guidance

Ecology has IPM planning guidance available for the management of aquatic plants, but no specific IPM guidance for management of aquatic animals. In 1994, Ecology developed *A Citizen’s Guide for Developing Integrated Aquatic Vegetation Management Plans* to help lake residents and local governments develop integrated plans for aquatic vegetation (Gibbons et al., 1994 – See Ecology’s website at <http://www.ecy.wa.gov/pubs/93093.pdf>). Ecology provides additional IPM guidance for aquatic plant management in Appendix C of the Aquatic Weeds Management Fund Program Guidelines at <http://www.ecy.wa.gov/pubs/9452.pdf>. These IPM guidance documents for aquatic plants may provide a useful starting point to help entities develop IPM plans for aquatic animals.

Public involvement and education are essential components of the IPM development process. It is crucial to invite all affected parties to participate throughout the planning process and keep them informed during implementation. Interested parties may include:

- Residents or property owners around the affected water body.
- Special user groups (e.g., Ducks Unlimited, fishing groups).
- Local government.
- State and federal agencies.

- Tribes.
- Water-related business (resorts, tackle and bait shops, dive shops).
- Elected officials.
- Environmental groups.

In general, an IPM plan should include:

- A problem statement.
- Management goals.
- Information about the infested water body or water bodies, including information about the beneficial uses of the water body, particularly those uses potentially affected by the invader or by the methods used to control the invading species.
- A map of the extent of the infestation.
- A description and discussion about the targeted invasive species that includes its life cycle, its potential impacts on the water body, and times in its life cycle where it may be more susceptible to control measures.
- Identification and discussion of all management alternatives, their effectiveness, environmental impacts, human health risks, costs, and the applicability of each method to the water bodies and the target organisms included in the plan.
- Action thresholds – eradication versus control or containment. A determination of what number of individual pests triggers management actions.
- An action strategy that selects the best combination of methods to achieve the management goals and objectives for the targeted pest.
- A process to evaluate the effectiveness of the action strategy after implementation.
- A process, using adaptive management principles, to revise the plan as needed to ensure that project proponents employ the most effective methodology.

Ecology advises starting the SEPA process for the IPM plan early in the planning phase.

Adaptive management

The following definition of adaptive management is from the *U.S. Department of the Interior Technical Guide to Adaptive Management* (Williams et al., 2007 <http://www.doi.gov/initiatives/AdaptiveManagement/TechGuide.pdf>).

Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing

to ecological resilience and productivity. It is not a ‘trial and error’ process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders.

Figure 2 illustrates the operational steps of an adaptive management process. These steps⁷ are very similar to the elements of IPM planning and include:

1. *Stakeholder involvement.* Ensure stakeholder commitment to actively manage the enterprise for its duration.
2. *Objectives.* Identify clear, measurable, and agreed upon management objectives to guide decision making and evaluate management effectiveness over time.
3. *Management actions.* Identify a potential set of management actions for decision-making.
4. *Models.* Identify models that characterize different ideas (hypotheses) about how the system works.
5. *Monitoring plans.* Design and implement a monitoring plan to track resource status and other key resource attributes.
6. *Iterative Phase*
7. *Decision making.* Select management actions based on management objectives, resource conditions, and enhanced understanding.
8. *Follow-up monitoring.* Use monitoring to track system response to management actions.
9. *Assessment.* Improve understanding of resource dynamics by comparing predicted versus the observed change in the resource status.
10. *Iteration.* Cycle back to Step 6, and, less frequently, to Step 1.

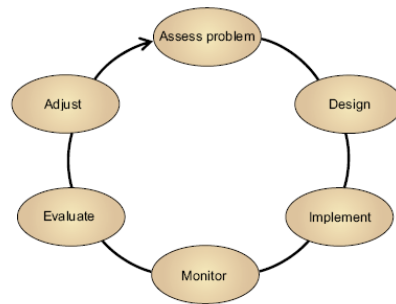


Figure 2 - The operational steps of an adaptive management process. From the U.S. Department of the Interior Technical Guide to Adaptive Management.

Ecology encourages agencies undertaking aquatic invasive species management projects to read the Department of Interior’s manual on adaptive management and apply the principles to their IPM plans and projects. Adaptive management is particularly suited to aquatic invasive animal management programs because many management methods are under development or are experimental.

Key points about adaptive management from the manual include:

⁷ Source -U.S. Department of the Interior Technical Guide to Adaptive Management (Williams et al., 2007 <http://www.doi.gov/initiatives/AdaptiveManagement/TechGuide.pdf>)

- The adaptive management promotes cooperative decision making in the face of uncertainty about the impacts of the management decision.
- Adaptive management produces management strategies consisting of actions tied to resource status and current understanding.
- Adaptive management brings resource managers, researchers, and other stakeholders together and encourages long-term collaboration.
- Resistance to institutional change and a complex legal environment can be impediments to adaptive management.
- Agencies must be willing to commit to monitoring and evaluation over the life of an adaptive management project.

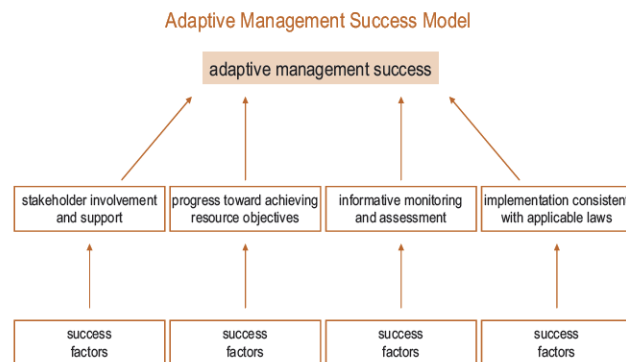


Figure 3 – Key points of the adaptive management process. *From the U.S. Department of the Interior Technical Guide to Adaptive Management.*

Impacts and mitigation

The IPM approach requires thoughtful planning, setting action thresholds, and evaluating potential management methods before selecting the method or combination of methods that will achieve the management goals. When the threat of the invading organism is severe and immediate action is crucial (e.g., citrus longhorn beetle), agencies can accelerate and compress this process. The Draft Aquatic Invasive Species Permit allows for immediate action by giving permit holders up to 18 months to develop their IPM plans after their initial chemical treatment. The impacts of the plan will depend on the control measures selected and the extent of the invasion. When developing an IPM plan, the project proponent must carefully consider all proposed techniques, or combination of techniques, in an ecological context. To facilitate this, project proponents should monitor the effectiveness and impacts of various control methods at selected sites on the target species. Ecology encourages state agencies to utilize the SEPA process when developing their IPM plans.

This FEIS discusses the potential environmental impacts and mitigation measures for each category of control method in each alternatives section. Some methods have the potential to cause some level of adverse environmental impact. Each alternative analysis contains mitigation

measures that may apply. The project proponent must incorporate appropriate mitigation measures into the final action plan developed as part of an IPM plan.

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Environmental Protection Agency Website EPA website
<http://www.epa.gov/opp00001/factsheets/ipm.htm>).

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<http://www.ecy.wa.gov/programs/wq/links/plants.html>

Williams, Byron K., Robert C. Szaro, and Carl D. Shapiro. 2007. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

<http://www.doi.gov/initiatives/AdaptiveManagement/TechGuide.pdf>

The No-Action Alternative: Continuing Current Practices

Description of the no-action alternative

The no-action alternative means that until Ecology issues an NPDES permit for the chemical control of aquatic invasive species, Washington state government entities cannot legally use chemicals to manage these organisms in an aquatic environment. One exception would be any treatment conducted under an EUP from WSDA; this limits the application of a specific chemical to one acre or less for the entire state per year. In an emergency (e.g., if zebra or quagga mussels were discovered in Washington before the NPDES permit for Aquatic Invasive Species was in effect), Ecology would issue an administrative order called a temporary modification of water quality standards to allow more extensive treatment. However, this administrative order will not shield the discharger from third party lawsuits filed under the Clean Water Act. The Fact Sheet, the companion document to the proposed Aquatic Invasive Species Permit, provides the legal background and basis for issuing NPDES permits for aquatic pesticide application to state waters and is incorporated by reference into the FEIS.

In 2006, the Washington State Legislature demonstrated its interest in the prevention and control of invasive species by creating the Invasive Species Council (RCW 79A.25.330). The law directs the Council to develop and periodically update a statewide strategic plan for addressing invasive species. This strategic plan, must address early detection and rapid response to new invasions and the control, management, and eradication of established populations of invasive species. The Legislature also directed that each state department and agency named to the council (includes Washington's natural resource agencies) make its best efforts to implement elements of the completed plan that are applicable to that agency.

In 2008, the Invasive Species Council released its first statewide plan – *Invaders at the Gate*. Recommendation 4 of this plan advises agencies to support coordinated approaches and to ensure tools are accessible to address invasive species issues. Action 4.2 of this recommendation urges agencies to ensure that new permits are available and processes expedited to enable quick responses for all likely control actions.

Issuing an NPDES permit for aquatic invasive species makes more management tools available and ensures that Ecology is following the legislative directive to implement elements of the Invasive Species Council statewide plan – *Invaders at the Gate*. If Ecology continued current practices by not issuing a permit for chemical treatment, it could find itself at odds with a legislative directive.

Current practices

The *Washington State Aquatic Nuisance Species Committee Report to the 2008 Legislature* (Meacham and Pleus, December 2007) provides an overview of state activities to manage aquatic invasive species. Currently there are few active management projects for invasive animal species in Washington, although there are some monitoring and prevention programs. Reasons may include:

- Lack of resources (financial, staffing) or statutory authority.
- Few known effective and environmentally benign management methods for aquatic animals, particularly once they are widespread within a water body.
- Incomplete survey and monitoring information for many aquatic animals (e.g., Washington does not have a comprehensive baseline assessment for Puget Sound indigenous and exotic species).
- Uncertainty about impacts of some invasive species on Washington's waters (e.g., Amur goby – would the control measures for amur gobies do more harm to the environment or to listed species like salmon than the Amur goby would do if left unmanaged?)

Ecology anticipates that as additional management tools become available and if invasion of high profile pest organisms such as the zebra and quagga mussel occur, more projects will take place in Washington. By developing this permit, Washington is being proactive in its readiness to tackle new aquatic invaders.

The aquatic invasive animal management projects currently ongoing in Washington's waters include:

Invasive tunicates⁸

By far the most extensive project to control existing aquatic invasive animal species in Washington at this time is for marine tunicates. Three invasive tunicate species (sea squirts) are present in Puget Sound and the Georgia Basin. Divers discovered the colonial tunicate *Didemnum* at the Edmonds Underwater Park in 2004. WDFW eradicated that population using chlorine tablets under tarpaulins covering the tunicates. Since then, divers have found small infestations of *Didemnum* at several other sites, mostly in south Puget Sound. WDFW or their agents hand removed some of these infestations. Removal activities are ongoing.

Divers located *Styela clava*, a solitary leathery tunicate commonly called the 'club' tunicate, at Blaine and Semiahmoo Marinas in Drayton Harbor, and at Pleasant Harbor and Home Port Marinas in Pleasant Harbor. In 2006, the Legislature and the Governor provided \$250,000 in emergency funding to contain the infestations to those areas. To accomplish this, WDFW

⁸ Information from the Aquatic Nuisance Species Committee, 2007. Washington State Aquatic Nuisance Species Committee Report to the 2008 Legislature. Prepared by P. Meacham and A. Pleus Washington Department of Fish and Wildlife.

worked with DNR, the Skokomish Tribe, and commercial dive companies to survey all of the docks and boats at the infested marinas. Divers cleaned infested boats at all of the marinas to prevent the spread to other areas. In addition, divers removed all tunicates from dock structures at Semiahmoo Marina, and approximately 50 percent of the tunicates from Pleasant Harbor docks. Diver focused on hand removing the largest tunicates to reduce reproduction.

Divers discovered *Ciona savignyi*, a transparent solitary tunicate, in geoduck beds in lower Hood Canal in 2005. In 2006, divers resurveyed the area and reported dense populations throughout lower Hood Canal east of Tahuya. Subsequent surveys found that the dense populations in lower Hood Canal have died off for unknown reasons and they have not returned in large numbers. Dr. Gretchen Lambert, a University of Washington researcher who has studied tunicates worldwide, indicated that outbreaks and disappearances of some tunicate species are common.

Ciona has been present in large numbers at Des Moines Marina and Edmonds Marina (mostly under docks or covered floats) for a number of years, but has apparently not spread. In 2006 and 2007, recreational divers found small populations of *Ciona* at other sites in Puget Sound and removed them.

The 2007 Legislature provided funding to the Puget Sound Action Team (now the Puget Sound Partnership) for tunicate management. The Action Team contracted with WDFW to determine the extent of invasive tunicate infestation in Puget Sound, to develop a tunicate management plan, and to research eradication methods. WDFW has a standard survey technique for marinas and uses commercial and agency divers and drop cameras to survey marinas. WDFW is researching possible eradication methods for *Styela clava*, *Didemnum*, and *Ciona savignyi*.

Because of the extent of the tunicate infestation in Puget Sound, WDFW is considering using chemicals for these invasive organisms. In 2008, WDFW started trials under an experimental use permit from WSDA using acetic acid (vinegar) to kill tunicates hanging from floating docks at Maury Island's Dockton Park. In one trial, they directly sprayed the tunicates, in another; they wrapped the float with thick sheets of plastic and pumped in the weak acid. WDFW reported that chemical treatment was not 100 percent effective, but the results were still promising. However, under an experimental use permit, WDFW may only treat one-acre total per year. This permit will allow expansion of treatment acreage that may help facilitate effective treatment and more rapid and cost-effective removal of these invasive organisms.

European green crab

WDFW continues to monitor for the presence of European green crab in Puget Sound (1998 to present). Nahkeeta Northwest is under contract with WDFW to recruit, train, and oversee an extensive network of monitoring volunteers (due to the recession, WDFW had to terminate the contract for 2010). These volunteers monitored between 90 and 100 sites throughout Puget Sound since the beginning of the program. The volunteers have not detected any green crab within Puget Sound, but a very small population has persisted in Willapa Bay with little change. There have been no reports of concern from the aquaculture businesses in that region. However, the threat of an invasion is still high with significant populations of green crab along the outer coasts of California, Oregon, and British Columbia. Nahkeeta has now expanded the program from monitoring for only green crab into monitoring for many other invasive species.

Atlantic salmon

In 2003, WDFW began conducting snorkel surveys in freshwater streams to look for Atlantic salmon juveniles and adults in western Washington rivers and streams. The Atlantic salmon discovered to date appear to be hatchery escapees. As of 2008, WDFW conducted over 635 surveys in 150 streams and rivers that resulted in the capture of 149 juvenile Atlantic salmon. All but three were from the same hatchery. Young Atlantic salmon are caught in fish traps in the Chehalis River each year and a small number are caught by recreational anglers in rivers near net pens in North Puget Sound.

Other species of concern

Nonnative crayfish

Surveyors have discovered nonnative crayfish of the genus *Orconectes* in many eastern Washington lakes. WDFW biologists are trying to reduce their populations by trapping them. In western Washington, red swamp crayfish *Procambarus clarkii* infest at least two lakes. People may have introduced these crayfish via aquarium dumping or by using them as live bait. Although WDFW prohibits most crayfish species, companies that distribute educational kits to schools and some pet stores still distribute these species. Efforts are underway by Sea Grant to educate teachers about using these prohibited species and in the proper disposal of any species used in science programs.

New Zealand mud snails

New Zealand mud snails are present in lakes and canals on the Long Beach Peninsula, in the lower Columbia River, and in Capitol Lake in Olympia. Due to the tiny size of New Zealand mud snails, humans easily spread them through their recreational activities, particularly on felt-soled waders used by anglers. WDFW and other agencies educate boaters and anglers about the importance of decontaminating boots and gear to avoid spreading them. Ecology requires its environmental monitoring staff to follow decontamination procedures for their gear when working in the aquatic systems to help prevent the spread of all invasive species.

Amur gobies

Researchers discovered Amur gobies in the Lewis River and the lower Columbia River. The species, which originates in Asia, migrates out to sea to spawn, and then returns to freshwater. They do not necessarily return to the same freshwaters where they reared, making it difficult to predict where they may next return. The fish are small, and very similar to native sculpin species, so it is difficult to assess the numbers present, or their impacts.

Aquarium species

There are large populations of Chinese mystery snails and possibly other non-native snail species present in many Washington lakes. Aquarium dumping is the most likely vector. WDFW receives several reports each year of anglers catching Piranha, Pacu, *Plecostomus*, and other aquarium fish species. Many Washington lakes have established populations of goldfish that compete with desirable species and destroy habitat. A joint report from Oregon State University and the U.S. Environmental Protection Agency indicated that a growing number of the nonnative species found in rivers and streams in 12 western states are aquarium species.

Zebra and quagga mussels

Zebra and quagga mussels are from the same family and their shells usually display similar striped designs, but differ slightly in size, shape, and habitat preferences. People discovered quagga mussels in January 2007 at Lake Mead and Lake Havasu in the Colorado River Basin. Since then, other western states report new infestations (but not Washington, Oregon, or Idaho as of January 2010). These two species have cost the Great Lakes region of the United States billions of dollars in damage and control efforts. The ecological damage they have done by altering the ecosystem and crowding out native species is on a catastrophic scale.

WDFW has conducted zebra mussel monitoring since 1997. Biologists from WDFW, Ecology, Public Utility Districts, and Tribes use plankton nets to collect samples from various sites along the Columbia River and in high use lakes to test for the presence of free-floating juvenile zebra or quagga mussels (veligers). In the 2007 monitoring season, samplers collected 131 plankton samples at 92 sites. WDFW increased monitoring and sampling efforts in the 2008 season. Portland State University oversees a substrate-monitoring program by distributing settling plates to approximately 90 sites throughout Washington. WDFW also does outreach and education to recreational boaters and inspects boats for the presence of invasive animal or plant species.

Table 2 - Summary of current management techniques for invasive animals present in Washington.

Nonnative, Invasive Animals	Current Management Measures
Tunicates (marine)	Diver hand removal Chlorine under tarps Weak acetic acid
European Green Crab (marine/estuarine)	Trapping
Atlantic Salmon (freshwater/marine)	Snorkeling surveys
Nonnative crayfish (freshwater)	Diver removal Trapping
New Zealand Mud Snails (freshwater)	Decontamination of field gear Drawdown or dewatering
Amur Gobies (freshwater/marine)	Survey only
Aquarium Species – snails, fish (freshwater)	Survey – incidental reports
Goldfish (freshwater)	Rotenone for fish management (occasionally)
Zebra and Quagga Mussels (freshwater)	Survey – monitoring – Not yet reported from Washington, Oregon, or Idaho (January 2010)

Potential impacts and mitigation under continuing current practices

Under this alternative, agencies will take no action for the management of aquatic invasive animals or they will continue to use manual or mechanical removal. See Section V for potential impacts and mitigation for manual or mechanical removals. Any chemical control will be under an Agriculture EUP.

Use of Physical (Manual) and Mechanical Control Methods Only

Overview of methods

The development of physical or mechanical methodologies to remove aquatic invasive animal populations or marine algae is in its infancy. In lieu of developed methodologies, people generally adapt technologies developed for aquatic plant management for aquatic invasive animal or marine algae removal. There is only a modest amount of information available about these methods in the scientific or gray literature or on the internet.

This section provides a general description and overview of various physical and mechanical removal methods for aquatic invasive animals and invasive marine algae, but does not present a thorough literature review of every management method for each potential invasive species. For a comprehensive review of methods available for marine invasive organisms of interest to Australia, see Mcennulty et al. (2001).

Physical removal methods include:

- Hand removal of the invasive species by divers or snorkelers.
- Using traps to capture and remove targeted species.
- Covering or smothering the invasive species with tarpaulins or bottom barriers.
- Dewatering and water level drawdown.
- Using heat or cold to kill invasives (altering temperature).
- Any method that physically removes the invasive species from the environment.

Mechanical methods include:

- Diver dredging.
- Other mechanical means or machinery to remove invasive animals or invasive marine algae from infested waters.

Manual removal

Description of method

Hand removal involves removing the entire animal or macro alga from the water manually and disposing of it on a terrestrial site. In shallow water, waders or snorkelers can typically reach the targeted species; deeper waters need divers to remove the organisms. Tools such as rakes, knives, hand scrapers, or even kitchen tongs may facilitate removal; people are inventive. Divers typically collect the targeted organisms in bags to convey them to the surface for disposal.

Hand removal is suitable for removing slow moving or sessile species like tunicates, starfish, or marine algae. Trapping or other control measures are better options for mobile animals that

would be difficult to capture by hand. For some species, hand removal may only target adults or mature forms, with other life stages having pelagic forms not suitable for physical removal efforts. Timing of any removal project may be crucial to remove animals/algae before they reach reproductive age.

With all invasive species removal projects, follow-up monitoring is crucial. Generally, divers will miss some individuals or life stages during any single hand-removal event. Successful eradication requires early detection, elimination of fragments, fragmented organisms, reproductive stages, repeated monitoring, and continual removal until surveyors cannot detect any target organisms.

It is also critical to involve trained workers for the project (Mcennulty et al. [2001]). Workers must be able to identify the targeted organism. They need to carry out removal in accordance with health and safety regulations and they need information about avoiding damage to non-target organisms or habitat.

Examples of manual removal for invasive species control

WDFW has contracted with commercial divers to remove invasive tunicates from recreational boats at marinas in Des Moines, Elliott Bay, and Drays Harbor in an effort to control their spread. WDFW divers removed tunicates from recreational boats moored in two marinas at Pleasant Harbor, Hood Canal, and in addition, they worked with commercial divers to clean docks. There are also volunteer diver groups that conduct independent work parties to remove tunicates under Scientific Collection Permits issued by WDFW. The Advanced Assessment Team from REED Environmental Education Foundation has removed tunicates from several areas in Hood Canal. They have also conducted several comprehensive presence/absence surveys of both native and non-native species.

The Washington Scuba Alliance, a volunteer group, removed the solitary, sessile tunicate *Ciona savignyi* from a location in Hood Canal in 2006. Six volunteer divers worked on the project - conducted at depths of 55 to 75 feet using kitchen tongs to pull each tunicate from its attachment on the rocks. When they could not physically remove an individual, they used a plastic spatula to mutilate and kill it. Read their report at

http://www.psparchives.com/publications/our_work/protect_habitat/tunicates/CionaRemovalReportOCT06.pdf

In another project, volunteer divers removed a different solitary tunicate species, *Styela clava*, from boat slips at Pleasant Harbor Marina (November 2005). Approximately 30 divers worked for two hours removing as many tunicates as possible by hand. This effort resulted in the removal of about one percent of the total infestation at that marina. Divers removed more than 1,200 pounds of tunicates and buried them on the grounds of a U.S. Fish and Wildlife hatchery in the area.

Culver and Kuris (2000) described the eradication from a Cayucos, California intertidal site of a South African worm (sabellid polychaete) that parasitizes abalone and other gastropods. Volunteers hand removed 1.6 million large native black turban snails from the beach near shell debris outfalls of an abalone processing facility (the source of the worm). Native snails served as

hosts to this parasite and larger animals were more susceptible to infestation by the worms. The removal of the native snails reduced the density of susceptible hosts below that needed to maintain transmission of the parasitic worm. Scientists did not detect any more South African worms at that location after volunteers removed the snails and the abalone facility installed screens to prevent the release of outfall water and infested shells.

About six years after the establishment of invasive sea stars in Tasmanian waters, the Port of Hobart organized a series of community dives to hand remove these organisms. Divers removed about 21,000 sea stars over a period of years, but by 2001, there were an estimated 140 million individuals in the area http://www.eoearth.org/article/Aquatic_invasive_species. For sea stars, hand removal by divers proved ineffective as a control method at the late stage of the invasion. However, even with large populations, hand removal can sometimes temporarily remove enough individuals from targeted areas to allow activities such as shellfish farming to occur.

Effectiveness

Physical removal is expensive, labor-intensive, and is generally suited to small-scale projects. Eradication is usually possible only if the invasion is in its early stages. Small populations of marine algae *Caulerpa taxifolia* and *Undaria pinnatifida* have both been successfully removed by hand removal techniques (Mcennulty et al. [2001]). Zuljevic and Antolic (2001) report that a small scale project to eradicate *Caulerpa taxifolia* from Croatian waters was accomplished by combining manual removal with shading using black polyvinyl chloride plastic as a covering material. At another site, on sandy substrate the divers used forks to uproot *Caulerpa taxifolia* rhizoids. Divers handpicked algae attached to cobbles. Preliminary attempts to remove *Caulerpa taxifolia* in infested New South Wales waters showed that two divers using hand removal techniques could clear a four square meter patch in one hour. However, this patch grew back in six months (Millar, 2002).

WDFW divers removed two commercial sized dumpsters full of a colonial tunicate (*Didemnum*) from Docton Park on Maury Island in 2008. Patches of the tunicate had grown back when they returned in 2009 and they were removed again (Meacham, personal communication).

Once an invasive species establishes throughout a water body, it becomes more difficult to eradicate. Even gaining control of the population may be unachievable using hand removal methods. A large-scale effort to control the brown alga *Sargassum muticum* in southern England was not successful despite volunteers having removed large amounts of the alga by hand and later by mechanical harvesting techniques (Critchely et al, 1986). Trowbridge (1999) reported that removal of the green alga *Codium fragile tomentosoides* from a beach in New Zealand was unsuccessful. Hewitt et al. (2005) pointed out that a difficulty of using manual removal for invasive macroalgae is the ability of many invasive species to grow or regenerate from microscopic stages (microscopic phase equivalent to a seed bank). In their study of hand removal of *Undaria pinnatifida*, they concluded that removal required a significant commitment, along with vector management to reduce the chances of re-inoculation and spread, monitoring to detect other invasion sites, and treatment to remove microscopic stages. Many invasive animals like tunicates and zebra mussels that are sessile as adults also have pelagic life stages that contribute to their spread. Species such as colonial tunicates may be spread via fragmentation.

Impacts due to physical removal/manual control

Earth

Sediments

Removing invasive animals or marine macro algae from the bottom of lakes or marine waterways may disturb sediments causing short-term turbidity. The degree and the duration of the turbidity will depend on the type and texture of the sediment. Increased turbidity may make it difficult to see remaining invasive species to remove them. Turbidity and the physical removal of the invasive species from bottom substrates may disturb native benthic organisms. Glasby et al (2004) indicated that physical removal of *Caulerpa taxifolia* in New South Wales, Australia was labor intensive, slow, and often resulted in reduced visibility that made locating the alga difficult. They also noted that *Caulerpa taxifolia* often fragmented during physical removal. Fragment creation facilitates dispersal.

Water

There should be little impact to surface water, ground water, or public water supplies through physical removal activities, except that this activity may result in short-term increased turbidity in limited areas. It is possible that removing organisms such as tunicates from older docks and marinas, and boats could release anti-fouling toxic materials into the water. Ecology and DNR prohibit the in-water hull cleaning of vessels painted with soft paints and tin-based paints. These paints pose more of a risk to the environment compared to hard paints.

Plants and animals

Plant habitat

Removing invasive animals that encroach on aquatic plant habitat or feed on aquatic plants should improve the habitat and growing conditions for plants or have no impact on plants. On the other hand, Hewitt et al (2005) found that physical disturbance by trampling of intertidal or shallow water communities can occur during these activities, particularly if large numbers of people are involved.

Animals

Invasive animals often displace native animals from their niches when they invade an ecosystem. They may also prey on native species and compete for the same resources. Selectively reducing the population of an invasive animal through physical removal should remove potential predators and improve food and habitat for native species. Removing invasive individuals selectively by hand will target just those species. Using a scraper or rake to facilitate removal of targeted invasives may also remove native species. Physical disturbance by trampling of the intertidal or shallow water communities may occur and interfere with native animal populations in those areas.

Water, land, and shoreline use

Aesthetics

This activity should have little impact on aesthetics.

Recreation

Removing invasive species from marine sanctuaries should improve diving experiences by allowing a more diverse native community to reestablish. Physical removal efforts may temporarily limit public access to an area while people remove the animals or algae.

Navigation

Physical removal efforts may temporarily limit public access to an area while people remove the animals or algae. This may have a short-term impact to navigation.

Mitigation for physical removal/manual control

Permits

WDFW reports that they did not need any permits for the hand removal of invasive tunicates in Puget Sound. It is unclear whether WDFW would require HPA's for hand removal of invasive animals in freshwater systems. This is likely dependent on whether the activity will affect fish or shellfish or their habitat. The project proponent should check with WDFW Habitat Program before beginning any project in freshwaters. For projects over \$2,500, check with the local jurisdiction to see if they require substantial development permits for the activity.

Sediment, water, plants, and animals

Impacts from physically removing invasive animals or marine algae should be minimal. To avoid impacts to fish, shellfish, or other spawning areas, agencies should evaluate the areas before project initiation to determine the significance of the area to fisheries and aquaculture, particularly in salmon-bearing waters. If possible, avoid critical spawning areas at critical times.

Avoid fragmenting the organism during hand removal. Removing an invasive alga such as *Caulerpa taxifolia* can create fragments that can facilitate its dispersal. Removal of colonial organisms such as colonial tunicates may also result in spreading the species. If feasible, designate people to skim the water with nets to remove fragments, or select a different control method for colonial organisms.

Time activities to occur before reproduction occurs to limit spread of the invasive species. When resources are limited, target reproductive individuals for removal.

To avoid water quality issues with toxic bottom fouling paint, do not clean boats that have soft anti-fouling paints in the water, or if this is not possible, avoid scraping. Instead, hand-remove the targeted species and do not dispose of them into the water.

It is unlikely that physical removal of invasive aquatic animals will affect rare plants but, if this is a possibility, check with the DNR's Natural Heritage Program to ensure that no rare plants exist at the location. If a unique species exists in the targeted water body, consult with Natural

Heritage Program staff for the best way to avoid adverse impacts to the rare plant species. Mitigation may include altering timing of the activity.

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Bottom barriers/covering

Description of method

A bottom barrier, also called a benthic barrier or a bottom screen, covers the sediment or substrate like a blanket. It is analogous to using landscape fabric under bark chips to prevent weeds. Barriers block light from plants and algae and may smother aquatic animals. Barriers can also isolate invasive species from the rest of the ecosystem, allowing for the introduction of chemicals in a controlled and sequestered environment.

An ideal bottom barrier fabric is durable, heavier than water, reduces or blocks light, is easy to install and maintain, and readily allows decomposition gases to escape without billowing upwards. People have used many different materials for bottom barriers such as burlap, plastics, perforated black Mylar®, and woven synthetics. There are also some commercial bottom barrier products available. The efficacy, durability, longevity, and the cost of materials vary by product.

Even the most porous materials can billow due to sediment gas buildup (Gunnison and Barko, 1989, 1990). Therefore, it is important to anchor the bottom barrier securely to the sediment. Natural materials such as rocks or sandbags (filled with clean sand) are preferred anchor materials. Fishing gear, anchors, vandalism, or storms can damage bottom barriers. Any tears in the fabric will reduce their efficacy. It may be difficult to anchor bottom barriers over rocks, fallen trees, and other underwater obstructions. Wave or tidal action may limit their use in some marine situations.

Bottom barriers are suitable for managing sessile or attached organisms. For some invasive animals, covering may only target adults, with other life stages having pelagic forms. Bottom barriers are not selective within the treatment area, but when placed correctly, they can be selective for small isolated areas containing non-mobile invasive species.

Examples of bottom barriers used for invasive species control

Plant managers have used bottom barriers to manage aquatic plants since the 1960s (Born et al. 1973, Nichols, 1974). Invasive animal specialists have only recently been using covering or bottom barriers to help manage invasive animals. WDFW used bottom barriers (tarps) to cover invasive tunicates in a marine sanctuary before putting chlorine tablets under each tarp. California successfully used a similar method to eradicate the marine invasive alga *Caulerpa taxifolia* from its waters. Scientists recently (2009) briefed members of the Tahoe Regional Planning Agency on studies concerning invasive Asian clams and said that under proper conditions, the use of plastic bottom barriers laid on top of clam beds resulted in 100% mortality of the clams within 28 days.

Hawaii has experimented with covering invasive animals like snowflake coral on pilings. They wrap each infested piling with plastic and secure it with tape. The smothering treatment works by cutting off oxygen and water flow. It has proven to be very effective at killing everything on the pilings. Bacterial growth returns after about a month of removing the wrapping.

Glasby et al. (2005) reported that smothering the marine alga *Caulerpa taxifolia* with hard rubber mats (conveyer belts) killed the alga. They indicated that although effective, conveyer belts were difficult to deploy and even more difficult to remove. The authors also used burlap matting to cover *Caulerpa taxifolia* infestations. Burlap is a natural fiber that degrades completely after about two years. Burlap matting worked well for small-scale applications, but in a larger scale trial, they found the buoyant matting was difficult to work with. The burlap barrier killed most vegetation along with many invertebrates under the barrier. However, the authors discovered that *Caulerpa taxifolia* grew between the joins in the material as well as through any tears that occurred during deployment.

Effectiveness

Bottom barriers are generally very effective in eliminating target organisms in the areas where they are deployed. Millar (2002) noted that all smothering methods were effective in killing *Caulerpa taxifolia* within three months. However, using bottom barriers for eradication is usually possible only if the invasion is in its early stages or limited to a small area. Installing, maintaining, and removing bottom barrier material is expensive and labor-intensive. These factors typically limit the use of bottom barriers within a water body.

Impacts due to bottom barriers/covering

Earth

Sediments

Installing and removing bottom barriers from lakes or marine waterways will disturb sediments causing short-term turbidity. The degree and the duration of the turbidity will depend on the type and texture of the sediment. It may also be difficult to install and maintain bottom barriers in deep soft sediments; their use over soft or flocculent sediments may not be appropriate (Gibbons 1986). Installation of bottom barriers in freshwater systems is associated with the release of gasses under the barriers. Gas evolution is proportional to the amount of biomass under the barrier and water temperature (Gunnison and Barko, 1992).

Water

Surface water

Oxygen levels can decline to near zero beneath bottom barriers. This may lead to phosphorus release from sediments and an increase in ammonia. However, impacts to water quality should be limited to areas covered by bottom barriers and to water trapped under the barriers. It should not affect overlying water, except when the project proponent removes the barriers.

Public water supplies

Bottom barrier use should not disrupt public water supplies. Bottom barriers installed around a water intake may help prevent vegetation from clogging the intake.

Plants and animals

Plant habitat

Bottom barriers are selective for small, isolated treatment areas, but their use can result in a non-selective loss of all aquatic vegetation within the areas covered by the barrier. Plant colonization of the bottom barrier surface or from below is possible with most materials.

Animals

Macroinvertebrates: A Wisconsin study revealed a two-thirds reduction of the lake benthic community under bottom barriers three months after installation (Engel 1990). Ussery et al., (1997) found that macroinvertebrate density under bottom screens declined by 69 percent within four weeks of barrier placement at Eau Galle Reservoir, Wisconsin. Within a few weeks of placement in ponds near Dallas, Texas, invertebrate densities declined by more than 90 percent.

Barriers also reduced macroinvertebrate taxa richness at these locations. However, biotic conditions in affected areas recovered rapidly after barrier removal. Ussery et al. (1997) noted that bottom barriers only affected macroinvertebrates directly under the barrier.

Fish: Bottom barriers can interfere with spawning if installed over spawning habitat or spawning sites.

Water, land, and shoreline use

Aesthetics

Because managers install bottom barriers underwater over sediments, they should have little to no impact on aesthetics, unless sediment gas buildup under the barrier causes billowing into the water column where it would be visible.

Recreation and Navigation

Bottom barriers are subject to lifting by gas production from sediments and decomposing plant and animal biomass. An improperly installed and poorly maintained bottom barrier can create a recreational and navigation hazard to boaters and swimmers if it floats into the water column. Periodic inspection of bottom barriers is required to ensure that they do not become hazards. If the project proponent uses metal anchoring materials instead of natural materials, over time these materials can corrode and pose a danger to waders and swimmers.

Mitigation for covering/bottom barriers

Permits

WDFW requires an HPA for the installation of bottom barriers in freshwater systems. It is unclear if WDFW requires an HPA in marine waters. For projects over \$2,500, check with the local jurisdiction to see if they require substantial development permits for this activity.

Earth

Sediments

If possible, install barriers when the biomass of vegetation is minimal and during the cooler months when microbial decomposition is low. This will help decrease the rate of gas release from decomposing biomass. Use natural materials such as sandbags filled with clean washed sand, pea gravel, or rocks as anchors. Remove synthetic barrier materials as soon as the invasive species is dead. Natural fabrics, such as burlap decompose slowly in place (typically within two years depending on temperature and other environmental conditions).

Water, plants, and animals

Bottom barriers generally cover limited areas; therefore, impacts should be minimal. Project proponents should limit the area covered by bottom barriers in each water body to avoid adverse impacts to native plants and animals. To avoid affecting fish or other spawning areas, agencies should evaluate the treatment sites before project initiation to determine the significance of the area to fisheries or aquaculture, particularly in salmon-bearing waters. Avoid critical spawning areas at critical times. Remove the barrier after the invasive species are dead to allow native

organisms to recolonize the covered area or use natural fibers such as burlap that will decompose naturally.

Check with the DNR's Natural Heritage Program to ensure that no rare plants exist at the location. If a unique species exists in the targeted water body, consult with Natural Heritage Program staff for the best way to avoid adverse impacts to the rare plant species. Mitigation may include altering timing of the activity.

Water, land, and shoreline use

Recreation and navigation

Anchor each barrier securely to the sediment and inspect it at regular intervals for several weeks after installation to ensure that gas buildup has not lifted it into the water column. If it is not possible to use natural anchoring materials like rocks or sand, remove metal anchoring materials as soon as possible. If left in place, they may corrode and injure swimmers and waders.

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Trapping

Description of method

Traps are devices for capturing and holding animals. Invasive species managers use various types of traps to remove aquatic invasive animals from the environment, including pitfall traps, minnow traps, and Fukui fish traps. They bait these traps with food or pheromones to attract targeted species. Unbaited pit traps capture animals when they fall into them and are unable to escape. Trapping is suitable for mobile animals, like invasive crabs or crayfish that otherwise may be difficult to locate, capture, and remove. Researchers agree that while trapping may reduce invasive species numbers, used as the sole management method trapping will not eradicate the population.

Examples of trapping for invasive species control

Trapping is cited by Rodgers et al. (2000) as the most environmentally sound and cost-effective option for the control of European green crabs in Washington, but the authors point out that since not all green crabs enter these traps, agencies may need to use additional methods of control. WDFW also uses pitfall traps, which are more permanent, at long-term monitoring sites.

WDFW⁹ used baited traps to survey for and reduce European green crab populations in Willapa Bay. Agency employees or volunteers set out traps from April to September when green crabs are most active. The objective was to capture and remove as many green crabs as possible. The traps are passive which means that the animal moves into an increasingly narrow tube seeking the bait. It cannot reach or find the opening to leave. Rogers et al. (2000) noted that the most effective, cost-effective, and easily deployed traps are modified crayfish traps, which are set in lower intertidal areas around the perimeters of the bays.

In Washington, trapping captures more male crabs than female crabs. Researchers speculate that male crabs are more aggressive and may keep females away or they may eat the female crabs and smaller crabs that enter the traps. Female crabs may also tend to be less mobile and may not encounter the traps. Sea Grant in Oregon (2000) also reports that brooding females have a tendency to avoid traps better than males.

⁹ Source: Deborah Holmes (2001). *The Green Crab Invasion: A Global Perspective, with Lesson from Washington State*. Master's Thesis. Evergreen State College. <http://academic.evergreen.edu/h/holmesd/index.htm>.

WDFW discontinued trapping in Willapa Bay in early 2003. Although there was a strong recruitment of young crab in late 2003 and again in 2005, the population diminished as the older crabs died and reproduction was extremely low. The same phenomenon is occurring with other green crab populations in Oregon and British Columbia (personal communication to WDFW staff by Sylvia Yamada, Oregon State University and Graham Gillespie, Fisheries and Oceans Canada).

Targeted trapping efforts have also been used to reduce green crab predation on commercial bivalves in small ponds and embayments (e.g., Martha's Vineyard, Massachusetts, Walton 2000).

Meacham and Pleus (2007) report that WDFW uses trapping to help reduce invasive crayfish in some Washington lakes.

Effectiveness

Although researchers report that trapping may help reduce populations of invasive animals, trapping by itself has not been shown to eradicate an invasive population (Hewett, date unknown). Catch records from green crab trapping at Martha's Vineyard, MA do not show decreases in catch per unit effort or changes in population structure despite large catches (CRIMP). In Sparkling Lake, Wisconsin, an intensive program of trapping by students and staff from the University of Wisconsin-Madison and the manipulation of fishing regulations to increase the number of fish that prey on small crayfish helped reduce the rusty crayfish population. Trapping in this 110-acre lake was intensive with 280 traps deployed around the lake. This approach significantly reduced the rusty crayfish population in the lake allowing the return of aquatic plants. <http://iz.carnegiennh.org/crayfish/phpbb3/viewtopic.php?f=15&t=308>, but it did not eradicate the crayfish population.

Agencies that use sustained trapping to reduce crayfish populations must do this regularly over the length of time they desire reduction. This is in part because trapping selects for larger animals and males, leaving small animals, juveniles, and females in the environment. For a good overview of crayfish control technologies including trapping, see *Investigation of Crayfish Control Technology*, Final Report, by Matthew W. Hyatt, Arizona Game and Fish Department at <http://www.usbr.gov/lc/phoenix/biology/azfish/pdf/CrayfishFinal.pdf>

Mcnulty (2001) report that trapping does not appear to be effective in reducing populations of invasive sea stars.

Note: WDFW biologists began trapping invasive northern crawfish in northeastern Washington in 2007 using 40 minnow traps. These efforts made no impact on the rapidly spreading population that is now present throughout the Columbia River Basin in large number. These invasive crawfish are negatively impacting native species and damaging habitat. In western Washington, the Louisiana red crawfish that was found in Pine Lake in 2001, is now found in ten King County Lakes. WDFW plans to allow harvest of invasive crawfish, along with native crawfish species, in an effort to slow down the population growth of invasive crawfish (Pam Meacham, WDFW personal communication).

Impacts due to trapping

Earth

Sediments

Deploying, anchoring, and removing traps may disturb sediments causing short-term turbidity. The degree and the duration of the turbidity will depend on the type and texture of the sediment. Reducing populations of invasive organisms such as crayfish or mitten crabs that may dig burrows may help stabilize shorelines and reduce impacts to sediments. Burrowing freshwater invasive species may undermine shorelines causing erosion and sedimentation of the waterway.

Water

There should be little impact to surface water, ground water, or public water supplies through trapping or netting activities, except for minor introduction of nutrient sources through the bait (beef liver, fish, etc.) used in traps to attract the targeted species. Removing and disposing of the trapped or netted targeted species away from the water body removes nutrients contained in their bodies from that water body. Trapping should result in a net removal of nutrients from the water body.

Plants

Plant habitat

Removing invasive animals such as crayfish should improve conditions for rooted macrophytes. Crayfish cut plant stems as they feed and can disrupt the native plant community. They may also help spread invasive plant species like Eurasian watermilfoil by creating additional fragments as they feed. Chambers et al. (1989) examined the effect of crayfish on four aquatic macrophytes. The crayfish significantly affected the growth of the macrophytes with female crayfish stimulating the growth on two plant species, probably due to the crayfish reducing snails. Male crayfish decreased plant growth. The authors concluded that even low densities of crayfish could affect the growth of submersed plants.

Animals

Invasive animals often displace native species from their habitat when they invade an ecosystem. They may prey on native animals and compete for the same resources. Selectively reducing the population of invasive animals through trapping should remove potential predators and improve food and habitat for native species. This is particularly true for the removal of invasive crayfish or other keystone species whose introduction may significantly alter the ecology of a water body.

Traps will also capture native animals, but small traps exclude most other species like fish. Because species like crayfish and crabs are aggressive, they may injure or kill other animals caught in the traps. Using live traps will ensure that the trapper can release any uninjured native species.

Water, land, and shoreline use

Aesthetics

Because of theft, trappers prefer to place traps in discrete locations. Trappers set crayfish traps underwater along shorelines where lake residents or the public will not notice them. For crab management, trappers set traps in the intertidal areas where they are not likely to be visible.

Recreation

Traps are located underwater or in the intertidal zone in marine environments, so they should have little effect on recreation.

Navigation

Traps should have little impact on navigation. Even if trapper fails to locate and remove all traps, they should remain submerged and not create a navigation hazard.

Mitigation for trapping

Permits

WDFW regulates trapping activities for crabs and crayfish in its Sport Fishing Rule Pamphlet (<https://fortress.wa.gov/dfw/erules/efishrules/>). WDFW management and control efforts for invasive species do not require permits for trapping. However, if trapping occurs in areas where threatened or endangered species are present, trappers must comply with ESA.

Sediment, water, plants, and animals

Impacts from setting and removing traps should be minimal. To avoid impacts to fish spawning areas, agencies should evaluate the areas before placing traps to determine the significance of the area to fisheries. Avoid critical spawning areas at critical times. The project proponent should check with WDFW fish biologists before setting traps in salmon-bearing waters.

Biologists should experiment with and modify trap designs to find the trap that is most effective at trapping and retaining the targeted organism, while excluding native species. Trappers need to check traps on regular basis to release native species. Before moving traps between water bodies, trappers should decontaminate all equipment to ensure that the traps are not a source of invasive species or disease. When finished with the trapping program, trappers must remove all equipment. Follow WDFW sport-fishing regulations to ensure that lost traps do not continue to capture and retain native organisms.

To protect rare plants, agencies should check with the DNR's Natural Heritage Program for locations of rare species. If a unique species exists in the targeted water body, agencies should consult with Natural Heritage Program staff for the best way to avoid adverse impacts to the rare plant. Mitigation may include altering the timing of the trapping activity or by avoiding the area altogether.

References for trapping

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Meacham, P., and A. Pleus. 2007. *Washington State Aquatic Nuisance Species Committee report to the 2008 legislature*. Prepared by P. Meacham and A. Pleus. Washington Department of Fish and Wildlife.

Rogers, R., R. Figlar-Barnes, and B. Dumbauld. 2000. *Monitoring and control of the European green crab (*Carcinus maenas*) in Washington State: A report to the legislature*. Washington State Department of Fish and Wildlife.

Diver dredging

Description of method

During diver dredging (suction dredging) divers use a hose attached to a small dredge to transport invasive organisms (generally aquatic plants or algae) to the water's surface for disposal. People typically modify dredges used for gold mining for this purpose. The term dredging is somewhat of a misnomer because in most operations, the diver does not purposefully remove (dredge) sediment. Instead, the diver removes the organisms from the substrate and hand feeds them into the hose. They travel to the surface by suction and are retained in a sieve. The water discharges to the water body. The hose and dredge merely facilitate transport to the surface (as opposed to divers having to place the organisms into bags and physically transport them to the surface). A good operator can accurately remove targeted invaders, minimizing effects to native species. Although currently mostly used for plant or algae removal, this technology could potentially be adapted to remove invasive aquatic animals.

Examples of diver dredging for invasive species control

In Hawaii, scientists use a modified diver dredge called a Super Sucker™ to remove invasive algae from coral reefs. The Super Sucker™ uses a Venturi vacuum pump. This means that there are no fans or blades to create additional fragments that could help spread the invasive algae. Hawaii's operation involves five people. Two divers equipped with a four-inch round, 100-foot hose descend to the reef where they hand remove invasive algae and feed it into the hose. The suction created by the Venturi system conveys it to the surface. On the support barge, algae, water, and any by-catch are deposited on a porous table where the surface crew sorts the invasive algae from native species and returns any native species to the water. They bag the algae in burlap sacks and transport the sacks to taro farms where they use the algae as fertilizer. Read more about this project at

<http://www.nature.org/wherewework/northamerica/states/hawaii/projectprofiles/art22268.html>.

While it is not likely that tropical algae species found infesting Hawaii reefs could become a problem in Washington, some temperate invasive marine algae are present in Puget Sound. Diver dredging could also be adapted to facilitate more effective invasive animal removal projects. WDFW is considering using a modified SuperSucker™ system to help with tunicate removal projects in Puget Sound.

As reported in Mcennulty (2001) managers in Croatia removed an early infestation of *Caulerpa taxifolia* using a suction pump. Spanish Scuba divers also used a suction pump to help them remove *Caulerpa taxifolia* in the Spanish Mediterranean. In France, oyster farmers use a specialized dredge to remove invasive sea stars from their oyster beds. Critchley et al. (1986) described a suction device used to remove *Sargassum muticum* from marine waters of southern England.

Effectiveness

Because of the expense and intensive effort, diver dredging would likely not be suitable for extensive infested areas. However, using this technology would greatly speed up removal efforts over that of conventional hand removal efforts.

The University of Hawaii operations supervisor estimates that the Super Sucker™ and crew can remove over 800 pounds per hour of invasive algae. This is equivalent to the effort generated by 150 volunteers and 10 divers using other methods.

For effective removal, Millar (2002) recommended that divers start around the margins of the infestation and work around in a circle. This reduces the amount of physical disturbance to the areas thick with plants. Mowing through the middle of a population can create and disperse fragments. Zuljevic and Antolic (2002) reported that while suction removal was a fast removal method for *Caulerpa taxifolia* growing on sandy or muddy substrates, it left fragments and rhizoids behind in the sediments. It was impossible for the divers to locate and remove them all. The authors stressed that it was important to follow-up to remove any new growths of algae from the area.

Impacts due to diver dredging

Earth

Sediment

The degree and the duration of turbidity caused by diver dredging activities will depend on the type and texture of the sediment. Diver dredging should not cause significant sediment disturbance if divers are careful not to touch the end of the hose to the sediment. However, hand removal of invasive animals or algae from the bottom of lakes or marine waterways during diver dredging operations may disturb sediments causing short-term turbidity. Increased turbidity may make it difficult to see remaining invasive species to target them for removal. Activities associated with diver dredging may disturb benthic organisms. This may harm them or lead to unintended effects from disturbing the sediment. Coughanowr (1997) did not recommend dredging as a method to remove sea stars from Derwent Estuary in Tasmania because dredging could resuspend toxic dinoflagellate cysts and heavy metals from the contaminated sediments in the estuary.

Air

There may be exhaust fumes associated with the dive barge and the pump operation, but overall suction dredging should have little effect on air quality.

Water

Diver dredging should have minimal impacts to surface water, ground water, or public water supplies, except that this activity may result in short-term increased turbidity in limited areas. Operation of machinery and a staging barge could result in the potential for spills of oil or gasoline.

Plants and animals

Plants and animals

Depending on the situation, divers can usually target invading species, avoiding impacts to native plants and animals. In some situations, the removal of some native species is unavoidable. In Hawaii, the operators of the Super Sucker™ inadvertently remove some native reef plants and animals along with the invasive algae. In a healthy ecosystem, native species typically return rapidly.

Water, land, and shoreline use

Aesthetics

The noise from pump motors on a dredge barge, and even the presence of the barge itself may annoy some people.

Recreation

Removing invasive species should improve diving experiences by allowing a more diverse native community to reestablish. Diver dredging efforts may result in limited access to an area for a short time while people remove the invading organisms.

Navigation

Physical removal efforts may result in limited access to an area for a short time while people remove the invading organisms. This may have some very short-term impacts to navigation.

Mitigation for diver dredging

Permits

WDFW generally requires Hydraulic Project Approval for diver dredging projects. The project proponent should check with local jurisdictions to see if any local regulations apply; they may need a shoreline substantial development permit. If the project proponent plans to remove any sediment or significantly disturb sediment, they should consult with the U.S. Army Corps of Engineers to determine if they need a Section 404 permit.

Sediment

Impacts from diver dredging should be minimal because the treatment areas are generally limited. However, it is likely that diver dredging will result in some resuspension of sediment. If turbidity becomes significant, the divers can cordon off the discharge site with a silt curtain. If conducted in an area of suspected contaminated sediments (e.g., combined sewer outfall area, landfill), the project proponent should test the sediments for toxicity using bioassays or other techniques prior to initiating the project.

Animals

The surface crew should sort the by-catch on board the dive barge and quickly return all uninjured native species to the water. During the operation, increased turbidity may make it difficult to distinguish the targeted species from native species. Suspend operations until clarity improves.

To avoid impacts to fish or other spawning areas, agencies should evaluate the area before starting a diver-dredging project to determine the significance of the area to fisheries or aquaculture. The project proponent should check with WDFW fish biologists before starting removal projects in salmon-bearing waters, particularly in areas where there are threatened or endangered species. Avoid critical spawning areas at critical times.

Water

To avoid water quality issues with petrochemicals, use biodiesel to run the dredge and support barge. Have a spill plan. Carry spill equipment and a list of people to notify in case of fuel or hydraulic fluid spills.

Plants

It is unlikely that diver dredging of invasive aquatic animals or algae will affect rare plants but, if this is a possibility, check with the DNR's Natural Heritage Program to ensure that no rare plants exist at the location. If a unique species exists in the targeted water body, consult with Natural Heritage Program staff for the best way to avoid adverse impacts to the rare plant species. Mitigation may include altering timing of the activity.

Aesthetics, recreation, navigation

Informing and educating the public about the project and why can help allay concerns. Prompt disposal of removed plant and animal matter should minimize the potential for unpleasant odors in the dredging area. Avoid weekends and holidays unless it is an emergency.

References for diver dredging

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<http://www.environment.gov.au/ssd/publications/ssr/129.html>

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Dewatering

Description of method

Dewatering involves removing all the water from a water body by draining it via an outlet structure or drawing the water down using pumps. Depending on the time of year, this exposes the sediments and invasive species to freezing/desiccation or heat/desiccation. Several factors determine whether dewatering will be effective including:

- Duration of exposure.
- Weather at the time of the activity.
- Climate (eastern Washington versus western Washington).
- Nature of the substrate (sand dries faster than clay).
- Presence of streams, springs, and other water inputs to the system that may prevent complete drying.
- Susceptibility of the invasive species to drying/freezing/heat.
- Ability of the invasive species to move from the dewatered area.

Dewatering directly kills many water dependent organisms such as fish. Others like crayfish may escape to nearby water bodies and later recolonize the water body or may burrow into the mud and survive until water returns. Some organisms may have spores, cysts, or resting stages that may allow them to survive dewatering and later recolonize the water body. Scientists do not know whether dewatering a zebra or quagga mussel infested water body can eliminate them, but they are susceptible to both freezing and desiccation.

Effectiveness

Dewatering for eradication purposes is only suitable in water bodies where the project proponent can completely drain the system and ensure that the sediments completely dry. Few water bodies in Washington have water control structures and the means to drain the water completely. It is unlikely that marine waters could be effectively dewatered. In mild wet climates like those in western Washington, total dewatering or desiccation of the sediments may not occur and that will likely hinder the efficacy of this method for eradicating invasive species.

While water level drawdown (partial dewatering) is a known and accepted technique for managing the excessive growth of some aquatic plant species, total dewatering of a water body is unusual. Researchers tried this in the UK to remove crayfish from a water body, but it was not successful. Virginia considered dewatering a quarry to eradicate an infestation of zebra mussels,

but rejected this option and used chemical control. A report on *Dreissenid* mussels prepared for the state of Utah indicates that these mussels are susceptible to exposure and desiccation and that dewatering may be an appropriate control measure in canals. Adult zebra mussels die when aerially exposed to freezing temperatures for varying lengths of time. Zebra mussels die in two days at 0° C, in five to seven hours at -3° C, and in less than two hours at -10° C. Duration to mortality is less for single mussels than for clustered mussels. Desiccation can eradicate zebra mussels in areas that can be dewatered for several days or can act as a population control in areas that cannot be completely dewatered (Heimowitz and Phillips, 2006).

Australia has dewatered small farm dams in successful efforts to eliminate red ear slider turtles. Dewatering is used in conjunction with sediment removal to local burrowing animals, using sniffer dogs to locate off site turtle nests and eggs, and traps for adults. Australian biologists caution that this technique is suitable for small water bodies that can be completely drained and that follow-up must occur for years after initial removal to achieve eradication (O’Keeffe, 2009).

New Zealand mud snails: In December 2009, Washington state agencies conducted a partial drawdown on Capitol Lake, Olympia, Washington to manage a newly discovered invasion of New Zealand mud snails. Capitol Lake has an outlet structure and a history of drawdown. Discovery of the New Zealand mud snails, coincided with an unusual cold spell (temperatures as low as 6° F.) that gave scientists an opportunity to study the effect of the drawdown and subsequent freezing on the snails. However, because of coordination issues (the cold snap occurred very soon after the snail discovery), the drawdown did not occur until ice had formed on the lake. The ice cover insulated the sediments from freezing to any depth. In areas kept clear of ice, scientists observed increased mortality of the snails over time at temperatures below freezing. After four days of freezing, WDFW observed 96% mortality of the snails in the test plots (Allen Pleus, personal communication).

Impacts due to dewatering

Earth

Sediments

Dewatering has significant impacts to sediment. It exposes the sediment to the atmosphere and affects the habitat for emergent and submersed plants, fish, invertebrates, waterfowl, and aquatic mammals. Depending on the time of the year, the sediments may dry out or may freeze. Sometimes dewatering may change the consistency of sediments (consolidates them) when the water returns.

Water

When water returns, nutrient release from sediments may trigger algae blooms. Dewatering may also affect shallow shoreline wells. A power company in the Spokane area stopped severe water level drawdowns on Lake Spokane because it affected adjacent area wells.

Plants

Dewatering has significant impacts to plants. Many native aquatic plants will die while the water is gone, but most species will eventually return from resistant rhizomes and roots, seeds, tubers,

and over wintering structures (turions). A Vermont report (1989) concluded that a drawdown in Lake Bomoseen, Vermont for Eurasian watermilfoil control caused major damage to deepwater wetland communities. Two rare plant species decreased after drawdown. Greening and Gerritsen (1987) noted that frequent drawdowns result in a reduction of species diversity and favor tolerant plants.

Animals

Dewatering will kill animals that are water dependent such as fish. Other animals may be able to relocate to nearby water bodies or may have life stages that can survive drying/freezing/heat. Impacts to animals by the Lake Bomoseen winter drawdown were significant. The drawdown decreased habitat for beaver and muskrat by preventing them from using their winter food supply and exposing them to adverse weather and predation. Habitat suitability decreased for species that overwinter in sediments such as frogs, turtles, and macroinvertebrates. Vermont managers concluded that the drawdown (which is much less severe than dewatering) had adverse impacts on all macroinvertebrates (snails, mussels, aquatic insects). Dewatering may affect other animals that depend on the water body for feeding or resting such as migratory waterfowl.

Water, land, and shoreline use

Aesthetics

Short-term impacts on aesthetics are significant. Dewatering exposes sediments for the duration of the dewatering event and turns a water body into mud landscape. As sediments dry out and the exposed plants and animals die, they may produce odors and appear unsightly, particularly during summer drawdowns. As water returns, nutrient release from sediments may trigger algae blooms.

Recreation

Dewatering eliminates water-based recreational activities for the duration of the drawdown. Depending on the success in removing the invasive species, recreational opportunities on the water body may improve if the invasive species was affecting them.

Navigation

Dewatering eliminates navigation in the affected water body for the duration of the drawdown.

Shoreline

Water intakes, docks and other shoreline structures will be nonfunctional for the duration of the dewatering. Conversely, dewatering allows easy access to docks and other structures for repair work.

Mitigation for dewatering

Permits

Because of significant impacts to fish and fish habitat, WDFW may require Hydraulic Project Approval for dewatering projects. It is likely that the local jurisdiction will require a shoreline substantial development permit.

Water

The project proponent needs to have a plan and a time schedule for refilling the water body.

Plants

The project proponent should inventory and map the submersed and emergent plant species prior to dewatering. Monitor the water body after the water returns and if plants do not recover within a reasonable time, institute a reintroduction program to help return the species to the water body. Use plants from near-by lakes that are uninfested with invasive species to avoid introducing new invaders and different genotypes.

Check with the DNR's Natural Heritage Program to ensure that no rare plants exist at the location. If a unique species exists in the targeted water body, consult with Natural Heritage Program staff for the best way to avoid adverse impacts to the rare plant species. Mitigation may include altering timing of the activity or removing the rare plants to another location and then reintroducing them after the water returns.

Animals

Inventory the animal species prior to dewatering. If possible, remove important native species and individual animals and place them in a refuge until the water returns. Institute a reintroduction program for any species that does not recover after dewatering.

Evaluate the significance of the area to fisheries. Weigh the impacts of total fish kill with removal of the invasive species.

Aesthetics, recreation, navigation

Notify the public and any residents well ahead of any dewatering event and involve them with planning efforts. Remove and dispose of dead and dying animals to avoid creating noxious odors or a health hazard.

References for dewatering

Greening, H.S. and Gerritsen, J. 1987. *Changes in macrophyte community structure following drought in the Okefenokee Swamp, Georgia, USA*. Aquatic Botany, 28:113-128.

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O'Keeffe, S. 2009. *The practicalities of eradicating red-eared slider turtles (Trachemys scripta elegans)*. In Aliens: The Invasive Species Bulletin. Newsletter of the IUCN/SSC Invasive Species Specialist Group. Issue Number 28. 2009.

Altering water temperature (heating/freezing)

Description of method

Using heat or freezing to kill invasive animals such as zebra mussels on equipment and gear is a recommended practice to avoid spreading these species to uninfested waters. In those situations, gear is placed in a freezer, submersed in very hot water, or equipment is pressure washed for specified periods using hot water. There are examples of using heat to manage terrestrial invasive plants (Kolberg and Wiles, 2002). Thermal weed control techniques include flame weeding and steam application. Typically, applicators apply flame or steam directly to the plants with varying degrees of effectiveness depending on variables such as plant species and growth stage. There are small commercial steam units and flame weeders available for sale to the public.

The use of freezing is mostly associated with dewatering situations when freezing the exposed sediments may result in suppressing or killing invasive plants and animals, although you can freeze gear to decontaminate it. WDFW biologists reported 96% mortality of New Zealand mud snails in test plots (kept clean of ice) after four days of exposure when Capitol Lake in Olympia was drawn down during a cold snap (Allen Pleas, personal communication).

Ecology was not able to find any examples of managers altering the temperature regime to manage invasive animals *in situ* in the literature (except for dewatered situations). However, Ecology expects that any thermal alteration for *in situ* invasive species management will not occur on a water body scale (unless the water body was very small). Efforts are expected to focus on targeted locations or on species within contained areas such as underneath tarps. In those situations, biologists may inject hot water under covered areas to kill the targeted organism. They may also use pressure washers to spray hot water directly on the species (Allen Pleas, personal communication). While there is literature available about the impacts of thermal pollution on aquatic ecosystems, this information relates to prolonged discharges from industry or wastewater treatments. These impacts are not relevant to the limited scope of thermal alteration proposed for use in the Aquatic Invasive Species Permit.

Impacts due to temperature alteration

Earth

Sediments

Impacts to sediments will be limited to the covered areas.

Water

The discharge of heated water to surface waters is a common practice (Langford, 1990) resulting from cooling water discharges from power generating plants, wastewater plants, and industry. Altering water temperature can cause changes in dissolved oxygen. Warmer water holds less oxygen than colder water. Warmer water also increases the decomposition rate of organic material that in turn depletes oxygen. At the same time, increasing temperatures increase the

metabolic rates of aquatic organisms. This increases oxygen demand at the time that oxygen levels are decreasing.

Altering temperature regimes can cause direct mortality to some organisms. A nuclear power generating station in Taiwan caused bleaching of corals near the discharge channel when the plant first began operating¹⁰. Conversely, some animal populations may benefit. Manatees in Florida flock around the nuclear power discharges during the occasional freezing spells. However, these environmental impacts are associated with long-term continuous discharges of heated water allowed under individual NPDES permits for industrial or municipal discharges of pollutants. Compared to these discharges, Ecology anticipates that altering temperature for aquatic invasive species control will be short-term and very limited in area. This short-lived alternation in temperature should cause impacts to water only in the immediate vicinity of the hot or cold-water application.

Plants and animals

Plants

In general, warm water increases plant growth rates and that may result in higher plant densities. It may also lead to a shift in species. Algae or cyanobacterial growth rates may also increase leading to algal blooms. However, these effects are associated with long-term thermal discharges. Given the limited area and the temporary alternation of the temperature regime allowed in the Aquatic Invasive Species Permit, any effects to non-target plants or algae should be minimal.

Animals

Altering temperature may cause species shifts as organisms move away from or towards warmer or cooler waters; non-motile species may be killed. These effects are associated with long-term thermal discharges. Given the limited area and the temporary alternation of the temperature regime allowed in the Aquatic Invasive Species Permit, any effects to non-target animals should be minimal.

Water, land, and shoreline use

Aesthetics

Biologists may temporarily cover pilings or docks with impermeable wrapping and this may look unsightly, but should be short-term.

Recreation

Altering the temperature under wraps may temporarily limit public access to an area while people conduct the activity.

Navigation

Generally, these efforts will take place on infrastructure so this should have no to minimal impacts to navigation.

¹⁰ Information on thermal pollution from <http://www.pollutionissues.com/Te-Un/Thermal-Pollution.html>

Mitigation for temperature alteration

Permits

Although altering the temperature of surface water is not a chemical application, entities conducting this activity require coverage under the Aquatic Invasive Species Permit. This is because altering temperatures may alter Washington's surface water quality standards for temperature on a temporary basis. Washington adopted temperature water quality standards in November 2006 (Jenkins, 2007).

Sediment, water, plants, and animals

To avoid impacts to non-target fish, shellfish, or other spawning areas, agencies should evaluate the areas before project initiation to determine the significance of the area to fisheries and aquaculture, particularly in salmon-bearing waters. If possible, avoid critical spawning areas at critical times.

It is unlikely that altering the temperature to control invasive aquatic animals or marine algae will affect rare plants but, if this is a possibility, project proponents must check with the DNR's Natural Heritage Program to ensure that no rare plants exist at the location. If a unique species exists in the targeted water body, they must consult with Natural Heritage Program staff for the best way to avoid adverse impacts to the rare plant species. Mitigation may include altering timing of the activity or other ways to avoid impacts.

Specific mitigation for temperature alteration

- Use hot or freezing water under tarpaulins or impermeable covers secured over the invasive organisms.
- Limit treatment to docks, boat hulls, and fixed objects or defined areas where the Permittee can secure impermeable covers.
- Remove covers as soon as the target organisms are dead.
- May use in conjunction with pressure washing to remove invasive organisms from docks and infrastructure.

References for temperature alteration

Jenkins, P. 2007. *Methods to reduce or avoid thermal impacts to surface water. A manual for small municipal wastewater treatment plants*. Ecology Publication #07-10-088.

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Use of Biological Control Methods Only

Overview of method

Biological control is the purposeful introduction of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biological control agents must be living organisms so that they can seek out the target pests. They may directly attack and kill the pest or they may weaken the hosts so that they are unable to reproduce at their normal rate.

Biological control is most suited for nonnative organisms not closely related to indigenous beneficial species. It is not suitable for organisms with many related members, which are of economic importance because the biocontrol agent may attack related species as well as the targeted pest. Examples of biological control includes the management of the citrophylus mealybug in California by the introduction of two parasitic species of wasps imported from Australia and the management of the European rabbit in Australia by the introduction of a virus that causes the disease myxomatosis in rabbits.

Classical biocontrol

In classical biological control, nonnative natural enemies of the pest are imported and released to bring about control. Scientists conduct extensive research before releasing any biocontrol organisms. This helps ensure that these organisms are host specific and minimizes the chances that they will harm the environment in other ways.

Search for a classical biological control agent typically starts in the region of the world that is home to the pest species. Researchers collect and rear insects, pathogens, and predators that appear to have an impact on the growth or reproduction of the target species in its home range. Scientists reject those organisms that appear to be generalists (feeding on or affecting other species) and select the most promising for further study. Often they never find a suitable biocontrol organism in spite of extensive survey and study. Approval of a biological control agent for release generally takes a number of years of study and specific testing. The United States only clears extensively researched, host-specific organisms for release. Once released, researchers conduct field establishment tests and evaluate the effectiveness of the biocontrol agent in controlling the pest species. However, Secord (2003) cautions that non-target impacts may occur even with well-researched, host-specific biocontrol agents.

Even with an approved host-specific biocontrol agent, control can be difficult to achieve. Some biological control organisms are very successful in controlling invasive species and others are of little value. A number of factors come into play. It can be difficult to establish reproducing populations of a biocontrol agent. Climate or other factors may prevent its establishment. Sometimes the biocontrol organism becomes prey for native predator species, and sometimes the impact of the organisms on the target invasive species is not enough to control its growth and reproduction. Biological control can take time; it may take several years until one can see an effect.

Even when successful, a classic biological control agent generally does not eliminate all targeted individuals. A predator-prey cycle establishes where increasing predator populations will reduce the targeted individuals. In response, the predator species will decline. The pest species rebounds due to the decline of the predator species. The cycle continues.

Although a successful biological control agent rarely eradicates a problem species, it can reduce populations substantially, allowing native species to return. Used in an integrated approach with other control techniques, biological agents can stress target organisms making them more susceptible to other control methods.

There are approved biological control agents for aquatic and terrestrial plants and there are approved biological control methods for pest insects such as mosquito larvae and invasive moths such as *Bacillus sphaericus*, *B. thuringiensis israelensis* and *B. thuringiensis* var. *kurstaki*. As of 2009, sources from the United States Department of Agriculture confirm that there are no approved classical biological control agents for nonnative invasive aquatic animals. However, there is ongoing research to develop biocontrol agents for the European green crab (see the National Aquatic Invasive Species Database for publications).

Secord (2003) expresses concerns about making assumptions that terrestrial biocontrol principles will apply to the marine environment. He cites three reasons for caution:

1. There is substantially less information and fewer data to make informed decisions about the risk and efficacy for marine biocontrol than for terrestrial biocontrol. Hundreds of both successful and failed biocontrol attempts exist for terrestrial biocontrol, where as only a handful of proposals exist for marine biocontrol efforts.
2. Marine systems are more complex and diverse than terrestrial environments. Terrestrial life represents only a small subset of higher-order biodiversity.
3. Marine organisms often have complex life histories and morphologies.

General biological control

Another type of biological control uses general agents to manage invaders. Unlike classical biocontrol agents, general agents are not host specific and may target many species. General agents are often exotic species themselves. An example of a general agent is the grass carp (white Amur). Grass carp originate from Russia and Asia and will feed on many species of aquatic plants (although they have definite food preferences). Managers use grass carp to manage problem aquatic plants. Grass carp have the potential to remove most aquatic vegetation (native and non-native) from a water body, but managers try to make them more selective by adjusting stocking rates.

Augmentative biocontrol

Augmentative biocontrol enhances populations of predators, parasites, or pathogens to manage a pest species. An example of augmentative biocontrol is the proposed use of native sea urchins to feed on exotic algae colonizing Hawaiian reefs. Researchers plan to rear and release native sea urchins that feed on the alien algae in areas that they have cleaned using the SuperSucker™. Healthy herbivorous fish populations can also keep algae in check, but many of these species (such as parrotfish and surgeonfish) been over fished in Hawaii. See this article for more

information:

<http://www.nature.org/wherewework/northamerica/states/hawaii/projectprofiles/art22268.html>.

McCannully et al. (2001) reported that experimental studies involving manipulating sea urchin numbers in *Undaria pinnatifida* beds are underway in Tasmania. The advantage of augmentative biocontrol is that it generally uses native organisms to control an invasive nonnative species. Control of an invasive organism like a nonnative crayfish may include overstocking fish like trout, bass, and catfish into a water body to eat nonnative crayfish and reduce their numbers. However, these fish will not eat only the invasive crayfish, but will also eat native crayfish and other aquatic organisms.

Genetic manipulation

In Australia, scientists are developing European male carp that are genetically incapable of producing female offspring. They anticipate that release of these genetically modified fish will eventually result in a non-reproducing European carp population. However, because carp are long-lived, they expect that it may take 20 to 30 years to see significant carp population reductions in selected water bodies. Read more at

http://www.invasiveanimals.com/research/freshwater_products_and_strategies/4.f.3-daughterless/index.html.

Examples of biological control for invasive species control

European green crab

The green crab is vulnerable to certain parasites and egg predators, but these potential biocontrol agents are in the preliminary stages of investigation.¹¹

Table 3 - Possible biocontrol agents for European green crab. From Kuris et al, 2005.

Potential Biocontrol Agents	Mode of Action	Biocontrol Potential
Parasitic isopod <i>Portunio moenadis</i>	Feminizes and castrates the male green crab	Unknown
Parasitic barnacle <i>Sacculina carcini</i>	Robbs nutrients, retards molting, interferes with reproduction of both species	Likely, host-specific, extensively studied
Nicothoid copepod – symbiont <i>Choniosphaera cancrorum</i>	Consumes green crab eggs	Unknown
Nemertean worms – <i>Carcinonemertes carcinophilia</i> and <i>C. epialti</i>	Crab egg predators – native to the west coast.	Unknown

Environmental impacts

Environmental impacts will vary by organism and type of biological control agents. Individual actions using biological control should be the subject of further SEPA review. See also the Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management for an overview of the impacts due to the general biological control agent—triploid grass carp (page 52 at <http://www.ecy.wa.gov/pubs/0010040.pdf>).

Mitigation for biological control

For classic biological control, researchers must submit host specificity studies of potential biological control agents to United States Department of Agriculture Animal and Plant Inspection Service and WSDA for review. Before the release of any biological control agent, these agencies must give their official approval. The initial release of classical biological control agents requires compliance with ESA and NEPA. This process takes many years. Since this regulatory process initiated in the 1970s, many scientists believe that few harmful impacts have been caused by biocontrol introductions, while successful control has been achieved for many targeted pests.

¹¹ Source: Centre for Research on Introduced Marine Pests. Technical Report Number 11. (1997) Proceedings of the First International Workshop on the Demography, Impacts, and Management of Introduced Populations of the European Crab, *Carcinus maenas*. Ronald E. Thresher (ed).

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Use of Chemical Control Methods Only

Introduction

Under this alternative, Ecology will issue a general NPDES permit, called the Aquatic Invasive Species Permit, for chemicals or practices that may alter Washington's Water Quality Standards and that do not cause unreasonable adverse impacts when used with mitigation. Unlike aquatic plants that have a number of herbicides registered by EPA for their management, there are few products specifically registered for management of aquatic animals or marine algae in marine or freshwaters. For the proposed Aquatic Invasive Species NPDES permit, Ecology developed a list of chemicals with potential to control aquatic invasive organisms by conducting a literature search, querying the NPDES permit advisory committees, the Washington Aquatic Nuisance Species Committee, and other invasive species experts for suggestions about potential pesticides, chemicals, or other suitable products. WDFW assigned an employee to research possible chemical controls and WDFW provided this list to Ecology. Ecology also considered any chemicals and products used elsewhere in the world to manage aquatic invasive species.

Once Ecology compiled this list, it eliminated chemicals/products considered too toxic or not likely to be of use by consulting with human health and environmental toxicologists and the permit development advisory committees. Although chemicals to manage animals tend to be more toxic than herbicides, Ecology weighed temporary toxicity associated with chemical use versus the long-term impacts of invasive species. In many cases, short-term environmental damage from chemical use is less damaging than the long-term ongoing impacts of invasive species. Ecology requires mitigations (treatment limitations, fish timing, and use restrictions) for the use of chemicals (see Tables 1 and 2 in the Aquatic Invasive Species permit).

Ecology currently allows the use of chemicals and products listed in this FEIS in aquatic pesticide NPDES permits for aquatic plant and algae control, mosquito management, and fish management. Other chemicals and products are new to the aquatic permitting program and may not have aquatic labels. Nevertheless, some of these "unlabeled" chemicals may be useful for managing aquatic invasive species. For example, EPA has not labeled chlorine for use as an algaecide in the marine environment, but managers in California were able to obtain an emergency exemption to use chlorine for *Caulerpa taxifolia* eradication. WDFW used a similar procedure to treat the marine tunicate *Didemnum* in the Edmonds marine sanctuary using chlorine swimming pool tablets. Because of the shortage of labeled products, invasive species managers are creative in their use of chemicals and other products in their effort to thwart the spread of invasive species and to manage established populations.

Risk assessment policy

Ecology typically requires independent state risk assessments for the chemicals used in the Aquatic Plant and Algae Management NPDES Permit and the Noxious Weed Control NPDES Permit. Ecology does not have independent risk assessments for some of the chemicals used in its other aquatic NPDES permits. Products currently used for mosquito control, invasive moth control, burrowing shrimp management, and in irrigation ditches may not have independent state

risk assessments. Some, but not all of the products used in these permits, are more toxic than the active ingredients allowed for use under the Aquatic Plant and Algae Management Permit or the Noxious Weed Control Permit.

RCW 90.48.445 requires Ecology to maintain the currency of the information on herbicides and evaluate new herbicides as they become commercially available for use in Ecology's Aquatic Plant Management Program. Since 2002, because of lack of staff and funding, Ecology has not been able to conduct timely environmental review of new commercially available herbicide active ingredients. RCW 90.48.445 is silent on requiring rigorous evaluation by Ecology for other aquatic pesticides.

Other state agencies, particularly WDFW, identified as being the lead agency for most invasive animal infestations, also do not have the financial resources or staff to develop independent risk assessments for chemicals that have the potential to control invasive aquatic animals. Not having an independent state risk assessment does not mean that there are no human health and environmental data available. Some of the chemicals/products included in the permit are common food items (salt, vinegar) or are ubiquitous in the environment (potassium chloride). Others are registered with EPA as pesticides, but may not have an aquatic label or a label for animal control.

Washington and the Pacific Northwest states are facing imminent invasive of zebra or quagga mussels from nearby infested states. Idaho had a scare late in 2009, when DNA testing indicated that zebra or quagga mussels were present in the Snake River. Officials now believe that these tests were false positives. However, other invasive species such as the New Zealand mud snail and exotic crawfish are invading new state locations (e.g., in November 2009, an informed citizen reported a new infestation of New Zealand mud snails in Capitol Lake, Olympia).

Due to the urgent need for a permit for aquatic invasive species management and lack of state resources to develop independent state risk assessments, Ecology has decided to issue this FEIS and the Aquatic Invasive Species Permit without having independently conducted state risk assessments for some of the chemicals or products listed for use. Ecology does permit many of the chemicals allowed in the Aquatic Invasive Species permit under other aquatic NPDES permits. Some of these products have state risk assessments developed for these permits (see http://www.ecy.wa.gov/programs/wq/pesticides/seis/risk_assess.html).

EPA registration and re-registration process

All pesticides sold or used in the United States must be registered by EPA based on scientific studies showing that they can be used without posing unreasonable risk to people or the environment. Because of advances in scientific knowledge, the law requires that pesticides that were first registered years ago, be reregistered to ensure that they meet today's stringent standards. In evaluating pesticides for re-registration, EPA obtains and reviews a complete set of studies from pesticide producers describing the human health and environmental effects of each pesticide. EPA imposes any regulatory controls to manage each pesticide's risk. EPA produces a Re-registration Eligibility Document called a RED that summarizes information about the pesticide and the re-registration decision. Some of the chemicals proposed for use in the Aquatic

Invasive Species Permit are also EPA-registered pesticides and in these instances, EPA RED documents were available and used in this document.

Chemicals proposed for use

The chemicals proposed for use in the Aquatic Invasive Species Permit include:

- Sodium chloride for marine and freshwater application
- Potassium chloride for marine and freshwater application
- Chlorine compounds including chlorine dioxide, sodium chlorate, sodium hypochlorite, and calcium hypochlorite for marine and freshwater application
- Acetic acid for marine and freshwater application
- Calcium hydroxide/oxide (lime) for marine and freshwater application
- Rotenone for freshwater application
- Antimycin for freshwater application
- Potassium permanganate (KMnO₄) for freshwater application
- Endothal (e.g., Hydrothol 191™): mono(N,N-dimethylalkylamine) salt of 7-oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid for freshwater application
- Sodium carbonate peroxyhydrate for freshwater application
- Methoprene for freshwater application
- Chelated copper compounds for freshwater application
- *Pseudomonas fluorescens* strain CLO145

Following a section on general environmental impacts and general mitigation for chemicals, each chemical will be evaluated separately for potential environmental impacts and human health risks.

General environmental Impacts due to chemical use

Earth

Sediments

Effects vary by chemical (see individual chemical sections). Some chemicals will bind almost irreversibly to the sediment and not be biologically available. Others break down into harmless components such as carbon dioxide and are not bound in the sediments.

Air

Air quality

There may be temporary impacts from motorized equipment and exhaust from application equipment. Some of the chemicals may have strong odors. However, any impacts to air quality should be short term and limited to the vicinity of application.

Water

Effects vary by chemical (see individual chemical sections). Toxicities and environmental persistence of each chemical may be influenced by temperature, pH, alkalinity, and other characteristics of each water body.

Plants and animals

Terrestrial plants and animals

Terrestrial plants and animals should have minimal exposure to any chemicals used for aquatic invasive species management. Therefore, Ecology anticipates no impacts to occur as long as Permittees follow safe chemical handling practices and have a spill response plan in place.

Water, land, and shoreline use

Aesthetics

Ecology expects impacts on aesthetics to be minimal and limited to the vicinity of the treatment area. However, when chemicals such as rotenone kill fish, odors from and the sight of dead and decaying fish may affect local residents.

Recreation

Impacts to recreation will depend on the chemical used and any whether Ecology or EPA (through supplemental label) imposes recreational restrictions because of chemical application to the area. This varies by chemical with most chemicals having no restrictions.

Navigation

Ecology expects minimal impacts to navigation through chemical use, but some areas could be cordoned off for a brief time as the control activity takes place.

Shoreline

Water intakes, docks and other shoreline structures will be nonfunctional for the duration of the dewatering. Conversely, dewatering allows easy access to docks and other structures for repair work.

General mitigations for chemical use

Permits

Ecology requires an NPDES permit for chemical use. Any use of a pesticide product not specified on the label will require a supplemental label from EPA and WSDA. For example, chlorine is a pesticide, but it is also not labeled as an algaecide. Yet, California was able to obtain an emergency exemption (and label) to treat an infestation of the marine alga *Caulerpa taxifolia*. The project proponent should check with local jurisdictions to see if any local regulations apply; they may need a shoreline substantial development permit.

General mitigations for chemical use

- **Restricted coverage:** Use of chemicals for aquatic invasive animal and algae control covered in this FEIS is restricted to state government agencies with coverage under the Aquatic Invasive Species NPDES Permit (Permittees). These state government agencies may contract with other state and local government entities, non-governmental organizations, or private applicators or individuals for chemical treatments. No private entity may operate under this permit unless they are a contracted agent of a state government agency holding permit coverage.
- **Permit restrictions and conditions:** The Aquatic Invasive Species Permit conditions and restricts uses of these chemicals or products. Permittees must follow all permit provisions and conditions.
- **Monitoring:** The Aquatic Invasive Species Permit requires monitoring for efficacy of treatment and environmental impacts.
- **Labels:** Agencies using pesticides that do not have an aquatic label for the proposed use must obtain a special local needs or an emergency label from the WSDA and EPA. For longer-term use, they may pursue a Section 3 label.
- **Balance impacts:** Permittees must weigh the benefits of eradicating the invasive species with the detriments of the proposed chemical to the environment.
- **Coordinate with regulatory agencies to protect sensitive species:** Permittees should identify economically important organisms sensitive to the proposed chemical, any threatened or endangered species, or rare plants and time the treatments to avoid sensitive life stages (if possible). Sensitive times could include critical breeding, rearing, and nesting periods of species of concern. Permittees must coordinate with appropriate federal, state, and local agencies to minimize or avoid impacts to these species.
- **Use IPM principles:** Permittees should use integrated pest management principles (e.g., such as selecting the least toxic chemical/product that is effective in killing the targeted species and using the lowest effective concentration).
- **Use safe chemical handling practices:** Permittees must follow safe chemical handling procedures including using personal protective gear when appropriate or called for. This includes mixing or unloading chemicals on impermeable surfaces and immediately cleaning up any spills using appropriate procedures.
- **Project specific FEIS recommendation:** For long-term, ongoing projects, Ecology recommends that the lead agency develop a project specific EIS that covers control activities using chemicals.

Information about each chemical

The following sections provide an overview of each chemical, biocide, or product proposed for use, followed by an assessment of potential environmental and human health impacts. Specific mitigation for individual chemicals/products, if warranted, will be specified in these sections.

In keeping with a programmatic FEIS, each chemical section is succinct. This FEIS is not a comprehensive literature review or risk assessment for each chemical. Some of the information sources consulted include EPA RED documents, human health risk assessments from the Agency for Toxic Substances and Disease Registry (ATSDR), state risk assessments, and scientific or gray literature. When possible, each section describes one or more instances where biologists used the chemical or biocide to manage an aquatic invasive species.

Sodium chloride

Overview

Sodium chloride (NaCl) is an inorganic solid crystalline compound and is the most common ingredient of table salt. It occurs abundantly in the natural environment (e.g., the average salinity of ocean water is ~3.5%). People use sodium chloride primarily to season or preserve food and consume it on a daily basis, although its consumption in excess is associated with hypertension. EPA¹² reports that people also use salt as a road deicer, in water softening treatments, in powdered soaps and detergents, and for industrial uses. Fish farmers use sodium chloride in aquaculture to control external parasites, fin rot, virus and bacterial infections, and ulcers in fish. They use sodium chloride as an osmorgulatory enhancer for fish, particularly during transport. Although the Federal Drug Administration (FDA) has not approved the use of sodium chloride for fish treatment, the FDA considers its use a low priority for enforcement.

Products containing sodium chloride were first registered as pesticides in the U.S. in 1954. Its use today as a registered pesticide is limited to a disinfectant used in poultry operations and in a slug and snail barrier (EPA-738-F-93-015 RED for Inorganic Halides). EPA reregistered sodium chloride for these uses in 1993. EPA did not perform an environmental assessment of sodium chloride for the Inorganic Halide RED because the registered uses of sodium chloride as a pesticide result in insignificant exposure to the environment. It is a component of seawater, and is in the diets of most terrestrial animals. EPA lists sodium chloride as a minimum risk pesticide (25b list). It can be toxic in high concentrations, especially to freshwater aquatic organisms. There is evidence that used in quantity as a road deicer NaCl impacts surface fresh waters and ground waters in urban areas.

Example of using sodium chloride for invasive species management

Glasby et al. (2005) reported on studies in Australia that investigated both the effectiveness of sea salt to kill *Caulerpa taxifolia* and the impacts of salt on infauna and seagrasses. They treated isolated patches versus blanketing the algal patches with salt. They found that treating isolated patches or not totally blanketing the alga with salt was not effective because to kill every frond, each frond needed to be in contact with the salt. A concentration of 50 kg/m² of sea salt was the most effective concentration. At this rate, the salt completely blanketed the algae and rapidly killed it. Higher concentrations, while effective, were not necessary to achieve the desired outcome. Salt affected non-targeted seagrass and infauna, but they generally recovered to pre-

¹² From EPA Regulatory Determination Support Document for Sodium at http://www.epa.gov/safewater/ccl/pdfs/reg_determine1/support_cc1_sodium_ccl_regdet.pdf

treatment abundance after six months. Applying salt for widespread infestations is expensive. The authors estimated that it would cost over \$60 million Australian dollars to treat all the invaded estuaries in New South Wales with just one application of salt.

Environmental and human health impacts

Most of the information about the effects of NaCl on the environment is from assessments on the use of rock salt as a road deicer. Environment Canada (2000) estimated that in the winter of 1997-1998, Canada used approximately 4.75 million tonnes of sodium chloride applied as deicers to Canadian roads. The Environment Canada document summarizes the acute and chronic toxicity data associated with sodium chloride (http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/psl2-lsp2/road_salt_sels_voirie/road_salt_sels_voirie-eng.pdf).

Earth

Sediments

The Aquatic Invasive Species Permit limits the addition of NaCl to areas under tarps or in areas that can be isolated from other waters. Given the limited area allowed for treatment and the high solubility of NaCl, it is unlikely that NaCl addition for invasive species management would cause more than temporary impacts to sediments and to benthic organisms.

Air

Air Quality

Ecology expects any adverse impact to air quality to be minor, such as small amounts of exhaust emissions associated with the use of application equipment when applying sodium chloride.

Water

Surface water

Sodium salts are water-soluble and can leach to freshwater. EPA reports that median concentrations of sodium in surface waters range from 4.7 mg/L in forest and rangeland areas to 21.0 mg/L in urban settings. EPA speculates that the higher concentrations seen in urban areas may be from road salt applications used for deicing. EPA also issued a non-enforceable guidance of 250 mg/L for salinity in ambient water. As reported in Environment Canada (2000) EPA concluded that, except possibly where a locally important species is very sensitive, freshwater organisms and their uses should not be unacceptably affected if:

- The four-day concentration of chloride when associated with sodium does not exceed 230 mg/L more than once every three years on average.
- The one-hour average chloride concentration does not exceed 860 mg/L more than once every three years on average.

The concentration of salts in ocean water is about 3.5% or 35 parts per thousand.

Given the limited amounts of salt proposed for use in the Aquatic Invasive Species Permit, it is unlikely that when used for invasive animal control sodium chloride would have any permanent impact on surface or ground waters.

Ground water

The U.S. or Canadian governments have established no water quality standards or criteria for sodium chloride. EPA reports that detections in groundwater approach 100 percent for all land use categories (urban, forest, rangelands). Environment Canada (2000) reported that their mass balance modeling indicated that for road salt application rates above 20 tonnes NaCl per two-lane-kilometer roads, regional scale groundwater chloride ion concentration > 250 mg/L will likely result under high-density road networks typical of urban areas. Compared to the use of deicing products, the amount and proposed uses of NaCl under the Aquatic Invasive Species Permit are minimal and should result in little impact to ground water.

Plants

Terrestrial plants

Sodium chloride damages both terrestrial and aquatic plants. Environment Canada (2000) lists a number of studies in which salt damage occurred to terrestrial vegetation along roadways from deicers. In New Hampshire during the 1950's approximately 14,000 trees died along salt-treated highways. As a result, the highway department removed the trees and investigated the impacts of road salt on vegetation. Siegel (2007) reported that elevated levels of sodium chloride in soils create an osmotic imbalance in plants that can inhibit a plant's water absorption and stunt root growth. Sodium chloride inhibits flowering, seed germination, and growth of roots and stems in affected vegetation. They noted impacts as far as 200 meters from salt-treated roads. Vegetation is damaged through root uptake and by splash and spray from treated roads. Environment Canada (2000) noted studies that showed that halophytic species (some native species, but many nonnative and invasive) readily invaded salt-impacted areas leading to changes in the occurrence and diversity of species along treated roadways. Although NaCl does affect terrestrial vegetation, the proposed aquatic uses of sodium chloride under the Aquatic Invasive Species Permit do not expose terrestrial species; therefore, there should be no impacts to terrestrial plants from this proposed use.

Aquatic plants

Aquatic plants and algae vary in their response to NaCl; some freshwater plants like submersed Eurasian watermilfoil and emergent cattail are tolerant to salt, but others are less so. Eurasian watermilfoil tolerates chloride concentrations of up to 4,964 mg/L. Algal tolerance varies from 71-36,400 mg/L chloride (Siegel, 2007). There should be limited, but temporary impacts to aquatic vegetation from the use of NaCl under the Aquatic Invasive Species Permit and impacts should be limited to the area of treatment or nearby areas.

Animals

Terrestrial

The LD₅₀ for acute oral rat is 3000 mg/kg and 4000 mg/kg for mouse (MSDS). Birds may eat salt granules thinking that they are mineral grit; this may kill them. As long as applicators promptly clean up any spills, there should be no impacts to terrestrial animals for the aquatic uses of NaCl proposed in the Aquatic Invasive Species Permit.

Aquatic animals

Environment Canada (2000) estimated that five percent of aquatic species would be affected (based on median lethal concentration) at chloride concentrations of about 210 mg/L. Ten percent at about 240 mg/L. Population shifts in lakes were associated with chloride concentrations of 12-235 mg/L. Chloride concentrations between 100 and 1000 mg/L or more have been observed in a variety of Canadian urban watercourses and lakes (Environment Canada, 2000). Presumably, these elevated chloride levels resulted from runoff from deicing operations.

Siegel (2007) reported acute and chronic toxicities of aquatic organisms to sodium chloride (see Table 4 in her report). She noted that the most sensitive aquatic species is the fathead minnow, affected at acute levels equivalent to 1,440 mg/L NaCl and chronic levels equivalent to 415 mg/L NaCl. Laboratory studies report that the LC₅₀ for six freshwater fish and crustacean species exposed to NaCl for one day ranged from 2,724 to 14,100 mg/L with a mean of 7,115 mg/L (Cowgill et al. 1990 as reported in Wegner and Yaggi, 2001). These values decreased significantly, as exposure time increased. The LC₅₀ for 17 species of fish, amphibians, and crustaceans exposed to NaCl for seven days ranged from 1,440 to 6,031 mg/L with a mean of 3,345 mg/L (Environment Canada, 2000). Stream studies in Northern New York revealed that benthic diversity decreases as salinity increases and dominance of salt-tolerant invertebrates coincides with periods of road-salt application (Wegner and Yaggi, 2001).

There should be limited, but temporary impacts to non-target animals from the use of NaCl under the Aquatic Invasive Species Permit. Impacts will be limited to the application area or nearby adjacent areas.

Humans

EPA lists sodium chloride on its Section 25(b) list of minimum risk pesticides. EPA's Drinking Water Equivalent Level for sodium is 20 mg/L although this is a non-enforceable guidance level considered protective against non-carcinogenic adverse health effects. EPA based this guidance on an American Heart Association recommendation issued in 1965. The MSDS lists sodium chloride as mutagenic for mammalian somatic cells and mutagenic for bacteria and yeast. In experimental animals, sodium chloride has caused birth defects and abortions in rats and mice (MSDS). It notes that sodium chloride has been used as an example that almost any chemical can cause birth defects in experimental animals if studied under the right conditions. The lowest published lethal dose for humans is 1000 mg/day (oral). NaCl can be a minor skin and eye irritant. Used for the management of aquatic invasive animals under the Aquatic Invasive Species Permit, sodium chloride should have no impact on human health. However, applicators

should wear eye protection, protective gloves, and body-covering clothing when handling the material (MSDS).

Water, land and shoreline use

Navigation

Applying NaCl under impermeable covers should not create any navigation hazards. If an area of a water body is isolated and treated, this area may limit boating for a short time period. However, Ecology anticipates that any treatment area would be limited in size.

Swimming

Ecology anticipates no impacts to swimming. People routinely swim in salt water in pools and in the ocean.

Fishing

Given the limited area allowed in the Aquatic Invasive Species Permit salt addition is unlikely to have any impact on fishing or the fishery.

Specific mitigation for sodium chloride

Mitigations required under the Aquatic Invasive Species Permit include:

- Limit treatments to the lowest effective concentration of sodium chloride needed to kill the targeted invasive species.
- Use under tarpaulins or impermeable covers secured over the invasive species.
- Limit treatment to docks, boat hulls, and fixed objects or defined areas where the project proponent can secure impermeable covers.
- Remove the covers as soon as the target organisms are dead.
- Permittees may apply sodium chloride directly on target organism if they are out of water (tidal).
- Permittee may treat defined areas, such as marinas, if the Permittee can limit water exchange behind impermeable barriers.

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Potassium Chloride

Overview

Potassium chloride (KCl) is a white or colorless salt that closely resembles sodium chloride. It is soluble in water and has a low vapor pressure (OECD SIDS, 2001). Potassium chloride occurs pure in nature as the mineral sylvite and combined in many other minerals, lake brines (e.g., Searles Lake, California), and ocean water. People use potassium chloride in fertilizers (muriate of potash), in home water softeners, and as a medication to prevent or treat low blood pressure (The Columbia Encyclopedia, sixth edition). People also use it as a deicer as potassium chloride is considered safer to use around vegetation than sodium chloride. Potassium chloride is present as a major and essential constituent in animals and plants. It is ubiquitous in the environment (OECD SIDS, 2001). Potassium is a normal dietary constituent for humans and the usual dietary intake by adults is 50 to 100 mEq per day (Drugs.com).

There are no records of potassium chloride registered as a pesticide in the U.S. until recently. Virginia successfully used potassium chloride as a molluscicide to eradicate an infestation of zebra mussels from Millbrook Quarry after obtaining a Section 18 emergency exemption for its use from EPA. Scientists are currently testing potassium chloride as a decontaminant for field sampling gear to kill New Zealand mud snails (Newell, 2009). California Department of Fish and Game reported 100% mortality against New Zealand mud snails using concentrations of 24.5 g/L potassium chloride to clean gear, but this was with a four-hour exposure time.

Example of using potassium chloride for invasive species management

The Virginia Department of Game and Inland Fisheries¹³ successfully eradicated an infestation of zebra mussels from 12-acre Millbrook Quarry Pond. They treated the pond with 174,000 gallons of a potassium chloride solution over a three-week period (January-February 2006). The

¹³ Information from Virginia Department of Game and Inland Fisheries website at:
<http://www.dgif.virginia.gov/zebramussels/>

target concentration in the pond was 100 mg/L and actual measured concentrations in the pond ranged from 98-115 mg/L KCl. The target concentration was over twice the minimum needed to kill zebra mussels, but is also well below the concentration that causes human health effects or significant ecological impacts. Mortality of the zebra mussels was 100% one month after treatment. Biologists report that other aquatic life in the quarry, which included turtles, fish, and aquatic insects, appeared to be thriving after the treatment. However, elevated levels of potassium may remain in the quarry for over 30 years. This will effectively protect the quarry from reinfestation from zebra mussels. See also the Fish and Wildlife Service Environmental Assessment at http://www.dgif.virginia.gov/wildlife/final_zm_ea.pdf.

Ecology anticipates that uses for potassium chloride under the Aquatic Invasive Species Permit would be similar to the Virginia treatment for zebra mussels and may include treatment of isolated water bodies for zebra or quagga mussels should they invade Washington waters. Given their rapid spread within western waters, this seems a certainty.

Environmental and human health impacts

Earth

Sediments

As an inorganic salt, potassium chloride does not degrade in the environment. In soil, transport/leaching of potassium and chloride is affected by clay minerals (type and content), pH, and organic material. Potassium is less mobile than chloride (which only binds weakly to soil particles) and follows water movement (OECD SIDS, 2001).

Air

Air quality

Environmental issues associated with air quality may include exhaust from the application boat. Ecology anticipates any impacts to be temporary and limited to the actual chemical application.

Plants

Potassium is one of the three major plant nutrients and chloride is an essential micronutrient for plants. The potassium requirement for optimal plant growth is in the range of 2-5% of the plant's dry weight. In most plant species, the chloride requirement for optimal growth is in the range of 0.2 – 0.4 mg/g dry matter. An adequate supply of potassium and chloride in plants tends to improve the plants resistance to several diseases. The authors of the OECD SIDS, 2001 noted that their literature search did not reveal any studies related to toxic effects on terrestrial organisms. It is unlikely that the application of KCl as allowed under the Aquatic Invasive Species Permit will cause any impacts to terrestrial vegetation. There should be little to no exposure of terrestrial plants to KCl.

Water

Surface water

Potassium chloride is highly water-soluble and readily undergoes dissociation (OECD SIDS, 2001). The National Secondary Drinking Water guideline for chlorides is 250 mg/L for humans. A water concentration of 100 mg/L was sufficient to kill the entire population of zebra mussels

in Millbrook Quarry and that is well under the drinking water guideline. In an enclosed system without dilution sources, such as in the Virginia quarry, potassium concentrations may remain high for many years. This may preclude reestablishment of species sensitive to potassium as long as these concentrations remain high.

Ground water

Potassium is strongly bound by clay particles. Leaching through soil and into ground water is important only on coarse-textured soils. Virginia authorities anticipated negligible impacts, if any, to nearby wells after the potassium chloride treatment of Millbrook Quarry.

Animals

Terrestrial

The acute oral LD₅₀ for potassium chloride is 2600 mg/kg for rat, 2500 mg/kg for guinea pig, and 1500 mg/kg for mouse (MSDS). It is unlikely that the application of KCl as allowed under the Aquatic Invasive Species Permit will cause any impacts to terrestrial animals.

Aquatic

The authors of the OECD SIDS (2001) reported that in all studies compiled on acute and chronic aquatic toxicity with fish, daphnia, and algae, the LC_{50s} or equivalent toxicity indicators were greater than 100 mg/L. They concluded that KCl is not hazardous to freshwater aquatic organisms. Because the background concentration of KCl in seawater is 380 mg/L K⁺ and 19,000 mg/L Cl⁻, they concluded that there was no need to do further investigation of KCl on marine species. The Pesticide Action Network (PAN) Pesticides Database acute aquatic ecotoxicity summary for aquatic species indicates that potassium chloride is slight to not acutely toxic.

Because potassium is an element, it does not degrade and remains in the system. In the case of Millbrook Quarry, with little flushing, scientists expect potassium levels to remain high enough to kill (or prevent the reestablishment of) zebra mussels for 30 years. In systems with native mussels or other sensitive organisms, addition of potassium chloride may alter species diversity for prolonged periods.

Specific mitigation for potassium chloride: Mitigation may include developing a water budget to determine retention times to see how long elevated potassium concentrations may persist in freshwater treatments. If there are sensitive species present in the treated water body, Permittees must consider a reintroduction program after potassium concentrations fall below the level of concern for the species. For smaller areas, the project proponent may consider covering the infestation and placing potassium chloride under the cover.

Human health

The oral LD₅₀ for humans for potassium chloride is 2500 mg/kg. Given intravenously, the lethal dose is about 100 mg/kg (used for lethal injections). According to the MSDS, inhalation of high concentrations of the dust may cause nasal or lung irritation. Potassium chloride is also a skin and eye irritant and ingesting large quantities can produce gastrointestinal irritation and vomiting. However, large oral doses generally induce vomiting. Potassium chloride is not known to be a carcinogen. It is reported as mutagenic for mammalian somatic cells and for bacteria and/or yeast (MSDS). However, it is unlikely that the application of KCl as allowed under the

Aquatic Invasive Species Permit will cause any impacts to humans. Virginia authorities reopened the Millbrook Quarry to recreational and instructional diving about three months after the potassium chloride treatment. They estimated that a human would need to drink about 19 gallons of Millbrook Quarry water a day just to consume the daily-recommended dose of potassium.

Water, land, and shoreline use

Ecology anticipates any uses of potassium chloride to be restricted to use under impermeable covers, or in coves or areas of larger water bodies that can be isolated behind barriers, or in small water bodies where water can be contained. Project proponents may choose to close a water body to recreation during treatment, but there should be no long-term impact to the public.

Navigation

The project proponent may choose to cordon off the area during the application of the product and this may result in a temporary impact to navigation, particularly if a cove is isolated from a main water body by a barrier.

Specific mitigation for potassium chloride

Mitigations required under the Aquatic Invasive Species Permit include:

- Limit treatments to the lowest effective concentration of potassium chloride needed to kill the targeted invasive species.
- Use under tarpaulins or impermeable covers secured over the invasive species.
- Limit treatment to docks, boat hulls, and fixed objects or defined areas where the project proponent can secure impermeable covers.
- Remove the covers as soon as the target organisms are dead.
- Permittees may apply potassium chloride directly on target organism if they are out of water (tidal).
- Permittee may treat defined areas, such as marinas, if the Permittee can limit water exchange behind impermeable barriers.

Freshwater mitigations:

- The Permittee may treat small water bodies where the threat of invasive species outweighs other environmental damage caused by the treatment and where water can be contained.
- For nonnative mussel eradication projects, the Permittee must take steps to restore native mussel populations in the treated water body, when practicable.

References for potassium chloride

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Chlorine – (Includes chlorine dioxide, sodium chlorite, and sodium and calcium hypochlorite)

Overview

Invasive species biologists have used various forms of chlorine to help eradicate both invasive algae and animals. Chlorine compounds discussed here include sodium and calcium hypochlorite (components of household bleach), chlorine dioxide, and sodium chlorite. EPA regulates industrial and municipal chlorine discharges to water (e.g., sewage treatment plants) through NPDES permits. EPA has determined that these regulated discharge amounts will not pose significant adverse effects on non-target organisms (EPA, 1984). The hypochlorites are more acutely toxic to aquatic animals than chlorine dioxide and sodium chlorite. Hypochlorites may also form trihalomethanes with organic material in freshwaters. When possible, Ecology would prefer that Permittees use chlorine dioxide/sodium chlorite instead of the hypochlorites.

Chlorine dioxide/ sodium chlorite

Chlorine dioxide (ClO₂) is a yellow green to orange gas (at room temperature) or a reddish brown liquid with a pungent, chlorine like odor. It is an unstable compound in water (EPA RED, 2006). Sodium chlorite (NaClO₂) is white solid, stable at room temperature, but a powerful oxidizer (EPA RED, 2006). Under reducing conditions, sodium chlorite is readily reduced to chlorine and to a lesser extent, chlorate. Chlorine dioxide converts mostly into chlorite ions (EPA Risk Assessment, 2006). The major use categories of chlorine dioxide/sodium chlorite include the treatment of human drinking water (disinfection); use in industrial processes and water systems; as preservatives; and as general disinfectants used in residential, agricultural, medical, and industrial settings.

EPA reregistered chlorine dioxide/sodium chlorite as an antimicrobial pesticide in 2006. As pesticides, their primary use is for the control of bacteria, fungi, and algal slime. Residential uses include disinfection of floors and bathrooms; disinfection of heating, ventilation, and air conditioning systems; and treatment of pool and spa circulation systems. In 2001, under an emergency exemption label, the U.S. government used chlorine dioxide to decontaminate a number of public buildings following the release of anthrax spores (ATSDR, 2004). There is also a continuous release gas product (sachet) for residential use to control odors (EPA RED, 2006),

although EPA now limits its use to outdoor or commercial settings such as in dumpsters. The re-registration of chlorine dioxide/sodium chlorite in 2006 met the requirements of FIFRA, and two other laws (the Federal Food, Drug, and Cosmetic Act (FFDCA) and the Food Quality Protection Act (FQPA)).

Water treatment managers use chlorine dioxide in drinking water for the control of tastes and odors associated with algae and decaying vegetation. It destroys taste and odor producing phenolic compounds and can oxidize iron and manganese. Chlorine dioxide also kills or inactivates bacteria, viruses, and protozoan pathogens (EPA Guidance Manual). Water treatment managers use chlorine dioxide rather than chlorine or ozone because chlorine dioxide does not react with organic matter to form trihalomethanes (ATSDR, 2004).

Hypochlorites

Sodium hypochlorite (NaOCl) is a clear, greenish to yellow liquid with a chlorine-like odor (ATSDR). Calcium hypochlorite ($\text{Ca}(\text{ClO})_2$) is a yellow to white solid that smells strongly of chlorine (ATSDR). In the presence of oxygen, both sodium and calcium hypochlorite react readily with organic matter and convert into sodium chloride or calcium chloride (EPA Fact Sheet). Calcium or sodium hypochlorite may react explosively or form explosive compounds with many common substances such as ammonia, amines, charcoal, or organic sulfides (ATSDR – ToxFAQ). EPA reregistered sodium and calcium hypochlorite for use as antimicrobial pesticides in 1986 (EPA RED). Their primary use as pesticides is for sanitizers and disinfectants of surfaces, water, and as chemicals to control microorganisms (bacteria, fungi, and algal slime) on certain foods (crops like stone fruits, vegetables, citrus, and many others). People use hypochlorites (bleach) to remove stains from laundry, disinfection of water, chlorination of swimming pools, and in endodontics.

Specific migration for chlorine

Because of the high toxicity of chlorine compounds to aquatic organisms, Ecology restricts the use of chlorine compounds to under impermeable covers such as described in the section below. This practice should limit chlorine impacts to the immediate area of application.

Examples of using chlorine for invasive species management

Tunicates

In Washington State, WDFW biologists used swimming pool chlorine tablets to control the invasive colonial tunicate *Didemnum spp.* in an underwater dive park located near the city of Edmonds in Puget Sound. WDFW obtained an Experimental Use Permit and an Ecology Administrative Order before treatment took place. Divers first covered the tunicates with plastic barriers before placing pool chlorine tablets (cut in thirds) under the plastic. The logistics were difficult because the tunicates were attached to the hull of a sunken ship. After several days, divers removed the plastic (the tablets were completely dissolved). Because it was difficult to seal the plastic completely to the hull, WDFW reported that there was some seepage of the chloride from under the barrier (Pam Meacham, personal communication). This treatment eliminated these tunicates from this location in Puget Sound.

Coutts and Forrest (2005) investigated using chlorine (sodium hypochlorite) to kill clubbed tunicates (*Styela clava*) infesting infrastructure in New Zealand waters. They limited their field application of chlorine to injection under plastic wrapped structures (pontoons). During preliminary laboratory trials, they found that free available chlorine concentrations immediately decreased by at least 50% after mixing with ambient seawater and continued to decline through the duration of the trials. In laboratory trials, they achieved 100% kill of *Styela clava* after 6- and 24-hour immersion periods using initial concentrations of 100, 200, and 500 g/m³ of free available chlorine. The actual measured free chlorine concentrations were approximately 50, 100, and >120 g/m³. According to EPA, the hypochlorites undergo rapid reaction to bromide ions in seawater to form hypobromite. Although hypobromite is toxic to sea life, it is highly volatile and does not persist in the environment.

During field trials, Coutts and Forrest did not achieve 100% mortality at an initial application rate of 200 g/m³, probably because the actual free chlorine concentrations were almost exhausted by the end of the 12-hour treatment period (see the table below). The authors speculated that the high biomass of kelp on the wrapped pontoons, consumed the free chlorine making the field treatments less effective than the laboratory trials.

Table 4 - *Styela clava* mortality and free available chlorine (FAC) observed after 12 hours of treatment. The initial target chlorine concentration was 200 g/m³. NA = not assessed. Adapted from Coutts and Forrest (2005).

Pontoon No.	Pontoon side	FAC (g/m ³)	<i>Styela</i> number	<i>Styela</i> mortality (%)
1	Light	4	30	100
	Dark	4	30	100
	Bottom	12	NA	NA
2	Light	<1	30	73
	Dark	12	30	100
	Bottom	10	NA	NA

To achieve 100% mortality of *Styela clava*, the authors recommend a treatment of $>200 \text{ g/m}^3$ for at least 12 hours with the free available chlorine levels maintained at $>20 \text{ g/m}^3$ during this time. They noted that one of the key advantages of using chlorine is that the concentrations can be determined with inexpensive test kits and biologists could add additional chlorine to maintain concentrations.

Caulerpa

California biologists used chlorine as an eradication tool for the marine alga *Caulerpa taxifolia*. Divers located and covered patches of the alga with 35-millimeter black polyvinyl chloride plastic liners that they sealed to the sediment with rebar and sandbags. They initially used a five percent liquid chlorine bleach solution delivered via a port in each tarp and pumped from storage tanks on shore. They later modified the treatment to use solid chlorine tablets (trichloroisocyanuric acid) for safety and ease of application (<http://www.sccat.net/#the-eradication-1e86c7>). They placed a tablet approximately every 5 cm on the alga before covering. Using this technique, they eradicated *Caulerpa taxifolia* from Californian waters.

Environmental and human health impacts

Earth

Sediments

Chlorate and chlorite ions undergo biodegradation under anaerobic conditions found in some sediment. The breakdown products are chlorine and oxygen (EPA RED, 2006). The Aquatic Invasive Species Permit only allows the addition of chlorine compounds to areas under tarps. Given the limited area allowed for treatment and the rapid degradation of chlorine compounds in water, it is unlikely that the addition of chlorine for invasive species management would cause any more than temporary impacts to sediments and to benthic organisms. Benthic animals should rapidly recolonize the affected areas when the cover is removed.

Air

Air quality

The Occupational Safety and Health Administration (OSHA) set a limit of 0.1 parts per million of chlorine of air in the workplace during an 8-hour shift, 40-hour workweek. Chlorine compounds degrade rapidly in air (ATSDR, 2004), and it is unlikely that bystanders to an aquatic treatment would notice any chlorine odor or other impacts to air quality.

Water

By restricting the application of chlorine compounds to areas covered with impermeable covers, Ecology limits the amount of chlorine applied to surface waters. These applications are unlikely to have significant impacts to surface or groundwater.

Surface water

Because chlorine dioxide and chlorite ions and salts are strong oxidizers, they will not persist in the environment for long periods of time (ATSDR, 2004). Both compounds break down rapidly in the presence of light. Expected half-lives are 25 to 30 minutes in sunlit water.

In seawater, hypochlorites undergo reaction with bromide ions to form hypobromite. When sodium hypochlorite is added to seawater, residual chlorine levels decline rapidly in the first hour. This rapid decline is followed by a much slower and continuous decline in residual chlorine levels. Although hypobromite is acutely toxic to aquatic organisms, from a chronic viewpoint it does not appear to be toxic because it is highly volatile and will not persist in the aquatic environment. The half-life of hypobromite is less than 96 hours in water (EPA RED). In freshwater the hypochlorites break down rapidly into non-toxic compounds when exposed to sunlight (EPA Fact Sheet). Using sodium or calcium hypochlorite to treat drinking water may form trihalomethanes. Trihalomethanes form from the reaction of chlorine with organic matter in treated water. Trihalomethanes have been shown to cause cancer in laboratory animals. EPA has set a maximum contaminant level of 80 parts per billion for trihalomethanes in drinking water.

None of the chlorine compounds bioaccumulate or biomagnify in the food chain (ATSDR).

Ground water

In water, chlorine dioxide forms chlorite that may move into groundwater, although reactions with sediments may reduce the amount of chlorite reaching the groundwater (ATSDR, 2004). The Centers for Disease Control Agency recommends disinfecting contaminated wells (bacterial contamination) with household bleach during an emergency.

Aquatic plants

There was only one chlorine/dioxide sodium chlorite toxicity study conducted for EPA registration on aquatic plants and that was a study with a green alga (*Selenastrum capricornutum*) rather than a macrophyte. The EC₅₀ was 1.32 mg/L indicating that chlorine/dioxide sodium chlorite is moderately toxic to algae. Based on the eradication of *Caulerpa taxifolia* using chlorine compounds, one can infer that marine macro algae species are also susceptible to chlorine compounds. Information on the internet indicates that some aquarists use diluted bleach solutions (no higher than a ten percent solution) to remove algae from aquarium plants, but they limit the exposure time. Aquarists also note that some plant species are very sensitive to bleach and many do not advise this cleaning practice.

EPA (1994) reported that low-level chlorination (0.05 to 0.15 mg/L) results in significant shifts in the species composition of marine phytoplankton communities.

Because Ecology limits application to chlorine to areas underneath tarps, effects to non-target aquatic plants or algae will be limited to the immediate treatment vicinity.

Terrestrial plants

Chlorine is toxic to plants, but is also essential to plant growth; crops need around five pounds or more of chlorine per acre (EPA, 1994). As referenced in EPA, 1994, Seiler et al. (1988) reported that acute toxicity to plants is characterized by defoliation, also leaf spotting, and marginal and interveinal injury. Toxicity testing results indicate that chlorine dioxide/sodium chlorite is moderately toxic to terrestrial plants.

Ecology expects that there will be no exposure to terrestrial plants with the restricted uses of chlorine allowed in the Aquatic Invasive Species Permit.

Animals

Terrestrial animals

The toxicity of chlorine dioxide/sodium chlorite ranges from slightly to highly toxic to birds on an acute oral basis. On a subacute dietary basis, the toxicity ranges from slightly toxic to practically non-toxic to birds. Results from the avian acute oral studies and subacute dietary studies indicate that the hypochlorites are low in toxicity to avian wildlife. EPA did not require chronic toxicity testing for these compounds, probably because they are not expected to persist in the environment. Chlorine LC₅₀ values for rats and mice are 293 mg/L for one hour and 137 mg/L for 1 hour respectively (EPA, 1994).

Ecology anticipates that there will be no exposure and therefore no impact to terrestrial animals with the uses proposed in the Aquatic Invasive Species Permit.

Human health

The concentration of chlorine in public pools is generally around 3.5 mg/L. For drinking water, the US national standards state that the maximum residual amount of chlorine is 4 mg/L. Municipal drinking water is usually chlorinated to provide a residual concentration of 0.5 to 2.0 mg/L.

Chlorine dioxide/sodium chlorite

During the RED process, EPA (2006) reviewed all toxicity studies available at the time and concluded that the acute toxicity of chlorine dioxide is moderate by oral route. The acute toxicity of chlorine dioxide using sodium chlorite as the test material is minimal by the dermal route. By inhalation using sodium chlorite as the test material, chlorine dioxide was moderately toxic. For primary eye irritation, chlorine dioxide was a mild irritant, but the technical material was not tested. For primary dermal irritation, sodium chlorite was a primary irritant. For dermal sensitization, there are no acceptable studies for chlorine dioxide or sodium chlorite (EPA RED, 2006). EPA or others have not assessed chlorine dioxide carcinogenic potential. EPA requires additional studies to evaluate this. It may be a mutagen, based on rat studies. However, there are no reliable studies of effects of chlorine dioxide or chlorite in developing humans. Based on these toxicity studies, EPA determined that chlorine dioxide and sodium chlorite pesticides, particularly those used to disinfect cooling towers could produce risks to human health. However, EPA also determined that they could mitigate these risks through product labels. EPA reduced the maximum application rate from 25 mg/L to 5 mg/L for intermittent applications (2.6 fluid ounces of product per 100 gallons of water)

Hypochlorites

Sodium and calcium hypochlorite can cause irritation of the eyes, skin, respiratory, and gastrointestinal tract and exposure to high levels can result in severe corrosive damage and can be fatal (ATSDR – ToxFAQ). However, chlorine's odor and irritant properties generally provide people with adequate warning of hazardous concentrations. The International Agency for Research on Cancer determined that hypochlorite salts are not classifiable as to their carcinogenicity to humans (ATSDR – ToxFAQ). The ATSDR reports that calcium and sodium hypochlorite was not included in *Reproductive and Developmental Toxicants*, a 1991 report

published by the U.S. General Accounting Office that list 30 chemicals of concern because of widely acknowledged reproductive and developmental consequences.

Under the Aquatic Invasive Species Permit, there should be negligible risk to human health from the use of these compounds, particularly if the Permittee chooses to use solid pellets rather than liquid formulations.

Aquatic animals

Chlorine has high acute toxicity to aquatic organisms; many toxicity values are less than or equal to 1 mg/L.

Chloride dioxide/sodium chlorite

Sodium chlorite has a 96-hour LC₅₀ of 216-600 ppm at 80% a.i. for rainbow trout, 62.6-89.8 ppm a.i. for sheepshead minnow, and 196-304 ppm a.i. for bluegill sunfish. Sodium chlorite at 80% a.i. has a 48-hour EC₅₀ to *Daphnia magna* of 0.021-0.031 ppm, and a 96-hour EC₅₀ of 21.4 and 0.576 ppm a.i. for eastern oyster and mysid shrimp, respectively. These numbers represent technical grade sodium chlorite at the highest percentages tested. At these levels, chlorine dioxide/sodium chlorite is considered slightly or practically non-toxic to freshwater fish, and slightly toxic to marine/estuarine fish. The most sensitive organism is the freshwater invertebrate *Daphnia magna* (EC₅₀ >0.021 / <0.031 mg/L a.i.). In this case, the risk quotient, even at the lowest application rate greatly exceeds the acute high-risk level of concern (0.5) (RQ = 238.1 = 5 mg/L a.i. / 0.021 mg/L a.i.). There have been no studies on the chronic toxicity of chlorine dioxide/sodium chlorite. Because chlorine has such a short half-life, there should be little chance of chronic exposure in the natural environment.

The acute toxicity studies to freshwater fish and invertebrates indicate that the hypochlorites are highly toxic to these organisms (PAN database).

Specific Mitigation: Because of toxicity of chlorine compounds to aquatic animals, Ecology will restrict chlorine to locations where the chemical can be completely contained under covers. It is possible to neutralize chlorine using vitamin C (ascorbic acid and sodium ascorbate). Vitamin C is not toxic to aquatic life at the levels used for dechlorinating water. One gram of ascorbic acid will neutralize 1 mg/L chlorine per 100 gallons of water with a fast reaction time (Land, 2005). Where possible, Ecology recommends testing chlorine concentrations and if present, neutralizing the chlorine with ascorbic acid before removing the cover.

Water, land, and shoreline use

Navigation

The Ecology permit limits chlorine applications to areas under impermeable covers. The project proponent may choose to cordon off the area during the application of the product and this may result in a temporary impact to navigation. For the *Caulerpa* eradication in California, authorities closed the area to avoid fragmentation and possible spread of any uncovered *Caulerpa* in the lagoons.

Swimming

Ecology has not imposed any swimming restrictions in the treatment area. However, the project proponent may choose to cordon off the area during the application of the product. There are no proposed restrictions on the recreational use of water in areas treated with chlorine dioxide/sodium chlorite. Due to the pending requirement for barrier systems, water in the treatment area would be available for swimming and fishing immediately after treatment. Shellfish harvesting can also be allowed immediately after treatment occurs.

Specific mitigation for chlorine compounds

Mitigations required under the Aquatic Invasive Species Permit include:

- Limit treatments to the lowest effective concentration or amount (e.g., if using swimming pool tablets) to kill the targeted organism.
- Where practicable, use chlorine dioxide/sodium chlorite instead of sodium hypochlorite or calcium hypochlorite.
- Use under tarpaulins or impermeable covers secured over the invasive organisms. Seal edges to the substrate as thoroughly as possible.
- Limit treatment to docks, boat hulls, and fixed objects or defined areas, where the Permittee can secure impermeable covers.
- Leave tarpaulins on for at least one day before removing. If this is not possible test for chlorine using a swimming pool test kit and neutralize any residual chlorine using ascorbic acid (vitamin C) before removing the cover.

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Acetic acid

Overview

Acetic acid (C₂H₄O₂), a naturally occurring, weak organic acid, is a common chemical found in all living organisms. Acetic acid plays a fundamental role in cell metabolism, particularly in the Krebs's cycle¹⁴. When used as a terrestrial herbicide, acetic acid functions as a cell membrane disrupter, causing loss of membrane integrity and leakage of cellular fluids causing the plant to dry out. Data suggest that acetic acid and its salts are not persistent in the environment.

In its diluted form, acetic acid is vinegar (generally, vinegar is a 4-8 % solution of acetic acid). Acetic acid has a long history of safe use as a food additive and it readily breaks down to carbon dioxide and water. EPA is currently evaluating acetic acid under the Food Quality Protection Act of 1996. EPA anticipates conducting a comprehensive ecological risk assessment for the terrestrial herbicide use of acetic acid, but this ecological risk assessment was not available at the time that Ecology was writing this EIS. EPA will also complete an endangered species assessment for all pesticide uses of acetic acid (Acetic Acid and Salts Summary Document Registration Review: Initial Docket March 2008, Case #4001).

EPA lists six registered pesticide products that use acetic acid as the active ingredient. None of these registered uses is for control of aquatic plants or animals. Consumers use products containing acetic acid to control terrestrial weeds, including some grasses. EPA considers acetic acid herbicides to be non-selective contact terrestrial pesticides. Acetic acid is also labeled as a preservative for post harvest stored grains and hay intended for livestock feed.

¹⁴ Information from EPA at <http://www.epa.gov/EPA-PEST/2005/August/Day-03/p15148.htm>

Examples of using acetic acid for invasive species management

Literature information shows that for invasive species management, people primarily use acetic acid experimentally to remove soft-bodied biofouling marine organisms such as tunicates from structures. Blue mussel growers in Prince Edward Island, Canada have tried several techniques to remove tunicates from aquaculture gear such as long lines and mussel socks. Until recently, growers used a dilute acetic acid solution (5% percent – vinegar) as an experimental treatment as reported in Locke et al. (2009). In commercial aquaculture operations, growers found a 5% acetic acid spray effective for removing colonial, but not solitary tunicates. Immersion for one minute killed solitary tunicates, but growers considered immersion impractical for commercial operations. The acetic acid solution diluted too quickly with multiple immersions. Some blue mussel mortality occurred when the growers combined both spraying and immersion.

Prince Edward Island growers stopped using acetic acid in 2005 (Locke et al., 2009). This was primarily because the dominate species of fouling tunicate changed from *Styela clava* to *Ciona intestinalis*. Some growers also reported that it was difficult for them to spray acetic acid evenly. They now use pressure washing to remove *C. intestinalis* from gear. Pressure washing is effective for removing *C. intestinalis* but not *S. clava*.

Forest et al. (2007) investigated using dilute acetic acid to remove biofouling organisms from aquaculture equipment in New Zealand waters. Laboratory and field experiments demonstrated that immersion in 4% acetic acid (in seawater) for as little as one minute can eliminate many soft-bodied fouling organisms (including tunicates), with lower concentrations requiring longer immersion times. Carver et al. (2003) found that a laboratory exposure time of 5-10 seconds of 5% acetic acid was 95% effective in killing *C. intestinalis*. They rinsed the organisms post-treatment to simulate conditions in the field where the acetic acid would be rapidly diluted by seawater. Coutts and Forest (2006) investigated a number of techniques to remove *S. clava* from artificial structures. One technique was to remove the structures and immerse them in acetic acid solutions. They found that complete mortality of *S. clava* was achieved with immersion in 4% to 5% acetic acid for one minute or longer. Another technique was to wrap the structure with impermeable plastic and introduce the chemical under the wrap. They found that their target concentration of 1% acetic acid resulted in 100% mortality within ten minutes. There was also almost complete mortality of non-target taxa after 20 minutes. Pacific oysters (*Crassostrea gigas*) and calcareous tubeworms (*Pomatoceros terraenovae*) survived the 12-hour treatment though.

The main drawback of using acetic acid is the handling and safety of the concentrated acid (Coutts and Forest, 2006). Acetic acid must be stored at temperatures greater than 17° C or in a partially diluted form (e.g., 50% solution) to avoid solidifying. It is hazardous to handle, being highly corrosive and creating respiratory problems. Applicators must be trained and wear appropriate safety gear when handling the concentrated acid.

The Aquatic Invasive Species Permit limits acetic acid use in water to dilute concentrations:

- Under impermeable covers, or
- Under docks or infested structures.

Environmental and human health impacts

Earth

Sediments

Acetic acid occurs naturally in sediments and comes from the anaerobic degradation of organic matter. Natural levels of acetic acid depend on organic composition and vary with season and depth (Spencer and Ksander, 1997). As reported in Spencer and Ksander (1997), Reeburgh (1983) reported acetic acid concentrations from 0.1 to 360- $\mu\text{mol l}^{-1}$ for marine and freshwater sediments. Because it is an important intermediate in sediment microbial metabolism, acetic acid may have a rapid turnover time (hours to a few days).

Spencer and Ksander (1999) flooded dry irrigation canal plots with either well water (0%), 2.5%, or 5% acetic acid solution. The purpose was to see if acetic acid could affect the sprouting of monoecious hydrilla tubers in the sediment. The researchers perforated some of the plots with 15 cm deep holes to enhance penetration of the acetic acid solution. They did not see any significant differences between treated, untreated, perforated, or unperforated plots for phosphorus, ammonia, nitrates, potassium, and percentage organic matter.

The permit allows for only limited treatment using dilute concentrations of acetic acid so Ecology anticipates impact to the sediments to be negligible and short-lived.

Air

Air Quality

Concentrated acetic acid has a strong vinegar-like odor and the vapors cause irritation to mucus membranes. People near the operation may notice a strong vinegar odor, but this will be transitory during spray events.

Water

Surface water

Adding acetic acid, even in dilute form, has the potential to lower the pH of the receiving waters. Lowering the pH may harm aquatic organisms. Forest et al. (2007) found that acetic acid is a more effective biocide than other acids adjusted to the same pH, so that acetic acid toxicity results from more than just a pH change to the water. Locke et al. (2009) speculate that a likely mechanism for the increased toxicity is the acetate ion.

The uses of acetic acid proposed in the Aquatic Invasive Species Permit will limit the area treated and impacts to surface water should be both short-term and temporary.

The following is a hypothetical exercise in calculating the amount of acetic acid that may enter the water after spraying a pier for invasive organisms such as marine tunicates.

Assumptions

- 10 percent acetic acid (C₂H₄O₂) solution used
- 1-gallon acetic acid solution treats 400 sq ft.
- All acetic acid solution applied to invasive species ends up in water at high tide
- 100 percent coverage of underwater (at high tide) surfaces by invasive species
- Water depth starts at zero feet and goes to a maximum depth of 40 feet at high tide
- Pier is 100 feet long
- Walking surface is 10 feet wide (flat on both top and bottom)
- Pilings are spaced every 20 feet along the pier
- Pilings are 1-foot in diameter (no taper)
- There is 2 feet of space for the pilings on either side of pier

1. Area of ventral side of walking surface (under water).

$$A_{ws} = \text{Length of pier} * \text{Width of walking surface}$$

$$A_{ws} = 1000 \text{ square feet}$$

2. Height of water on pilings (at high tide)

Bottom angle: 22 degrees

Pier angle: 68 degrees

From Shore (feet)	Height of Water (feet)
20	8
40	16
60	24
80	32
100	40

$$\frac{\sin(\text{Bottom Angle})}{\text{Depth of water}} = \frac{\sin(\text{Pier Angle})}{\text{Distance from Shore}}$$

3. Surface area of pilings (A_p) under water (depends on h, the height of water on the piling at high tide).

From Shore (Feet)	Area of Piers Underwater (sq ft)
20	50.3
40	100.5
60	150.8
80	201.1
100	251.3

$$A_p = 2\pi r * h * (\text{number of piers at depth})$$

$$A_p \text{ total} = 754 \text{ square feet}$$

4. Total Surface Area Underwater (covered with invasive species).

$$A_T = A_{ws} + A_p \text{ total} = 1754 \text{ square feet}$$

5. Volume of water (at high tide) that is under pier (Area under pier is a right triangle - calculate volume using appropriate formula). Total width considered as under the pier is 14 feet.

$$V_{up} = \frac{1}{2} bhw$$

$$V_{up} = 28,000 \text{ cubic feet or } 209,500 \text{ gallons}$$

6. Amount of acetic acid treatment solution
400 sq ft treated per gallon of solution

$$\text{Amount solution used} = \frac{\text{Total Area Underwater}}{400 \text{ square feet treated per US gallon}}$$

$$\text{Amount solution used} = 4.4 \text{ US gallons} = 16.6 \text{ liters.}$$

7. Amount (grams) of acetic acid in 4.4 gallons of treatment solution

$$\text{Acetic Acid} = 60.05 \text{ g/mol}$$

$$\text{Density} = 1.05 \text{ g/mL}$$

$$10\% \text{ acetic acid solution}$$

$$1 \text{ US Gallon} = 3.785 \text{ Liters}$$

$$\% \text{ Volume} = \frac{\text{Volume Solute}}{\text{Total Volume Solution}}$$

$$\text{Volume Acetic Acid} = 0.44 \text{ US Gallons} = 1.7 \text{ liters}$$

$$\text{Mass} = \text{Density} * \text{Volume}$$

$$\text{Mass Acetic Acid} = 1785 \text{ grams} = 29.7 \text{ mols}$$

8. Concentration (Molarity (M)) of acetic acid in treatment solution

$$(M) \text{ Molarity} = \frac{\text{Moles Solute}}{\text{Total Solution Volume}}$$

$$\text{Acetic Acid Solution} = 1.8M$$

9. Concentration of acetic acid in water under pier

$$\text{Molarity 1} = \text{Acetic acid solution only}$$

$$\text{Volume 1} = \text{Acetic acid solution only}$$

$$\text{Molarity 2} = \text{Seawater with addition of acetic acid solution (unknown term)}$$

$$\text{Volume 2} = \text{Seawater plus acetic acid solution}$$

$$M_1 = 1.8M$$

$$V_1 = 16.7 \text{ Liters}$$

$$M_2 = \text{Unknown}$$

$$V_2 = 792958 \text{ Liters}$$

$$\text{Molarity}_1 * \text{Volume}_1 = \text{Molarity}_2 * \text{Volume}_2$$

$$M_1V_1 = M_2V_2$$

$$M_2 = \frac{M_1 V_1}{V_2}$$

$$M_2 = 3.77 \times 10^{-5} M$$

Based on these calculations, the amount of acetic acid from spraying a pier for invasive species should be minimal and have little impact on the non-target organisms in the water.

Ground water

EPA did not include acetic acid in its list of drinking water contaminants. In wells contaminated with hydrocarbons, a cleanup method uses acetic acid to destroy or reduce the initial concentration levels of these contaminants. The U.S. Geological Survey National Water Quality Assessment program has no information on acetic acid in ground water. Used as allowed under the Aquatic Invasive Species Permit, there should be no concern for ground water contamination by acetic acid.

Plants

Aquatic plants

Although EPA registered acetic acid for use as a terrestrial herbicide, it does not have a label that allows aquatic use. As such, there is little information available on the impacts of acetic acid on aquatic plants. Some researchers are investigating applying dilute acetic acid to dry irrigation ditches as way to inhibit the germination of tubers or overwintering structures of problem aquatic plants. Spencer and Ksander (1999) found that applying a solution of 2.5% acetic acid (equivalent to half strength vinegar) to dry sediments was effective in reducing the survival of monoecious hydrilla tubers in Oregon House Canal. Spencer et al. (2003) also applied dilute solutions of acetic acid to dry irrigation canals in the Nevada Irrigation District Canal in Northern California to manage another common weed, American pondweed in irrigation canals. In some cases, the vinegar treatment reduced American pondweed biomass in the plots by more than 90% five weeks after treatment.

Based on its herbicide effects to terrestrial plants and Spencer's and Ksander's research, Ecology expects that acetic acid treatment may affect aquatic plants or their reproductive propagules in sediments in areas adjacent to treatment sites when treating invasive animals. Because acetic acid is a contact herbicide, these plants should recover and impacts will be temporary.

Terrestrial plants

Acetic acid is the active ingredient in non-selective, contact herbicides registered for use against terrestrial weeds. Agriculture Research Service scientists¹⁵ tested vinegar on agricultural weeds (common lamb's quarters, giant foxtail, velvetleaf, smooth pigweed, and Canada thistle) in greenhouse and field studies. They found that 5-10% concentrations killed the plants in their early growth phase (first two weeks). Older plants required higher concentrations of vinegar to kill them. At higher concentrations (15-20% acetic acid), vinegar has an 85-100% kill rate at all growth stages. Except for accidental spills of acetic acid, Ecology does not anticipate any impacts to terrestrial plants from the uses allowed in the Aquatic Invasive Species Permit.

¹⁵ From website "Spray Weeds with Vinegar? At <http://www.ars.usda.gov/is/pr/2002/020515.htm>

Animals

Terrestrial animals

Based on environmental fate characteristics, mode of action, and mammalian development study results, EPA concludes that the chronic risks to birds and mammals from terrestrial acetic acid herbicide use (labeled uses) are unlikely to exceed its level of concern. This statement refers to a 6% liquid formulation for consumer use as a home and garden herbicide in non-food crop areas. Acetic acid use as allowed in the Aquatic Invasive Species Permit is unlikely to have any effect on terrestrial animals.

Human health

The United States Food and Drug Administration generally recognize acetic acid as safe for humans. (21 CFR 184.1005 and 21 CFR 184.1754). Acetic acid is non-toxic at concentrations consumed by humans (4-8%). EPA has no knowledge of any incidences of allergic response to acetic acid. Acetic acid is not a known mutagen, teratogen, nor oncogen. It is not a known endocrine disruptor or related to any class of known endocrine disruptors.

Acetic acid in its undiluted form is corrosive to skin and eyes. The vapor is irritating and can be destructive to the eyes, mucous membranes, and respiratory system. EPA considers the risk for contact to be a concern only to applicators. Applicators can mitigate their risk by wearing protective chemical-resistant gloves, aprons, and footwear. Working with concentrated acetic acid is very unpleasant for the people diluting the acid before application. Researchers testing acetic acid application to tubers in irrigation canals indicated that working with this chemical was very irritating to their eyes and respiratory tracts.

Aquatic animals

Based on environmental fate characteristics such as the buffering capacity of water and mode of action, EPA concludes that risks to fish and aquatic invertebrates from terrestrial acetic acid herbicide use are unlikely. EPA's conclusion refers to the 6% liquid formulation for consumer use as a home and garden herbicide in non-food crop areas. In this case, applicators do not directly apply the pesticide to water.

The Aquatic Invasive Species Permit allows limited areas of treatment with diluted acetic acid. In these instances, dilute acetic acid will enter the water. EPA reports the following toxicity values to aquatic organisms from unreviewed studies for acetic acid based on glacial acetic acid (100% ai.).

- Acute freshwater fish (bluegill sunfish) EC_{50} 75 mg/L.
- Acute freshwater invertebrate LC_{50} 65 mg/L.¹⁶
- Algae EC_{50} 4000 mg/L.

Canadian researchers conducted toxicity tests on several aquatic organisms using acetic acid (Locke, et al. 2009). See below:

- The 96-hour LC₅₀ for threespine stickleback (*Gasterosteus aculeatus*) was 178 mg/L acetic acid.
- The 96 hour LC₅₀ for sand shrimp (*Crangon septemspinosa*) was 158 mg/L acetic acid.
- The 14-day chronic LC₅₀ for sand shrimp was 116 mg/L acetic acid. There was no effect on the growth of sand shrimp from acetic acid.
- Sub lethal impacts on bacteria occurred at lower concentrations of acetic acid. The estimated IC₅₀¹⁷ of acetic acid in the Microtox test was 88.5 mg/L acetic acid.

Based on these tests, one would expect lethal impacts on many aquatic organisms from the use of acetic acid at vinegar concentrations, particularly if these organisms were unable to move away from any areas of low pH. Given the limited area allowed for treatment under the proposed permit, Ecology anticipates that affected species will rapidly recolonize the treated area from adjacent unaffected areas.

Motile organisms may be able to detect and move away from acidic conditions. As reported in Davies (1991), acetic acid was investigated in Australia during and after World War II as a shark repellent, due to its irritant effect. Davies (1991) researched the effect of lowering the pH of seawater on the avoidance behavior of sand smelt (*Atherina boyeri* Risso). These data suggest that sand smelt were able to detect acid at levels of less than one pH unit, but did not show significant avoidance response until the pH level was 6.5-6.6. The author did not observe any short-term harmful effects. These data suggest that changes in pH may elicit avoidance behavior at acute sub lethal acidity levels.

Water, land, and shoreline use

Navigation

Anticipated uses for dilute acetic acid under the Aquatic Invasive Species Permit are to kill soft-bodied invasive species such as tunicates attached to docks and other infrastructure. Control may involve spraying the underside of docks or wrapping structures and introducing dilute acetic acid under the wraps. During control activities, the project proponents may cordon off the area while these activities take place, resulting in short-term loss of access to the treated areas.

Swimming

The Aquatic Invasive Species Permit will restrict swimming in the treatment area for 12 hours after any direct spraying of docks or infrastructure, due to the potential for skin or eye irritation. However, many potential treatment areas may not be suitable for swimmers anyway because they will be in marinas and around other infrastructure.

¹⁷ The concentration that causes inhibition by light by 50%.

Specific mitigation for acetic acid

Permittees must use dilute acetic acid under impermeable barriers or spray it directly onto invasive species infesting infrastructure. When working with concentrated acetic acid, applicators need to wear appropriate safety equipment and must dilute the concentrated acid on impermeable surfaces where any spills will not enter the surface or groundwater. To avoid respiratory distress to onlookers, applicators should restrict public access to the area when diluting the concentrated acid.

Mitigations required under the Aquatic Invasive Species Permit include:

- Limit treatments to the lowest effective concentration or amount to kill the targeted organism (vinegar concentrations – 5-10% are reported to be effective for soft-bodied marine organisms).
- Use under tarpaulins or impermeable covers secured over the invasive organism. Seal the edges to the substrate as thoroughly as possible.
- Limit treatment to docks, boat hulls, and fixed objects or defined areas where the Permittee can secure impermeable covers.
- Remove covers as soon as the target organisms are dead.
- In marine or estuarine waters, the Permittee may directly spray the target organisms if they are out of water.
- In marine or estuarine waters, the Permittee may treat defined areas, such as marinas, if the Permittee can limit water exchange behind impermeable barriers.

References for acetic acid

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Calcium hydroxide (lime)¹⁸

Overview

Calcium is a common element. It is present in the earth's crust as silicates that weather to give free calcium ions. Calcium is abundant in seawater and is an important nutrient for living organisms. Calcium oxide (quicklime), made by heating limestone, reacts exothermically with water to produce calcium hydroxide, a strong base. Calcium hydroxide (slaked lime - Ca(OH)₂) is an odorless, colorless or white powder. Calcium hydroxide solutions react with gaseous carbon dioxide to give a white, milky precipitate of calcium carbonate (Ebbing and Gammon (2002)).

Table 5 - The natural background levels of calcium in different systems. From data submitted to the European Chemicals Bureau of the European Commission by Solvay S. A. Brussels.

Aqueous System (Rock Type Drained)	Calcium Concentration (mg/L)
Seawater	412
Groundwater (limestone)	80
Stream (granite)	4
River/unpolluted	13.4
River/including contribution of human activities	14.7
Public water supply/100 US cities	26 (mean); 1-145 (range)

Calcium hydroxide has many uses including the production and manufacturing of building materials and the treatment of wastewater and biosolids. Calcium hydroxide neutralizes phosphorus and nitrogen in wastewater and animal wastes. EPA specifically prescribes the use of

¹⁸ Except where otherwise noted, information on calcium hydroxide was taken from Ecology's Draft Human and Environmental Risk Assessment for Calcium Hydroxide on the web at: http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/lakes/RISK%20ASSESSMENT%20OF%20CALCIUM%20HYDROXIDE.pdf

lime treatment for human wastewater sludge and as such, calcium hydroxide routinely enters waters through sewage treatment plant discharges. Calcium hydroxide has uses in the dairy industry, the sugar industry, and in baking. Bakers make tortillas with lime treatment.

Calcium hydroxide is on list 4 of the EPA's list of inert pesticide ingredients of minimal concern. EPA recently registered calcium hydroxide as a terrestrial pesticide under a Section 18 (emergency exemption) label in the state of Hawaii. The purpose is for the management of the invasive coqui frog and greenhouse frogs. See the label at http://hawaii.gov/hdoa/pi/pest/PEST_Calcium_Hydroxide_Section_18_label.pdf. EPA deleted calcium oxide from its list of hazardous substances in 1979.

Examples of using calcium hydroxide for invasive species management

Lime (both calcium oxide and calcium hydroxide) has a long history of use in managing marine biological pests in aquaculture or fisheries (Locke et al., 2009, Shumway et al., 1988). There are scientific studies from the early 1940's documenting the use of quicklime to control starfish in oyster beds and biologists suggested the use of quicklime for this purpose in the early 1900's. Galtsoff and Loosanoff (1938) carried out studies under the provisions of a special appropriation of Congress in 1935 to aid oyster growers with starfish management. Because quicklime is very effective in killing echinoderms and there was a history of use elsewhere, the California Department of Fish and Game applied it to selected areas to eliminate sea urchins that were destroying commercially harvested kelp beds (as reported in Bernstein and Welsford, 1982). California applicators achieved sea urchin kill rates in excess of 95% with an apparatus that mixed quicklime with seawater and pumped the slurry through a hose to a diver who directed the slurry onto sea urchins. Divers applied between one to two tons of lime per acre and treated up to two acres per day.

Bernstein and Welsford (1982) built and field-tested a liming apparatus in Nova Scotia for similar purposes. Using their apparatus, they achieved an echinoderm kill rate of greater than 70% using about four tons of lime per acre. The authors speculated that they got a lower kill rate because the waters off Nova Scotia are much cooler than Californian waters. The sea floor in Nova Scotia also has more relief than the sea floor in California so the quicklime was not easy to apply evenly and likely did not reach all the targeted sea urchins.

Today, mussel growers on Prince Edward Island, Canada use lime to manage biofouling on aquaculture gear. They immerse mussel spat collectors or other gear into a trough filled with a saturated solution of calcium hydroxide in seawater. They may also use a low volume sprayer to treat infested gear.

Field observations by Locke et al. (2009) indicated that the pH of the hydrated lime solutions in the troughs was in the range of 12 to 12.6 pH units. They observed a cloud of lime particles visible in the water immediately below the area where the treated gear exits the treatment trough. The pH in the area around the discharge was about 10, but readings rapidly dropped to pH 8.3 to 9.0 approximately 0.7 meters from the area of discharge. Readings were always less than 8.5 approximately 1 meter from the area of discharge, at depth to about 1 meter. Diver observations made after a release of 45 kg of hydrated lime, indicated that the cloud of lime particles settled to

the bottom. Organisms such as blue mussels, rock crabs, and gastropods continued their normal activities even when engulfed in the cloud. Animals found in the lime troughs after treatment often died, but the European green crab showed no obvious ill effects then and a week later.

For further information about the use of lime as a control method to manage marine pests, see Australia's National Introduced Marine Pest Information System (<http://www.marine.csiro.au/crimp/nimpis/Default.htm>)

Environmental and human health impacts

Earth

Sediments

Calcium hydroxide is slightly water-soluble and when mixed with carbon dioxide will form calcium carbonate. Calcium carbonate does not adsorb to sediment.

Air

Air quality

According to OSHA standards the legal airborne permissible exposure limit is 15 mg/m³ for total dust and 5 mg/m³ for respirable dust averaged over an 8-hour work shift. Worker handling the lime must use personal protection gear.

Water

Surface water

Lake managers use lime in the form of both calcium hydroxide and calcium carbonate to restore acidified lakes and ponds. They have used this technique extensively during the last 25 years to increase the alkalinity and pH of acidified lakes in eastern Canada and Europe. Liming ponds is also a common practice in southeastern U.S. ponds.

Lake managers also use lime to inactivate phosphorus in eutrophic hard waters. Ecology allows liming as a nutrient-inactivation technique under the Aquatic Plant and Algae Management NPDES Permit. When used for nutrient inactivation, EPA does not consider lime to be a pesticide. The city of Lakewood conducted a 2008 study in Lake Steilacoom to determine if adding lime to the lake would prevent toxic cyanobacterial blooms. Their applicator added 86,000 pounds of calcium oxide to the lake. Calcium oxide dissociates in the water to form calcium hydroxide that reacts with carbon dioxide to form calcium carbonate. Unfortunately, the treatment did not prevent a toxic cyanobacteria bloom from occurring.

When used in freshwaters, applicators must buffer the calcium hydroxide to avoid the pH rising above 10. Under most conditions, a pH over 10 will cause increased mortality of aquatic organisms. By introducing carbon dioxide soon after the calcium hydroxide enters the system, it is possible to keep the pH below 10 for an extended period. Lake residents and the consultant monitoring Lake Steilacoom after the calcium hydroxide treatment did not observe any mortality of fish, waterfowl, or other organisms (Lake Steilacoom report).

Locke et al. (2009) reported that hydrated lime is sometimes added to anaerobic marine environments for odor control. There is a long history of aquaculturists and state agencies using quicklime to manage echinoderms in kelp beds along the California coast and in oyster beds on the east coast of North America.

Ground water

There are no available data for any groundwater sampling for the presence of calcium hydroxide in the U.S. Liming for invasive species management is unlikely to pose a problem for groundwater.

Aquatic plants

There should be little effect on aquatic plants or algae from the addition of calcium hydroxide. Lake managers have used calcium hydroxide as a stabilization or nutrient management tool in lakes for many years. There may be indirect impacts to aquatic plants and particularly to algal biomass from reduction in nutrient levels.

Terrestrial plants

No impact with the uses proposed in the Aquatic Invasive Species Permit.

Animals

Terrestrial animals

No impact with the uses proposed in the Aquatic Invasive Species Permit.

Human health

Industry uses calcium hydroxide in food production to maintain pH levels and act as a texturing, firming, and anti-caking agent. Farmers apply lime to their fields. However, there are some risks to the applicator when handling the powder. Calcium hydroxide and calcium oxides are corrosive chemicals with an alkaline pH. Direct contact with the eyes may cause chemical eye burns. Prolonged contact with the skin may cause a rash, ulceration, and skin corrosion. If deliberately ingested, calcium hydroxide causes pain, vomiting, diarrhea, collapse, and even death (1995 Occupational and Safety Health Guideline for Calcium Hydroxide <http://origin.cdc.gov/niosh/docs/81-123/pdfs/0092.pdf>). Inhalation of calcium hydroxide dust can cause irritation to the upper respiratory tract. Applicators must wear chemically resistant protective clothing that includes gloves and boots. Safety glasses, goggles, or face shield must be worn when handling the powder.

Table 6 - Acute oral toxicity values for calcium hydroxide. *Information taken from European studies.*

Species	LC 50	Reference
Rat	7340 mg/kg body weight	Solvay S.A. Brussels
Mouse	7300 mg/kg body weight	Minermix S.R.L. Fasano

There is no literature information about whether calcium hydroxide is a mutagen, teratogen, nor oncogen, or an endocrine disruptor, but the Pesticide Action Network (PAN) database does not list calcium hydroxide as such.

When added to water for nutrient inactivation or to manage invasive species, neither hydroxide nor calcium carbonate should cause any permanent or lasting effects to humans. Calcium carbonate will precipitate and the hydroxide will combine with any free positive ions in the water.

Aquatic animals

Information available on the toxicity of calcium hydroxide or calcium oxide to aquatic animals is primarily limited to marine organisms found in or near oyster or mussel beds. The toxicity of lime appears related to the alkalinity of the chemical and changes in pH. Bernstein and Welsford (1982) reported that quicklime kills echinoderms by causing epidermal lesions that permit bacteria to enter the coelomic fluid. The affected animals die of resultant infections from a few days to several weeks after lime treatment, depending on dosage of the lime and the water temperature. Shumway et al. (1988) noted that oyster growers have used quicklime in Connecticut every year for over 40 years with no evident adverse effects on the density or annual regularity of potential oyster setting.

Canadian researchers Locke et al. (2009) report that much of the published literature in the marine environment relates to calcium oxide (quicklime) rather than calcium hydroxide. The authors indicated that the mechanism of toxicity of both chemicals is associated with their strongly alkaline nature. They consider calcium hydroxide as less toxic than calcium oxide, but calcium hydroxide may have a longer exposure time. The authors hypothesize that marine organisms unaffected by calcium oxide should not be affected by calcium hydroxide addition to seawater (see Locke et al. (2009) for a list of unaffected organisms). At heavy application rates, quicklime killed echinoderms, jellyfish, some sponges, some polychaetes, bryozoans, sea cucumbers, abalone, keyhole limpets, larval American lobsters, some larval fishes, and adult flatfishes.

Locke et al. 2009 conducted toxicity tests on several aquatic organisms using calcium hydroxide (hydrated lime). See below:

- The 96-hour LC₅₀ for threespine stickleback (*Gasterosteus aculeatus*) was 457 mg/L.
- The 96 hour LC₅₀ for sand shrimp (*Crangon septemspinosa*) was 158 mg/L.
- The 14-day chronic LC₅₀ for sand shrimp was 53.1 mg/L. There was no effect on the growth of sand shrimp from hydrated lime.
- Sub lethal impacts on bacteria occurred at lower concentrations. The estimated IC₅₀¹⁹ of hydrated lime in the Microtox test was 31.0 mg/L.

The researchers noted that pH levels rose with increasing concentrations of lime, up to 12.61 for the sand shrimp test.

¹⁹ The concentration that causes inhibition by light by 50%.

Table 7 - Acute toxicity of calcium hydroxide on freshwater fish. *These European data do not meet compliance for product registration through EPA's Office of Pesticide Programs.*

Species	Exposure Period	LC ₅₀ mg/L
<i>Gambusia affinis</i>	24 hour	240
<i>Gambusia affinis</i>	48 hour	220
<i>Gambusia affinis</i>	96 hour	160
<i>Clarius gariepinis</i>	96	33.9
<i>Micropterus sp.</i>	7 day	100
Goldfish, bass, sunfish	5 hour	100 (these species have survived 7 or more days at 50 mg/L)

In freshwaters, there should be little to no adverse effect to animals from the addition of calcium hydroxide to aquatic ecosystems, as long as the applicator ensures that pH stays below 10. In marine waters, both calcium oxide and calcium hydroxide kill sensitive organisms in the treated areas. Based on reported uses, divers can direct the lime slurry to infested areas and target organisms, leaving uninfested areas untreated.

Water, land, and shoreline use

Navigation

The project proponent may choose to cordon off the area during the application of the product and this may result in a temporary impact to navigation.

Swimming

Ecology has not imposed any swimming restrictions in the treatment area. However, the project proponent may choose to cordon off the area during the application of the product.

Specific mitigation for calcium hydroxide

Handlers of the powder must wear personal protection gear. When applying to freshwater, use buffers to maintain pH between 6 and 10.

Mitigations required under the Aquatic Invasive Species Permit include:

Marine/estuarine water

- Limit treatments to the lowest effective concentration or amount to kill the targeted organism.
- The preferred method is to use under tarpaulins or impermeable covers secured over the invasive organism and limit treatment to docks, boat hulls, and fixed objects or defined areas where the Permittee can secure impermeable covers.
- For direct applications, apply on to target organism. Do not treat uninfested areas.

Freshwater

- Whole water body applications permitted.
- The pH of the receiving water must remain between 6 and 9.

References for calcium hydroxide

Bernstein, B. B. and R. W. Welsford. 1982. *An assessment of feasibility of using high-calcium quicklime as an experimental tool for research into kelp bed/sea urchin ecosystems in Nova Scotia*. Can. Tech. Rep. Fish. Aquat. Sci. 968: ix + 51p.

Ebbing, D. D. and S. D. Gammon. 2002. *General Chemistry*. 7th edition. Houghton Mifflin Company.

Galtsoff, P. S. and V. L. Loosanoff. 1938. *Natural history and method of controlling the starfish (*Asterias forbesi*, Desor)*. Bulletin of the Bureau of Fisheries. Bulletin No. 31.

Locke, A., K. G. Doe, W. L. Fairchild, P. M. Jackman, and E. J. Reese. 2009. *Preliminary evaluation of invasive tunicate management with acetic acid and calcium hydroxide on non-target marine organisms in Prince Edward Island, Canada*. Aquatic Invasions, Vol. 4, Issue 1:221-236.

McLain, K. 2005. *Draft human and environmental risk assessment of calcium hydroxide*. On the web at http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/lakes/RISK%20ASSESSMENT%20OF%20CALCIUM%20HYDROXIDE.pdf

Shumway, S. E., D. Card, R. Getchell, and C. Newell. 1988. *Effects of calcium oxide (quicklime) on non-target organism in mussel beds*. Bull. Environ. Contam. Toxicol. 40:503-509.

Rotenone

Overview

Rotenone is a natural plant alkaloid extracted from the roots of tropical plants in the pea family. Indigenous peoples in Asia, South America, and Australia historically used rotenone to catch fish by throwing crushing the roots of rotenone-containing plants (a number of species contain rotenone) and throwing them into the water. The fish came to the surface and where they could be easily caught.

Consumers have used rotenone as an organic insecticide on crops, livestock, and pets (flea powder), but recently pesticide companies have voluntarily withdrawn these uses from EPA's registration. At this time, piscicidal use is the only registered use of rotenone. EPA registers four basic aquatic formulations of rotenone: powdered extracts, emulsifiable liquids, emulsifiable liquids with the synergist piperonyl butoxide, and baits.

Rotenone acts by affecting cellular respiration and is readily absorbed by organisms that rely on gills. This makes rotenone highly toxic to fish, insects and other gill-breathing species. It is much less toxic when ingested or through dermal contact. Inhalation is the significant route of exposure for terrestrial organisms.

The use of rotenone for fish management is well studied. WDFW first developed an EIS for the use of rotenone in 1976. They have periodically updated this EIS issuing major supplements in 1992 and 2001 (<http://wdfw.wa.gov/hab/sepa/2001eis.pdf>). In 2008, WDFW and the US Fish and Wildlife Service also coauthored a Draft Programmatic Environmental Assessment for the WDFW Statewide Lake and Stream Rehabilitation Program (EA) (http://wdfw.wa.gov/hab/sepa/08060_draft_ea.pdf). WDFW's Fish Management Program funded the preparation of a risk assessment for the piscicidal formulations of rotenone (finalized in June 2007 by Compliance Services International).

WDFW currently applies rotenone on an annual basis to selected lakes, ponds, and streams to manage populations of fish, mostly in eastern Washington. They use rotenone under an individual NPDES permit to eliminate or significantly reduce entire fish populations. WDFW also uses rotenone in streams and rivers flowing into other water bodies as a barrier treatment to keep fish from escaping into these waters.

Ecology anticipates that uses for rotenone under the Aquatic Invasive Species Permit will be similar to those uses covered in WDFW's EIS, subsequent supplements, the 2007 risk assessment, and the 2008 EA. Rotenone use may facilitate the eradication of invasive fishes such as, but not limited to northern pike, Asian carp, and gobies or other aquatic invasive species. Therefore, in this programmatic Aquatic Invasive Species EIS, Ecology will summarize information about rotenone from these documents. We refer readers to those documents for more detailed information about the environmental toxicity and human health effects of rotenone.

Ecology extracted the information presented below mainly from the *Risk Assessment for Piscicidal Formulations of Rotenone*, prepared by Compliance Services International (http://www.ecy.wa.gov/programs/wq/pesticides/seis/csirotenone_ra062907.pdf). This document is incorporated by reference into this FEIS as is the 2001 WDFW EIS on rotenone, and the 2008 EA. Except where otherwise noted, the information presented below is taken almost verbatim from the risk assessment.

Environmental and human health impacts

Earth

Sediments

Rotenone adsorbs to sediments or particulate material, including plants in the water column and is unlikely to move through the sediment. Because rotenone is not persistent and is strongly bound to sediments until it breaks down, its use is not considered of concern to benthic organisms.

Air

Air quality

Environmental issues associated with air quality include objectionable odors from rotenone and decaying fish, elevated levels of emission from motorized equipment required for application, particulate dust from equipment and vehicle use, and dust from rotenone application. Given that the application of rotenone is short-lived, the effects are temporary (Temple and Anderson, 2001). The rotenone label encourages the project proponent to remove any dead fish that wash up along the shoreline. This minimizes odors from decaying fish. Others sink and the nutrients from their decomposing bodies help phytoplankton and zooplankton rebound from the rotenone treatment.

Plants

Rotenone is not toxic to either terrestrial or aquatic plants, nor should its application pose any risk to them.

Water

Surface water

Rotenone is relatively insoluble in water with low volatility. Its half-life ranges from a few hours to several weeks. Persistence is longer at lower temperatures and high pH. Typically, fish managers can restock fish within 2-4 weeks after rotenone treatment. There is low bioconcentration potential in aquatic organisms so rotenone should not biomagnify up the food chain.

Ground water

Rotenone strongly adsorbs to sediments, plants, and particulate matter in treated waters. As a result, rotenone should not leach into groundwater. No one has detected rotenone in groundwater, even in test areas associated with rotenone treatments. The EA and the risk assessment addresses ground water issue in areas of fractured basalt.

Animals

Terrestrial

Rotenone does not affect birds, mammals, reptiles, and crayfish at piscicidal levels. Losses of forage for piscivorous birds and mammals following treatment are temporary. There are no restrictions or warnings on watering livestock or wildlife in rotenone-treated water because there are no adverse effects when used according to the label (Temple and Anderson, 2008).

Aquatic

Rotenone is highly toxic to fish. In studies cited in the EPA RED for rotenone, the LC₅₀ for rainbow trout is 1.95 µg/L. Bullheads, catfish, and goldfish are considerably less sensitive to rotenone than most other tested fish. Rotenone formulations containing piperonyl butoxide are about six times as toxic as formulations without this synergist. Chronic toxicity data for fish are limited but suggest that chronic toxicity is not substantially greater than seen in acute tests.

Limited laboratory data indicate variable toxicity to aquatic invertebrates. Cladocerans appear to be the most sensitive genera with LC₅₀ values as low as 3.7 µg/L. Benthic invertebrates including amphipods, crayfish, and mollusks are much less sensitive. Data from field observations following treatment indicated serious, but mostly short-term effects on zooplankton with recovery occurring in several months to as long as several years. Even in observations where researchers considered zooplankton eradicated, overall zooplankton recovery occurred, although not necessarily with the same species diversity. Some benthic organisms are affected.

Gilled stages of amphibians are moderately sensitive to rotenone with LC₅₀ values as low as parts per billion reported for larval southern leopard frogs (*Rana sphenoccephala*). Adult frogs tested in water were much less sensitive with LC₅₀ values as low as 3.2 mg/L. Observations following rotenone treatment have not generally noted effects on amphibians.

Indirect effects may occur for species that rely on fish or zooplankton, resulting from a loss of a food supply. Typically, terrestrial organisms can find other locations or types of food sources. For aquatic species, such effects will generally be of limited duration.

Effects on threatened and Endangered (T &E) species are not expected. Although T & E fish species are susceptible, Permittees will not use rotenone except under the Aquatic Invasive Species Permit and with oversight from National Marine Fisheries Service and Fish and Wildlife Service where appropriate.

Human health

The toxicity database with respect to humans is somewhat incomplete. On an acute basis, inhalation toxicity is of most concern, with oral toxicity also classified as highly toxic. Females are more sensitive than males in all studies where scientists classified the results according to gender. Chronic toxicity data for rotenone are limited to oral exposure. In a two-generation rat study, a no-observed-adverse-effect-level was 7.5 mg/Kg diet based upon weight gain in offspring. EPA waived chronic inhalation data because they expect no chronic inhalation exposure to occur after the cancellation of non-piscicidal uses (e.g., consumers used flea powder containing rotenone on their pets).

There is no evidence of carcinogenicity, mutagenicity, or teratogenicity. An older study that found tumors at low doses did not find them at higher doses, which contradicts dose-response theory. Newer, more thorough studies found no evidence of carcinogenicity. Rotenone mimics an effect associated with Parkinson's disease. Researchers have used rotenone to assess the effects of drugs that may inhibit the development of the disease. This is not a concern for the piscicidal uses of rotenone because the study required chronic injection of rotenone into the jugular vein of rats to produce the effect. No such exposure would even remotely approximate exposure from invasive species management. However, a recent study from the East Texas Medical Center and the University of Texas Health Science Center suggested that people with Parkinson's were ten times more likely to have been exposed to rotenone. Proposed new EPA labeling precludes exposure to applicators by respirators, protective clothing, and closed application systems. Managers using rotenone under the Aquatic Invasive Species Permit will be required to follow the WDFW rotenone application procedures that are in place to reduce applicator and public exposure to rotenone.

Water, land, and shoreline use

Fish removal projects typically occur during the fall or in months when crop irrigation, swimming, and other human recreational activities are not likely. WDFW typically closes treated waters to public access and patrols the shoreline to ensure that people do not swim during rotenone application. This will cause short-term limitations on recreation or other water uses for humans.

Navigation

The project proponent may choose to cordon off the area during the application of the product and this may result in a temporary impact to navigation.

Specific mitigations for rotenone

Managers using rotenone under the Aquatic Invasive Species Permit will be required to follow the WDFW rotenone application procedures that are in place to reduce applicator and public exposure to rotenone. Mitigations include:

- For freshwater application only.
- ESA listed fish species must not be present at the time of treatment and for three months following treatment, unless the state and federal fish agencies approve the treatment.
- Except for emergencies or when in situation where invasive species may move out of the water body if treatment is delayed (e.g., Asian carp invasion), limit treatment to periods of low water, usually September or October.
- In open water areas accessible by boat, use powdered rotenone mixed with water and applied as slurry. Limit airborne dust.
- Use liquid rotenone for spot applications only in areas that are not practicably accessible by boat.
- Unless the outlet is being treated for invasive species, in water bodies with flowing outlets, neutralize rotenone to eliminate downstream impacts. Below the neutralization zone (distance the water travels in 20 minutes), the rotenone must be totally neutralized using potassium permanganate. The resident potassium permanganate is not to exceed 2 mg/L past the neutralization zone.
- Follow all permit monitoring requirements.
- Restock appropriate fish species after the invasive species is eradicated.

References for Rotenone

Hisata, J. S. 2001. *Draft supplemental environmental impact statement – lake and stream rehabilitation: rotenone use and health risks*. Washington State Department of Fish and Wildlife 88 p. <http://wdfw.wa.gov/hab/sepa/2001eis.pdf>

Temple, R., and J. Anderson. 2008. *Draft programmatic environmental assessment for WDFW statewide lake and stream rehabilitation program*. 66p.
http://wdfw.wa.gov/hab/sepa/08060_draft_ea.pdf

Turner, L., S. Jacobson, and L. Shoemaker. 2001. *Risk assessment for piscicidal formulations of rotenone*. Prepared by Compliance Services International. 104 p.
http://www.ecy.wa.gov/programs/wq/pesticides/seis/csirotenone_ra062907.pdf

Antimycin A

Overview

Antimycin A is an antibiotic complex used as a piscicide only in freshwaters. Biologists apply the liquid directly to the water to remove fish populations. Antimycin A kills fish by inhibiting electron transport in the cellular mitochondria. There is a single antimycin A product, Fintrol® Concentrate (23% antimycin A), registered for use for this purpose. Used at concentrations of 5-25 µg/L active ingredient (a.i.), biologists can get a complete kill of most fish populations. Biologists use antimycin A instead of the more commonly used rotenone when they need more rapid degradation of the toxicant, greater selectivity among fish species, or fewer effects on invertebrates. However, because antimycin A is not effective in deep lakes (lakes with depths greater than five feet) or in alkaline waters (pH values greater than or equal to 8.5), it is mainly used for treatment of streams or shallow ponds. It is more expensive than rotenone, which limits its use.

Biologists in other states have used antimycin A as a fish toxicant since 1964 and there is substantial information about its fish toxicity. WDFW has never used in Washington waters. There is little information about antimycin A's toxicity to other organisms because until recently, there were no analytic methods to detect residues. Because its use and potential exposure routes are very limited and EPA has stringent label requirements governing its use, EPA waived many registration toxicity-testing requirements for re-registration of this product.

Because of its cost and the limited applicability of antimycin A for use in alkaline eastern Washington lakes, WDFW did not include antimycin A in its EIS or the EA developed for the rotenone program. WDFW's Fish Management Program paid for the preparation of a risk assessment for antimycin A (finalized in June 2007 by Compliance Services International). See also the EPA RED at http://www.epa.gov/oppsrrd1/REDs/antimycin_A-a.pdf.

Ecology anticipates that uses for antimycin A under the Aquatic Invasive Species Permit will be similar to those uses covered in the 2007 risk assessment. Antimycin A may be a potential eradication tool for invasive fish such as, but not limited to northern pike, Asian carp, and gobies or other invasive species. Other states have used Antimycin A to eliminate non-native trout from streams to allow native fish species recovery. Therefore, in this programmatic FEIS, Ecology summarized information from the risk assessment, but will refer the reader to the risk assessment, the EPA RED, and the National Parks Service's antimycin A field manual for more detailed information about environmental and human health information for antimycin A.

Ecology excerpted the information presented below from the *Risk Assessment for Piscicidal Formulations of Antimycin A*, prepared by Compliance Services International (http://www.ecy.wa.gov/programs/wq/pesticides/seis/csiantimycin_Aa_ra062907.pdf). This document is incorporated by reference into this FEIS. Except where otherwise noted, the information presented below is taken almost verbatim from the risk assessment.

Environmental and human health impacts

Earth

Sediments

No data are available. Based on the physical-chemical properties of antimycin A, it appears likely that it will adsorb strongly to sediments, plants, and particulate matter (Moore, et al., 2008).

Air

Air quality

There are no data available about impacts of antimycin A on air quality, but it is not volatile. The label requires the collection and burial of dead fish. This should eliminate objectionable odors from decaying fish after treatment.

Plants

Antimycin A is unlikely to be toxic to either terrestrial or aquatic plants. Limited testing showed no impact to a variety of aquatic plant species.

Water

Surface water

Antimycin A has low solubility in water and it degrades quickly through hydrolysis. Shorter half-lives occur at higher pHs. EPA estimates that the half-life of antimycin A ranges from several minutes to approximately 12 hours and that least 99% will have degraded after seven days. EPA requires neutralization of any antimycin A treated waters with potassium permanganate to mitigate any downstream impacts (EPA RED).

Ground water

Antimycin A adsorbs strongly to sediments, plants, and particulate matter in treated waters. As a result, antimycin A should not leach into groundwater.

Animals

Terrestrial

Technical antimycin A has a high-to-very-high toxicity to birds. A 90-day rat study had a no-observed-effect-level of 0.5 mg/Kg/day based on diarrhea symptoms that probably resulted from the antibiotic effects on intestinal flora. However, there should be limited exposure to terrestrial organisms from antimycin A use. Antimycin A is not likely to present significant drinking water

exposure to wild mammals because human presence will temporarily drive away wildlife and antimycin A degrades rapidly (EPA RED).

Aquatic

EPA classifies antimycin A as very highly toxic to fish on an acute basis. No chronic toxicity data are available. The 96-hour LC₅₀ for coho salmon is 0.009 µg/L. Salmonids in general are highly sensitive to this compound. Relatively insensitive fish include catfish, shortnose gar, bowfin, goldfish, green sunfish, white crappie, and mosquito fish. Small fish are more sensitive than larger fish. Very limited laboratory data indicate that toxicity to aquatic invertebrates can be high; the most sensitive species tested, an amphipod, had an LC₅₀ of 0.008 µg/L. When compared to field application rates, the effects from actual use would not be as pronounced as indicated solely by LC₅₀ values. At higher application rates, ranging from 40-100 ppb, field effects on invertebrates were obvious, but the duration of such effects was generally short. Impacted populations took several months to a year to recover. Gilled stages of amphibians are moderately sensitive to antimycin A, but data are limited.

Human health

The toxicity database with respect to humans is incomplete. EPA did not require additional human health data for antimycin A because its labeled use imposes stringent limitations for human exposure. The highest potential exposure to humans is from the preparation and application of antimycin A. Applicators must wear personal protection gear and follow all label requirements. EPA believes that a detailed Standard Operating Procedure manual is necessary for antimycin A use because the ways in which it is applied are significantly more complex than typical agricultural pesticides (EPA RED). Fish killed by antimycin A treatment cannot be consumed by humans or livestock. As an example of standard operating procedures when using antimycin A, the National Parks Service closes the area to the public during and for a period after treatment to ensure no human contact with the treated water.

Water, land, and shoreline use

Invasive species removal projects using antimycin A will temporarily impact typical uses such as fishing, swimming, and irrigation. The EPA label restricts swimming, boating, and fishing in the treatment area during treatment and for seven days after treatment.

Navigation: Because antimycin A is suitable only for streams or shallow water bodies, it is unlikely to have any impact on larger navigable water bodies.

Specific mitigations for antimycin A

Managers using antimycin A under the Aquatic Invasive Species Permit must implement specific mitigations in the permit to reduce applicator and public exposure to antimycin-A. Mitigations include:

- For freshwater application only.
- ESA listed fish species must not be present at the time of treatment and for three months following treatment, unless the state and federal fish agencies approve the treatment.

- Except for emergencies or when in situation where invasive species may move out of the water body if treatment is delayed (e.g., Asian carp invasion), limit treatment to periods of low water, usually September or October.
- Unless the outlet is specifically being treated for invasive species, in water bodies with flowing outlets, neutralize antimycin-A to eliminate downstream impacts. Below the neutralization zone (distance the water travels in 20 minutes), the rotenone must be totally neutralized using potassium permanganate. The resident potassium permanganate is not to exceed 2 mg/L past the neutralization zone.
- Follow all permit monitoring requirements.
- Restock appropriate fish species after the invasive species is eradicated.

References for antimycin A

Moore, S., M. Kulp, B. Rosenlund, J. Brooks, and D. Propst. 2008. *Field manual for the use of antimycin A for restoration of native fish populations*. Natural Resource Report NPS/NRPC/NRR – 2008/033. 149p.

http://www.nature.nps.gov/water/FisheriesReports/NPS_Antimycin_SOP_2008_reformat.pdf

Reregistration Eligibility Decision for Antimycin A. Case No. 4121. May 2007. Environmental Protection Agency. 34 p. <http://www.epa.gov/oppsrrd1/REDs/antimycin-a.pdf>

Turner, L., S. Jacobson, and L. Shoemaker. 2001. *Risk assessment for piscicidal formulations of Antimycin A*. Prepared by Compliance Services International. 74 p.

http://www.ecy.wa.gov/programs/wq/pesticides/seis/csiantimycin_Aa_ra062907.pdf

Potassium permanganate

Overview

Potassium permanganate (KMnO₄) is a strong oxidizing agent used in many industries and laboratories. It is non-volatile, non-flammable, and stable under normal conditions. It breaks down into potassium, manganese, and water. These elements are common in nature. Managers used potassium permanganate to treat drinking water by oxidizing the organic compounds that may create harmful byproducts later in the treatment process. Potassium permanganate controls tastes and odors and removes color from potable water. According to EPA, concentrations used in drinking water treatment range from 0.25 to 20 mg/L. Alkaline conditions enhance the capability of potassium permanganate to oxidize organic matter, but it is a better biocide under acidic conditions (http://www.epa.gov/OGWDW/mdbp/pdf/alter/chapt_5.pdf). CAIROX ZM® is a potassium permanganate compound registered for the control of zebra mussels in raw water intake lines of drinking water and industrial water treatment systems (Sprecher and Getsinger, 2000).

In fisheries and aquaculture, fish farmers use potassium permanganate as a treatment for some fish parasites. Scientists have found that potassium permanganate can control some species of

invasive freshwater mollusks (Asian clam and zebra mussel). Potassium permanganate effectively controls adult zebra mussels at 2.0 mg/L and inhibits veliger settlement at 1.0 mg/L and below, but municipalities primarily use this chemical to manage zebra mussel infestations on infrastructure (reported in Sprecher and Getsinger, 2000).

When downstream transport of rotenone or antimycin A from treatment sites is of concern, fish biologists use potassium permanganate to deactivate these fish toxicants. In their EIS, WDFW indicated that potassium permanganate had no deleterious environmental effects at the concentrations normally used to neutralize rotenone. The individual NPDES permit issued to WDFW by Ecology for their fish management program allows the use of potassium permanganate when necessary to prevent damage to non-targeted organisms and to maintain water quality downstream. The EPA RED for antimycin A and rotenone use calls for the use of potassium permanganate to neutralize any outflow waters containing these chemicals.

Ecology anticipates that permittees covered under the Aquatic Invasive Species Permit will use potassium permanganate (where indicated) for neutralizing rotenone or antimycin A after treatments to eradicate invasive fish. There may also be some use of potassium permanganate to manage invasive mollusks or other aquatic invasive animals.

WDFW discussed the use of potassium permanganate in its 2001 supplemental EIS for fish management (<http://wdfw.wa.gov/hab/sepa/2001eis.pdf>). In 2008, WDFW and the US Fish and Wildlife Service coauthored an EA for the WDFW Statewide Lake and Stream Rehabilitation Program that also discusses potassium permanganate use. Therefore, in this programmatic FEIS, Ecology summarized information from the supplemental EIS and the EA, but will refer the reader to these documents for more detailed information about impacts. Except where otherwise noted, the information presented below is taken almost verbatim from the above referenced documents.

Environmental and human health impacts

Earth

Sediments

A strong oxidizing agent, organic material in the water and sediments will reduce potassium permanganate.

Air

Air Quality

The MSDS for potassium permanganate describes the chemical as being odorless. Applicators wear personal protection gear and breathing apparatus when working with chemical.

Plants

There is little information about the effect of potassium permanganate on terrestrial or aquatic plants. Potassium permanganate is an effective algaecide at concentrations of 4-16 mg/L, although copper is more effective and less expensive. Anecdotal accounts indicate that aquarists

use potassium permanganate to disinfect their aquarium plants by bathing them in a potassium permanganate solution for about 15 minutes. They report that if they are careful with concentrations, and rinse the plants afterward, potassium permanganate works well to remove snails and other animals, while leaving the plants unharmed. Used as a neutralizer for rotenone or antimycin A, there should be little impact to aquatic plants from potassium permanganate.

Water

Surface Water

In the presence of organic reducing agents (rotenone), permanganate will not persist. Managers use potassium permanganate to treat drinking water, primarily to control taste and odor problems. With potassium permanganate concentrations properly balanced with fish toxicant concentration and the water's organic demand, toxic levels can be reduced in a matter of minutes through the oxidation of organic material and fish toxicants in the water.

Ground water

Potassium permanganate is used for the removal of organic contaminants in potable groundwater wells. There should be no impacts to groundwater.

Animals

Terrestrial

The acute oral toxicity for potassium permanganate is 1090 mg/Kg LD₅₀ (rat) and 2157 mg/Kg LD₅₀ (mouse). There should be little opportunity for terrestrial organisms to contact potassium permanganate when used under the Aquatic Invasive Species Permit.

Aquatic

Aquatic toxicity differs among species. EPA reports toxicity at concentrations of 1-2 mg/L. Therapeutic doses (to treat fish parasites) range from 2 to 25 mg/L, depending on the time prescribed for treatment (i.e. prolonged bath versus dip treatments). Potassium permanganate is toxic to aquatic invertebrates and zooplankton although there is a wide range of tolerance between various freshwater invertebrates. Toxicity of *Daphnia* sp ranged from 84 to 3500 µg/L. Archer (2001) reported that in field application, potassium permanganate is quickly reduced to naturally occurring compounds that are not toxic.

Human health

Hazardous exposure to humans from potassium permanganate may occur via inhalation, ocular, or dermal routes. In its concentrated form, potassium permanganate is dusty and caustic to mucous membranes in the nose and throat. Applicators wear protective clothing and breathing apparatus. The dry material is inert, but becomes active when dissolved in water.

There is no data available on whether potassium permanganate is a carcinogen, teratogen, or has impacts on development toxicity. It is mutagenic for bacteria and/or yeast. The lowest published lethal oral dose for women is 100 mg/Kg and the lethal human oral dose is 143 mg/Kg. Based on animal studies, potassium permanganate may cause adverse reproductive effects on male and female fertility or affect genetic material (data source – MSDS). However, used as a neutralizing

agent for fish toxicants under standard operating procedures, potassium permanganate has no deleterious effects at concentrations normally associated with this process.

Water, land, and shoreline use

Invasive species removal projects using fish toxicants and the neutralization compound potassium permanganate will temporarily affect typical uses such as fishing, swimming, navigation, and irrigation primarily because of the presence of the fish toxicant rather than potassium permanganate.

Specific mitigations for potassium permanganate

Mitigations required under the Aquatic Invasive Species Permit include:

- For freshwater application only.
- Use under tarpaulins or impermeable covers secured over the invasive species.
- Limit treatment to docks, boat hulls, and fixed objects or defined areas where the Permittee can secure impermeable covers.
- The Permittee may treat defined areas such as a marina, if the Permittee can limit water exchange behind impermeable barriers.
- The Permittee may treat enclosed, small water bodies where the threat of the invasive species outweighs other environmental damage.
- When used to neutralize rotenone or antimycin A treated waters – use calibrated equipment to achieve the minimum effective concentration of potassium permanganate to oxidize the rotenone or antimycin A within the neutralization zone.

References for potassium permanganate

Archer, D. L. *Rotenone neutralization methods*. 2001. American Fisheries Society.
<http://www.fisheries.org/units/rotenone/rewards/01archer.pdf>

EPA Guidance Manual. Alternative Disinfectants and Oxidants. April 1999.
http://www.epa.gov/OGWDW/mdbp/pdf/alter/chapt_5.pdf

Sprecher, S. L. and K. D. Getsinger. 2000. *Zebra mussel chemical control guide*. Zebra Mussel Research Program. U.S. Army Corps of Engineers. ERDC/EL TR-00-1. 116p.

Endothall

Overview

Endothall is included in Aquatic Invasive Species Permit because it is used a biocide to manage mollusks in cooling towers and water systems and may have some use against nonnative invasive animals in freshwater. Both the dipotassium salt formulation of endothall (Aquathol®) and the more toxic mono (N, N-dimethylalkylamine salt of endothall (Hydrothol 191®) are registered as

aquatic herbicides. Lake managers use the mono salt of endothall for algae management and the mono salt is registered for use as a biocide (Td2335 Industrial biocide-molluscicide® and EVAC®). Ecology permits both forms of endothall in its Aquatic Plant and Algae Management NPDES Permit. EVAC®, registered as a molluscicide, has a similar chemical formula to Hydrothol 191®. Mussels do not sense endothall in the water and do not close their shells. Endothall acts as a corrosive to gills. It controls established populations of freshwater and saltwater mollusks and prevents settlement of their immature forms. Toxicity is dependent on concentration and exposure time (Sprecher and Getsinger, 2000). Treatments of 2.3 mg/L for six to seven hours were equivalent to those at 5 mg/L for two hours.

Environmental and human health impacts

Ecology's Final Supplemental Environmental Impact Statement for Freshwater Aquatic Plant Management (<http://www.ecy.wa.gov/biblio/0010040.html>) adequately covers the environmental and human health impacts for both the dipotassium salt and mono salt of endothall. Ecology based the endothall information in its Aquatic Plant Management SEIS on a risk assessment prepared by Compliance Services International in 2000 (<http://www.ecy.wa.gov/biblio/0010044.html>). Both documents are incorporated into the Aquatic Invasive Species FEIS by reference. For detailed information about environmental and human health information about endothall, see the risk assessment and Aquatic Plant Management SEIS. Another source of information about endothall is the EPA RED (http://www.epa.gov/oppsrrd1/REDs/endothall_red.pdf).

Specific mitigations for endothall

Mitigations required under the Aquatic Invasive Species Permit include:

- For freshwater application only.
- Treatment shall occur from the shoreline outward into the water body.
- Juvenile salmon species and Endangered Species Act listed species must not be present at the time of treatment.

References for endothall

Reregistration Eligibility Decision for Endothall. Case Number 2245. September 2005. Environmental Protection Agency. 219 p. http://www.epa.gov/oppsrrd1/REDs/endothall_red.pdf

The Final Supplemental Environmental Statement for Freshwater Aquatic Plant Management. 2001. Washington Department of Ecology Publication No. 00-10-040. <http://www.ecy.wa.gov/biblio/0010040.html>

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Sodium carbonate peroxyhydrate

Overview

Sodium carbonate peroxyhydrate is a white, odorless, free flowing powder. Consumers use it mainly as a bleaching chemical in laundry detergents, additives, and dishwasher products, but also for drain cleaning or for cleaning dentures (HERA, 2002). Sodium carbonate peroxyhydrate is the active ingredient in some EPA-registered algaecide and fungicide products. EPA classified sodium carbonate peroxyhydrate ($2 \text{Na}_2\text{CO}_3 \cdot 3\text{H}_2\text{O}_2$) as eligible for reduced data requirements for pesticide registration. It is a non-complex chemical and its physical and chemical characteristics are well understood. In the presence of water, sodium carbonate peroxyhydrate breaks down into hydrogen peroxide and sodium carbonate. According to EPA, neither of these breakdown products engenders toxicological concern. The hydrogen peroxide oxidizes the critical cellular components of the target organism and kills it. Hydrogen peroxide itself is very unstable in the environment and rapidly breaks down to water and oxygen. EPA registers products containing sodium carbonate peroxyhydrate for both terrestrial and aquatic use.

Ecology allows the use of sodium carbonate peroxyhydrate in its Aquatic Plant and Algae Management NPDES Permit for the control of filamentous algae and cyanobacteria. Ecology anticipates that uses for sodium carbonate peroxyhydrate under the Aquatic Invasive Species Permit may include management of marine invasive algae.

Environmental and human health impacts

Earth

Sediments

Sodium, carbonate, and hydrogen peroxide do not adsorb to sediment. The half-life of hydrogen peroxide in both surface water and sediment can be significantly less than one day, but in some cases, it can be up to five days (HERA, 2002).

Air

Air quality

Sodium carbonate peroxyhydrate is a granular, odorless product and its application should have no impact on air quality.

Plants

Used as an aquatic algaecide, sodium carbonate peroxyhydrate is unlikely to be toxic to terrestrial or aquatic plants. EPA registered it for use as an algaecide, and pesticide companies report efficacy against cyanobacteria and filamentous green algae.

Water

Surface water

Hydrogen peroxide, inorganic carbon, and sodium are naturally present in the environment. Sodium carbonate peroxyhydrate dissolves rapidly and biodegrades in the presence of water by disassociating to hydrogen peroxide and sodium carbonate. Hydrogen peroxide has a half-life of less than eight hours in water and degrades via hydrolysis, photolysis, anaerobic and aerobic metabolism, leaching, adsorption/desorption, and sediment dissipation. Adding sodium carbonate to the water may cause increased alkalinity and a resultant increase in pH. The raise in pH depends on the buffering capacity of the receiving waters (HERA 2002).

Ground water

There are no federal drinking water/groundwater standards for sodium carbonate peroxyhydrate or hydrogen peroxide. There should be no concerns with the use of sodium carbonate peroxyhydrate and groundwater contamination.

Animals

Terrestrial

The available information on sodium carbonate peroxyhydrate indicates that it is not very acutely toxic in laboratory animal studies, but can cause severe eye damage. It is slightly toxic to mammals on an acute basis. It is highly toxic to bees, but aquatic uses should not expose bees. Birds or other animals may ingest spilled granules so applicators must immediately clean up any spills. Given the rapid breakdown of the active ingredient, post-application exposure is expected to be minimal.

Aquatic

New York Department of Environmental Conservation reports substantial aquatic organism toxicity data for sodium carbonate toxicity (67 records) and hydrogen peroxide toxicity (123 records). These are available through EPA's ECOTOX online database. Sodium carbonate has a very low toxicity to all organisms for which results are reported. Hydrogen peroxide was at most moderately toxic in the reported studies. Ecology anticipated no adverse impacts from sodium carbonate to aquatic animals when used according to the EPA label.

Human health

Because sodium carbonate peroxyhydrate can cause severe eye damage, the algacide labels require the use of protective eyewear and other personal protection gear for the applicators safety. Given the rapid breakdown of the active ingredient and hydrogen peroxide, EPA expects post-application exposure of the public to these products to be minimal. The maximum potential concentration of treated water at the maximum label rate is approximately 8.5 mg/L. Hydrogen peroxide concentrations as high as 5,000 mg/L have no negative effect on human skin, eyes, or respiratory systems. The concentration of hydrogen peroxide in over-the-counter antiseptic solutions is 30,000 mg/L. According to the HERA risk assessment, sodium percarbonate and its breakdown products do not present a risk for human reproductive, developmental, or systemic toxicity. As an additional safety precaution for humans, in its Aquatic Plant and Algae Management Permit, Ecology advises that swimmers avoid the treatment area during and for two-hours after treatment.

Water, land, and shoreline use

Invasive species removal projects using sodium carbonate peroxyhydrate will temporarily impact swimming in the treatment area, although this is advisory only. The EPA label does not restrict access.

Navigation: Application of sodium carbonate peroxyhydrate should not have any impacts to navigation, although boaters may choose to avoid the area during treatment.

Specific mitigation for sodium carbonate peroxyhydrate

Ecology advises no swimming in the area of application during and for two hours after application to avoid eye irritation.

References for sodium carbonate peroxyhydrate

Department of Environmental Conservation. http://pmep.cce.cornell.edu/profiles/fung-nemat/febuconazole-sulfur/sodium_carb_perox/sodperox_mcl_0904.html

HERA - Human and Environmental Risk Assessment on ingredients of European household cleaning products. Sodium percarbonate. 2002. 33p.

Sodium Carbonate Peroxyhydrate (128869) Fact Sheet. September 2002. Environmental Protection Agency. 30 p.
http://www.epa.gov/pesticides/biopesticides/ingredients/factsheets/factsheet_128860.htm

Sodium Carbonate Peroxyhydrate NYS DEC Letter: Registration of one new pesticide product, GreenClean Granular Algaecide (EPA Reg. No. 70299—4), which represents a major change in labeling for the active ingredient sodium carbonate peroxyhydrate. 2004. New York State

Methoprene

Overview

Methoprene is an insect growth regulator with activity against a variety of insect species (EPA, 2001), but mosquitoes and midges show the greatest susceptibility to methoprene. It mimics the action of an insect growth-regulating hormone and prevents the normal maturation of insect larvae. EPA considers methoprene to be a biochemical pesticide because it controls targeted pests by interfering with the insect's life cycle, rather than through direct toxicity. EPA first registered methoprene in 1975 and issued the RED for methoprene in 1991 (EPA, 2001).

Methoprene comes in liquid, granular, pellet or briquette forms, some labeled for residential use. Mosquito districts apply methoprene directly to the water where mosquito larvae live. The food industry uses methoprene in the production of a number of foods including meat, milk, eggs,

mushrooms, peanuts, rice, and cereals (to control insects). The Food and Drug Administration allows methoprene as a food additive for use in cattle feeds to control horn flies. Consumers use methoprene on dogs and cats and in bedding to control fleas. Methoprene is the “plus” in Frontline Plus™, a product applied directly to the pet to control fleas.

In Washington, mosquito districts use methoprene to control mosquito larvae under Ecology’s Aquatic Mosquito Control Permit. As an example, the Grant County Mosquito Control District No. 1 began using methoprene in 1983 and currently uses about 400 gallons annually to control mosquitoes over a 1,000 square mile area (Johnson and Kinney, 2006). They apply most of the methoprene by air. Ecology is not aware of any methoprene use for the management of aquatic invasive species at this time, but is including it in the Aquatic Invasive Species Permit because it is allowed for mosquito control and it may have possible use against an invasive species in the future. Ecology anticipates that uses, if any, for methoprene under the Aquatic Invasive Species Permit will be for the control or eradication of invasive freshwater insects or other invertebrates.

Environmental and human health impacts

Earth

Sediments

According to the EPA Fact Sheet on methoprene, it rapidly metabolizes in soil in both aerobic and anaerobic conditions. Carbon dioxide is the major breakdown product. Methoprene does not leach so is not expected to persist in soil or contaminate ground water.

Air

Air quality

Although mosquito districts apply methoprene by air, Ecology anticipates that any application of methoprene to control aquatic invasive insects or other organisms will be by direct application to the water. Therefore, there should be no impacts on air quality.

Plants

Methoprene is a biopesticide and is not toxic to either terrestrial or aquatic plants, nor does it accumulate in plants (EXTOXNET, 1995). There should be no impact to either terrestrial or aquatic plants by using methoprene to manage aquatic invasive animals.

Water

Surface water

The solubility of methoprene in water is 1.4 to 2.0 mg/L and it rapidly breaks down in both the laboratory and field environment (as reported in Johnson, 2005). Degradation in surface water is due to both microbial metabolism and photolysis (EPA, 2001). Johnson and Kinney (2006) found that methoprene levels in surface waters from Grant County Mosquito District No. 1 rarely exceeded 0.2 µg/L even when they collected the samples close to the time of application. The authors detected methoprene only four times out of 68 samples. The Ontario Ministry of Environment monitors methoprene in surface waters where it is used for mosquito control. Although they have analyzed hundreds of samples, they almost never find methoprene in open

waters. They have detected methoprene in municipal catch basins, but concentrations were highly variable (as referenced in Johnson and Kinney, 2006). Given the low rate of detection and the low concentrations detected in surface waters, there should be minimal impacts to surface water from the use of methoprene to control aquatic invasive animals in freshwater.

Ground water

New York's Suffolk County Department of Health Services analyzed methoprene in hundreds of surface and well water samples, but had no hits at a detection limit of 0.2 µg/L. They found methoprene (at a detection limit of 0.01 µg/L) only when they collected samples immediately after spraying (as referenced in Johnson and Kinney, 2006). Because methoprene does not leach and breaks down rapidly, EPA does not expect it to contaminate ground water (EPA, 2001). Therefore, there should be no adverse impacts to ground water from the use of methoprene for aquatic invasive animal control.

Animals

Terrestrial

Methoprene is practically non-toxic to terrestrial species including mallard ducks and quail (EPA, 2001). In mammals, methoprene is rapidly and completely broken down and excreted. Some metabolites, such as acetates, may be incorporated into natural body components (EXTOXNET, 1995). The acute oral rat LD₅₀ was greater than 34,000 mg/kg (highest dose tested). The acute dermal rabbit LD₅₀ was greater than 2,000 mg/kg (highest dose tested). The acute inhalation rat LC₅₀ was greater than 5.19 mg/L air (Material Safety Data Sheet from Altosid® Liquid Larvicide Mosquito Growth Regulator). These data indicate that methoprene use in the aquatic environment is unlikely to have no adverse impact to terrestrial species.

Aquatic

Applicators use methoprene mosquito products at very low concentrations in water. EPA concluded that ecological effects studies on file or submitted by the registrant, indicate minimal acute and chronic risk to freshwater fish, freshwater invertebrates, and estuarine species from exposure to methoprene mosquito products. Acute, short-term, and subchronic effect studies on non-target immature and adult arthropods (Crustacea, Insecta, and Mollusca, including shrimp, damselfly, beetle) show 24-48-hour LC₅₀ values at greater than 900 µg/L. Aquatic species sensitive to methoprene are species highly related to mosquitoes (EPA, 2001). This indicates that most non-target aquatic species are unlikely to be adversely affected by methoprene application to manage aquatic invasive species.

There has been concern that methoprene may cause deformities in frogs or make frogs more susceptible to the agents that cause deformities. For this reason and at the request of WDFW, Ecology's mosquito permit restricts its application in areas (critical habitats for threatened, endangered, candidate, and sensitive species) designated by WDFW to protect endangered frogs. An exception to this restriction may occur if local and state health authorities discover and acknowledge a public health threat and issue an emergency health declaration. However, Antunes-Kenyon and Kennedy, 2001 reviewed the scientific literature and found no evidence to suggest that the labeled application of methoprene will lead to amphibian malformations.

Lobster growers implicated mosquito pesticides (methoprene, but mostly malathion) as one cause of a lobster die off in Long Island Sound (as reported in Antunes-Kenyon and Kennedy, 2001). However, subsequent research concluded that environmental factors and a new lobster disease were the primary culprits causing the deaths and that it was unlikely that pesticide concentrations in the Sound were high enough to cause mass mortality of lobsters. Never the less, the lobster industry reportedly received a \$12.5 million settlement from the chemical company Cheminova that sells malathion for mosquito control (during a West Nile outbreak in New York, there was extensive spraying for mosquitoes).

Human health

EPA concluded that methoprene is of low toxicity and poses very little hazard to humans and other non-target species. Exposure via drinking water, dermal, and inhalation toxicity routes are negligible. Methoprene is not a developmental toxicant, a mutagen, and has no potential for estrogenic, androgenic, anabolic or a glucocorticoid effects (EPA, 2001). EPA considers methoprene to pose no risks to people who are occupationally exposed, but the Altosid® liquid larvicide concentrate label indicates that the liquid can cause moderate eye irritation.

Water, land, and shoreline use

Used at label concentrations, there should be minimal impact to water, land, and shoreline use. The label indicates no swimming, fishing, or other use restrictions after treatment.

Navigation

When used at label concentrations, there should be no impact to navigation.

Specific mitigation for methoprene

Do not apply in state-listed restricted use areas identified in Ecology's mosquito NPDES permit without consulting with WDFW habitat biologists.

References for methoprene

Antunes-Kenyon, S. and G. Kennedy. 2001. *Methoprene – a review of the impacts of the insect growth regulator methoprene on non-target aquatic organism in fish bearing waters* (ver. 2.0). Massachusetts Pesticide Bureau, Department of Food and Agriculture. 40 p. http://www.mass.gov/agr/mosquito/docs/Methoprene_review_final_ver.2.0.pdf

Johnson, A. 2005. *Quality assurance project plan. Methoprene monitoring in Grant County Mosquito Control District #1*. Washington State Department of Ecology Publication No. 05-03-108. 30 p. <http://www.ecy.wa.gov/pubs/0503108.pdf>

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EXTOXNET. Pesticide Information Profile for Methoprene. 1995.
<http://pmep.cce.cornell.edu/profiles/extoxnet/haloxfop-methylparathion/methoprene-ext.html>

Material Safety Data Sheet for Altosid® Liquid Larvicide Mosquito Growth Regulator.
http://www.altosid.com/pdfs/liquid_larvicide.pdf

Chelated copper compounds

Overview

The element copper has a long history as an agricultural pesticide and more recently as an aquatic pesticide. Copper sulfate was registered in the mid-1950s for use in controlling algae and replaced the more toxic and less acceptable sodium arsenite (Gallagher and Haller, 1990). However, even before registration, people used copper sulfate to control algae in swimming pools, potable water supply, and for aquatic weed control. Since the 1950's, copper products have been some of the most widely used algaecides in the United States (CSI, 2002). Copper has broad-spectrum algaecidal activity and has low toxicity to humans, livestock, and crop plants. There are few water use restrictions after the use of copper and this makes it desirable for potable water treatment.

EPA registers aquatic uses of copper as an algaecide, aquatic herbicide, molluscicide (snails), and for macroinvertebrate management (leeches). Aquatic copper applications occur in aquaculture facilities, drainage canals, ponds, fountains, lakes, and reservoirs (EPA, 2008). EPA also registers copper for use on virtually all food/feed crops, and copper is among the few pesticides permitted for use on crops with organic certifications (EPA, 2006).

Copper sulfate is a copper salt combining the cupric ion (2^+) with the sulfate ion. The chelated copper complexes are the cupric ion (2^+) combined with one or more of several compounds such as monoethanolamine, triethanolamine, and ethylene diamine. For the chelated copper pesticides, the cupric ion may come from copper sulfate, copper oxide, or copper carbonate, but it exists in solution as the cupric ion (Cu^{2+}) with the amine chelating agents listed above (CSI, 2002). The toxicologies of the chelated copper forms are distinct from copper sulfate and each other. The use of chelated copper-complexes is preferred over copper sulfate products because copper-complexes are generally considered safer for fish. Copper herbicide labels do not permit the use of copper at concentrations higher than 1 mg/L, but at least one product allows a concentration of 2.5 mg/L Cu for the control of shrimp in rice fields.

Under its aquatic pesticide permitting programs, Ecology allowed the use of copper for the management of algae (but not aquatic plants or animals) in lakes for many years. In 2002, Ecology restricted the use of copper to irrigation canals, based on its potential to build up to toxic concentrations in sediments of regularly treated lakes. Ecology does not currently regulate pesticide use in water bodies five acres or less that are artificial and do not drain to natural waters during and for two weeks following treatment (as long as the pesticide is not biologically active

when the water returns). There are thousands of small farm ponds used for irrigation that fall into this category. It is likely that many farmers continue to use copper sulfate or other copper algaecides to manage algae in these ponds. In 2001, Ecology funded a risk assessment for copper by Compliance Services International, but did not incorporate the copper information from the risk assessment into its Aquatic Plant Management Program SEIS, because it no longer allowed copper use in lakes.

Examples of using copper for invasive species management

Ecology anticipates that uses for copper under the Aquatic Invasive Species Permit will be for the control of aquatic invasive invertebrates or marine algae. Kennedy, et al. (2006) investigated the sensitivity of various life stages of zebra mussels to copper sulfate and a chelated commercial copper pesticide called Cutrine®-Ultra. The authors assessed the toxicity to zebra mussel larvae using 24-hour-long toxicity tests. The toxicity of copper sulfate was similar for all tested early life stages (larvae) of zebra mussel. The LC₅₀ ranged from 2-5 µg/L. The toxicity of the Cutrine®-Ultra varied with the larval life-stage (the LC₅₀ ranged from 1-13 µg/L). Adult zebra mussels were much more tolerant of copper (several orders of magnitude). They closed their valves, which limited filtering activity and chemical exposure, but the authors noted that adults in general were more resistant to copper toxicity than the larval stages. They estimated that a 24-hour dose at 200 µg/L Cu or a 3-hour dose at 400 µg/L Cu would control 99% of zebra mussel larvae, while a continuous 96-hour of dosing at 2,000 µg/L Cu would be required to achieve a similar level of control for adults. EPA labels Cutrine®-Ultra for application at water concentrations of 1mg/L for algae control purposes.

The Department of Defense (DOD) used copper sulfate (target concentration of 1 mg/L Cu) to eradicate an infestation of zebra mussels in Offutt Base Lake, located at Offutt Air force Base in Nebraska, under an EPA Special Local Needs label. The manmade lake is approximately 115 acres in size with an average depth of 15 feet. The lake is a popular recreational site for military families and retirees.

Using contractors, DOD applied copper in September 2008 and again on April 2009 (URS, 2009). At the time of the URS final report, no live zebra mussels had been detected in the lake (none detected after the first copper treatment). The EPA Special Local Needs label specified no recreation in the lake until testing showed copper levels below 1.3 mg/L. According to post-treatment monitoring, the concentration in the lake did not exceed 1 mg/L at any time and residual copper concentrations in the lake water decreased slowly over 30 days.

Fish mortality occurred following both the 2008 and 2009 copper sulfate treatment and extended over a prolonged period in both events. The EPA label required DOD to pick up and bury all dead fish. Approximately 97% of the fish killed (by weight) were non-game fish and less than 0.2% were game fish (bass, catfish, walleye/saugeye, and crappie). URS concluded that although the treatment killed some game fish, a fish survey completed in May 2009 showed that a healthy and sustainable population of game fish continues to exist at the lake and non-game fish are still abundant in the lake.

Uchimura et al. (2000) investigated the use of copper (Cu²⁺), potassium (K⁺), and sodium (Na⁺) for the control of *Caulerpa taxifolia*. They found that the Cu²⁺ concentrations required to obtain

100 % mortality was orders of magnitude lower than required for K^+ or Na^+ . They also explored using ion-exchange textile covers that allowed the controlled release of cupric ions directly to the target algae without dissemination in the marine environment.

Australia used copper sulfate and sodium hypochlorite to eradicate an infestation of black striped mussel *Mytilopsis sallei* in Darwin Harbor. They discovered the invasive mussels in three marinas. Because of the great tidal range in Darwin, these marinas have lock gates they can close to sequester their waters. The Minister for Primary Industry and Fisheries quarantined (and isolated) the marina waters and any boats in the marina in March 1999. The most infested site, Cullen Bay Marina, had approximately 10,000 mussels per square meter with mussels covering almost every vessel hull, fender, rope, rock, pylon, concrete wall and similar structures (Ferguson, 2000). After initial chlorine treatment, they discovered that many mussels survived the chlorine treatment and followed up with copper sulfate. In total, they added 160 tonnes of liquid sodium hypochlorite and around 6 tonnes of copper sulfate to the three marinas over two weeks (a tonne equals 2,204.62 pounds). They removed the dead fish (over four tonnes from Cullen Bay Marina, which is a 12-acre site). The marinas opened in April after extensive testing and diver surveying declared all mussels dead.

Ecology obtained the copper environmental and human health information presented below from several sources including its Supplemental Environmental Impact Statement Assessments of Aquatic Herbicides: DRAFT Volume 6 – Copper. <http://www.ecy.wa.gov/programs/wq/pesticides/seis/copperrisk.pdf> and incorporated by reference into this FEIS.

Environmental and human health impacts

Earth

Sediments

The free cupric ion has a high sorption affinity for soil, sediments, and organic matter (EPA, 2006). However, sorption does not remove copper from the system; copper merely moves from the aqueous phase to the sediment phase where it remains in the system indefinitely (although it is likely not bioavailable). Serdar, (1995) reported sediment copper concentrations up to 258 mg/L in Lake Sylvia, Washington. As referenced in CSI (2002), Serdar also found concentrations of copper up to 1,100 mg/L in sediments from Lake Steilacoom, Washington. Both lakes had long histories of repeated copper sulfate treatments for algae management (about 25 years of treatment at rates about 2.2 pounds of copper sulfate per acre-foot of water). The Fact Sheet for Ecology's superseded Nuisance Weed and Algae NPDES Permit indicated that the agency's major reason for restricting copper use in lakes was to prevent its accumulation in lake sediments. For an interim period before completely restricting copper use in lakes in 2002, Ecology allowed copper addition to lakes only where sediment copper concentrations were less than 110 mg/L (based on the Ontario Provincial Guidelines for sediment quality for copper) and in water bodies with no salmon runs.

Specific mitigation for copper: To avoid sediment build up of copper during any use under the Aquatic Invasive Species Permit, Ecology restricts copper applications to water bodies where sediment concentrations are 110 mg/L or less, except for eradication efforts for zebra or quagga

mussels. Permittees must monitor sediment concentrations prior to treatment and seven days after treatment.

Air

Air quality

The vapor pressure of the copper-complexes is low and they are not volatile. Because their low volatility, the risk to the public from inhalation exposure to copper is minimal during its aquatic use. Applicators generally apply copper products through subsurface injection making aerial drift outside of the treatment area unlikely. There is negligible odor associated with copper treatments. There may be a small amount of exhaust emissions associated with the use of application equipment.

Plants

Terrestrial

EPA (2006) concluded that copper pesticides do not appear to pose a risk to terrestrial plants. Because of application methods, there should be minimal exposure to terrestrial plants from the aquatic application of copper compounds.

Aquatic

The use of commercial chelated copper-complexes at labeled rates is likely to have adverse effects on non-target species of algae and aquatic plants in the treatment area. Aquatic plants are more sensitive to copper than terrestrial plants (EPA, 2006) which is why copper is an effective contact herbicide for some species. Copper is also very toxic to algae. It causes increased permeability of the cell membrane and leakage of the cell contents (EPA, 2008). EPA labels copper products for algacidal and herbicidal uses and conditions their use to avoid creating areas of low oxygen when treating dense algae or aquatic plant growth. Used for invasive animal management, copper will affect algae and some sensitive aquatic macrophytes. If the Permittee needs to treat extensive areas, low oxygen conditions will likely develop as macrophytes and algae decompose.

Water

Surface water

Copper in the water column occurs as dissolved ions and as a part of inorganic and organic complexes. The toxic form of copper is the cupric ion. The amount of this ion in the environment and its toxicity to aquatic animals is dependent on a number of water quality parameters including pH, alkalinity, and dissolved organic carbon (EPA, 2006). However copper and chelated coppers typically disappear rapidly from the water column, particularly in alkaline waters. In Sylvia Lake (15 acre, soft water lake) where the applicator treated two-thirds of the surface area with 0.5 mg/L copper sulfate, the copper concentrations dropped to about 0.067 mg/L, 0.036 mg/L, and 0.012 mg/L in 1, 4, and 18 days respectively (Serdar, 1995).

CSI (2002) report that in Washington, no copper concentrations that exceeded the limit of detection were found in public water supplies. A copper concentration in water of 1.0 mg/L Cu is

believed to be safe for potable water uses, and livestock watering. Ecology's water quality criterion for aquatic organisms is 0.017 ppm (acute at 100 mg/L hardness) as dissolved copper.

Specific mitigation for copper: Permittees cannot apply copper to the water if the hardness is less than 50 mg/L expressed as calcium carbonate. Permittees must determine hardness 24 hours prior to treatment. Permittees cannot apply copper to water if the pH is less than 6.0. The only exception is for zebra and quagga mussel eradication.

Ground water

Copper is not likely to contaminate ground or surface waters through leaching or runoff since copper binds strongly to soil and sediment (EPA, 2006). There should be no impact to ground water from any aquatic invasive animal species management projects using copper.

Animals

Terrestrial

Copper is practically nontoxic to honey bees with an acute LC₅₀ of greater than 110 µg/bee (EPA, 2006). EPA does not consider copper hazardous to livestock or wildlife drinking the water if the water contains less than 1 mg/L Cu. Guidelines for copper tolerance in livestock drinking water from other counties varied from 0.5 mg/L to 5.0 mg/L (less for sheep) (CSI, 2002). Domestic animals do not metabolize elemental copper and rapidly eliminate it from muscle tissue, but it is deposited in the brain, heart, spleen, liver, kidney, and blood (CSI, 2002). EPA does not have any restrictions on potable water for humans, pets, or livestock on its crop labels.

Aquatic

Aquatic animals are more sensitive to copper than terrestrial animals. The main cause of toxicity to aquatic organisms is through rapid binding to gill membranes (EPA, 2006). The toxicity of copper depends on the amount of bioavailable cupric ion in the water. *Daphnia* are the most sensitive genera of aquatic invertebrates for which data are available and *Daphnia magna* is the most sensitive species tested. The genus *Onchorynchus* is the most sensitive fish genera (EPA, 2006).

Copper-complexes are generally much less toxic to fish than copper sulfate. For example, when tested in soft or hard water, most species of fish were not affected at typical use rates of Komeen® (a chelated copper) of 0.5 to 1.0 mg/L Cu, since the LC₅₀ for Komeen® ranged from 4.6 to 558 mg/L Cu. The acute risk quotient for copper generally does not exceed the short-term low level of concern (0.1 mg/L) in hard water. In soft water, copper may affect trout and other salmonids at low treatment rates and kill them at higher treatment rates.

Although the chelated copper complexes are less toxic than copper sulfate to fish, real safety to fish may occur only under hard water conditions and/or conditions where the sediment has a high cation exchange capacity. Scientists have demonstrated that copper has sublethal impacts to juvenile coho and sockeye salmon smolts. Salmon are not able to withstand seawater challenge tests and successfully make the transition from freshwater to saltwater after exposure to copper (CSI, 2002). There may also be other sublethal impacts to salmon (interference with olfaction).

Specific mitigation for copper: For these reasons, Ecology will restrict the use of chelated copper in the Aquatic Invasive Species Permit to non-salmon bearing waters only and to waters with hardness of 50 mg/L or more, except for zebra or quagga mussel eradication projects.

For almost any direct water application of copper, there are likely to be effects on invertebrates and a reduction of primary production. In aquatic systems where applicators apply copper frequently, the planktonic community may shift to more copper tolerant organisms (EPA, 2006). CSI (2002) indicated that not much acute toxicity data is available for chelated coppers and even less for chronic toxicity data. However Cutrine® did not appear to be toxic (LC₅₀ 10.0 to 16.4 Cu) in either soft water (15 mg/L CaCO₃) or hard water (140 mg/L CaCO₃) for freshwater *Ostracods*, *Cladocerans*, *Calanoids*, and *Cyclopids*. In general, the toxicity of commercial copper products to fish and invertebrates is expected to be as follows:

Copper sulfate >Clearigate® >K-Tea™ ~ Cutrine® ~ Captain™ > Nautique™ ~ Komeen®

Because of the toxicity of copper to aquatic biota, commercial products should not be applied to soft water (<50 mg/l CaCO₃). Due to antagonistic effects from low pH, copper products are likely to be less effective when applied to water with pH of less than 6.0. The commercial chelated complexes are unstable at a pH less than 6 (CSI, 2002).

Specific mitigation for copper: Permittees operating under the Aquatic Invasive Species Permit cannot apply copper to the water if the hardness is less than 50 mg/L expressed as calcium carbonate. Permittees must determine hardness 24 hours prior to treatment. Permittees cannot apply copper to water if the pH is less than 6.0. An exception is made for zebra and quagga mussel eradication projects where there are no other effective alternatives.

Human health

EPA does not consider the use of copper to be of human health concern to non-applicators. Copper is one of the micronutrients essential to human health. It is ubiquitous in the environment and naturally occurs in foods such as nuts, organ meats, and grains and in drinking water. EPA (2008) concluded that current available data and literature studies indicated that there is a greater risk from the deficiency of copper intake than from excess intake. When dietary copper is high, excretion of copper increases, protecting against excess accumulation of copper in the body. Therefore, EPA did not require a quantitative toxicity assessment for dietary, dermal, oral, or inhalation exposures for the RED process for copper (EPA, 2008). There is also no evidence of copper or its salts being carcinogenic, teratogenic, or posing any other systemic toxicity in animals having normal copper homeostasis. The available human health and ecological effects data do not indicate any evidence of endocrine disruption (EPA, 2006). EPA has determined that drinking water should not contain more than 1.3 mg/L copper.

Some copper pesticides may cause acute and dermal eye irritation to applicators. As a result, EPA requires appropriate personal protective equipment or precautionary labeling language to protect end users (EPA, 2006).

Water, land, and shoreline use

Typically, the use of copper does not result in any use restrictions for human activities; although in the case of Offutt Base Lake, EPA restricted water recreation until copper was 1.3 mg/L or less for a whole lake treatment. Used whole lake, copper may result in recreational restrictions.

Navigation

Typically, the use of copper does not result in any use restrictions for human activities. However, used in a whole lake treatment, it is possible that boating activities will be temporarily suspended.

Specific mitigation for chelated copper

Mitigations required under the Aquatic Invasive Species Permit include:

- Limit treatments to the lowest effective concentration or amount to kill the targeted organism.
- Sediment copper concentrations in the treatment area must be less than 110 mg/L. Emergency exception for zebra or quagga mussel treatment.
- Do not apply copper if the water hardness is less than 50 mg/L expressed as calcium carbonate (emergency exception for zebra or quagga mussel treatment).
- Do not apply copper if the pH is less than 6.0. Emergency exception for zebra or quagga mussel treatment.
- Juvenile salmon species and Endangered Species Act listed species must not be present at the time of treatment, unless the state and federal fish agencies approve the treatment.

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***Pseudomonas fluorescens* strain CLO145**

Overview

A consortium of New York State electric power generation companies collaborated in funding the New York State Museum Field Research Laboratory to screen bacteria as potential biological control agents for zebra and quagga mussels. Extensive screening of over 700 bacterial strains identified an isolate of *Pseudomonas fluorescens* that proved lethal to these mussels. Of all the strains of *Pseudomonas fluorescens* that they tested, only one strain - CL145A is lethal to zebra and quagga mussels. This strain was isolated from soil obtained from a riverbank in New York. *Pseudomonas fluorescens* encompasses a group of common, nonpathogenic saprophytes that colonize soil, water, and plant surfaces. It has a worldwide distribution and is present in all North American water bodies. It does not normally cause human illness in healthy people.

Some strains of *Pseudomonas fluorescens* have biocontrol properties such as protecting the roots of some plant species against parasitic fungi and nematodes. There is one EPA-registered *Pseudomonas fluorescens* biopesticide product called Frostban B that farmers use to reduce the growth of frost growing bacteria when applied to leaves and blossoms of almonds, apples, peaches, pears, tomatoes, cherries, potatoes, and strawberry plantings, and in helping suppress fire blight and discoloration on pear and apple crops (EPA, 2009). This is a different strain than CL145A, but the same bacteria species.

According to the research laboratory, when a zebra or quagga mussel ingests high densities of CL145A, a toxin within these bacterial cells destroys the mussel's digestive system. Dead bacteria cells are equally lethal as live cells to zebra and quagga mussels. Scientists have interpreted this to mean that the mussels die from a toxin produced by the bacteria and not from bacterial infection. Researchers are undertaking efforts to purify, characterize, and identify the compounds produced by this bacterial strain. They found more than 18 compounds in two

different chemical classes that work together to cause activity. They concluded that this chemical complexity makes it unlikely that mussels will develop resistance to the product's chemistry.

The laboratory developed techniques to kill the bacteria without any reduction in their lethality to the mussels. Using killed bacteria will reduce public concerns about introducing bacteria to water bodies. Because no live bacteria are involved, *Pseudomonas fluorescens* CL145A is a biopesticide rather than a biological control method for zebra and quagga mussels.

New York patented *Pseudomonas fluorescens* CL145A and the director of the State Museum Field Research Laboratory expects mass production of a commercial product to begin in 2010. In 2007, the Museum entered into a commercial partnership with Marrone Bio Innovations (MBI) to bring CL145A (trade named Zequanox™) to market. According to its website, the California based MBI, discovers, develops, and markets effective and environmentally responsible natural products for weed, pest, and plant disease management. The Museum, MBI, and the U.S. Bureau of Reclamation are conducting field studies in cooperation with regulatory agencies in Arizona and Nevada under Arizona experimental use permits for closed system testing. Similar tests, including a complete hydroelectric facility treatment, are being conducted in Ontario, Canada in partnership with Ontario Power Generation. Health Canada's Pest Management Regulatory Agency and the Ontario Ministry of Environment are overseeing the Canadian trials, which allow open water discharge for treated water. Native mussel habitat restoration studies, which would be conducted in partnership with Ontario Ministry of Natural Resources, are also being considered for 2010.

Laboratory and facility trials conducted by New York State Museum Field Research Laboratory and MBI demonstrated that six-hour treatments at 25-100 ppm (dry bacterial mass per unit volume) gave the highest mussel mortality. Mortality appeared related to water temperature (more mortality at higher temperatures), water hardness (higher mortality in harder water), dissolved oxygen (low levels inhibit feeding activity), turbidity (less mortality at higher turbidity), and active siphoning behavior (more ingestion of the bacteria with actively siphoning mussels). All mussel sizes tested (length 1-25mm) appear to be equally susceptible to kill by CL145A. Trials against zebra and quagga veligers show that this stage is even more susceptible to bacterial treatment than the attached mussel stages and that both species are susceptible.

MBI submitted a full Section 3 registration package to the Biopesticide Division at EPA in December 2008, with an anticipated spring or summer 2010 registration. In June 2009, under permits from the Ontario Ministry of the Environment and Health Canada's Pest Management Regulatory Agency, trials of Zequanox™ were conducted at Ontario's DeCew 2 Generating Station. In November 2009, the Bureau of Reclamation applied to EPA for an Emergency Exemption for *Pseudomonas fluorescens* CL145A. The Bureau wants to treat dams, water distribution (e.g., canals, pipes, and plumbing), water treatment, water pumping facilities, irrigation and power generation facilities infested with invasive quagga and zebra mussel and associated reservoirs, water holding marinas and watercraft, recreational facilities (e.g., beaches, boat launches), fish hatcheries and fish protection facilities (e.g., fish ladders and screens). EPA recently informed MBI that they will approve the Section 18 label for infrastructure treatments along the lower Colorado. MBI anticipates that a label and monitoring plan should be available in January 2010.

Ecology anticipates that Permittees will use *Pseudomonas fluorescens* CL145A under the Aquatic Invasive Species Permit for the management of zebra and quagga mussels should they be detected in Washington waters. There is little peer-reviewed published information available about *Pseudomonas fluorescens* CL145A, so Ecology obtained most of the information about this emerging control technology from web documents produced by the Museum and MBI.

Environmental and human health impacts

Earth

Sediments

Pseudomonas fluorescens, a nonpathogenic saprophyte, is already present in soil, plants, and water. They are environmentally versatile bacteria that possess the ability to degrade multiple pollutants and are studied for their use as bioremediants (http://www.ncbi.nlm.nih.gov/sites/entrez?db=genomeprj&cmd=Retrieve&dopt=Overview&list_uids=12300). There should be no impact to soil or sediments from the use of CL145A.

Air

Air quality

MBI describes the commercial product as a milky liquid the color of lemonade, although they have both a liquid and spray-dried powder formulations under development. In documents requesting Emergency Exemption from EPA, the Bureau of Reclamation indicates that they plan to apply CL145A using standard aquatic pesticide application equipment, such as sprayers, mixers, injection pumps, and/or weighted hoses. Application of this product is unlikely to result in adverse impacts to air quality, except from exhaust from application equipment.

Plants

The genus *Pseudomonas* is a prolific colonizer of plant surfaces and represents a significant component of normal plant microflora (Pitts). It is unlikely that this biocide would have any impact on terrestrial or aquatic plants. Its target is zebra and quagga mussels.

Water

Surface water

EPA did not identify *Pseudomonas fluorescens* as a cause of impairment of any water bodies listed under section 303(d) of the Clean Water Act nor did they receive any comments, data, or information regarding any water quality issues related to *Pseudomonas fluorescens* in general (EPA, 2009). During the 2009 trial at the DeCew II facility, MBI measured naturally occurring *Pseudomonas* loads in the creek below the hydro plant prior to the application of Zequanox. Once the treated pipes discharged, the dilution was such that the *Pseudomonas* load in the creek was unchanged (Personal communication, Keith Pitts, MBI). It is unlikely that application of CL145A would result in any impairment to surface water. It would be rapidly cleared from the water through the filtering action of zebra or quagga mussels or other non-target organisms that filter water.

Ground water

Documents submitted to EPA in support of the registration package indicated that it would be unlikely for *Pseudomonas fluorescens* CL145A to enter the ground water through applications to surface water to control zebra and quagga mussels.

Animals

Terrestrial

See the human health section. The Frostban A (*Pseudomonas fluorescens*) product was found to be practically non-toxic to honey bees on contact (EPA, 2009). MBI contracted for a study of Zequanox™ against the mallard duck and reported that the biopesticide is nontoxic to mallards (http://marronebioinnovations.com/pdf/zequanox_bg2.pdf). *Pseudomonas fluorescens* CL145A, applied to zebra or quagga mussel infested waters, is unlikely to have any impact to terrestrial animals, including any oral or dermal ingestion by wildlife or pets. The bacterial cells are not live.

Aquatic

Malloy and Mayer (2007) report that at bacterial dosages that produced high zebra mussel mortality (76-100%), they did not see any bacteria-induced mortality among the tested non-target aquatic organisms. However, they did not report actual data, just a summary of their findings. They tested fathead minnow (*Pimephales promelas*), young-of-the-year brown trout (*Salmo trutta*), and juvenile bluegill (*Lepomis macrochirus*). Fish did not tolerate exposure to high levels of live bacteria. Dead cells were harmless to the fish, but still lethal to *Dreissena*. Commercial products will contain dead cells. In trials with the freshwater ciliate *Colpidium colpoda* the authors found that the bacteria served as a food source. There was no mortality to *Daphnia magna*, the freshwater shrimp *Hyaella azteca*, or to blue mussels (*Mytilus edulis*) or any of six native unionid clam species from *Pseudomonas fluorescens* CL145A.

Human health

Several toxicity studies were completed in support of the EPA registration process for *Pseudomonas fluorescens* CL145A. These included acute oral rat (>5,000 mg/kg live bacteria); acute dermal rate (>5050 mg/kg live bacteria). The toxicity rating for the acute IV test was mild to moderate toxicity. Intravenous toxicity-pathogenicity testing on rats indicated that the bacteria were non-pathogenic to mammals. The acute inhalation toxicity rating for rat was not toxic. The acute eye irritation for rabbit was minimal irritant and the acute dermal for rabbit was slight irritant (Pitts). Pitts concluded that these results indicate no risk to human health or the environment from *Pseudomonas fluorescens* in general or specifically the strain CL145A. EPA required testing on live bacteria because humans may be exposed to the live bacteria during the manufacturing process. *Pseudomonas fluorescens* does not produce recognized toxins, enzymes, or virulence factors associated with mammalian invasiveness or toxicity. EPA has no knowledge of *Pseudomonas fluorescens* as an endocrine disruptor nor is it related to any class of known endocrine disruptors (EPA, 2009). There are no reports of hypersensitivity reported from personnel working with this organism (Pitts).

Water, land, and shoreline use

MBI originally proposed Zequanox™ for the management of zebra and quagga mussels in enclosed systems. Due to the recent invasion of western waters by these species, there is interest in using Zequanox™ in open waters. The low toxicity to non-target organisms may allow for its use in lakes and rivers. Because this is a dead bacteria and toxicity testing shows very low toxicity to mammals and non-target organisms, MBI considers it unlikely that EPA will impose drinking or recreational restrictions when the product is registered.

Navigation

The project proponent may choose to cordon off the area during the application of the product and this may result in a temporary impact to navigation, but this is unlikely to occur.

Specific mitigation for *Pseudomonas fluorescens* CL145A

Permittees will use according to the EPA label.

References for *Pseudomonas fluorescens* CL145A

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Responsiveness Summary

Non-Project Environmental Impact Statement Aquatic Invasive Species Control April 2011

Introduction

The Washington State Department of Ecology (Ecology) issued the draft Environmental Impact Statement (DEIS), in part, to satisfy the State Environmental Policy Act (SEPA) requirements for its action in developing and issuing a National Pollutant Discharge Elimination System (NPDES) Permit to allow the chemical treatment of nonnative invasive freshwater and marine animals and nonnative invasive marine algae. The Aquatic Invasive Species Management NPDES permit (permit) and the DEIS were concurrently developed with information from the DEIS used to develop mitigation measures in the permit.

The DEIS document analyzes reasonable alternatives for aquatic invasive species management, the probable significant adverse and beneficial environmental impacts of these alternatives, and their relation to existing policies, rules, and regulations. This DEIS analyses five possible alternatives.

1. The use of an integrated pest management approach that incorporates adaptive management principles (the recommended alternative).
2. The “no action” alternative – continuing current practices.
3. The use of physical removal/mechanical methods only.
4. The use of biological methods only.
5. The use of chemical methods only (the proposed action).

The DEIS discusses the principle features and mitigation measures for each alternative. The recommended alternative is the use of an integrated pest management approach that incorporates adaptive management principles.

Ecology encouraged the public to comment on the DEIS and the draft permit. A comment period was open from April 21, 2010 until June 11, 2010. Ecology held a workshop and public hearing in Lacey Washington on June 7, 2010. Most comments pertained to the permit language, however, there were four communications that specifically included comments about the DEIS. A numbered list of persons submitting comments is referenced at the end of this section. Comment originators are referenced by this list number. Responses to the comments follow each comment. There were no changes to the DEIS based on these comments.

Comments and Responses

Comment: *It is my opinion that this draft permit and the DEIS on which to some extent it is based, is a permit for unleashing more poisons into marine waters, for too long a period of time, without an adequate understanding of what the impact will be to the target species, to non-targeted species, to marine life in general and to public health. And there appears to be inadequate administrative oversight during the life of the permit. (#1)*

Response: Comment noted. Ecology wrote this DEIS to research and develop an understanding of the proposed chemicals and other management methods and their impacts to the target species, non-targeted species, and to public health.

Comment: *Neither the EIS nor the NPDES drafts address the very serious problem of assuring that rigorous science governs all aspects of deciding whether a so called non-native invasive species is actually detrimental in the long run to the ecosystem in which it has arrived, understanding the underlying reasons for its arrival as well. Citing lack of funding -- to assure that decisions are made on reliable scientific information, and preventing the revisiting of decisions because of new information which becomes available -- is irresponsible. (#1)*

Response: Ecology relies on state and federal listing processes outside of its regulatory authority to determine which organisms are nonnative and invasive and pose a threat to Washington waters. The DEIS specifically recommends that project proponents follow an integrated approach using adaptive management principles. It also recommends that the project proponent prepare a project EIS to cover specific on-going activities.

Comment: *I find the determination that certain species are non-native, invasive, and harmful and need to be eradicated has been approached subjectively, not with the scientific rigor that would result in an objective discussion and decision. In general, the impacts of the species that are the subject of the permit are totally speculative, based on a presumption that they will be harmful to the ecosystem, and that removing them will be beneficial (#1).*

Response: Listing processes to determine invasive species detrimental to Washington State are outside of the scope of this DEIS and Ecology's regulatory authority. Ecology disagrees with the commenter that the impacts of aquatic nonnative invasive species are speculative. In the DEIS Ecology provides examples of invasive species and the effects that their invasion has had on the environment and the economy. The impacts of the zebra mussel, for example, are well documented, although Ecology agrees with the commenter that not all species have as much documentation of impacts as the zebra mussel does.

Comment: *And don't you think sound science would demand an evaluation as to how these eradications relate to concerns about global warming, coastal erosion from sea level rises, ocean acidification, oxygen deprived waters et al. or are our WA. State agencies among the deniers of climate change challenges.*

I have witnessed a shameful lack of scientific rigor and subjectivity in a very personal way. In regard to spartina, for instance there was never any discussion about how the removal of

spartina would impact shoreline erosion, and never an objective scientific study of what the grass's actual role in the ecosystem meant and responsible management alternatives were dismissed. The popular mantra was that East and Gulf coast science re spartina was irrelevant. And although one of the prominent oyster growers maintained at public meetings that the grass was never a concern of the oyster growers—it was the birds---you find that that myth has been perpetuated, by government agencies and the oyster grower himself. I never realized before living on Willapa Bay that science could be so corrupted.

Re objective decision making re Invasive Species: A colleague of mine, Boyce Thornmiller, a marine biologist, graduate of the U of WA. pointed out a few years ago that there is no national scientific guidance for rapidly and effectively assessing the threat posed by an introduced species—and determining the preferred environmentally responsible management alternative. For example in Humboldt County where USFWS is funding mechanical removal of spartina, before removal occurs local scientists have insisted that the impact of removal on the food chain needs to be studied prior to removal. Good science. But that consideration never occurred in WA. State or in other parts of California because the eradication effort was politically driven.

My experience with spartina and seeing how the weed boards, county and state and the invasive species regulators act, is that decisions are rarely based on sound science but on speculation fueled by an interest in eradication with the use of chemicals. I see nothing in the DEIS or the Draft Permit to insulate science from the kind of politics that has driven it in the past. (#1)

Response: Comment noted.

Comment: *There is a growing body of science that is challenging what has become a faddish discussion re invasive species and the resulting determination to eradicate them. There is a real need for taking a new look at invasive species, focusing on keeping them out of the ecosystem, and not giving short shrift to the no action alternative. (#1)*

Response: Government scientists and regulators agree that preventing an invasion from occurring is the best strategy. Washington's Department of Fish and Wildlife (WDFW) and other Washington agencies invest many resources to preventing the introduction of new aquatic invasive species. However, in spite of best prevention efforts, invasive species are introduced.

Comment: *DOE requires risk assessments be done only on the active ingredient. Although this may be consistent with EPA requirements, the State can raise the standard, and there is no justification not to do so and there are plenty of reasons to raise the standard. It is well known that the active ingredient is only a part of the commercial product used, and frequently surfactants are added to make that product effective. Surfactants require no EPA approval. By U.S. law, only active ingredients (AIs) are reported.*

In addition to active ingredients, pesticide products may contain one or more "inert" ingredients. Many "inert" ingredients in current use have known adverse human and environmental effects. Frequently as in the case of glyphosate, one chemical product is mixed with another chemical product as in the case of Aquaneat and Polaris. Currently risk assessments do not

require testing the combination of either the active ingredients much less the commercial products with the surfactants. Imazapyr for instance is 27% AI, (73% unknown) and glyphosate 53%AI (47% unknown).

Since ultimately we taxpayers pay for these assessments, unless they are done correctly, what is the point—it's just a waste of our money. More importantly, it gives a sense of false security to what the actual impact both short term and long term will be. The commercial product, with the surfactant and the intended mixture is what needs to be tested. Its common sense. -Not having adequate budget to do appropriate testing is an inappropriate, unacceptable excuse.

Related to concerns re the structural inadequacy of the risk assessment process is the failure to adequately understand the impact of biocides that are used in non-terrestrial situations, in this case the marine environment. It is not denied that chemicals will act differently in fresh water than they would in marine water. For instance the NPDES permit that governs the spraying of spartina throughout the state--has permitted Imazapyr, which EPA now says should be prohibited in marine and estuarine situations.

This chemical was permitted in 2003, even though it was very clear that there had been no marine toxicity tests. And of course Kim Patton, of WSU and Miranda Wecker, Commissioner of DFW, aggressive promoters of chemical eradication had to be aware of that. And Brett Dumbauld, now of USDA at Newport, advised Entrix, author of the Patton inspired risk assessment (2003) not to test imazapyr on crabs because there was virtually no crab industry in Willapa Bay. Glyphosate --which is also permitted and is being associated with reducing the immunity of oysters to vibrio, as well as other serious human issues--was never tested on plankton something that certainly should have preceded its permitted use. AND THIS IS NOT JUST ABOUT WILLAPA BAY, THESE CHEMICALS ARE SPRAYED ALL OVER PUGET SOUND, ALL OVER WASHINGTON STATE.

In conclusion, neither the EIS or the NPDES drafts seem to address the very serious limitations of science in deciding whether a so called non-native invasive species is actually detrimental in the long run to the ecosystem in which it has arrived, Understanding the underlying reasons for its arrival as well. And risk assessments of biocides to be used, have to be looked at realistically, and to even approach that, what's being used must be the subject of the assessment. THE BOTTOM LINE IS THAT THE CURE SHOULD NOT BE WORSE THAN THE DISEASE, AND PERHAPS INVASIVE SPECIES DESERVE A PRESUMPTION OF NOT BEING WORTH THE RISK OF WHAT IT TAKES TO ERADICATE THEM.(#1)

Response: The new Aquatic Invasive Species Management Permit will regulate chemical treatments performed by state agencies to manage the invasion of invasive, nonnative aquatic species. Some of these organisms have the potential to cause hundreds of millions of dollars in economic damage to infrastructure and untold damage to altered ecosystems and natural areas through a successful invasion of Washington waters. There are few effective non-chemical controls for many aquatic species and even rigorous prevention activities often fail. Ecology and its sister agencies continually wrestle with the impacts of not taking action versus allowing some mitigated chemical use or other management activity to occur. Ecology does not take its role as a regulatory agency overseeing chemical application to waters lightly. Ecology agrees that it is important to ensure that

using chemicals does not cause more damage to the environment than taking no action and thereby allowing the establishment of a nonnative species. Writing and researching the information in the DEIS, along with advice from an external advisory committee, helped Ecology select appropriate chemicals and mitigations for each chemical.

The Environmental Protection Agency (EPA) regulates the sale, distribution, and use of pesticides in the U.S. under the statutory framework of the *Federal Insecticide, Fungicide, and Rodenticide Act* of 1979, to ensure that when used in conformance with the label, pesticides will not pose unreasonable risks to human health and the environment. All new pesticides must undergo a registration procedure under FIFRA during which the EPA assesses a variety of potential human health and environmental effects associated with use of the product. Under FIFRA, the EPA is required to consider the effects of pesticides on the environment by determining, among other things, whether a pesticide "will perform its intended function without unreasonable adverse effects on the environment," and "whether when used in accordance with widespread and commonly recognized practice [the pesticide] will not generally cause unreasonable adverse effects on the environment." 7 U.S.C. 136a(c)(5). The EPA also considers data from field tests where the commercial product is used as do Ecology's risk assessments when these data are available. The commercial product includes the active ingredient along with inert ingredients.

Chemical companies consider inert ingredients to be proprietary information and they do not generally release that information to the public (although the EPA and the Washington Department of Agriculture (WSDA) know what these ingredients are). EPA is currently considering making inert ingredients public. Ecology agrees with the commenter and supports this effort by the EPA.

Applicators do not use surfactants for animal control efforts. They use surfactants to treat emergent vascular plants. This permit does not cover vascular plant chemical treatment. However, to address your concern, WSDA requires aquatic toxicity testing of any surfactants allowed for use in aquatic situations and only approves surfactants that meet certain criteria. In its aquatic plant management permits, Ecology limits all adjuvants to those that meet WSDA criteria for aquatic application.

Note: EPA has reregistered imazapyr for marine and estuarine use. However, imazapyr is not one of the chemicals allowed for use under this permit because it only targets vascular plants.

Comment: *I am greatly concerned about the Draft EIS and what information is available to base a safe decision on. Comments such as "limited in part by lack of information"; "Ecology has not been able to conduct timely environmental review of new commercially available herbicide active ingredients"; and "Ecology has tentatively decided to issue this DEIS and the Aquatic Invasive Species Permit without having independently conducted state risk assessments for some of the chemicals or products listed for use" are deeply troubling. Puget Sound is a critical body of water to many species and enjoyed by the general public. If Ecology cannot*

provide the scientific proof of the efficacy or safety of a chemical/pesticide it should consider requiring peer-reviewed studies before putting it at risk. (#2)

Comment: *“This DEIS will be limited in part by lack of information on methods and their impacts, because there is simply little information available.” This statement puts in question how the DEIS allows for treatment but also protects the ecological functions of the areas treated. Allowing application of chemicals without adequate assurance should not be allowed. “Ecology weighed temporary toxicity associated with chemical use versus the long-term impacts of invasive species. In many cases, short-term environmental damage from chemical use is less damaging than the long-term ongoing impacts of invasive species.” “Other chemicals and products are new to the aquatic permitting program and may not have aquatic labels.” How can these statements support the use of chemicals/pesticides? There has to be strong evidence showing minimal “collateral” damage to support the application of chemicals and pesticides into Puget Sound. (#3)*

Response: Ecology limits its permit to state agencies only. State agencies do not undertake these projects without carefully considering all options and alternatives. The project proponent (state agency) will need to weigh up the impacts of the invasive species on the ecological functions of the area versus the impacts of a chemical treatment on the ecological functions. If the risks of chemical treatment result in more impacts to the environment than the impacts of an established invasive species, then the project proponent should not use chemicals or perhaps any control method at all. Ecology includes mitigation for each chemical in its Aquatic Invasive Species Management Permit to minimize environmental impacts.

Any chemical legally applied to the aquatic environment, although not currently labeled for that use now, will have an Environmental Protection Agency (EPA) label when applied under this permit. It is the responsibility of the project proponent to work with the EPA and the Washington Department of Agriculture to acquire a label before applying any chemical to an aquatic environment.

Comment: *“RCW 90.48.445 requires Ecology to maintain the currency of the information on herbicides and evaluate new herbicides as they become commercially available for use in Ecology’s Aquatic Plant Management Program. Since 2002, because of lack of staff and funding, Ecology has not been able to conduct timely environmental review of new commercially available herbicide active ingredients. RCW 90.48.445 is silent on requiring rigorous evaluation by Ecology for other aquatic pesticides.” This must change if Ecology is to use this EIS to support chemical applications.*

“Due to the urgent need for a permit for aquatic invasive species management and lack of state resources to develop independent state risk assessments, Ecology has tentatively decided to issue this DEIS and the Aquatic Invasive Species Permit without having independently conducted state risk assessments for some of the chemicals or products listed for use.” Same as above. It seems challenging to justify the use of chemicals and pesticides with the above statements. Ecology has a responsibility to ensure that actions taken under general permits issued will have minimal “collateral damage” to native species and their ecological functions in whatever ecosystem it is being used in. Specific to Puget Sound, currents and winds carry anything applied

- correctly or not - to areas far away from the intended area of application potentially having an effect on native species. To not know what will be impacted because of a “lack of information” due to a “lack of staff and funding” or a “lack of state resources” cannot be accepted. There has to be clear and compelling evidence these chemicals were chosen due to their safety and effectiveness in addressing the problem.

While there is no question non-native invasive aquatic species are a risk, making a decision without an adequate understanding of what the long-term consequences of the action proposed is a far higher risk. Until there is compelling evidence showing the use of pesticides and chemicals in the waters of Puget Sound is effective and at the same time have minimum impact to the native species this should not move forward.

Thank you for considering these thoughts as the Department of Ecology considers how to deal with a very real problem in an effective manner. (#3)

Response: Ecology is being upfront with the problems faced with lack of resources for independent state risk assessments. Even in good economic times, it is difficult for agencies to acquire funding or staff for these activities. Right now, all state agencies are required to make more and more cutbacks to achieve a balanced budget. There is also a very real and imminent threat of invasion from organisms like the zebra mussel that have the potential to cause hundreds of millions of dollars in economic damage to the state. The permit proactively prepares Washington to react immediately should state agencies detect these species. Ecology does not want a lack of resources to limit the state’s ability to control these organisms when action becomes imperative. Therefore, Ecology believes that it is better to have a permit available for these activities, even in the absence of independent state risk assessments for each chemicals allowed for in the permit.

Even though Ecology was not able to conduct independent risk assessments of every chemical does not mean that the agency did not consider and evaluate potential impacts and toxicity of these chemicals before allowing for their use. Ecology conducted literature searches and consulted with environmental and human health toxicologists. Because of the consultation, Ecology modified the list of chemicals initially proposed because of toxicity issues raised by these scientists. Toxicologists and scientists indicate that the current chemical list is acceptable with appropriate mitigation practices.

Comment: *My Main Concern: Toxic Chemical Exposure to Environment & Humans when more Enviro-friendly ways can be adopted.*

1. *not proposed*
2. *not proposed*
3. *not proposed*
4. *not proposed*
5. **The use of chemical methods only (the proposed action)**

*I disagree with the proposed action, and believe you should use other means than chemicals!!!
(#4)*

Response: The proposed action by Ecology that triggered the need for an EIS was the development of an Aquatic Invasive Species Management general permit. Ecology determined that invasive aquatic species management by chemical treatment may have significant adverse environmental impacts, and that an EIS was necessary. Under SEPA rules, the proposed action is the use of chemical methods allowed in the permit. The DEIS document analyzes reasonable alternatives for aquatic invasive species management, the probable significant adverse and beneficial environmental impacts of these alternatives, and their relation to existing policies, rules, and regulations.

This DEIS analyses five possible alternatives. Alternatives 1-4 are not proposed because these alternatives are not regulated by Ecology and are not the subject of the permit (the trigger for the DEIS). The proposed alternative (use of chemical methods only) is not Ecology's **preferred** alternative. Ecology's preferred and recommended alternative is Alternative #1 - the use of an integrated pest management approach that incorporates adaptive management principles. The recommended alternative uses the most effective and environmentally protective mix of management methods and includes adaptive management elements.

Comment: *The DEIS on Pg. 12 will be limited in part by the lack of information on methods and their impacts because there is simply little information available.*

Why not get the information and then make a decision? (#4)

Response: Acquiring this information for every possible invasive species and chemical method would cost many millions of dollars, potentially for each species and each chemical. It would require extensive laboratory and field research trials and studies and it is simply not something that a state agency can afford. Instead, we have made use of existing information and studies already available. In addition, many of chemicals proposed for use are naturally occurring chemicals in the environment such as salts.

Comment: *Potential adverse human health impacts particularly for chemical control methods. My daughter was exposed at age 13 to the herbicide Endothall (Copper Sulfate & Hydrothol 191) in May/June 1992 at Gravelly Lake, Washington after the application. She became very ill after swimming, with nausea, vomiting, headache, fever, and severe G.I. Inflammation. Her menstrual period stopped for 3 months. She was seen by a family doctor in June, and again in July, for continued fever, coughing brown sputum, resistive bronchitis. Many antibiotics were tried: Ceclor, Augmentin, erythromycin. On July 27th, she had pneumonia and persistent vomiting. The Poison Center was contacted and the Dept. of Health for Toxic Substances*

responded, with a list of symptoms to exposure to endothal, which were quite similar to those of my daughters.

Reference to http://www.a1articles.com/print_1237197_23.html

Reference to <http://www.examiner.com/x-18534-Hartford-Health-and-Science--Examine...> pg.

Breast and genetic Changes Environmental Toxins: breast cancer studies show that more than 80,000 synthetic chemicals are used in the US and many remain in the environment for years accumulating in the body fat and breast tissue. Compounds that disrupt the hormone production process in endocrine organs and tissues have been shown to affect the risk for breast cancer in humans. Copper is also mentioned and a high serum copper was in her blood also in 1997 with a hair sample, which causes the brain to rapid fire.

*My daughter was diagnosed with Inflammatory Breast Cancer (Stage 3) on July 1, 2009, and was genetically tested for the BRCA1/BRCA2 genes, and tested **negative**, which means it's not genetic. She is 30 yrs old. She has undergone extensive chemotherapy, had a single mastectomy performed on her right breast and lymph nodes removed. She has had extensive radiation to the chest and it has progressed to Stage 4, and gone to her brain. She has had total brain radiation for 3 weeks to stop the brain edema. We are waiting now for the results of a PET scan of the total body, which should be in Friday.*

If not successful in decreasing brain METS the Gamma-knife surgery will be considered.

PLEASE NO MORE "UNTESTED ON HUMANS" chemicals in our environment!

SHORT TERM use of toxic chemicals in our environment might be the most economical --- but LONG TERM health risks and costs are NOT factored into the equation when using these chemicals, and the cost is OBSCENE and emotionally heartbreaking.(#4)

Response: We are very sorry to hear about the health problems that your daughter is facing. Ecology considered the effects of each chemical on human health when evaluating each chemical in the DEIS. It also consulted with toxicologists about the chemicals allowed in the permit. Ecology believes that they can be used safely around humans so long as the project proponent follows permit and label conditions.

List of persons providing comments

1. Fritzi Cohen – Interested party.
2. Jules Michael – Interested party
3. Laura Hendricks – Cascade Chapter of the Sierra Club
4. Sandra DeFazio – Interested party