A Comparative Policy Analysis on Washington and Oregon Management Policies for Zebra Mussel Infestations within the Columbia River Basin.

By
Jesse Joseph Rutherford Cantin

A Thesis
submitted in partial fulfillment
of the requirements for the degree
Master of Environmental Study
The Evergreen State College
June 2009

This Thesis for the Master of Environmental Study Degree

by

Jesse Joseph Rutherford Cantin

has been approved for

The Evergreen State College

by

Martha Henderson
Member of the Faculty

Date

ABSTRACT

A Comparative Policy Analysis on Washington and Oregon Management Policies for Zebra Mussel Infestations within the Columbia River Basin.

Jesse Joseph Rutherford Cantin

Invasive species are costing the world billions of dollars economically, environmentally, and ecologically. Whether they are outcompeting natives, disrupting food chains, or killing humans, successful management encompassing all invasive species must occur. Which management approaches are effective? The Columbia River flows through several jurisdictional and political boundaries. How do two states manage invasive species within the Columbia River Basin? This comparative policy analysis uses the management of the zebra mussel (*Dreissena polymorpha*) within the states of Oregon and Washington as a case study to answer this question. Both Oregon and Washington have strengths and weaknesses over the neighboring state's management, however, currently both states are not effectively collaborating with one another. Increased coordination between Oregon and Washington must take place if the Columbia River Basin is to be kept clear of the zebra mussel. Invasive species are not bound by political and geographic boundaries; therefore successful management can only occur if there is coordination across state and national boundaries.

Table of Contents

List of Photos, Tables, and Figures

Acknowledgments

I would like to thank all people who have helped and inspired me during my thesis.

First and foremost I want to offer my sincerest gratitude towards my faculty reader, Martha Henderson. Her feedback, support and encouragement made this thesis happen. To other Master of Environmental Studies (MES) faculty, Ted Whitesell, Paul Butler, and Peter Dorman – thank you for your help in the refinement of my thesis. All four of you directed me down a feasible path.

All my MES classmates have helped this journey become a great event. Thank you for being there and providing support of all kinds. As much as I'm going to miss our Thursday adventures, I will always love you all and look forward to everyone's futures!

To my good friends outside of the program, I can't express what you have meant to me. You have kept me from going completely insane and have all contributed something vital. Annie (Gangster!), thanks for keeping me down to Earth, your conversations have always meant the most to me. Alex (Peterson!), although I don't see you as much as I would like, I can always count on you for a laugh. Rebecca (Maddog!), your intelligence and kindness helped me pull through some of the most trying times of this project. Thank you for always being there and never losing faith in me.

My deepest gratitude goes to my mother. Her everlasting love to me has been the greatest thing I've ever received. I would not be the man I am today without her endless praise and encouragement. She has inspired me more than any other individual will ever achieve and I love her for this. Never have I had to wonder whether she was there to provide support if I encountered difficulties. Her wisdom and knowledge helped motivate me to achieve a Masters degree at a young age. I appreciate everything she has ever done and sacrificed for me. I love you, mom.

Introduction

Invasive species cost ecosystems, economics, and social environments billions of dollars each year. Entire ecosystems and native life forms are susceptible to invasive species intrusions. Invasive plants, pathogens and parasites are causing crop yields to plummet and livestock to sicken. Invasive species disrupt many natural habitats, threatening ecosystems as they choke out native species. Invasives cause serious ecological disturbances, placing extreme pressure on native plants and animals. For example, the non-native brown tree snake has nearly decimated the avian population of Guam, reducing the total number of species from twelve to two, each with a remaining population of less than 200. Kudzu, an invasive vine, has taken over natural areas in Southeastern United States, growing out of control in the hot, humid summers, frequent rainfall, and temperate winters. West Nile disease, an invasive pathogen, has claimed over 1000 human lives in the United States alone. The zebra mussel, an aquatic invasive, has established itself throughout the freshwaters of the American Midwest, impacting the region ecologically, biologically, and economically. Rich, diverse communities of native life are becoming barren, desolate areas, comprised of exotics that are of no benefit to the local wildlife. Ultimately, invasive species alter habitats, reduce biodiversity, and cause costly management requirements. As globalization, travel, and climate change continue to rise, invasive damages will only be exacerbated.

As the fourth largest watershed in North America, the Columbia River Basin flows through several states and two countries. The size of the Basin causes the water

to flow through several jurisdictional and political boundaries. Due to its size and spread across state and national boundaries, the Columbia River Basin has several managers. The river is the boundary for the two states, Oregon and Washington (United States Geographic Names, 1980).

How do all the varying jurisdictions manage invasive species within the Columbia River Basin? To answer this question, this paper examines Washington and Oregon state management of one specific invasive, the zebra mussel within the State boundaries. The primary goal of the analysis is to locate policy, differences between state laws and regulations, research and management funding levels, and gaps in scientific funding. The comparison also addresses different/similar management designs and their implications. How effective is the current management of the Columbia River Basin with regard to invasive species? Who is benefitting? What are the costs associated with the existent policy? Finally, are there cheaper, more cost-effective methods available for the management of invasive species within the Columbia River Basin? This paper offers recommendations and conclusions following a comparative analysis of both management levels.

The Columbia River Basin

The Columbia River Basin is a crucial resource for the Pacific Northwest. The Basin includes hydrological, cultural, economical, biological, ecological, recreational, and historical resources. A half million acres of dry yet fertile land in Washington are irrigated with Columbia River waters. Crops such as potatoes, beans, and orchard fruit are a small percentage of the total agriculture production of the Basin. The river system has hundreds of dams, providing hydroelectricity, flood control, navigation, stream flow regulation, and the storage and delivery of stored waters. Ecologically, it is vital as the American portion of the Columbia River and its tributaries are home to myriad anadromous fish such as the various salmon species that have been essential to the stream's ecology. Culturally, the salmon have been a central aspect to the Native Americans, providing them with food and sustenance for several thousand years (National Research Council, 2004).

Over time, the ability of the Basin to maintain its physical and social capabilities has changed. The Columbia River has been so greatly altered, that it is almost unrecognizable. Life forms in the river are beginning to die. Biodiversity is now drastically reduced and only a few select species will survive if critical issues are not immediately addressed. Similar to the Basin's salmon population, most life forms of the Columbia River will soon face extinction. Human modification of the landscape has altered the Columbia River Basin so extensively, that habit has become degraded or damaged, further weakening its susceptibility towards an invasive species

establishment. As global climate patterns shift, the distribution of species is bound to change. The Columbia River will become increasingly susceptible to non-natives and current natives will find themselves unsuitable to the new landscape. If these acts continue, our crucial resource will end up a desolate, empty river system, void of biodiversity (Independent Scientific Advisory Board, 2007).

Zebra Mussel (*Dreissena polymorpha*)

The destruction of the zebra mussel has attracted a great deal of attention in the recent decades. Originally from the Caspian Sea within Russia, it was introduced to the Great Lakes' region during the mid '80s through an exchange of ballast water by one or more transoceanic ships (Columbian, 2002). Appearing initially within Lake St. Claire, the connecting lake to the two Great Lakes, Huron and Erie, the temperate, freshwater species quickly found the plankton-abundant habitat to be quite suitable (United States Army Corps of Engineers (USACE), 2002). Using river currents and the boating industry, the extraordinarily prolific and costly invasive quickly (within five years) established itself in all five of the Great Lakes and several major rivers, including the Mississippi, Tennessee, Hudson and Ohio River (Nijhuis, 2007). It did not take long to recognize the economic and ecological factors that were at risk.

Ecological Impacts

The female zebra mussel, although some as small as the period at the end of this sentence, can produce more than a million eggs annually (Aquatic Nuisance Species Task

Force (ANSTF), 2009a). Each individual mussel can filter a liter or more of water every day, consuming considerable amounts of microscopic organisms, algae, and other edible particles. A population of zebra mussels could filter an entire Great Lake in one day. This might appear to be a positive factor and although the clarity of the water might increase, the microscopic material that is being consumed is also the food source for a myriad of aquatic invertebrates, which in turn reduces the food for larval and juvenile fishes. The zebra mussel can quickly disrupt an entire freshwater's ecological food web (USACE, 2002; Wu & Culver, 1991).

Due to the vast amount of water filtered by the zebra mussel and their high body-fat content, zebra mussels are quite susceptible to the accumulation of PCBs and other toxic contaminants. They can acquire up to ten times more in pollutants than the native mussels (Gulf of Main Research Institute (GMRI), 2005; ANSTF, 2009a). Transferred directly up the food chain to the waterfowl and fish that eat them, this causes a great potential to significantly affect contaminant cycling within the Great Lakes, a region where health advisories already exist for consumption of many species of fish (ANSTF, 2009a).

Biological Impacts

In addition to ecological impacts, there are also several biological impacts of the zebra mussel. The zebra mussel, like other mussel species, attaches themselves to hard surfaces. However, unlike other mussel species, it will readily attach themselves to the other native mussels (Parker, 1998). This process, known as bio-fouling, can significantly

affect the populations of the native mussels. Although some natives are resistant to bio-fouling, they become more susceptible to other population delimitating factors, such as extreme water temperatures, lack of food, or parasites and disease. It is possible that the rarer of the native species will become completely eliminated with the intense competition (Sea Grant, 2001).

Photo 1: A "Druse" of Zebra Mussels (ANSTF, 2009a).

Economic Impacts

Due to their ability to colonize hard substrates in high densities, the zebra mussel is the cause of many expensive problems, becoming one of the most troublesome aquatic invasive species. Once a single mussel has settled, others quickly form, settling around or near the older, larger mussels. The expansion is almost exponential, forming a clump called a "druse" (See Photo 1) (Claudi and Mackie, 1993). Their affinity towards hard surfaces causes pipes and other underwater openings to be highly susceptible towards infiltration and clogging. For example, water intake structures of multiple

power and municipal water plants are at high risk of becoming quite fouled, causing a reduction in water pumping capabilities and occasional shutdowns. For example, in Monroe, Michigan, zebra mussels clogged the sole intake pipe of the town's water treatment plant, forcing a two-day shutdown of Monroe's schools, industries and businesses (Walker, 1991). This reduction in drinking water can negatively impact cities whose primary water source is these fresh water reservoirs. Factories and industries that pull in water for cooling are also detrimentally affected (O'Neill, C. 1997). Other surfaces susceptible to zebra mussel infiltration include ship and boat hulls, marine structures, grates and navigational buoys.

Since its introduction in North America, the zebra mussel has cost the United States billions in preventative and management costs. In the United States, congressional researchers estimated the mussel cost the power industry alone $3.1 billion in the 1993-1999 period. Its total impact on industries, businesses, and communities reached over $5 billion. In Canada, Ontario Hydro has reported zebra mussel impacts of $376,000 annually per generating station (New York Sea Grant 1994a).

Human and Wildlife Health Impacts

In addition to the clogging of pipes and devouring of most available microscopic food supply, the zebra mussel may present a health hazard by increasing human and wildlife exposure to deadly organic pollutants (PCBs and PAHs). Research has shown that the zebra mussel can accumulate pollutants more than 300,000 times greater than

concentrations of the environment (GMRI, 2005). The pollutants are then deposited as pseudofeces, loose pellets of mucous mixed with particulate matter that they filter from the water. This matter can significantly lower the oxygen levels, raising the pH to acidic levels and generating toxic byproducts. If scavenging animals eat or absorb these pseudofeces, the pollutants may be passed up the food chain.

Recreational Impacts

Recreation-based industries and activities along zebra mussel infestations are also affected by the mussels which take up residence on the unprotected docks, breakwalls, buoys, boat bottoms, engine outdrives, and beaches. As zebra mussels clog cooling water inlets and colonize boat hulls, the boats' steerage can be affected and may experience both drag and clogged engines causing overheating or complete failure of the system (ANSTF, 2009a; USACE, 2002).

Both swimmers and divers are also negatively impacted. As the zebra mussels coat the beaches, the sharp-edged mussels can quickly become a nuisance to the bare feet of humans (See Photo 2). By autumn of 1989, extensive deposits of zebra mussel shells were on many Lake Erie beaches. Divers, who typically are attracted to the underwater features such as shipwrecks and aquatic geography, are affected as the hard surface-attaching zebra mussel quickly obscures the attributes of the aquatic terrain with its vast numbers.

Zebra mussels are one of the most dangerous aquatic invasive species. They affect the ecological food web, disrupt recreational activities, and threaten native

species. The zebra mussel is costing billions to manage. State and Federal agencies are working to help contain and manage the zebra mussel and other aquatic nuisance species threat.

Photo 2: Dead zebra mussels washed up on Lake Erie beach (NISC, 2009).

Washington State Management of Zebra Mussel

RCW 77.60.130 defines the term aquatic nuisance species (ANS) as a "nonnative aquatic plant or animal species that threatens the diversity or abundance of native species, the ecological stability or infested waters, or commercial, agricultural, or recreational activities on such waters" (Washington State Legislature, 2007). Taking residence in more than 20 states and two Canadian provinces, the zebra mussel is considered an ANS (Washington Department of Fish and Wildlife (WDFW), 2001a). Inhabiting 22 states, the zebra mussel has yet to become established in Washington State. However, this does not mean the state should be lax in the management of the

mussel. Spending millions to prevent inhabitation is cheaper than spending billions to manage and eradicate it.

In 1996, the development of a state management plan was called for in Section 1204 of the National Invasive Species Act of 1996 (Appendix A), which provides an opportunity for federal cost–share support for the implementation of state plans approved by the National Aquatic Nuisance Species Task Force. Management actions are undertaken and funded by the responsible state agencies (Public Law, 1996). The agencies responsible are Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Invasive Species Council.

Washington Department of Fish and Wildlife

Washington Department of Fish and Wildlife was one of the forerunners of the invasive prevention movement within the state. Taking on the responsibility of the development of the required state action plan, the Washington State Aquatic Nuisance Species Planning Committee was formed with WDFW assigned as the lead agency to coordinate the drafting of the required state plan (WDFW, 2001a). This committee consisted of Department of National Resources (DNR), Department of Energy (DOE), Noxious Weed Control Board (NWCB), and WDFW representatives for the purpose of fostering state, federal, tribal, and private cooperation to prevent the introduction of ANS. Published in 1998, the committee completed The Washington State Aquatic Nuisance Species Management Plan, an attempt to coordinate all ANS management actions, especially those relating to ANS animals. The coordinated efforts contained

within the plan were designed to reduce the impacts on Washington's environment, economy, and human health through enhanced early detection and rapid response capabilities (2001a).

During 2001, Washington Department of Fish and Wildlife (2007) began to establish a network of trained volunteers throughout the state that would help conduct surveys for the inch-long mussels, which are easily identified by their alternating dark and light stripes (WDFW, 2001b). Volunteers typically consisted of boat owners and waterfront property owners. Shoreline property owners would be asked to suspend special PVC pipe sampling kits in the water and make routine checks for the attachment of zebra mussels. Other volunteers were needed to walk beaches and shoreline, looking for mussels attached to rocks or other hard surfaces. Volunteers were also asked to help provide substrate monitoring data of the zebra mussel by hanging a PVC pipe from a dock, pier, or other support, periodically checking the pipe for attached invasives. WDFW has now initiated volunteer monitoring programs in several lakes and along the Columbia and Snake Rivers, requiring that out of state participants in fishing contests to undergo boat inspections. This early detection through sample monitoring greatly increases the chances WDFW could control and possibly eradicate new zebra mussel infestations. Washington State Patrol Commercial Vehicle Inspectors check some of the boats that are commercially hauled into the state at the ports of entry, but not all haulers are required to stop. WDFW is increasing boater education efforts, and inspections of privately hauled recreational boats being transported from out of state.

Zebra mussels have been prohibited in Washington since 2002, but now that

zebra mussels are beginning to appear in some western states, officers have pursued stronger action against contaminated vehicles. In 2007, WDFW enforcement officers shifted from warnings to citations, issuing their first citation in October to two out-of-state trucking companies hauling large boats to the Pacific Coast that were found contaminated with zebra mussels. One truck from Ontario and the other from Iowa were both spotted during Washington State Patrol commercial vehicle inspections at a Washington-Idaho port-of-entry weigh station east of Spokane (WDFW, 2007). This shift in protocol should hopefully help keep Washington's waters free of an invasive species that threatens native fish and wildlife. Mike Cenci, WDFW deputy chief of enforcement, hopes that these citations (up to $5,000) will raise awareness, demonstrating "that this state looks at invasive species very seriously – once a species like this gets into our waters, it is very unlikely we can contain it" (2007, p. 2).

Washington Department of Ecology

In 1997, the Lake Water Quality Assessment Program was initiated by Washington's Department of Ecology (2009). Working in cooperation with U.S. Fish and Wildlife Service (USFWS), the program began monitoring for zebra mussels in 30 selected lakes (See Table 1) throughout Washington. This program was appended to an existing lake monitoring process where volunteers would measure the lake's water quality twice monthly. The zebra mussel monitoring was conducted by dropping an attached brick approximately ten feet into the water. If the lake was inhabited, zebra mussel veligers (young free-floating offspring) would drift onto the brick, attaching

themselves to the hard surface, allowing them to be readily seen as the brick is drawn from the water.

Washington DOE's Lake Water Quality Assessment Program was launched as an ongoing nation-wide effort to help maintain, monitor, and protect watersheds from initial or further infiltration of the invasive zebra mussels (2009). Although there has been no observation of zebra mussels west of the continental divide, they have been found in boat bilges as far west as Canada and many scientists believe their arrival in the Pacific Northwest is imminent.

Alice (King)	Bosworth (Snohomish)	Clear (Spokane)
Crawfish (Okanogan)	Curlew (Ferry)	Deep (Stevens)
Gravelly (Pierce)	Haven (Mason)	Hicks (Thurston)
Ki (Snohomish)	Limerick (Mason)	Long (Kitsap)
Long (Thurston)	Loon (Stevens)	Mason (Mason)
Nahwatzel (Mason)	Newman (Spokane)	Palmer (Okanogan)
Phillips (Mason)	Roesiger (north arm) (Snohomish)	Roesiger (south arm) (Snohomish)
Samish (east arm) (Whatcom)	Sawyer (King)	Spanaway (Pierce)
Tapps (Pierce)	Thomas (Stevens)	Wenatchee (Chelan)
Wildcat (Kitsap)	Wooten (Mason)	Wye (Kitsap)

Table 1: Washington monitored lakes of 1997
(Washington Department of Ecology, 2009)

Washington DOE's zebra mussel monitoring program was primarily volunteer-based and is currently unfunded. DOE believes a federal grant is essential to expand and implement a properly maintained state-wide zebra mussel monitoring program. Federal funding would allow DOE to monitor additional waters using a variety of "sophisticated monitoring techniques" (2009). These sophisticated measures were not described in any depth. With the lack of funding, lake monitoring was discontinued in

2000 and the volunteer monitoring component lasted an additional year. DOE still files data from volunteers who have chosen to continue, but there is no longer an active recruitment of volunteers (Global Change Master Directory, 1999). Currently, Washington's DOE does not have any state-wide monitoring or assessment plan for zebra mussels.

Washington Invasive Species Council

In 2006, originating from the engrossed substitute Senate Bill 5385, the Washington Invasive Species Council (WISC, 2009) was developed to help provide policy direction, planning, and coordination to individuals or organizations engaged in the prevention, detection, and eradication of invasive species (WISC, 2007). As stated in Section 5 of Bill 5385, the Council was required to create and submit a statewide strategic plan for addressing invasive species to legislature in 2007 (Washington State Legislature, 2006). This plan was "designed to build upon local, state, and regional efforts, while serving as a forum for invasive species education and communication" (WISC, 2009). The Council is made up of a representative group of experts from several organizations including but not limited to DNR, USFWS, DOE, WDFW, Department of Administration (DOA), United States Department of Agriculture (USDA), Department of Transportation (DOT), and Environmental Protection Agency (EPA) (WISC, 2007). This coalition's vision is to sustain Washington's human, plant, and animal communities by preventing the introduction, dispersion, and advancement of invasives.

The WISC was successful in its development of the 2008 strategic plan,

completing and releasing *Invaders at the Gate – 2008 Strategic Plan* near the end of 2007. The strategic plan outlined several recommendations for both short- and long-term specific action items. With the majority of the Washingtonians completely unaware of the threat of invasive species, the Council realizes that education and outreach programs are one of the most important lines of defense for invasive control and prevention. The Council states that everyone has a stake in reducing the harmful effects of invading plants and animals and that ultimately, the success of Washington's strategic plan hinges on the collaborative efforts of public agencies and active participation by the public (WISC, 2007).

WISC plans to build on the existing and successful models set forth by the noxious weed boards and other significant work that has been accomplished by both the private and public agencies and organizations (WISC, 2007). Working with existing models, the state's effectiveness at minimizing the effects of invasive species should be more easily accomplished. One of the most important recommendations that WISC calls for is the increase and enhancement of communication across all entities: state, federal, tribal, private, public, and any other stakeholders. This recommendation would ensure that coordinated approaches are supported and tools are accessible to address invasive species issues. Current communication channels between sectors need to be enhanced to facilitate rapid response and stronger coordination. Time is precious when dealing with invasives. If managers do not respond quickly and efficiently, the tougher it becomes to stop the introduction, colonization, and naturalization of an invasive species.

State managers are important to the success of invasive species management. WDFW, WDOE, and WISC are a few agencies that have made significant contributions towards state level management. This type of management is not feasible at the federal level. Each state must have agencies similar to Washington's if it is to implement effective invasive management policy.

Oregon State Management of Zebra Mussel

On the opposing side of the Columbia River, several agencies have kept Oregon State's waters clear of the zebra mussel. Oregon Department of Fish and Wildlife, Oregon Invasive Species Council, and Oregon Department of Environmental Quality have all worked on management plans and policy similar to Washington State. These agencies realize that they cannot be lax in the management of the zebra mussel.

Oregon Department of Fish and Wildlife

Over the past 30 years, the State of Oregon has noticed that its landscape has changed, affecting not only the fish and wildlife populations, but human use as well. Seeing that past conservation efforts had primarily been crisis-driven, Oregon Department of Fish and Wildlife (ODFW) established a goal of a strategic and comprehensive approach to address species and their habitats across broad landscapes and local sites (ODFW, 2006). In 2006, ODFW completed their goal of creating the first overarching state strategy towards the management of fish and wildlife and the habitat they live in. The *Oregon Conservation Strategy* helped refine several conservation efforts within Oregon, creating a conceptual framework for long-term conservation

efforts of Oregon's native plants and wildlife (2006).

This plan is quite similar to *Invaders at the Gate – 2008 Strategic Plan*, Washington's conservation plan (WISC, 2007). These conservation plans are extremely valuable, as they address several key points such as education, outreach, increased communication, efficiency, and coordination between invasive management entities and the pinpointing of areas where conservation activities would have the greatest benefit. These conservation plans highlight ways to expand, enhance, and improve conservation work. Instead of creating more laws and regulations that further hinder the management of invasives, these strategic plans work effectively to interweave themselves with existing law and stature, encouraging voluntary action and collaboration by both private landowners and public land users (ODFW, 2006).

Oregon Invasive Species Council

Oregon's Invasive Species Council (OISC), similar to Washington's Invasive Species Council, also originated out of legislature (Oregon State Legislature, 2007). OISC began official business at the beginning of 2002, four years prior to Washington's council. The Council, in a similar fashion to Washington's, consists of several members that represent agencies with leading roles in invasive species management: Oregon Department of Agriculture (ODOA), Portland State University (PSU), and Oregon Department of Fish and Wildlife. The purpose of the OISC is to conduct a coordinated and comprehensive effort to prevent the spread or introduction of new invasives and effectively manage, reduce, or eliminate invasives that have already been established

within Oregon (ODFW, 2005).

The Council's mission is carried out through four primary functions: "a.) create, maintain, and publicize a system for invasive species sightings; b.) enhance awareness of invasive species through outreach and education efforts; c.) develop and maintain a statewide plan to deal with invasive species; and d.) administer a trust account to fund outreach and education, and eradication and control projects. The Council also develops a list of 100 most dangerous invaders threatening Oregon" (OISC, 2007).

Although the OISC was not entirely successful with all of its goals and efforts to secure funds and donations to the Trust Fund Account were not possible in 2007 without the presence of an OISC Coordinator, it was completely successful at excluding invasive species from Oregon in 2007 (OISC, 2007). Working with ODFW, USDA Forest Service, U.S. Fish and Wildlife Service, Port of Portland, Bureau of Indian Affairs – Warm Springs, and other government, nonprofit, and private entities, the OISC helped sponsor and launch a "Stop the Invasion" statewide campaign against invasive species. Occurring on Earth Day (April 22), this event is the first-of-its kind, incorporating a documentary, publications, volunteer opportunities, a coordinated effort to identify, prevent and control invasive species and research to gauge the awareness and attitudes of Oregonians toward the invasive problem (OISC, 2008).

Oregon Department of Environmental Quality

Although Oregon's history of environmental regulation dates back to the 1930's, the Oregon Department of Environment Quality (ODEQ) was not established until 1969.

ODEQ became officially recognized as an independent state agency and was charged with cleaning up and protecting the state's water and air (ODEQ, 2009). ODEQ's vision is to work cooperatively with all Oregonians for a healthy, sustainable environment, promoting several cultural values, including: environmental results, public services, partnerships, diversity, economic growth through quality environment and more.

In 2007, Senate Bill 643 was passed, a modification of Oregon's previous Ballast Water Program, creating Oregon's Shipping Transport of Aquatic Invasive Species Task Force (Oregon State Legislature, 2007b). The Task Force was formed out of growing concern over the potential pathways of non-native species introductions associated with shipping traffic. The Task Force continues the responsibilities of the previous Ballast Water Task Force, but has a new mandate to investigate a larger range of ANS. Members of the Task Force are appointed by the ODEQ director and include representatives from Washington and California, federal agencies, maritime industry, and the environmental and academic communities. Under Oregon's Senate Bill 643's objectives and responsibilities, the Task Force is directed to study and make recommendations that prevent ANS associated with shipping-related transport into Oregon waters. Investigating possible changes or modifications to current ballast water regulations that may include: shipping industry compliance, practicable and cost-effective ballast water treatment technologies, and developing appropriate standards for the discharge of treated ballast water into waters of Oregon are a few recommendations (2007b; ODEQ, 2008a).

The Shipping Transport of Aquatic Invasive Species Task Force has been

successful. Implementation of stricter ballast water requirements, a recommendation to the 2009 Oregon Legislature, will bring Oregon's ballast water requirements to be in alignment with California and Washington's preventative measures (ODEQ, 2008b). All states need to collaborate to effectively prevent the spread of invasives such as the zebra mussel. Several Task Force recommendations to ODEQ bolstered efforts to halt the arrival and spread of ANS, thus preventing further degradation of existing ecosystems and the displacement of native species.

Some recommendations to regulate Oregon's ballast water reporting system include (ODEQ, 2008c):

- Amendment of state statutes to provide ODEQ with the authority to board and inspect regulated vessels, audit ballast water records, and collect ballast water samples.
- Update the state's penalties to ballast water regulations. By raising the maximum penalty amount, Oregon would be brought in line with similar regulations to Washington and California.
- Request supplemental funding to pay for the expenses of a strengthened ballast water regulatory system.
- Request additional funding through federal monies or grants to conduct a more thorough monitoring of Oregon waters. Specifically, the water that is part of the shipping paths and susceptible to aquatic invasive species. A systematic survey of this scope has not been completed since 2001.

The 2008 Task Force has encouraged ODEQ to prepare and administer a voluntary hull-husbandry survey for commercial vessels operating in Oregon waters. Additionally, it was recommended that ODEQ's Ballast Water Program consolidate and clarify ballast water report forms to enhance vessel compliance efforts. Currently, there

are conflicting definitions for vessels that are subject to the Oregon Ballast Water Management Program and these conflicts are confusing for all parties and have complicated outreach to the shipping industry. The ODEQ would work closely with the state of Washington to develop more efficient, coordinated management of inter-port operations on the Columbia River as well as help better characterize bio-fouling, the growth of animals and plants on the surface of submerged objects, risk in Oregon waters (Woods Hole Oceanographic Institute, 1952). Finally, the Task Force recommended that the ODEQ further refine and develop its rules regarding ballast water discharge standards, standardizing them with neighboring states' (Washington and California) standards, until a federal program is established in the near future (ODEQ, 2008b & 2008c).

Similar to Washington, Oregon's state managers have played a crucial role in the invasive management. Without the managers listed above, both states would have severely limited invasive policy. However, state management is not the only level of management that should occur. Federal management is also vital to a successful management program.

Federal Management of Invasive Species

Federal managers have brought national leadership to the invasive species threat. The National Invasive Species Council has helped create a coordinated national effort to address invasive species. The Aquatic Nuisance Species Task Force (ANSTF) was

given the responsibility to develop and implement a national program to help prevent the introduction of and to control the spread of aquatic nuisance species. Finally, the U.S. Fish and Wildlife Service (USFWS) worked across state and federal jurisdictions to develop effective statewide aquatic nuisance species management. It is the Federal management that has helped and allowed the other stakeholders and agencies to develop effect invasive policy.

National Invasive Species Council

In response to the urgings of farmers, ranchers, scientists, and state officials the National Invasive Species Council (NISC) was established by President Clinton on February 3, 1999 by Executive Order 13112 (NISC, 2008 &Executive Order No. 13112, 1999). The new agency's purpose was to create an inter-Department council that helps coordinate and ensure complementary, cost-efficient and effective Federal activities regarding invasive species – a coordinated national effort to address the invasive problem. One of the primary duties of the Council is to provide national leadership regarding invasive species, overseeing and working in cooperation with stakeholders and existing organizations that address invasive species, such as the Aquatic Nuisance Species Task Force, the Federal Interagency Committee for the Management of Noxious and Exotic Weeds, and the Committee on Environment and Natural Resources (1999). One of the greatest challenges for the Council is to create a biennial national invasive species management plan. In 2001, the challenge was met and the Council published *Meeting the Invasive Species Challenge: National Invasive Species Management Plan*

(2001).

This plan was effective in developing a blueprint that could be used for federal action in coordination with other nations, states, and local and private programs, prioritizing nine interrelated and crucial actions that need to be addressed. The following actions were listed as the nine categories that the Council needed to address in coordination and partnership with other stakeholders as appropriate: 1) Leadership and Coordination; 2) Education and Public Awareness; 3) Information Management; 4) Research; 5) International Cooperation; 6) Restoration; 7) Control and Management; 8) Early Detection and Rapid Response; and 9) Prevention (NISC, 2008). Although several obstacles arose, the Council has made significant and important progress over the past eight years since the creation of the management plan.

In 2003, the Council released a progress report to help measure their success since the release of the National Invasive Species Plan (Plan). The Plan contains nine general categories broken down into 57 action items with 86 varying subparts. Since the release of the Plan, 26 of the 86 total action items and subparts have been completed or established, 47 are in progress, and 12 have not yet been started (NISC, 2003). NISC (2003) does make a note that 51 of the 86 call for on-going coordination efforts and a continuing commitment of resources and the remaining 35 call for discrete actions that once completed will require little on-going coordination and few (if any) routine revisions or supplementations.

By 2005, the list of accomplishments grew, providing further evidence that the NISC was certainly helping coordinate and enhance invasive species actions across

spatial boundaries. The 86 identifiable actions almost doubled, growing to 170 with 70 "discrete" and 100 "on-going" (NISC, 2005). Of the 170 identifiable actions, 76% (130) are completed/established or in progress, "indicating both significant progress made and important work to be done" (2005).

Three years later and as mandated by Executive Order 13112 (1999), a revised plan was required. Developed collaboratively by 13 federal departments and agencies and their partners, the adoption of the new *2008 – 2012 National Invasive Species Management Plan* (2008 Plan) took place in August, 2008. The completion of this revision was a crucial step towards the management of invasives. This document directs Federal efforts to prevent, control, and eradicate invasive species and their impacts over the next five years. Co-chair Dirk Kempthorne, Secretary of Interior stated, "Its significance cannot be overstated because invasive species cause great damage to the nation's environment, economy and human health—harming fisheries, forests, croplands and natural areas; impairing recreation; and endangering public health through threats like West Nile virus" (US Department of the Interior (USDI), 2008).

Since its formation in 1999, NISC and its partners have developed much larger knowledge and public awareness of invasive species. The 2008 Plan is not a comprehensive list of all federal invasive species actions. It builds off the 2001 Plan, taking the input of NISC member agencies, ISC staff, stakeholders, expert review and public comment to hone federal efforts to prevent and control invasive species. The culmination of work builds on the successes to date, creating a targeted set of priority strategic action plans with objectives and implementation tasks that are intended to be

completed in the next several years (NISC, 2008 & USDI, 2008).

Unlike the 2001 Plan, the 2008 Plan places responsibility on specific agencies. Currently, the 2008 Plan requires the work of 35 different entities, defined as "agencies or bureaus within NISC members' departments and agencies" (NISC, 2008). The identified agencies are given the role of either "Lead" or a "Participant" to describe their role played during the specific action item.

NISC depends on the cooperation from local, state, tribal, private and public partners from around the world to accomplish its mission. The awareness of the problems caused by invasive species has dramatically risen as shown by the increased activity across all levels. In 2005, there were only 17 states with invasive species councils whereas now, there are more than half the states with similar coordinating structures (NISC, 2005 & 2008). The distribution of information among the federal, private, tribal, and public sectors has been a benefit to the management of the myriad of invasives that cause economic or environmental harm, or even harm to human health.

Aquatic Nuisance Species Task Force

The Aquatic Nuisance Species Task Force is an intergovernmental agency comprised of ten Federal agency representatives and twelve Ex-officio members. It is co-chaired by the USFWS and National Oceanic and Atmospheric Administration (ANS Task Force, 2009b). In response to the zebra mussel infestation and other concerns about ANS, the task force was established by the *Nonindigenous Aquatic Nuisance*

Prevention and Control Act of 1990 (NANPCA), reauthorized in the National Invasive Species Act of 1996 (NISA), to help prevent the introduction of and to control the spread of introduced aquatic nuisance species (Public Law 101-636, 1990 & Public Law 104-332, 1996). Consisting of the U.S. Fish and Wildlife Service, the U.S. Coast Guard (USCG), the Environmental Protection Agency, the Army Corps of Engineers (USACE), and the National Oceanic and Atmospheric Administration, the ANS Task Force was given the responsibility to act as a coordinating force in developing and implementing a national program:

- Prevent the introduction and dispersal of aquatic nuisance species (ANS);
- Monitor, control and study such species;
- Conduct research on methods to monitor, manage, control and/or eradicate such species;
- Coordinate ANS programs and activities of ANS Task Force members and affected state agencies; and
- Increase public understanding of the importance of reducing the introduction, spread, and impact of ANS and recommends appropriate domestic and international actions (ANS Task Force, 2007 & 2009b).

In 2007, the ANS Task Force created a strategic plan for the next five years that outlines the primary goals and objectives of the agency. This strategic plan was a great accomplishment, providing the Task Force with a blueprint that breaks the various objectives down, allowing ANSTF to fulfill its mission.

To carry out the implementation of the strategic plan's goals, an organizational hierarchy was adopted, establishing six regional panels, each consisting of representatives of the affected sectors of government, including Federal and State agencies, state representatives, tribes, non-governmental organizations (NGOs),

industry groups, commercial interests, neighboring countries, and academia (ANS Task Force, 2007). This regional breakup allowed individual panels to focus on their area, identifying, addressing, and making/providing regional recommendations to the ANS Task Force. These recommendations would then be examined by a specific ANS Task Force committee, the next level of the hierarchy. Each committee is focused on an individual, essential portion of the ANS Program. There are five committees in total:

- Prevention
- Detection and Monitoring
- Control
- Research
- Communication, Education, and Outreach

Committees consist of experts in the subject matter and agency member representatives, allowing them to obtain the necessary technical coordination of various ANS activities (e.g. The Research Committee would tackle ballast water research) (ANS Task Force, 2007). The ANS Task Force has done quite well at preventing the introduction and dispersal of ANS; monitoring, controlling, and studying these species; and using this data to further combat the aquatic invasive species.

One example includes the Western Regional Panel which was responsible for the 100^{th} Meridian Initiative, a cooperative effort between state, provincial, and federal agencies to prevent the westward spread of zebra mussels and other ANS (USFWS, 2007). If ANS are detected, the secondary goal of the Initiative is to monitor and control the invasive species within the contained area. To ensure its relevance in preventing the

spread of the zebra mussel and other ANS, U.S. Fish and Wildlife Service is currently administrating the Initiative, working to inform and educate the public, complete boat inspections and boat surveys, and monitor and evaluate the effectiveness of the 100th Meridian Initiative.

In addition to these committees, the ANS Task Force encourages state participation, stating that it "is essential to the effective coordination of prevention and control programs" (2004, p32). In accordance to the 1996 National Invasive Species Act's requirement of a state management plan, "the ANS Task Force encourages states to develop management plans for ANS and provides guidance, technical support, and financial resources [See Figure 1] to help implement the approved plans" (2004, p32).

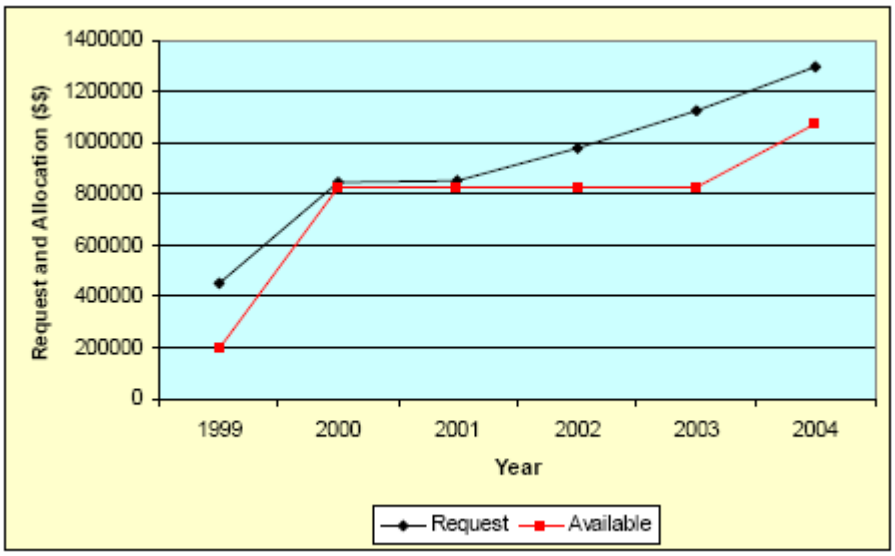

Figure 1: Cost-share Grant Requests and Available Funds for State Management Plans

For example, the Center for Lakes and Reservoirs at Portland State University (the Center) was given the responsible of the development of Oregon's ANS State

Management Plan (2001). Following the implementation of the plan, action was focused on building partnerships and expanding the funding base for ANS work in Oregon. Chairing the Oregon Invasive Species Council and working closely with ODFW, the Center helped provide technical assistance to ANS management. The Center was also successful in leveraging for funds from the fiscal year 2004 (FY 2004), allowing them to implement several objectives of the plan, in particular, surveying and management planning. Outreach and education were also high priorities in 2004 working in cooperation with the 100th Meridian Initiative to develop informative signs on the hazards of invasive species transport and recommended actions to help reduce risk (ANSTF, 2004).

Washington also received a large amount of help from the ANS Task Force. At the time of the state-wide assessment of the accomplishments of the FY 2004, Washington's management plan had been in effect for three more years than Oregon. This allowed Washington to accomplish a great deal more than Oregon. A few achievements during FY 2004 include:

- ANS Monitoring for Zebra Mussel, European Green Crap, and Atlantic Salmon
    - Over 70 volunteers were trained to monitor substrate samples, almost 75 water samples were collected and analyzed, the Washington State Police conducted more than 1,000 recreational boat inspections as well as several commercially hauled vehicles, and educational material was developed and distributed to boaters, fishers, and other water recreationalists.
- Ballast Water Management

    - Implemented and enforced ballast water law by hiring a ballast water ship inspector.
    - Maintained a ballast water database and continued to research effective ballast water treatment technology.
- Outreach and Education
    - Educational presentations were given to Asian/Pacific Islander communities, schools, community centers, and other community stakeholder groups.
    - Educational material was distributed in Cambodian, Vietnamese, and Laotian.
    - Conducted 100th Meridian Initiative boat surveys.
- Early Detection and Rapid Response Activities
    - Draft of a Washington early detection and rapid response plan was completed.

Oregon and Washington are not the only two states to work collaboratively with the ANS Task Force. At the time of ANSTF's FY 2004 assessment, there were fourteen total states with approved management plans and thirteen states with management plans under development, leaving less than half the states without any ANS management (See Figure 2). The achievements mentioned above were not luck or an accident. ANS Task Force's smartest decision was to break the invasive issue down into manageable chunks. One agency cannot be completely responsible for every invasive across every state. By dividing into regionalized panels and further breaking the hierarchy into committees and subcommittees, the ANS Task Force set itself up for success (ANS Task Force, 2004).

Two other national campaigns sponsored by the ANSTF are the Stop Aquatic Hitchhikers! (SAH) and Habitattitude public awareness campaigns. Both of these events have the same goal of protecting our resources and preventing aquatic invasive species, however, they have been directed at two varying social areas. SAH's focus lies with the American recreational user, one who loves spending his/her time on the water, where on the other hand, Habitattitude's audience consists primarily of the aquarium hobbyists, backyard pond owners, water gardeners, and others who are passionate towards their smaller, more personalized ecosystems (SAH, 2009; Habitattitude, 2009).

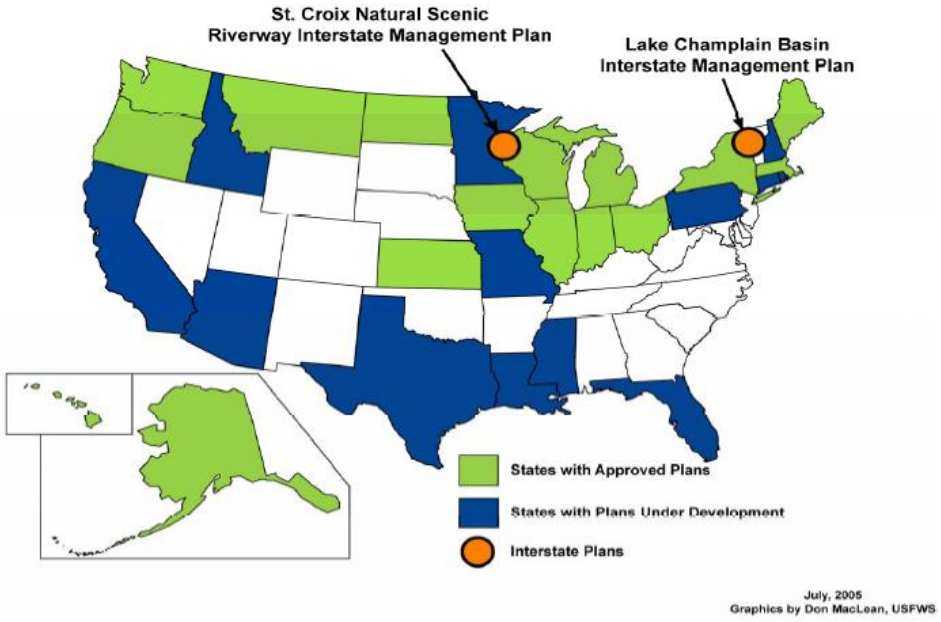

Figure 2: Status of State ANS Management Plans, 2005

Both websites, although similar provide altering incentives directed at their intended audience. For instance, a few from SAH's home page include, reduction in game and fish populations, damaged boat engines and jammed steering equipment, and

unusable lakes/rivers for boaters and swimmers. Habitattitude's page however contains links such as reduction in natural biodiversity, degradation of ecosystem functions, and reduction in property values. This dichotomy is quite effective, allowing ANSTF, the sponsor of both campaigns, to help educate two varying public sectors towards their common mission: dedication to the prevention and control of aquatic nuisance species.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) is the only agency of the U.S. Government whose primary responsibility is the conservation of the nation's fish, wildlife, and plants (USFWS, 2009). Therefore, addressing the impacts of invasive species across the nation is a high priority to the agency. The USFWS has participated in the development of several invasive management plans. Co-chairing the ANS Task Force with the National Oceanic and Atmospheric Administration as well as providing an Executive Secretary to the Force, the USFWS has worked across state and federal jurisdictions to develop effective statewide ANS management (ANSTF, 2009c). Not only serving with the ANS Task Force, the USFWS has worked effectively to create a comprehensive, environmentally friendly approach to manage pests (including invasive species). The Integrated Pest Management approach uses a combination of strategies that pose the least hazard to people, property, and the environment (US DOI, 2007 & USFWS, 1990).

Analysis

The management of invasive species has skyrocketed over the past 20 years. Not that invasive species did not exist before – there is clear evidence of previous diffusions. Species have been out competing one another since the beginning. However, over the past few decades, several new pathways have opened up to the world, allowing species to cross barriers that once stood erect in their way. As transoceanic ships crossed entire oceans, a variety of plant and animal species reached new foreign lands – lands that did not evolve with these new exotics. These regions were not prepared for this new threat; its inhabitants were vulnerable to the overbearing non-natives. Entire populations of flightless birds were wiped out as predators and critters were brought to these foreign lands. The brown tree snake is a classic example of an invasive that has demonstrated the negative impacts of an invasive species. Introduced to Guam in the 1950s, the brown tree snake quickly became quite abundant with the large prey base and absence of natural predators. Left unchecked for many decades, the snake has now wiped out 10 of the 12 native bird species of birds in Guam, leaving the remaining two populations with fewer than 200 birds. Costing the world billions in management and prevention, invasive species around the globe have opened the public's eyes to the invasive threat.

Compared to the brown tree snake, the management of the zebra mussel within Washington and Oregon's portion of the Columbia River Basin is quite similar. Without proper invasive species management the Basin's biodiversity is at risk. Zebra mussels

are outcompeting native species in the Midwest and it would not be any different in the Pacific Northwest. As the largest river to flow into the Pacific Ocean, the Columbia River passes through several jurisdictions. How is the zebra mussel diffusion being addressed across these political boundaries? How effective is the current policy? What is the research and management funding levels? What are the differences between the state laws and regulations? How do Oregon and Washington compare against one another? The following portions offer recommendations and conclusions to these questions.

Oregon versus Washington

Out of the forty-eight continental states, almost half (22) have become inhabited by the mussel. Neither Oregon nor Washington has had a zebra mussel population become established. Both states would like to keep it this way and they realize that they cannot be lax in the management of the mussel, despite its nonexistence in the Pacific Northwest. Both Oregon and Washington are incredibly susceptible to the threat of ANS. The common boundary of the Columbia River and its mouth requires cooperative management. If one state is not effective in the protocol or management of the zebra mussel, it places the other state at a high risk, despite the other's efforts.

Oregon and Washington's Department of Fish and Wildlife have played a crucial role in the policy field, bringing together several organizations to form invasive action committees. These committees have created state conservation plans that are extremely valuable, addressing several key points such as education, outreach, increased communication, efficiency, and coordination between the invasive

management entities, and the pinpointing of areas where conservation activities would have the greatest benefit. Although both Departments of Fish and Wildlife were the forerunners of the invasive prevention movement, Oregon was slightly delayed in comparison to Washington's management plans.

It was not until 1996 when the National Invasive Species Act came out, that invasive management began to occur at the state level (Public Law, 1996). With WDFW as the leading agency, the Washington State Aquatic Nuisance Species Planning Committee was formed. With representatives from several entities representing state, federal, tribal, public, and private sectors, The Washington State ANS Management Plan was published in 1998, two years after the NISA. Oregon on the other hand took several more years to develop a plan, finally completing the Oregon ANS Management Plan in 2001, five years after the NISA. Again, these strategies are a key step to the state level of management. They are formed through a committee process; committees that have representatives from all sectors of government. This allows these conservation plans to not only interweave themselves with current law and stature, but prevent unnecessary laws and regulations that further hinder the management of invasive species. These state management plans help delegate tasks and provide coordination and collaboration among the various invasive management agencies, encouraging voluntary action and cohesiveness by both private landowners and public land users (ODFW, 2006). Yet once again, if one state is not up to par at certain levels, the other state's actions remain ineffective.

This gap in Oregon policy is the catalyst of several other missing portions of stature. For instance, it was not until 2009 Oregon Legislature that Oregon's minimalist ballast water discharge standards were addressed. Although Oregon has had ballast water requirements, the state still trails California and Washington's more strict regulations. Still falling short in several places, Oregon's Shipping Transport of ANS Task Force made recommendations in 2009 to realign itself with California and Washington's preventative measures. If a zebra mussel population had become established, weakened policy similar to Oregon's ballast water discharge policies would have led to severe detrimental effects, economically, ecologically, and biologically. Although Oregon's policy has had a slower start than Washington's, Oregon still was one of the few states that had an invasive species council at the turn of the millennia. Oregon's Invasive council formed in 2002 and by 2005, three years later, only 17 states total had an invasive council (NISC, 2005 & 2008).

In comparison to its neighboring states, Oregon's development of its ANS management plan was below standards; however, Oregon was a great deal more proactive in the development of an overall statewide invasive species management plan. Both Oregon and Washington developed an invasive species council, Oregon in 2002, Washington in 2006. In comparison, Washington was four years behind in its development and effort to prevent the spread and introduction of all invasive species, terrestrial and aquatic. In similar fashion of Washington's ANS plan achieving more, Oregon's Invasive Species Council was capable of accomplishing more. For instance,

Washington completed their statewide management plan in 2007 and Oregon had already acquired funds and helped sponsor several statewide campaigns, including "Stop the Invasion" and others that coordinate volunteers and state agencies to identify, prevent, and control the invasive threat.

A reoccurring barrier towards invasive management is the lack of funding, especially as the United States enters another recession. Both states and all agencies, both state and federal, have stressed that not enough work can be completed with their current allocated budget. Several action items have been identified, but with insufficient finances, not everything can be completed. For instance, Oregon has not completed a systematic survey of its waters that are part of the shipping paths since 2001. These waters are highly susceptible to ANS and Oregon's Shipping Transport of ANS Task Force is planning on requesting additional funding through federal funds to conduct a more thorough monitoring (ODEQ, 2008c). Washington's Department of Ecology ran short on funds and had to discontinue its zebra mussel monitoring program back in 2000. Without federal funding, Washington's DOE will not be able reestablish, implement, or expand upon a properly maintained state-wide zebra mussel monitoring program (WA DOE, 2009). As Oregon and Washington, and many other states throughout the nation, undergo budgetary restrictions and lose financial support, certain goals of the state management plans will not be addressed. However, the purpose of these state conservation and management plans is to represent the highest

standard possible, rather than what is likely to happen if we are to have effective invasive species management (WDFW, 2001a; ODFW, 2005 & WISC, 2009).

The current state plans have been improved several times from the initial publications. Initially, both Oregon and Washington failed to effectively delegate tasks to the numerous agencies, stakeholders, and other invasive organizations. Over time as objectives were not accomplished, it became quite apparent that delegation and acceptance needed to occur. Currently, the invasive committees responsible for the state plans address funding and delegate and accept management goals. Both committees help provide a level of coordination between the local, state, national, international, and other agencies to provide a comprehensive biosecurity framework. The committees remedy and mitigate economic and ecological risks posed by invasive species (Cusack, Harte, & Chan, 2009). Coordination is certainly happening between Oregon and Washington, especially as the invasive management movement has taken off, but more needs to happen. For instance, under the Senate Bill 643, Oregon's Shipping Transport of ANS Task Force has been directed to study and make recommendations towards the prevention of ANS associated with shipping-related transport to Oregon's Department of Environmental Quality. One suggestion of the 2008 Task Force is to work closely with the state of Washington to develop more efficient, coordinated management of inter-port operations on the Columbia River (ODEQ, 2008b & 2008c).

Although coordination and communication are key objectives towards a successful invasive strategy, there is a common problem. To effectively coordinate and manage hundreds of state, federal, international, public, private, tribal, and other agencies, it costs money – and once again, budgets are being cut across the globe. There is at least one extremely cost-effective resource that is crucial to the success of invasive management: the Internet. Over the past decade, a wealth of information regarding invasive species has developed. The Internet allows the spread of this information and knowledge instantaneously at a relatively low price. The Internet has played a crucial role in helping organizations and agencies work and collaborate, utilizing one another's databanks and research.

Despite possibilities, there is room for improvement. State websites need to be improved and linked to one another, allowing them to facilitate access to current information on management activities statewide. Improvements on the latest aquatic invasive species technological advances, data and research need to be made readily available and easily accessible. This increased accessibility to websites and databases will improve statewide coordination and help managers and researchers coordinate and effectively strike down the invasive threat (California Department of Fish and Game (DFG), 2008).

How do we account for the distribution and spread of invasive species? Burdick (2005), senior editor at Discover Magazine, states that the key factor is opportunity. The more frequently and persistently a foreign plant or animal is exposed to a new

environment, the better its odds of invading. If zebra mussels continue to be transported across the natural biogeographic barriers, whether it is the mountain ranges or the oceans, barriers that have historically kept the planet's native species partitioned off, eventually, the zebra mussel will successfully establish itself in yet another location, even if only one or two zebra mussels make it though at a time. It is inevitable that eventually, the persistent, prolific mussel will pass through and become successful.

Although inevitable, management of the zebra mussel must be continued. Educational and outreach programs cannot discontinue at this point. A cost-benefit analysis similar to the report prepared for OISC is a great asset to state management (Cusack et al., 2009). Researching and projecting the control costs to various stakeholders like hydropower facilities or fisheries, provides incentives to create effective policy. If a hydropower plant realizes that an establishment of zebra mussels will cost 25 million dollars a year, it might spend several million to help prevent the invasive from becoming established. Spending millions to save billions has to persist. We will never be able to prevent all introductions. However, early detection of the invasive and quick, coordinated response will allow the containment of an introduction, allowing proper eradication or management of the species, usually at a much lower cost than long-term control, which, as we have seen, can be extremely expensive.

The majority of scientists believe that the zebra mussel cannot be eradicated at this point, so the objective now is to learn to control or accommodate them (Sea Grant,

2001). Research needs to continue; perhaps as more scientific work is done, stronger management and eradication methods will come to light, but until then, we need to continue to educate and raise public awareness.

Every individual has a stake in reducing the negative impacts of invasive species. Federal and State agencies are certainly crucial to the success of invasive species management, but the key resides in the public. Public action of individuals, local businesses, organizations, local agencies and more has to be supported by the larger governmental agencies. Invasive species are everyone's responsibility; however, not everyone realizes this. The public needs to become aware that their actions can result in the introduction and spread of invasive species. Mike Cenci, WDFW deputy chief of enforcement believes that, "Any real success in controlling the spread of the [zebra mussel] will rely heavily on boat owners taking responsibility for their vessels . . . it is important that they know what to look for and thoroughly clean their boats" (2007). It is indeed the responsibility of recreational boaters to clean their boats and equipment before moving from one water body to another. However, it is the responsibility of State officials to spread their knowledge and raise the awareness of the public. Public outreach is the key to the invasive threat.

Federal managers listed above have a similar objective – to coordinate and implement a national cost-efficient and effective effort to address the invasive problem, terrestrial or aquatic. To complete this task, the federal managers consist of intergovernmental agencies, typically comprised of multiple Federal agency reps and ex-

officio members. These coordinated forces have helped achieve a national leadership regarding invasive species. The federal managers have worked effectively with one another, creating several national campaigns like the 100th meridian, an effort that combined state, provincial, and federal government support. These forces have also been extremely beneficial to the management of the individual states, encouraging and working in partnership to create effective state-wide policy.

For instance, ANS Task Force helped both Washington and Oregon to create their state ANS management plans. However, Oregon's publication took nearly five years in comparison to Washington's two. This gap in policy again stunted Oregon's management development. By the time the ANS Task Force created an assessment of their accomplishments, Washington had received three additional years of grants and funding from ANSTF to achieve their goals. Oregon however, still had yet to create a management plan with objectives that would require grant money. This allowed Washington to accomplish a great deal more in the management of the aquatic invasive species.

Currently, Oregon and Washington have had varying levels of success. Failure is typically the result of insufficient policy, inadequate research and management funding, and gaps in scientific knowledge. The general problem is not being addressed. What is needed is comparative policy analysis to address the entire issue of invasive threat, rather than individual invaders (Simberloff et al., 2005). This more complete policy analysis would elucidate which policy approaches are resulting in successful outcomes.

As further collaboration takes place and the sharing of information across continents and among agencies forms, the management of invasive species will strengthen, further protecting the Earth's resources.

Recommendations

There are several key recommendations that have to be addressed if a successful invasive management program is to take place. These objectives have appeared repetitively throughout all invasive management literature, both governmental and nongovernmental. Each objective has been addressed during this paper, but it is vital that each be brought to light within its own context. The following recommendations will enhance invasive species management:

1) **Coordination & Collaboration** – This cannot be reiterated enough. Coordination between all the stakeholders must occur. Voluntary action needs to be encouraged and both private landowners and public land users will have to work together. A collective database needs to be made accessible to everyone, allowing research, management techniques, and case studies to be analyzed and interpreted.

2) **Early detection & monitoring** – Develop and carry out environmentally sound programs that ensure the early detection of new invasive species and monitoring and controlling of current, unwanted species. Successful eradication is more likely if the distribution is limited. This coupled with the fact that early detection of introductions and quick, coordinated response is more cost effective than long-term management is why this objective is listed as number two.

3) **Rapid response & eradication** – This hinges off of early detection and monitoring. The more quickly we are capable of performing a risk assessment of the current invasive, the more quickly we can subdue the introduction and hopefully eradicate the new threat. This requires a collaborative effort to succeed, especially with aquatic invasive species like the zebra mussel!

4) **Prevention** – The most cost effective objective towards the management of invasive species. By minimizing and preventing unintentional introduction and dispersal of invasive species throughout each state, we have saved ourselves possibly billions of dollars in further management costs.

5) **Long-term Management** – If an invasive becomes too well-established, long-term management will have to happen. This objective involves controlling the non-native from spreading further and minimizing its impacts on native habitats and species. This does not need to occur with every individual invasive population. There has to be a clear and significant impact and the control of said population has to be both technically and economically feasible.

6) **Education/outreach** – The public and all stakeholders need to become aware of the threat of invasive species. Impacts of individual species should be made clear as well as providing the preventative measures one can take to reduce their individual impact. Classroom curricula should encourage students to think about invasive species. Educational materials need to be developed and distributed to those individuals who partake in potential invasive activities (i.e. boating, fishing, hiking, biking, traveling, et cetera).

7) **Research** – Tying in with objectives one and six, shared research is a necessity. Currently scientists of universities, institutions, and other state agencies are researching all aspects of biology, ecology, and the control and management of invasive species. As new invasive species become lucid, more research will be essential. Shared knowledge will also prevent ineffective resource allocation (i.e. two scientists spending their time, energy, and money working on the same issue, but not together). There will constantly be a growing demand for research on environmentally safe eradication methods.

8) **Volunteer Efforts** – Do not underestimate the results of volunteer action. Volunteer monitoring groups can play an important role in early detection – especially with zebra mussels. A well-informed beach walker is more cost effective than a paid state official that travels to every beach in a county searching for that characteristically striped shell. Conducting prevention, detection, management, and education are just a few ways volunteers are beneficial towards the overall success.

9) **Policy Improvements** – State and federal laws need to ensure that they are promoting the prevention and management of invasive species management, not hindering it. Increased policy in regions that are invasive introduction hotspots should develop (i.e. ballast water regulations).

10) **Delegation of Responsibility** – Objectives listed in state, federal, or any management plan must be made accountable. Delegation of the completed task must occur at all levels of government.

11) **Assessment/Evaluation** – One of the last recommendations, yet extremely crucial, is the value of assessment and evaluation. Although invaluable, frequently this does not occur. This should be addressed in the initial planning and budging phase of a management plan. The evaluation of a project needs to happen to provide data, tips, strategies, obstacles, to future managers. This assessment needs to be clearly and easily accessible to all.

Conclusion

One might certainly consider globalization a good thing; however, it has a few undesirable traits including a rising amount of invasive species occurrences. As globalization and travel accelerate, an increasing number of pathways and opportunities allowing invasive species to establish themselves in new areas grow exponentially. Invasive species, not only the zebra mussel as identified in this paper, is a threat that must be addressed. The mussel threatens social, economic and ecologic resources. Billions of dollars has been spent on direct control, yet we continue to lose more and more money resource value yearly. Other environmental costs are species extinction and ecosystem degradation. Rivers and all freshwater systems are at high risk of losing native life and biodiversity to the zebra mussel, including the Columbia River Basin.

This analysis of the zebra mussel in the Columbia River Basin indicates that Oregon and Washington must work across jurisdictional boundaries to succeed at invasive management. Recommendations offered in this analysis will develop an effective zebra mussel invasive management plan.

Both Oregon and Washington have varying strengths and weaknesses over one another's management, however if the two began to collaborate more effectively, both management plans would grow synergistically. Invasive species span jurisdictions and geographic boundaries, therefore successful management can only occur if there is coordination across state and national boundaries. Currently, the management of the zebra mussel has been enough to prevent an establishment within the Columbia River Basin; however, increased coordination between Oregon and Washington must take place if the Columbia River Basin is to remain a healthy environment.

List of Acronyms

2001 Plan or The Plan - *National Invasive Species Plan*
2008 Plan - *2008 – 2012 National Invasive Species Management Plan*
ANS - Aquatic Nuisance Species
ANSTF or ANS Task Force - Aquatic Nuisance Species Task Force
DFG - California Department of Fish and Game
DNR - Department of National Resources DOA - Department of Administration
DOE - Department of Ecology
DOT - Department of Transportation
EPA - Environmental Protection Agency
FY 2004 - Fiscal Year 2004
GMRI - Gulf of Main Research Institute
MES - Master of Environmental Studies
NANPCA - *Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990*
NISA - National Invasive Species Act of 1996
NISC - National Invasive Species Council
NGO - Non-governmental organization
NWCB - Noxious Weed Control Board
ODOA - Oregon Department of Agriculture
ODEQ - Oregon Department of Environment Quality
ODFW - Oregon Department of Fish and Wildlife
OISC - Oregon Invasive Species Council
PAH - Polycyclic aromatic hydrocarbon
PCB - Polychlorinated biphenyl
PSU - Portland State University
PVC - Polyvinyl chloride
SAH - Stop Aquatic Hitchhikers!
The Center - The Center for Lakes and Reservoirs at Portland State University
US - United States
USACE - United States Army Corps of Engineers
USCG - United States Coast Guard
USDA - United States Department of Agriculture
USDI - United States Department of the Interior
USFWS - United States Fish and Wildlife Service
WDFW - Washington Department of Fish and Wildlife
WISC - Washington Invasive Species Council

Literature Cited:

Alberta Invasive Plants Council. (2009). *Who Should Care?* Retrieved April 28, 2009, from http://www.invasiveplants.ab.ca/whoshouldcare.htm.

Aquatic Nuisance Species Task Force. (2004). Report to Congress – Fiscal Year 2004. Retrieved April 15, 2009, from http://www.anstaskforce.gov/Documents/ANSTF_RTC_Final.pdf.

Aquatic Nuisance Species Task Force. (2007, March). *Strategic Plan (2007 – 2012).* Retrieved April 15, 2009, from http://www.anstaskforce.gov/Documents/ANSTF_Strategic_Plan_2007_Final.pdf.

Aquatic Nuisance Species Task Force. (2009a). *Harmful Aquatic Hitchhikers: Mollusks: Zebra Mussel*. Retrieved March 9, 2009, from http://www.anstaskforce.gov/default.php.

Aquatic Nuisance Species Task Force. (2009b). *The Aquatic Nuisance Species (ANS) Task Force. Dedicated to the prevention and control of aquatic nuisance species.* Retrieved April 15, 2009, from http://www.anstaskforce.gov/taskforce.php.

Aquatic Nuisance Species Task Force. (2009c). ANSTF Membership Contact List. Retrieved May 20, 2009, from http://www.anstaskforce.gov/ANSTF_Members_May_2009.pdf.

Burdick, A. (2005, May). *The Truth about Invasive Species – How to stop worrying and learn to love ecological intruders*. Discover Magazine. Retrieved April 28, 2009, from http://discovermagazine.com/2005/may/cover.

California Department of Fish and Game. (2008). *California Aquatic Invasive Species Management Plan*. State of California Resources Agency. Retrieved May 1, 2009, from http://groups.ucanr.org/Ballast_Outreach/files/49547.pdf.

Center for Lakes and Reservoirs at the Portland State University. (2001, June). *Oregon Aquatic Nuisance Species Management Plan*. Produced by Erik Hanson and Mark Sytsma. Retrieved April 15, 2009, from http://www.clr.pdx.edu/publications/files/OR_ANS_Plan.pdf.

Claudi, R. and G.L. Mackie. (1993). *Practical Manual for Zebra Mussel Monitoring and Control*. Boca Raton: Lewis Publishers.

Cusack, C., Harte, M., & Chan, S. (2009). *The Economics of Invasive Species.* Prepared for the Oregon Invasive Species Council. Retrieved May 1, 2009, from http://www.oregon.gov/OISC/docs/pdf/economics_invasive.pdf.

The Columbian. (2002, June). *Boaters Asked to Watch Out for Mussels*. Pg. C.3.

Executive Order No. 13112. (1999, February). *Invasive Species*. Federal Register. Vol. 64, No. 25. Retrieved March 9, 2009, from http://www.archives.gov/federal-register/executive-orders/1999.html.

Global Change Master Directory. (1999). *Zebra Mussel Monitoring in Washington State*. Retrieved March 9, 2009, from http://gcmd.nasa.gov/records/GCMD_wa_de_zebramusselmonitoring.html.

Gulf of Main Research Institute. (2005). *Zebra Mussels*. Retrieved March 9, 2009, from http://www.gma.org/surfing/human/zebra.html.

Habitattitude. (2009). *Habitattitude – Adopt a conservation mentality. Protect our environment by not releasing unwanted fish and aquatic plants.* Retrieved April 15, 2009, from http://habitattitude.net/.

Independent Scientific Advisory Board. (2007). *Human Population Impacts on Columbia River Basin Fish and Wildlife*. ISAB Human Population Report 2007-3.

National Atlas of the United States. (2008). *Zebra Mussel Distribution in North America*. Retrieved March 9, 2009, from http://nationalatlas.gov/mld/zmusslx.html.

National Invasive Species Council. (2001). *Meeting the Invasive Species Challenge: National Invasive Species Management Plan.* Retrieved April 10, 2009, from http://www.invasivespeciesinfo.gov/docs/council/mpfinal.pdf.

National Invasive Species Council. (2003, October). *Progress Report on the National Invasive Species Management Plan.* Retrieved April 10, 2009, from http://www.invasivespeciesinfo.gov/council/progressrpt2003.pdf.

National Invasive Species Council. (2005, July). *Progress Report on the Meeting the Invasive Species Challenge: National Invasive Species Management Plan.* Retrieved April 10, 2009, from http://www.invasivespeciesinfo.gov/council/progressrpt2005.pdf.

National Invasive Species Council. (2008). *2008 – 2012 National Invasive Species Management Plan.* Retrieved March 9, 2009, from http://www.invasivespeciesinfo.gov/council/mp2008.pdf.

National Invasive Species Council. (2009). Home Page. Retrieved March 9, 2009 from http://www.invasivespeciesinfo.gov/council/main.shtml.

National Research Council. (2004). *Managing the Columbia River: Instream Flows, Water Withdrawals, and Salmon Survival*. National Academies Press.

New York Sea Grant. (1994). "Policy issues." *Dreissena polymorpha.* Information review. Zebra Mussel Clearinghouse Newsletter 5(1):14-15.

Nijhuis, Michelle. (2007, March). *Wish You Weren't Here.* High Country News. Vol. 39, Iss. 4; pg. 8, 7 pgs.

O'Neill, C. (1997). *Economic impact of zebra mussels - Results of the 1995 National Zebra Mussel Information Clearinghouse Study*. Great Lakes Research Review 3(1).

Oregon Department of Environmental Quality. (2008a). *Shipping Transport of Aquatic Invasive Species Task Force*. Retrieved March 9, 2009, from http://www.deq.state.or.us/lq/pubs/factsheets/cu/ShippingTransportofAquaticInvasiveSpecies.pdf.

Oregon Department of Environmental Quality. (2008b, September). *Management of Aquatic Invasive Species Risks from Shipping Transport Pathways.* Prepared by The Oregon Task Force on the Shipping Transport of Aquatic Invasive Species for the 2009 Oregon State Legislature. Retrieved March 9, 2009, from http://www.deq.state.or.us/lq/pubs/docs/cu/STAISManagingAquaticInvasiveSpeciesRisks.pdf.

Oregon Department of Environmental Quality. (2008c, October). *Aquatic Invasive Species Task Force Makes Recommendations to 2009 Legislature*. News Release. Retrieved March 9, 2009, from http://www.deq.state.or.us/news/prDisplay.asp?docID=2760.

Oregon Department of Environmental Quality. (2009). *About Us*. Retrieved March 9, 2009, from http://www.oregon.gov/DEQ/.

Oregon Department of Fish and Wildlife. (2005, June). *Oregon Invasive Species Action Plan*. Retrieved March 9, 2009, from http://oregon.gov/OISC/docs/pdf/oisc_plan6_05.pdf.

Oregon Department of Fish and Wildlife. (2006, February). *The Oregon Conservation Strategy.* Retrieved March 9, 2009, from http://www.dfw.state.or.us/conservationstrategy/document_pdf/Foreword.pdf.

Oregon Invasive Species Council. (2007). *Report Card*. Retrieved March 9, 2009, from http://oregon.gov/OISC/docs/pdf/oisc_rpt_card07.pdf.

Oregon Invasive Species Council. (2008, April). *Oregon Launches "Stop the Invasion" Statewide Campaign Against Invasive Species.* Retrieved March 9, 2009, from http://www.oregon.gov/OISC/docs/pdf/pr_campaign408.pdf.

Oregon State Legislature. (2007). *Chapter 561 – State Department of Agriculture*. Retrieved March 9, 2009, from http://www.leg.state.or.us/ors/561.html.

Oregon State Legislature. (2007b). *Chapter 783 – Liabilities and Offenses Connected with Shipping and Navigation*; Shipbreaking; Ballast Water. Retrieved March 9, 2009, from http://www.leg.state.or.us/ors/783.html.

Parker, B.C., Patterson M.A., and Neves, R.J. (1998). *Feeding interactions between native freshwater mussels (Bivalvia-Unionidae) and zebra mussels (Dreissena polymorpha) in the Ohio River.* American Malacological Bulletin 14:173-179.

Public Law 101-636. (1990, December). Nonindegenous Aquatic Nuisance Prevention and Control Act of 1990 [As Amended Through P.L. 106-580, Dec. 29, 2000]. Retrieved April 15, 2009, from http://www.anstaskforce.gov/rules.php.

Public Law 104-332. (1996, October). *National Invasive Species Act of 1996.* Retrieved April 15, 2009, from http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=104_cong_public_laws&docid=f:publ332.104.pdf.

Rizzo, D.M., and Garbelotto, M. (2003). Sudden oak death: endangering California and Oregon forest ecosystems. *Front Ecol Environ* 1 (5): 197-204. Retrieved May 20, 2009, from http://www.suddenoakdeath.org/pdf/MGBinder.Frontiers.Rizzo.pdf.

Sea Grant. (2001, September). *Zebra Mussels and Other Non-indigenous Species*. Retrieved March 10, 2009 from

http://www.seagrant.wisc.edu/Communications/greatlakes/glnetwork/exotics.html.

Simberloff, D., Parker, I., and Windle, P. (2005). Introduced species policy, management, and future research needs. *Front Ecol Environ*. 3(1): 12-20.

Stop Aquatic Hitchhikers! (2009). Protect Your Waters and Stop Aquatic Hitchhikers! Retrieved April 15, 2009, from http://www.protectyourwaters.net/.

United States Army Corps of Engineers. (2002). *Zebra Mussel Information System*. Retrieved March 9, 2009, from http://el.erdc.usace.army.mil/zebra/zmis/.

United States Department of the Interior. (2008, August). *News Release: Secretary Kempthorne, Secretary Schafer and Other Leaders Adopt National Plan to Combat Invasive Species*. Retrieved April 10, 2009, from http://www.doi.gov/news/08_News_Releases/080801.html.

United States Department of the Interior. (2007). Integrated Pest Management Policy. Department Manual. Series: Environmental Quality Programs Part 517: Pesticides. Retrieved May 20, 2009, from http://www.fws.gov/contaminants/Documents/DOI517DM1.pdf.

United States Fish and Wildlife Service. (1990, August). Pest Management Policy and Responsibilities. Release 30-5. Retrieved May 20, 2009, from http://www.fws.gov/contaminants/Documents/FWS30AM12.pdf.

United States Fish and Wildlife Service. (2009, April). *Invasive Species.* Retrieved April 15, 2009, from http://www.fws.gov/invasives/.

United States Fish and Wildlife Service. (2007). 100th Meridian Initiative – Help us stop the spread of Aquatic Nuisance Species. Retrieved April 15, 2007, from http://100thmeridian.org/.

United States Geographic Names. (1980). Feature Detail Report for: Columbia River. Retrieved March 9, 2009, from http://geonames.usgs.gov/pls/gnispublic/f?p=gnispq:3:558267075972371::NO::P3_FID:1140014

United States Geological Survey. (2009). Zebra Mussel Sightings Distribution. Retrieved March 9, 2009, from

http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/zebramusseldistribution.asp.

Walker, T. (1991). Dreissena disaster: scientists battle an invasion of zebra mussels – Dreissena polymorpha – Cover Story. *Science News*. Retrieved May 20, 2009, from http://findarticles.com/p/articles/mi_m1200/is_n18_v139/ai_10808825/.

Washington Department of Ecology. (2009). Ecology's Zebra Mussel Monitoring Program. Retrieved March 9, 2009, from http://www.ecy.wa.gov/programs/eap/lakes/wq/lk_zebra.html.

Washington Department of Fish and Wildlife. (2001a). Washington State Aquatic Nuisance Species Management Plan. Retrieved March 9, 2009, from http://wdfw.wa.gov/fish/ans/2001ansplan.pdf.

Washington Department of Fish and Wildlife. (2001b). State zebra mussel monitoring program seeks Northwest Washington volunteers. News Release Archive. Retrieved March 9, 2009, from http://wdfw.wa.gov/do/newreal/release.php?id=aug0101a.

Washington Department of Fish and Wildlife. (2007). First Washington citations issued for zebra mussel contamination. News Release Archive. Retrieved March 9, 2009, from http://wdfw.wa.gov/do/newreal/release.php?id=oct2907a.

Washington Invasive Species Council. (2007). *Invaders at the Gate – 2008 Strategic Plan.* Retrieved March 9, 2009, from http://www.rco.wa.gov/documents/Invasive_Species/InvasiveSpeciesStrategicPlan.pdf.

Washington Invasive Species Council. (2009, February). Homepage. Retrieved March 9, 2009, from http://www.rco.wa.gov/invasive_species/council.htm.

Washington State Legislature. (2006). Engrossed Substitute Senate Bill 5385. Retrieved March 9, 2009, from http://www.leg.wa.gov/pub/billinfo/2005-06/Pdf/Bills/Senate%20Bills/5385-S.E.pdf.

Washington State Legislature. (2007). RCW 77.60.130 Aquatic nuisance species committee. Retrieved March 9, 2009, from http://apps.leg.wa.gov/rcw/default.aspx?cite=77.60.130.

Woods Hole Oceanographic Institute. (1952). *Marine Fouling and Its Prevention.* Contribution No. 580 from the Woods Hole Oceanographic Institute. George Banta Publishing Co., Menasha, WI. Retrieved May 1, 2009, from https://darchive.mblwhoilibrary.org/bitstream/1912/191/8/chapter%201.pdf.

Wu, L. and D.A. Culver. (1991). Zooplankton grazing and phytoplankton abundance: An assessment before and after invasion of *Dreissena polymorpha.* J. Great Lakes Res.