DEPARTMENT OF
ECOLOGY
State of Washington

Final Environmental Impact Statement

Management of Zostera Japonica on Commercial Clam Beds in Willapa Bay, Washington

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Final Environmental Impact Statement: Management of *Zostera japonica* on Commercial Clam Beds in Willapa Bay, Washington

March 26 2014

Water Quality Program

Washington State Department of Ecology

Olympia, Washington

Cover Memo

March 26, 2014

Management of *Zostera japonica* on Commercial Clam Beds
in Willapa Bay, Washington
Final Environmental Impact Statement

Environmental Review. This Final Environmental Impact Statement (FEIS) is being distributed to Tribes, agencies, organizations, and individuals with an interest in the Ecology proposal to issue a National Pollutant Discharge Elimination System (NPDES) general permit for the use of the herbicide imazamox on commercial clam beds (excluding geoducks) in Willapa Bay, Washington, for the purpose of controlling the non-native seagrass *Zostera japonica (Z. japonica)*. The proposed action analyzed in this FEIS is the discharge of imazamox onto commercial clam beds in Willapa Bay for the purpose of controlling *Z. japonica*. The FEIS analyzes the potential impacts of the proposed action and alternative management methods for controlling *Z. japonica* on commercial clam beds in Willapa Bay.

Washington State Department of Ecology Action Required. The proposed action requires coverage under a NPDES State waste discharge permit. The Washington State Department of Ecology (Ecology) may issue coverage under a NPDES general permit to licensed pesticide applicators and their sponsors requesting coverage under the permit.

The permit defines a sponsor to mean an individual or an entity (business) that has the legal authority to make a decision to apply herbicide to its commercial clam beds. A sponsor will typically be a commercial clam grower with a vested or financial interest in the control of *Z. japonica* on their property. The sponsor may hire or contract with a licensed applicator to apply pesticides or the applicator may be the sponsor or a staff member of the sponsor's business. Entities such as a consortium of individual growers cannot be sponsors under this permit.

The duration of the proposed NPDES general permit is five years.

Other Permits and Approvals Required. Applicators will also be required to obtain a license for aquatic application of registered pesticides from the Washington State Department of Agriculture. Authorization under a local (City or County) shoreline permit may also be required.

Public Review and Comment Opportunities. Tribal, agency, and public comments were invited on the proposed action and alternatives. The FEIS is available in electronic format on Ecology's website at: http://www.ecy.wa.gov/programs/wq/pesticides/eelgrass.html.

Printed versions of the FEIS are available for review at the location indicated below.

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Comments were due to Nathan Lubliner of Ecology's Water Quality Program by 5 p.m. on February 15, 2014. All comments submitted within the 45-day comment period (January 2, 2014 through February 15, 2014) will receive a response in the FEIS.

The Proposal and Alternatives. The Washington State Department of Ecology proposes to issue a NPDES general permit for a period of five years to allow discharge of the aquatic herbicide imazamox and marker dyes to Willapa Bay for the management of *Z. japonica* on commercial clam beds.

The FEIS evaluates three alternatives for implementing the proposed action of controlling *Z. japonica* on commercial clam beds: 1) No Action–Continuing Existing Management Practices, 2) Use of Chemical Methods Only, and 3) Use of an Integrated Pest Management (IPM) Approach with Adaptive Management Principles.

Alternative 3 is the preferred alternative. Shellfish growers would combine the use of chemical treatments with existing manual and mechanical methods of *Z. japonica* control to achieve the most efficacy while minimizing use of the herbicide in the aquatic environment.

Key Environmental Issues. The Washington State Department of Ecology (Ecology) Water Quality Program and Shorelands and Environmental Assistance (SEA) Program administers the State's Water Pollution Control Act (Chapter 90.48 RCW). Under this authority, Ecology must balance competing beneficial uses, and avoid contamination or other alteration of the physical, chemical or biological properties of waters of the state. To facilitate its review of these issues, the FEIS describes existing conditions for the following elements of the affected environment of Willapa Bay, and evaluates the potential impacts, including cumulative impacts, and mitigation measures for the proposed action in relation to existing conditions: sediments, air quality, surface water, plants, animals, birds, mammals, threatened and endangered species, aesthetics, recreation, navigation, and human health.

The Ecology Water Quality Program appreciates your interest in this proposal. If you would like more information about the proposed use of the herbicide imazamox to control the non-native seagrass *Z. japonica* on commercial clam beds in Willapa Bay and/or the environmental review that has been conducted, please contact Nathan Lubliner, Aquatic Plant Specialist, at the physical address, e-mail address, or telephone number indicated above.

Thank you.

Heather R. Bartlett
Heather R. Bartlett
Water Quality Program Manager

Date: 3/26/14

Fact Sheet

Project Title:	Management of *Zostera japonica* on commercial clam beds in Willapa Bay, Washington.
Project Description:	The proposed action is to discharge the herbicide imazamox for control of the State-listed noxious weed *Zostera japonica* on commercial clam beds in Willapa Bay. Issuance of a five-year National Pollutant Discharge Elimination System (NPDES) general permit by the Washington State Department of Ecology (Ecology) is required to authorize the use of imazamox. This is a non-project proposal under the State Environmental Policy Act (SEPA) rules. The Environmental Impact Statement (EIS) will be integrated with on-going agency planning and permitting processes for aquatic herbicides.
Purpose and Objectives:	The Willapa-Grays Harbor Oyster Growers Association (WGHOGA) has requested a NPDES general permit for the purpose of allowing chemical treatment of the noxious weed *Zostera japonica* with the herbicide imazamox on commercial clam beds in the Willapa Bay tide flats. The objectives of the proposal are to: • Facilitate the commercial cultivation and harvest of clams on Willapa Bay tide flats by reducing obstructions and other effects caused by the presence of *Z. japonica*. • Maintain beneficial uses of State waters. • Control a State-listed noxious weed on commercial clam beds in Willapa Bay.
Alternatives Considered:	This FEIS identifies and analyzes three alternatives as follows: 1. No Action – Continuing Existing Management Practices (status quo) 2. Use of Chemical Methods Only 3. Use of an Integrated Pest Management (IPM) Approach with Adaptive Management Principles. Alternative 3 is the preferred alternative, where shellfish growers would combine the use of chemical treatments with existing manual and mechanical methods of *Z. japonica* control to achieve the greatest efficacy in controlling *Z. japonica* while minimizing the use of imazamox in the aquatic environment. The FEIS also includes a section that describes other alternatives considered and eliminated from detailed evaluation.
Project Proponent:	Willapa-Grays Harbor Oyster Growers Association (WGHOGA) PO Box 3 Ocean Park, WA 98640

Lead Agency:	Washington State Department of Ecology Water Quality Program PO Box 47696 Olympia, WA 98504-7696
SEPA Responsible Official:	Heather R. Bartlett, Program Manager Water Quality Program
Contact Person, and Person to Whom to Direct Comments:	Nathan Lubliner, Aquatic Plant Specialist Water Quality Program Phone: 360-407-6563 Fax: 360-407-6426 nathan.lubliner@ecy.wa.gov
Permits and Approvals Required:	The list below reflects State and local permits and licenses that may be required for the chemical control of *Z. japonica* in Willapa Bay. Requirements may change or may vary for a particular commercial shellfish operation. Applicants should check with State resource agencies and local and Federal government agencies to determine actual permit requirements for their particular project.
Washington State Department of Ecology:	Coverage under NPDES / State waste discharge permit
Washington Department of Agriculture:	Applicator's license for aquatic application of registered pesticides
Local Government(s):	Shoreline Permit (possible in certain locations)
EIS Authors and Principal Contributors:	Jacob Moore, formerly with Willapa-Grays Harbor Oyster Growers Association Brian Sheldon, Willapa-Grays Harbor Oyster Growers Association Morris, Vicki Morris Consulting Services Nathan Lubliner, Ecology Water Quality Program Kathy Hamel (Retired), Ecology, Water Quality Program
FEIS Date of Issue:	March 26, 2014
Draft EIS Comment Period:	January 2, 2014 through February 15, 2014
Address Comments to:	Nathan Lubliner, Aquatic Plant Specialist Washington State Department of Ecology Water Quality Program PO Box 47696 Olympia, WA 98504-7696 360-407-6563 nathan.lubliner@ecy.wa.gov

Location of Reference Material:	Water Quality Program Department of Ecology 300 Desmond Drive Olympia, WA 98503
Availability:	A digital version of this FEIS is available on Ecology's website at: http://www.ecy.wa.gov/programs/wq/pesticides/eelgrass.html
Schedule for Implementation:	The schedule is to make a decision on issuance of the NPDES General Permit by spring 2014.

Reader's Guide for this Final EIS

An Environmental Impact Statement (EIS) attempts to strike a balance between the technical information and format required by the State Environmental Policy Act (SEPA), and readability for persons interested in the project who may be unaccustomed to this manner of organizing the document. The Reader's Guide highlights the contents of this FEIS, and suggests locations where information of interest can most readily be found.

Information in this FEIS was drawn from a variety of sources and the citations provided come from research that was performed for various purposes that range from dissertations, to the advancement of the body of knowledge in scientific journals, to a response to shellfish industry concerns. Citations can be grouped into three categories reflecting various levels of scientific rigor:

1) Peer reviewed and published scientific journal articles.
2) Grey literature, which includes: Agency technical reports, consulting company white papers, websites, and unpublished study results.
3) Anecdotal observations and personal communications.

The **Table of Contents** provides a complete list of the subjects covered in the document. Lists of figures and tables may also be a key to the location of topics of interest.

Chapter 1 provides an introduction to the issue, the purpose and need to which the proposal is responding, and brief descriptions of the proposed action and alternative *Zostera japonica* management methods considered. Potential impacts of implementing the proposed action, and measures to avoid, minimize, or compensate for these impacts (mitigation measures) are summarized in a table in Chapter 1. Areas of controversy and uncertainty are described in Section 1.6. The reader is encouraged to review more detailed information in Chapters 2 and 3 on any topic summarized in Chapter 1, to gain a more complete, "in-context" understanding.

Chapter 2 describes the purpose and objectives of the proposal, explains Manila clam aquaculture, and describes current adverse economic impacts associated with *Z. japonica* colonization on commercial clam beds in Willapa Bay. A section in this chapter describes the regulatory context that applies to commercial shellfish aquaculture, *Z. japonica* as a noxious weed, physical/mechanical methods used to control *Z. japonica*, and chemical applications, including EPA statutory requirements for pesticides. This chapter also includes a more thorough description of the alternative management approaches considered, and includes a table that summarizes the potential impacts of each alternative. Potential cumulative impacts associated with use of another aquatic pesticide in Willapa Bay for which Ecology has received an application are described in Section 2.9.

Chapter 3 is the real substance of the environmental review presented in the FEIS. It begins with a Biological Background Information section that summarizes the results of a large number of scientific studies that provide more information about *Z. japonica*, its distribution, how it functions in the estuarine environment, and how it compares to the native eelgrass (*Z. marina*). Thereafter, the chapter is organized by elements of the environment: sediments, air quality, surface water, plants, animals, birds, mammals, threatened and endangered species, aesthetics, recreation, navigation, and human health. Existing environmental conditions are described for each of these elements under the heading Affected Environment. Following the description of the environmental setting, Potential Impacts are described for each of the alternatives. Each impact analysis is followed by a description of mitigation measures that could be implemented to avoid or minimize potential adverse impacts of measures to control *Z. japonica* on commercial clam beds in Willapa Bay. All sources cited throughout the document are listed in **Chapter 4: References**.

Ecology's contact person regarding the proposed issuance of the NPDES general permit and this Environmental Impact Statement is Nathan Lubliner, Aquatic Plant Specialist. His address, telephone number, and e-mail address are provided in the Cover Memo that precedes this Reader’s Guide. Instructions for submitting written comments also appear in the Cover Memo. Notice of availability of the FEIS will be sent to all affected agencies, Tribes, organizations, and interested parties.

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1.0 Summary

At the request of the Willapa-Grays Harbor Oyster Growers Association (WGHOGA), the Washington State Department of Ecology (Ecology) is proposing to develop a general permit under the National Pollutant Discharge Elimination System (NPDES) for the control of the State-listed noxious weed *Zostera japonica* (Japanese eelgrass) on commercial clam beds (excluding geoducks) in Willapa Bay, Pacific County, Washington. The proposed permit would authorize *Z. japonica* control activities that result in the discharge of the aquatic herbicide imazamox and marker dyes in Willapa Bay.

Ecology issues general permits in place of a series of individual permits when the permitted activities are similar. Agencies, organizations and individuals that receive coverage under the general permit must comply with the terms and conditions of the permit.

As lead agency under the Washington State Environmental Policy Act (SEPA), Ecology has made the determination that issuance of a NPDES general permit for management of *Z. japonica* on commercial clam beds in Willapa Bay may have significant environmental impacts, therefore requiring that an Environmental Impact Statement (EIS) be prepared. Ecology asked the applicant (WGHOGA) to prepare the Draft EIS for Ecology's review and use, to evaluate the potential impacts of and mitigation measures for applications of imazamox (and alternative or supplemental measures) to control *Z. japonica* on commercial clam beds in Willapa Bay.

Z. japonica occupies tideflats of the west coast of North America extending from Vancouver Island, British Columbia to Humboldt Bay, California (Baldwin and Lovvorn 1994; and McBride 2002). *Z. japonica* is capable of colonizing unvegetated tideflats and has become well established in Willapa Bay, Washington. *Z. japonica* reproduces both vegetatively via rhizomatous growth and through production of viable seed. Since the mid- to late 1990s, the total area of *Z. japonica* has increased in Willapa Bay, altering formerly unvegetated tideflats through changes in water flow, and rate and location of sedimentation (Fisher, Bradley and Patten 2011).

The Washington Department of Fish and Wildlife (WDFW), Washington State Noxious Weed Control Board (WSNWCB), and Washington State Department of Ecology’s Shorelands and Environmental Assistance Program (Ecology SEA) recently clarified that *Z. japonica* is not to be afforded the same protections as the native eelgrass *Zostera marina (Z. marina)*. In 2011, WDFW changed the Priority Habitats and Species listing from *Zostera* spp. to *Z. marina* in order to clarify that it is not the intent of WDFW to protect *Z. japonica*. In January 2012, WSNWCB listed *Z. japonica* as a Class C noxious weed on commercially managed shellfish beds (WAC 16-750-015). In January 2013, WSNWCB expanded the listing of *Z. japonica* as a Class C noxious weed to all areas of the State, and affirmed the classification in November 2013. In August 2013, Ecology SEA clarified that *Z. japonica* would no longer be considered a critical saltwater habitat within Shoreline Master Programs under WAC 173-26-221(2)(c)(iii)(A).

At this time, there is not a clear consensus among scientists whether *Z. japonica* acts as a beneficial non-native or whether it is a noxious invasive species (Shafer et al. 2013). At the Science and Management of *Zostera japonica* in Washington: A Meeting for State Agencies (Ecology 2013), a summary of the panel’s assessment of ecosystem services provided by

Z. japonica was developed. The panel's summary of available scientific information identified 12 ecosystem services provided by *Z. japonica* that support natural resources and function, two that had negative impacts and three with no impacts. The panel's assessment of the economic effects of *Z. japonica* identified five impacts that negatively affected livelihoods and socioeconomic services, and one with a positive effect and one with no effect.

Williams (2007), in a paper about seagrass status and concerns, observed that *Z. japonica* poses a management conundrum in Washington State. *Z. japonica* populations add new habitat, increase primary productivity and biodiversity in estuaries, but populations are expanding and not all impacts are known. Shellfish growers are seeing negative impacts on hard-shell clam production from *Z. japonica*, and this triggered their decision to request listing this species as a noxious weed in Washington.

In an ecological analysis of Washington seagrasses, Pawlak and Olson (1995) observed that when State agencies treat all eelgrass species the same, the assumption is that the habitat altered by the non-native eelgrass is equal to or greater than the habitat that it replaces, and that *Z. japonica* does not pose a direct or indirect threat to native species or other habitat. They concluded that although the research available did not suggest that *Z. japonica* would be an ecosystem threat, there were unknowns, particularly as related to vegetation of previously unvegetated tideflats by *Z. japonica*.

Z. japonica forms dense populations that reduce clam condition (meat weight per clam on tide flats (Tsai 2010). The extensive root and rhizome network as well as the foliage interfere with the cultivation and harvest of shellfish (personal communications with WGHOGA members 2011; and Fisher Bradley and Patten 2011). Recent data also show that *Z. japonica* provides cover for shellfish seed predators, and acts to convert tideland substrate to conditions suitable for other predators (Patten 2013 and Ruesink 2013; see Washington State Department of Ecology 2013).

WGHOGA originally asked Ecology's Water Quality Program to develop a NPDES general permit to authorize use of the aquatic herbicide imazamox to control *Z. japonica* on commercial shellfish beds throughout Washington. After receiving public and agency input on the proposed permit development, Ecology narrowed the focus to only commercial clam beds (excluding geoduck beds) in Willapa Bay. For the purposes of the proposed permit, Ecology defines a commercial clam bed to mean "a marine or estuarine clam growing area where clams are raised and harvested for sale under a current Washington State business license."

The preferred alternative for managing *Z. japonica* is an Integrated Pest Management (IPM) approach that uses the most effective combination of existing management practices, chemical methods, and adaptive management elements. Other alternatives analyzed include No Action–continuation of current practices only; and Chemical Methods Only. Several methods used to control aquatic vegetation in freshwater environments where no clam crop is present were found to be impractical for the proposed action. These are described in FEIS Section 2.7.4, and were eliminated from further consideration.

1.1 Introduction and Problem Formulation

Eelgrass

There are two species of eelgrass found in Washington: the native species (*Zostera marina*), and the non-native species (*Zostera japonica)*. Common names for *Z. japonica* include Japanese eelgrass, dwarf eelgrass, Asian eelgrass, duck grass, and narrow-bladed eelgrass (Mach et al. 2010).

Z. japonica is native to Asia, specifically the far east of the Russian Federation, China (Hebei, Liaoning, and Shandong Province), Japan, Korea, Taiwan, and Vietnam (WSNWCB 2011). Its native range includes tropical and sub-tropical latitudes, but scientists generally regard *Z. japonica* as a temperate species (Lee 1997; and Shin and Choi 1998, as cited in Ruesink et al. 2010). In parts of its native range on western Pacific shores (i.e., in Asia), *Z. japonica* is declining, but it is increasing where introduced (Lee 1997 as cited in Ruesink et al. 2010). In Willapa Bay, Fisher, Bradley and Patten (2011) report *Z. japonica* has been present since the mid-1950s. The authors note that populations did not expand until about 1998, at which time populations of *Z. japonica* "exploded and aggressively carpeted many areas of Willapa Bay" (Ruesink 2010).

Shellfish growers farming in Willapa Bay report that *Z. japonica* is interfering with shellfish production (particularly Manila clam culture). Manila clams (*Venerupis philippinarum*) represent a substantial portion of the shellfish industry in Willapa Bay. A suitable tidal elevation for Manila clam cultivation is 0 to + 5 meters (m) above mean lower low water (MLLW). Growers have reported that *Z. japonica* has colonized these formerly unvegetated intertidal zones used for Manila clam culture in Washington, interfering with shellfish planting and harvesting, and reducing yields (Fisher Bradley and Patten 2011).

The total area of Willapa Bay is approximately 88,000 acres. Ruesink et al. (2010) reported that, as of 1997, Z. *marina* occupied 9.6% of Willapa Bay and Z. *japonica* occupied 7.7%. Ten years later, in a 2006/2007 survey of Willapa Bay, Dr. Dumbauld with the U.S. Department of Agriculture (USDA) estimated that there were approximately 13,762 acres of Z. *marina* (15.6% of Willapa Bay) and 12,183 acres of Z. *japonica* (13.8% of Willapa Bay) (see Figure 1-1) (Dumbauld and McCoy 2006/2007). This did not include any acres with thinly populated *Z. japonica*. To illustrate that *Z. japonica* distribution in Willapa Bay is thought by some to be expanding, an estimation of *Z. japonica* distribution was conducted in 2012 using anecdotal data to estimate that 18,000 acres of *Z. japonica* occurred in Willapa Bay (Figure 1-2).

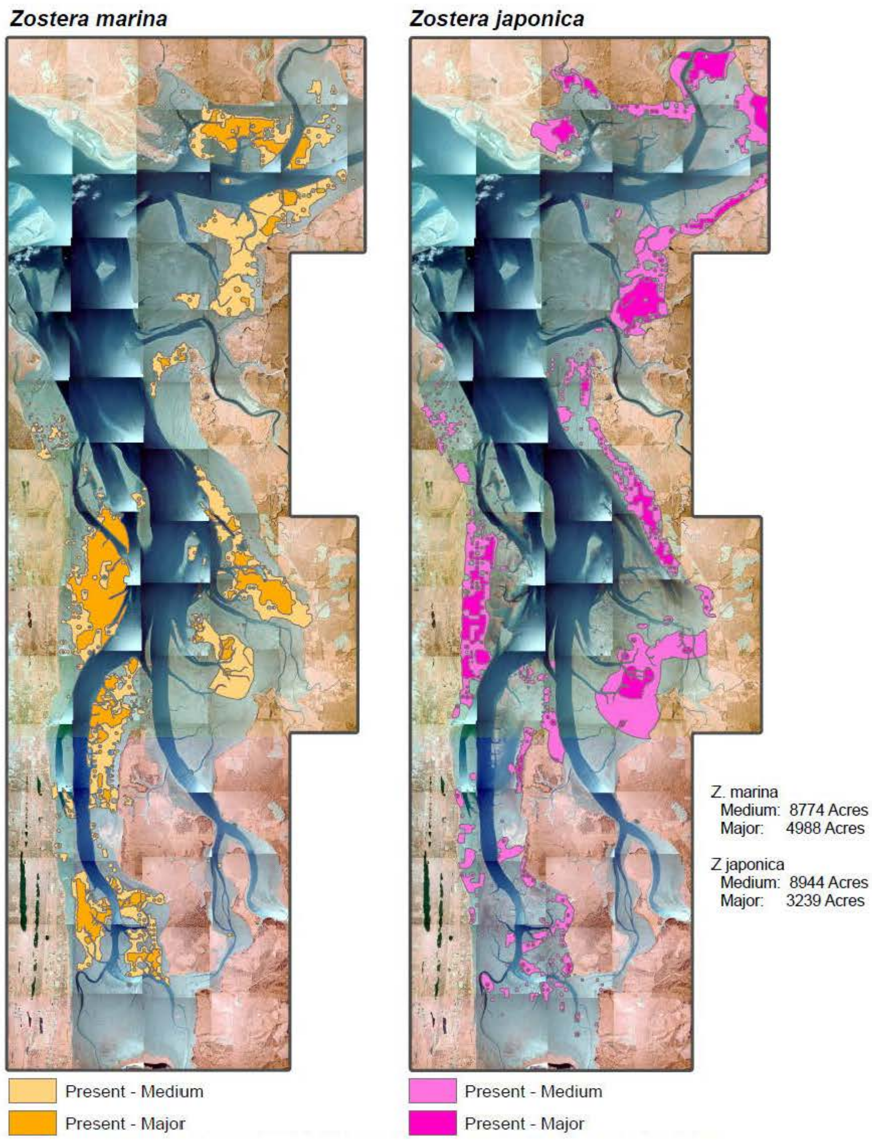

Figure 1-1. Interpolated *Zostera marina* and *Zostera japonica* density and distribution from 2006/2007 grid survey by USDA of 4,238 points throughout Willapa Bay, WA.

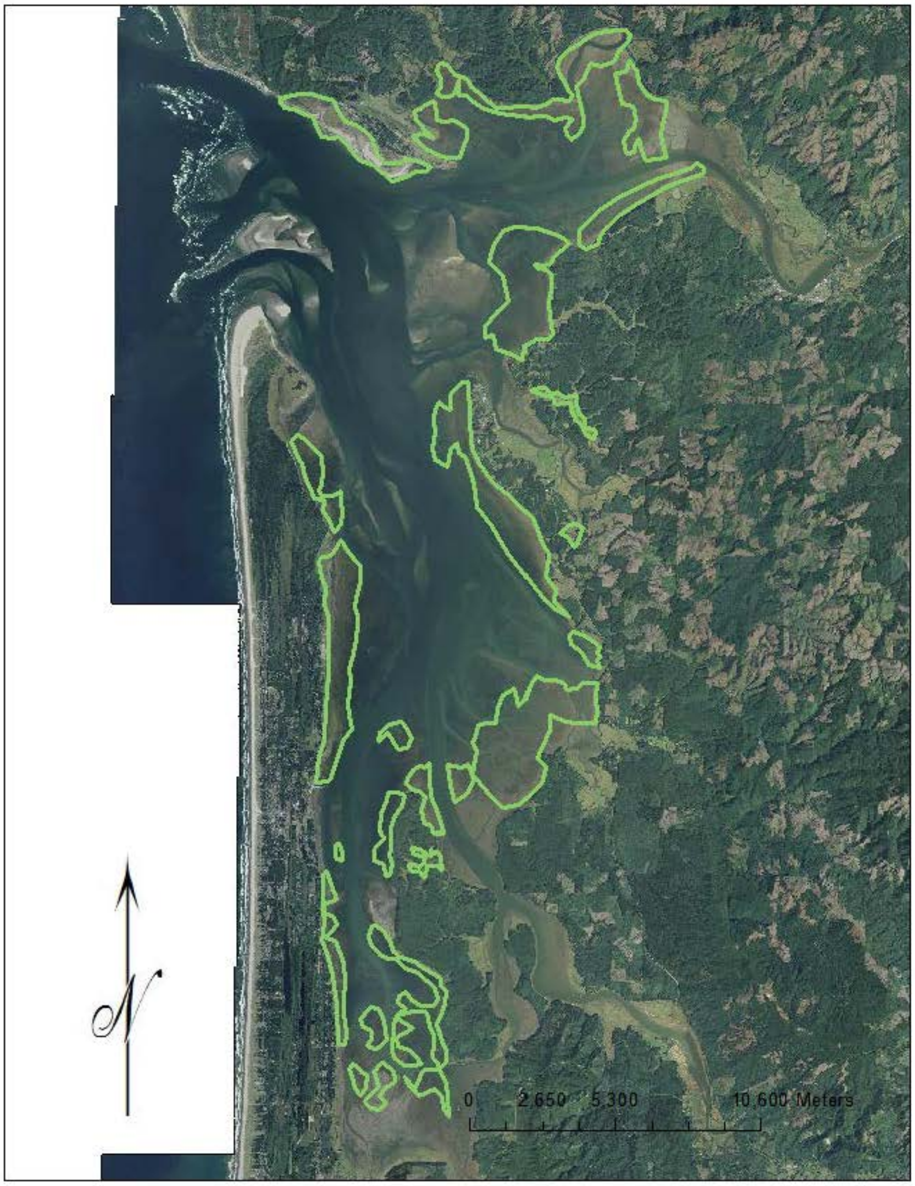

Figure 1-2. Estimated distribution of *Zostera japonica* in Willapa Bay, WA (18,116 acres). Source: Anecdotal information provided by Jacob Moore (WGHOGA Project Coordinator) and commercial shellfish growers (December 2012).

Commercial Clam Beds

According to the U.S. Fish and Wildlife Service (2009), there were 25,562 acres in Willapa Bay being used for aquaculture activities in 2009 (Figure 1-3). This includes ground that was actively being farmed and ground that had been previously farmed but was fallow at the time.

According to grower estimations in 2012, there were approximately 26,000 acres of aquaculture tidelands in Willapa Bay (WGHOGA Member Survey 2012). This estimate includes approximately 20,000 acres of tidelands that growers have identified as suitable for oyster production and 6,000 acres suitable for clam culture. Approximately 9,000 acres of tidelands were being actively farmed for oysters and about 1,100 acres actively farmed for clams in 2012.

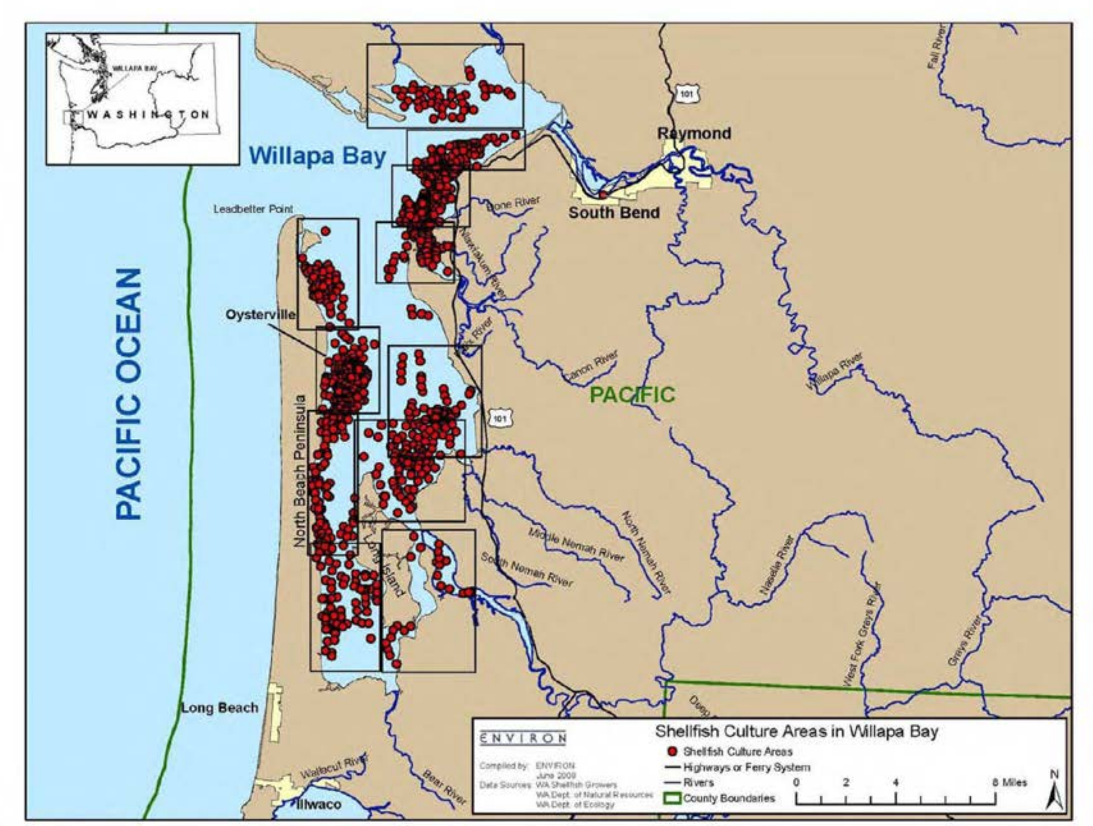

Figure 1-3 Willapa Bay Shellfish Aquaculture Farm Locations Based on NWP 48 reporting to the US Army Corps of Engineers (from ENVIRON 2012).

The current extent of *Z. japonica* colonization of previously unvegetated tideflats is estimated to cause an average 44% decrease in mean yield clam production on beds in current cultivation (Fisher Bradley Patten 2011). There are presently approximately 1,100 acres of cultivated clam beds in Willapa Bay (WGHOGA Member survey 2012). These beds are capable of producing an average of 1 pound of clams per sq. ft. per four years of production. Potential annual gross economic losses from these beds are estimated at $12.6 million (1,100 acres x 43,560 sq ft/acre x 1 lb/sq ft x 44% x $2.40/lb / 4 years = $12,600,000), assuming all 1,100 acres currently in production are impacted by *Z. japonica* colonization.

Growers report that there are another approximately 3,000 acres of previously cultivated and uncultivated clam beds currently out of production in Willapa Bay due to Z. *japonica* colonization (WGHOGA Member Survey 2012). An average annual yield estimate for these beds is 0.4 lb per sq ft (Brian Sheldon personal communication 2013). Because they are not in production, the losses from these beds are 100%. Based on these assumptions and a 4-year harvest cycle, the losses from these beds are estimated at $31 million (3,000 acres x 43,560 sq ft/acre x 0.4 lb/sq ft x $2.40/lb / 4 years = $31,000,000).

1.2 Purpose and Need to Which the Proposal is Responding

Members of the Willapa Grays Harbor Oyster Growers Association (WGHOGA) have found that the growth of *Z japonica* on commercial clam beds in Willapa Bay is advancing at a rate faster than they can control with existing manual and mechanical practices, with the result that approximately 50% of the acreage of clam beds can no longer be farmed. Growers are experiencing significant economic losses due to the effects of *Z. japonica*, which may impact local communities through jobs, taxes, and spending.

For this reason, WGHOGA has requested that Ecology issue a NPDES General Permit to allow chemical treatment of *Z. japonica* with the herbicide imazamox. Ecology is developing a permit to allow imazamox applications, limited to commercial clam beds (other than geoduck) in Willapa Bay. Issuance of the permit is subject to completion of the environmental review process, which will include Ecology's review of potential impacts of and mitigation measures for the proposed action, and consideration of public and agency comments on the draft permit and Draft EIS.

1.3 Description of the Proposed Action

The Washington State Department of Ecology proposes to issue a NPDES general permit for a period of five years to allow discharge of the aquatic herbicide imazamox and marker dyes to Willapa Bay for the management of *Z. japonica* on commercial clam beds.

The NPDES general permit will allow Ecology to:

- Mitigate and condition the aquatic use of the herbicide imazamox,
- Monitor impacts of imazamox treatments to native eelgrass (*Z. marina*) beds,
- Monitor sediment concentrations of imazamox in treated beds,
- Record imazamox use rates and locations,
- Ensure that notifications and postings occur in areas where the public or local residents may access the treated areas.

1.4 Alternatives Considered

This FEIS identifies and analyzes alternatives to chemical control, probable significant environmental impacts, and potential mitigation measures for each alternative. The potential impacts and mitigation measures for each alternative are described in Chapter 3. The information provided will be used by decision-makers to assess reasonable alternatives and identify appropriate mitigation requirements for the proposed chemical applications should they be allowed. The alternatives evaluated include:

Alternative 1: No Action Alternative – Continuing Existing Management Practices. Under the No Action Alternative, manual and mechanical methods of *Z. japonica* control would continue without the use of imazamox. Current practices include removal by hand during clam harvest, and use of harrowing and sweeping techniques that cause foliage damage and minimal root/rhizome damage.

Mechanical and manual removal methods such as harrowing and sweeping cannot be used while clams are present or when clam recruitment is occurring (See table 1.5-1 and 2.8-1).

Alternative 2: Use of Chemical Methods Only. Under this alternative, existing manual and mechanical methods of *Z. japonica* management would be discontinued, and Willapa Bay shellfish growers would apply imazamox to their commercial clam beds for control of *Z. japonica*.

Imazamox was selected as the preferred herbicide after research trials conducted by the Washington State University Long Beach Extension Office, under Washington State Department of Agriculture Experimental Use Permits, showed the herbicide to be effective on dewatered *Z. japonica* plants. It functions systemically, being rapidly absorbed into the foliage and translocated throughout the plant.

Alternative 3 (Preferred Alternative): Use of an Integrated Pest Management (IPM) Approach with Adaptive Management Principles. This alternative would combine crop rotation timing,[1] clam harvesting and existing *Z. japonica* control practices (described above under the No Action Alternative) with chemical applications of the herbicide imazamox. The high efficacy of imazamox combined with shellfish culture activities and general integrated pest management practices should reduce the interval at which imazamox applications will be necessary; i.e., it is expected that it will not be necessary for commercial clam farmers to apply imazamox to the same bed every year under this alternative. The IPM approach relies on the use of imazamox in order for any of the other control methods to be viable. The proposed NPDES general permit will require that applicants develop Discharge Management Plans (DMPs) for the use of imazamox to manage *Z. japonica* on commercial clam beds in Willapa Bay. The DMPs will serve as the IPM plans.

This FEIS also describes other alternatives considered and eliminated from detailed evaluation (see Chapter 2, Section 2.7.4).

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[1] "Crop rotation timing" as it applies to clam aquaculture refers to the activity of harvesting mature clams, then waiting for the next clam seed size to grow to a harvestable size.

1.5 Summary of Impacts and Mitigation Measures

The full text of the Affected Environment, Potential Impacts, and Mitigation Measures for the proposed action and alternatives is presented in Chapter 3. A summary matrix of potential impacts and mitigation measures is provided in Table 1.5-1. In some cases, the table's descriptions are considerably abbreviated from the full discussion in Chapter 3 and lack explanations of terminology and background information. Chapter 3 is where reference citations can be found for the summarized information found in Table 1.5-1.

For these reasons, readers are encouraged to review the more comprehensive discussion of issues in the FEIS to develop the most accurate understanding of potential impacts and mitigation measures for the proposed action and alternatives.

Table 1.5-1. Summary matrix of environmental impacts and mitigation measures associated with management of *Zostera japonica* on commercial clam beds in Willapa Bay.[2]

Potential Impacts	Mitigation Measures
Sediments	
Manual and/or mechanical methods of removing *Z. japonica* under Alternative 1 would add to turbidity on incoming tides. These activities occur in small areas (approximately 3 acres), at times associated with harvest (approximately 0.02 acre per tide cycle).	No sediment mitigation measures are required for the continuation of existing *Z. japonica* management practices under Alternative 1.
Removal of *Z. japonica* from commercial clam beds would eliminate the sediment-trapping function of this seagrass, allowing these sediments to be flushed from the estuary by normally occurring wave, current, and tidal actions.	Under Alternative 2 or 3, the NPDES general permit may require additional sediment testing to assess imazamox levels and persistence in treated estuarine sediments to ensure that imazamox does not persist in Willapa Bay sediments to the extent that its presence may harm plant growth in desired species (such as *Z. marina*).
Under Alternative 2, minor sediment disturbance would occur with chemical applications made using backpack sprayers, or working from all-terrain vehicles (ATVs) using a hand-held nozzle or boom sprayer; however, more frequent chemical applications may be required without other concurrent methods of *Z. japonica* control.	Incidental sediment disturbance that may occur during imazamox applications is not expected to result in turbidity that would exceed State Water Quality Standards; therefore, no mitigation for this potential effect is proposed.
Under Alternative 3, the sediment-disturbing effects of existing *Z. japonica* management practices would continue, and the temporary minor turbidity effects associated with imazamox applications would occur at separate times.	Same as above.

[2] Statements summarized in the Mitigation Measures column describe elements of the proposal that will avoid, minimize, or compensate for potential adverse effects.

Potential Impacts	Mitigation Measures
Under Alternative 2 or 3, no impacts to upland soils are anticipated if label instructions and permit conditions are followed.	Applicators must follow all mixing and loading procedures indicated on the herbicide label to prevent spills on unprotected soil. In the event of a spill, applicators will be required to follow spill response procedures outlined in the NPDES general permit. NPDES general permit conditions will restrict imazamox applications to conditions when the wind speed is 10 mph or less, and the use of aircraft for imazamox applications will be prohibited. These permit conditions will minimize or avoid the risk of off-target drift onto upland soils.
Significant Unavoidable Adverse Impacts: No significant unavoidable adverse impacts to sediments are anticipated as a result of the use of imazamox to control *Z. japonica* on commercial clam beds in Willapa Bay.	
Air Quality	
Manual methods of *Z. japonica* control under Alternative 1 occur primarily during harvest. There are vehicle emissions to the air associated with the transport of workers to the clam beds. Transport and operation of mechanical equipment for *Z. japonica* control also results in gasoline and diesel emissions to the air. Vehicle emissions from these sources are minor in the context of well-circulated air within Willapa Bay, adjacent to the Pacific Ocean.	No air quality mitigation measures are required for the continuation of existing *Z. japonica* management practices under Alternative 1.
There are vehicle emissions to the air associated with the transport of workers to the clam beds. Vehicle exhaust emissions to the air under Alternative 2 or 3 would depend on the method of imazamox application: backpack sprayers or working from ATVs using a single hand-held nozzle or boom sprayer. In either case, the quantity of emissions would be minor in the context of well-circulated air within Willapa Bay, adjacent to the Pacific Ocean.	Under Alternative 2 or 3, it will be the responsibility of the applicator to select appropriate application equipment and treat commercial clam beds only during appropriate environmental conditions when wind speed, temperature, and tidal elevation would minimize the risk of spray drift, to avoid off-target dispersion. The permit will also prohibit any aerial applications (such as by airplane or helicopter).

Potential Impacts	Mitigation Measures
The aquatic formulation of imazamox is considered to be non-volatile and imazamox has an EPA toxicity rating of practically non-toxic to mammals. There should be little to no risk from inhalation exposure to the applicator during applications in the aquatic environment. Because Imazamox is odorless, nearby homeowners, aquaculture workers, and other shoreline users may become exposed unknowingly. Potential exposure to the public or other shoreline users.	To help prevent human exposure, the proposed NPDES general permit required to implement Alternative 2 or 3 specifies that imazamox application sites shall be posted to notify users of the application. Pre-treatment plans will be posted on the *Z. japonica* Management on Commercial Clam Beds in Willapa Bay General Permit website to inform the public of proposed treatment sites. Particular care will need to be taken during application and FIFRA label requirements must be followed. Imazamox will be applied on private tidelands located well away from any public gathering locations; therefore, there should be little to no potential exposure to the public or other shoreline users.
Significant Unavoidable Adverse Impacts: No significant unavoidable adverse impacts to air quality are anticipated as a result of the use of imazamox to control *Z. japonica* on commercial clam beds in Willapa Bay.	
Surface Water	
There are short-term, localized occurrences of turbidity associated with manual and mechanical methods of *Z. japonica* management under Alternative 1: • Manual removal during harvest disrupts approximately 0.02 acre of substrate per tide cycle. • Harrowing and other mechanical removal methods disrupt up to about 3 acres per tide cycle.	No surface water mitigation measures are required for the continuation of existing *Z. japonica* management practices under Alternative 1.
Minor turbidity would occur on incoming tides as a result of imazamox applications made under Alternative 2 or 3 using backpack sprayers or working from ATVs using a single hand-held nozzle or boom sprayer. It is uncertain what effect the removal of *Z. japonica* will have on near shore turbidity levels over time as silt trapped by this seagrass is no longer held in place by the roots and rhizomes.	To mitigate imazamox dispersal and to facilitate plant uptake (treatment efficacy) under Alternative 2 or 3, the proposed NPDES general permit will require that imazamox applications precede tidal inundation by at least one hour to allow "dry time" for plant uptake of the herbicide. Longer exposure would allow the plants more time to "take up" the systemic herbicide.

<table>
<tr><th>Potential Impacts</th><th>Mitigation Measures</th></tr>
<tr><td>[continued]</td><td>Applying imazamox to plants exposed at low tide would also assure that herbicide applications occur during maximum light exposure to optimize photolytic degradation.

The half-life of imazamox in the presence of light is 6.8 hours. The proposal to apply this herbicide to Z. japonica on low tides when the plants are exposed and mostly dewatered will:
• Optimize photolytic degradation.
• Function more like terrestrial herbicide applications, optimizing adherence to Z. japonica (i.e., applications will not be made directly into water).
Minimize the persistence of imazamox in the water column due to shallow depth and constant, powerful tidal movement within Willapa Bay.</td></tr>
<tr><td>No significant adverse effect on dissolved oxygen (DO) in the bay is anticipated, since plants treated with a systemic herbicide (like imazamox) generally die back slowly after treatment, and the tidal exchange will have a diluting effect.</td><td>The EPA Pesticides General Permit requires all applicants to file a Notice of Intent (NOI), and to develop and implement Pesticide Discharge Management Plans that include comprehensive integrated pest management (IPM) practices.

Ecology's proposed NPDES general permit will require that applicants develop Discharge Management Plans (DMPs) for the use of imazamox to manage Z. japonica on commercial clam beds in Willapa Bay. The DMP will serve as the IPM plan required by EPA.

Minimum standards and guidelines for DMP development will be described in Appendix D of the draft NPDES general permit. EIS mitigation measures may be substituted for some of the DMP elements, where appropriate.

The 1997 Integrated Pest Management Law requires all State agencies that have pest control responsibilities to follow IPM principles. Ecology has incorporated these IPM principles into its aquatic pesticide NPDES general permits.</td></tr>
</table>

Potential Impacts	Mitigation Measures
Significant Unavoidable Adverse Impacts: With implementation of the Discharge Management Plan (DMP) and Integrated Pest Management (IPM) principles required by the NPDES general permit, no significant unavoidable adverse impacts to surface water are anticipated as a result of the use of imazamox to control *Z. japonica* on commercial clam beds in Willapa Bay.	
Plants	
It is uncertain whether plant fragments disrupted in one location, under alternatives 1 and 3, and distributed by the tide to other sites may potentially exacerbate the spread of *Z. japonica*.	No plant mitigation measures are required under Alternative 1.
While risks to non-target aquatic vegetation are of potential concern, no effects to the native eelgrass *Z. marina* were observed when it was covered with 20 to 30 cm of water, or at a distance of 6 meters from the spray zone during field testing and monitoring (ENVIRON 2012). It is expected that *Z. marina* within treatment sites that do not lie within a drainage will be killed by imazamox applications. No effects to unicellular algae or macroalgae were observed during field tests.	Applicators should avoid spraying directly into drainages containing the native eelgrass (*Z. marina*) on commercial clam beds. The proposed NPDES permit should include buffers around imazamox treatments to protect off-site *Z. marina*. Determination of what buffer distance is sufficient to protect off-site *Z. marina* from lethal effects of spraying imazamox on commercial clam beds is needed. The imazamox label describes treatment mitigations to reduce spray drift to avoid potential impacts to off-site, non-target plants. It will be the responsibility of the applicator to select appropriate application equipment and treat only during appropriate environmental conditions (wind speed, temperature, and tidal elevation) to avoid off-target dispersion. The proposed permit will also prohibit any aerial applications (such as by airplane or helicopter).
With alternatives 2 and 3, there is potential for plants to become herbicide-resistant over time in response to repeated herbicide application.	The proposed NPDES general permit should limit the application of imazamox to one application per season per treated area.
Significant Unavoidable Adverse Impacts: With implementation of the mitigation measures for the protection of native eelgrass (*Z. marina*), no significant unavoidable adverse impacts to plants, located off of the commercial clam bed property, are anticipated as a result of the use of imazamox to control *Z. japonica* on commercial clam beds in Willapa Bay. *Z. marina* located on treated clam beds may be killed due to imazamox treatment.	

Potential Impacts	Mitigation Measures
Animals (including Threatened and Endangered Species)	
Existing *Z. japonica* management practices under Alternative 1 disturb sediments and therefore disturb benthic invertebrates. Some organisms likely perish during manual and mechanical removal methods, though these areas are likely recolonized by other members of the same species when disturbed sediments are restabilized during subsequent tide cycles. Manual and mechanical removal of *Z. japonica* upper plant parts may reduce the spawning substrate for baitfish. Manual and mechanical removal of *Z. japonica* upper plant parts may diminish shelter for juvenile salmonids at some tidal elevations, though studies indicate they show no preference for *Z. japonica* over bare tide flats, but do prefer to remain in and around native eelgrass (*Z. marina*) in deeper areas. If mechanical and manual removal of *Z. japonica* occurred on all of the approximately 1,100 acres of currently cultivated clam beds, approximately 10,900 acres of the total 12, 183 acres of *Z. japonica* in Willapa Bay would remain available for waterfowl foraging. No significant adverse impact to mammals is anticipated as a result of continuing existing manual and mechanical methods of *Z. japonica* control.	No mitigation measures for animals are required under Alternative 1.
The EPA (2008) *Environmental Fate and Ecological Risk Assessment* prepared for imazamox found that the chronic risk of imazamox to invertebrates is negligible.	Because negligible risk to invertebrates is projected with imazamox applications to commercial clam beds, no mitigation measures are proposed to avoid or minimize these potential effects.
No adverse impacts to baitfish are anticipated under Alternatives 2 & 3, since imazamox is practically non-toxic to fish. Herbicidal removal of *Z. japonica* upper plant parts may reduce the spawning substrate for baitfish.	Under Alternative 2 or 3, the proposed NPDES general permit would limit the imazamox application period to daylight hours during the period April 15 through June 30 in any year in which the permit is in effect, and would only allow one application per season per treatment area (commercial clam bed).

Potential Impacts	Mitigation Measures
Herbicidal removal of *Z. japonica* upper plant parts may diminish shelter for juvenile salmonids at some tidal elevations, though studies indicate they show no preference for *Z. japonica* over bare tide flats, but do prefer to remain in and around native eelgrass (*Z. marina*) in deeper areas.	The imazamox application window would occur within the U.S. Army Corps of Engineers in-water work window that is protective of forage fish; for example, after the herring spawning season in Willapa Bay.
No toxicity effects to finfish are anticipated. At the highest imazamox concentration tested, there were no observed acute adverse effects to fish or aquatic invertebrates. The herbicide does not bioconcentrate in fish; they adsorb and rapidly excrete the herbicide. Ecology does not anticipate any significant chronic exposures of imazamox to fish or estuarine animals in Willapa Bay due to large tidal exchanges that will dilute the herbicide. Based on the response of fish to imazamox, the potential for bioaccumulation and/or biomagnification in the aquatic food chain is considered low.	The imazamox application window is within the in-water work window (March 2-October 14) allowed by WDFW in their Hydraulic Project Approval program to avoid sensitive life cycles of fish within Willapa Bay.
Under alternatives 2 and 3, no significant toxic effects to birds (including waterfowl) are expected from chemical control of *Z. japonica* using imazamox. The herbicide is slightly-to-practically non-toxic to birds on an acute oral basis and on a sub-acute dietary basis. No adverse impact to migratory waterfowl foraging requirements is anticipated with treatment of approximately 3,000 acres of clam beds to control *Z. japonica*. After waterfowl foraging and *Z. japonica* control on commercial clam beds are accounted for, it is estimated that more than 7,000 acres of unmanaged *Z. japonica* would remain in Willapa Bay.	A preliminary foraging budget for waterfowl reliance on *Z. japonica* in Willapa Bay estimates the amount of *Z. japonica* consumed by dabbling ducks and shows that the amount available in Willapa Bay is several orders of magnitude more than what would be consumed, even with implementation of the proposed action (Appendix A).
As an acetolactate synthase (ALS) inhibitor, imazamox has low toxicity toward animals, likely because the ALS biochemical pathway does not exist in animals.	Because exposure risk to wild mammals from imazamox treatments on commercial clam beds would be transient and minimal, no mitigation measures are proposed to avoid or minimize potential effects to mammals.

<table>
<tr><th>Potential Impacts</th><th>Mitigation Measures</th></tr>
<tr><td>Due to the lack of imazamox toxicity to aquatic and terrestrial animals, no direct adverse impacts to threatened or endangered (T&E) species are anticipated.

No significant impact to the food source and habitat requirements of Federally-listed or State Priority species is anticipated as a result of reducing or eliminating Z. japonica from approximately 3,000 acres of clam beds, since approximately 9,000 acres of unmanaged Z. japonica would remain in Willapa Bay.

It is unlikely that imazamox would pose a risk to adult green sturgeon for the following reasons:
• Imazamox is practically non-toxic to fish because the acetolactate synthase (ALS) inhibitor pathway does not exist in animals.
• The herbicide will be applied to dewatered plants, not directly into water, and Willapa Bay has excellent tidal flushing.
• Field data indicates that green sturgeon feeding pits may occur less frequently in areas of Z. japonica (Corbett, Faist, Lindley, Moser 2011) (Fisher Bradley and Patten 2011).</td><td>Shellfish growers managing Z. japonica under any alternative will avoid any direct or indirect harm to species listed as threatened, endangered, or candidates for listing under the Endangered Species Act (ESA).

Because no direct adverse impacts to T&E animal species are anticipated from applications of imazamox to commercial clam beds in Willapa Bay, no specific mitigation measures are proposed to avoid or minimize potential effects to T&E species.</td></tr>
<tr><td colspan="2">Significant Unavoidable Adverse Impacts: No significant unavoidable adverse impacts to animals are anticipated as a result of the use of imazamox to control Z. japonica on commercial clam beds in Willapa Bay.</td></tr>
<tr><th colspan="2">Aesthetics</th></tr>
<tr><td>Existing Z. japonica management practices under Alternative 1 are small-scale, short-term activities that occur on privately-owned or leased tidelands managed for clam aquaculture, at times concurrent with harvest.</td><td>No mitigation measures for aesthetics are required under Alternative 1.

These areas are not highly visible to the public.

Imazamox applications under Alternative 2 or 3 would occur at a different time than harvest. Certified applicators would visit commercial clam beds wearing a backpack sprayer or working from an ATV using a single hand-held nozzle or boom sprayer. The herbicide would be applied during a low tide, and the applicator would leave the site within approximately 5 hours or less.</td></tr>
</table>

<table>
<tr><th>Potential Impacts</th><th>Mitigation Measures</th></tr>
<tr><td>[continued]</td><td>The proposed NPDES general permit conditions will specify that no clam bed would be visited for the purpose of receiving imazamox applications more frequently than once per year.</td></tr>
<tr><td>The optimum time for imazamox treatments under Alternative 2 or 3 is spring, before substantial growth of Z. japonica plants; therefore, no significant quantity of dead plant material would be expected to appear on the tide flats or become suspended in surface water.

If the benefit of IPM methods under Alternative 3 results in less frequent imazamox applications, the amount of dead plant material left on the tide flats would be comparable to Alternative 2.</td><td>The proposed NPDES general permit will limit imazamox applications to the period between April 15 and June 30 in any year for which the permit is in effect. Since Z. japonica dies back during winter months, the biomass will still be low this early in the growing season, which will help minimize the amount of dead vegetative material that will result from imazamox treatments.

Treated plots of tide flat could be restored in appearance to how they looked prior to colonization by Z. japonica.

Minimizing the amount of dead vegetative material generated as a result of imazamox treatments on commercial clam beds will help minimize the quantity of plant material in the wrack of vegetative debris that naturally forms in Willapa Bay in the fall each year.</td></tr>
<tr><td colspan="2">Significant Unavoidable Adverse Impacts: No significant unavoidable adverse impacts to aesthetics are anticipated as a result of the use of imazamox to control Z. japonica on commercial clam beds in Willapa Bay.</td></tr>
<tr><th colspan="2">Recreation</th></tr>
<tr><td>Existing practices of Z. japonica management under Alternative 1 have no impacts to recreational opportunities as they are small-scale activities that occur on privately-owned or leased tidelands designated for clam aquaculture.</td><td>No mitigation measures for recreation are required under Alternative 1.</td></tr>
<tr><td>The imazamox aquatic label does not include any swimming restrictions. The Clearcast® product has not been found to irritate eyes or skin and is practically non-toxic to mammals.

Imazamox has no fishing or fish consumption restrictions. Therefore, its use should have no effect on recreational fishing within Willapa Bay.</td><td>Since no adverse impacts to recreation are indicated associated with imazamox applications to commercial clam beds under Alternative 2 or 3, no mitigation measures are proposed to avoid or minimize such impacts.</td></tr>
</table>

Potential Impacts	Mitigation Measures
Boaters should be less impacted by *Z. japonica* wrack fouling boat engines.	
Significant Unavoidable Adverse Impacts: No significant unavoidable adverse impacts to recreation are anticipated as a result of the use of imazamox to control *Z. japonica* on commercial clam beds in Willapa Bay.	
Navigation	
Existing practices of *Z. japonica* management under Alternative 1 have no impacts to navigation within Willapa Bay.	No mitigation measures for navigation are required under Alternative 1.
The application of imazamox to commercial clam beds in Willapa Bay under Alternative 2 or 3 would not interfere with boating or navigational routes because these applications will occur at a time when the tide flats are exposed and not navigable. A quantity of vegetative material breaks off and forms floating "wrack" in Willapa Bay during the fall.	Since no adverse impacts to navigation are indicated associated with imazamox applications to commercial clam beds under Alternative 2 or 3, no mitigation measures are proposed to avoid or minimize such impacts. Die-back will occur early in the season as a result of imazamox applications made between April 15 and June 30, before *Z. japonica* plants reach their full vegetative growth. This may reduce the quantity of vegetative material that breaks off and floats, thereby reducing boating hazards.
Significant Unavoidable Adverse Impacts: No significant unavoidable adverse impacts to navigation are anticipated as a result of the use of imazamox to control *Z. japonica* on commercial clam beds in Willapa Bay.	
Human Health	
There is some degree of risk of injury related to use of hand rakes for harvest and mechanical methods of *Z. japonica* management under Alternative 1; however, growers use experienced field crews to minimize these risks.	No human health mitigation measures are required under Alternative 1.
Because rat toxicity testing showed that imazamox was practically non-toxic to mammals on an acute basis, no significant human health concerns have been identified for application of this herbicide where humans may come into contact with it. An EPA exemption from tolerance designation waives all food residue tolerance requirements	While no mitigation for potential impacts to human health under Alternative 2 or 3 are indicated by the results of testing the herbicide imazamox, the proposed NPDES general permit conditions should include the following measures that will be protective of human health: • In Washington, all Aquatic labeled

Potential Impacts	Mitigation Measures
for potential food or feed uses of imazamox, including fish, shellfish, crustaceans, and irrigated crops. This means that EPA determined the total quantity of imazamox in or on food presents no hazard to public health.	pesticides are classified as restricted-use pesticides and require an aquatic pesticide applicators license to purchase or use. Aerial application of imazamox is prohibited. • Ecology will post pre-treatment plans on the NPDES permit webpage to notify the public prior to imazamox applications. • All corners of proposed imazamox application sites must be posted to notify users of the application.
Significant Unavoidable Adverse Impacts: No significant unavoidable adverse impacts to human health are anticipated as a result of the use of imazamox to control *Z. japonica* on commercial clam beds in Willapa Bay.	

1.6 Areas of Controversy and Uncertainty, and Issues to be Resolved

Areas of controversy and uncertainty were raised in comments received on the NPDES permit development notice and EIS Scoping Notice. Each of these issues is addressed in this FEIS.

Difficulty in Assessing the Habitat Values of Z. japonica vs. Its Adverse Effects. Both the native *Z. marina* and the non-native *Z. japonica* provide many similar food, shelter, and habitat functions, but to a different degree. Mach et al. (2010) concludes that it is difficult to assess the effect of *Z. japonica* on biological community interactions when some species use it for food or habitat, while others are negatively affected by its density or performance, and some species have no response to the presence of *Z. japonica*. Implementation of the proposed action will not result in eradication of *Z. japonica* from Willapa Bay. The proposed NPDES general permit, if approved, will authorize applications of the herbicide imazamox only to commercial clam beds, which constitute less than half the total area of *Z. japonica* colonization within the bay. If *Z. japonica* is controlled on clam beds, there would still be a patchwork of *Z. japonica* that could be used by species that may have a preference for that habitat.

Uncertainty Regarding the Effect of Reducing Z. japonica as a Possible Food Source for Migratory Waterfowl. Willapa Bay is a critically important feeding and resting area for a large variety of birds. The Willapa National Wildlife Refuge (9,600 acres of Federal land and open water, and 10,000 acres of State-owned tidelands and water) was established for the protection of high quality habitat for wintering and migrating aquatic birds, including ducks, geese, brant, swans, shorebirds, and wading birds. Use of the Willapa Bay estuary by loons, grebes, cormorants, herons, bitterns, ducks, geese, brant, plovers, sandpipers, dunlin and other shorebirds is of special significance, because Willapa Bay is one of ten major wintering and resting areas for waterfowl and shorebirds along the Pacific Flyway. As a major flyway stopover point and staging area, Willapa Bay is of critical importance for fuel replenishment for migrating aquatic birds: they depend on the abundance of mudflat invertebrates, seagrasses, native saltmarsh plants, and associated invertebrates. The birds tend to feed mostly in the high intertidal mudflats, which are the first areas available as the tides recede and the last ones covered by incoming tides (USDI/USFWS 1997).

The reduction in *Z. japonica* on Willapa Bay commercial clam beds is not expected to adversely affect waterfowl. USDA estimated approximately 12,000 acres of moderate to heavy-density *Z. japonica* in Willapa Bay in 2007 (Dumbauld and McCoy 2006/2007). This did not include any acres with thinly populated *Z. japonica*, nor did it include any increase in acres or density of *Z. japonica* since 2007. Migratory waterfowl foraging budgets for *Z. japonica* presented in Appendix A to this FEIS conservatively estimate that approximately 1,600 acres of *Z. japonica* may be needed for waterfowl forage. If shellfish growers control *Z. japonica* on 3,000 acres of clam beds in Willapa Bay, there would still be approximately 7,000 acres of unmanaged *Z. japonica* within the bay.

A study in Yaquina estuary, Oregon, conducted by Lamberson et al. (2011) commented on the concern that shorebirds would be impacted by *Z. japonica* supplanting the *Neotrypea* (burrowing shrimp)/sand habitat. They concluded that there were no significant differences between *Z. japonica* and *Neotrypea* /sand habitat for any metric of bird use studied. Based on this study, it is unlikely that shorebirds will be affected under any of the alternatives being considered.

Uncertainty Regarding the Risk to Native Eelgrass (Z. marina). Risks to non-target aquatic vegetation are of concern with the use of imazamox, given that the herbicide was designed to be a broad-spectrum agent to control unwanted plant growth. However, field monitoring of effects on native eelgrass showed no effect to *Z. marina* 6 meters from the spray zone (ENVIRON 2012).

The fate of *Z. marina* sprayed within the treated zone in the ENVIRON 2012 trial varied by location. Sparse *Z. marina* not covered by water (i.e., not within a drainage swale) was 100% affected (eliminated). Loss of *Z. marina* directly sprayed but covered by < 10 cm of standing pooled water was reduced by 57%, and there was no effect on *Z. marina* if it was covered by 20 to 30 cm of water. There was no measured effect of imazamox on *Z. marina* in the drainage swale beyond 6 meters from the treated zone (ENVIRON 2012).

Ecology expects the proposed NPDES general permit will protect off-site *Z. marina* from inadvertent lethal effects of imazamox use on nearby treated clam beds. Nearby *Z. marina* beds should be underwater at the time of treatment. There may also be *Z. marina* on the treated clam beds, some of which would be in lower elevation drainages that applicators would avoid spraying since clams do not grow in these areas and it is recommended that the permit limit spraying directly into them. *Z. japonica* should have a minimum of one hour to take up the herbicide, and some would degrade before the flood tide washed herbicide residues off the clam bed. It is recommended that the proposed NDPES general permit require buffers to protect off-site *Z. marina* from the herbicidal effect of imazamox.

Uncertainty Regarding Potential Effects to Green Sturgeon. The southern distinct population segment of green sturgeon is Federally-listed as threatened, but is not a State-listed species. Green sturgeon are found along the western coast of the USA, Canada, and Mexico. They are present in Willapa Bay, but do not spawn in Washington waters. According to a National Oceanic and Atmospheric Administration (NOAA) website, the principal factor in the decline of the green sturgeon on the west coast is reduction of the spawning area to a limited section of the Sacramento River.

Because imazamox is practically non-toxic to fish, the herbicide will be applied to dewatered plants, and Willapa Bay has excellent tidal flushing, it is unlikely that the application of imazamox would pose a toxicity risk to adult green sturgeon present in Willapa Bay.

It is uncertain what effect the removal of *Z. japonica* on commercial clam beds would have on green sturgeon foraging. Green sturgeon foraging pits have been observed to be less frequent on *Z. japonica* beds than on beds treated with herbicide (Corbett Faist Lindley Moser 2011) (Fisher Bradley and Patten 2011).

Uncertainty Regarding the Toxicity of Imazamox in the Aquatic Environment. Imazamox rapidly dissipates from the ecosystem. The lowest effect level for imazamox is 10 to 40 ppb for 120 hours static test for algae, diatom and aquatic vegetation, and the no effect level (96 hour exposure) for aquatic invertebrates is 94,000 to 122,000 ppm (ENVIRON 2012). Imazamox dilutes in the leading edge of the water column 1 order of magnitude every 24 hours (60 ppb to 6 ppb) (ENVIRON 2012). Imazamox is highly water soluble, adheres poorly to all soil types, and breaks down rapidly in the presence of light (half-life of 6.8 hours by photolysis). Imazamox is an acetolactate synthase (ALS) inhibitor. Herbicides of this type demonstrate low toxicity toward animals (including humans), likely because the ALS biochemical pathway does not exist in animals. Imazamox has a marine/estuarine label from the U.S. Environmental Protection Agency (EPA). EPA considers imazamox to be a reduced-risk herbicide. For all of these reasons, it is anticipated that the exposure risk to invertebrates, birds, fish, reptiles, amphibians, mammals, and humans from the use of imazamox on commercial clam beds would be transient and minimal.

Uncertainty Regarding the Potential for Z. japonica to Develop Resistance to Imazamox. The herbicide imazamox has a single mode of action as an ALS inhibitor. Target plant species can become ALS-resistant within 3 or 4 generations. Restricting imazamox applications to once per year and implementing an IPM plan to reduce the frequency of imazamox treatments may slow the development of resistance of *Z. japonica* to imazamox.

2.0 Description of the Proposal and Alternatives

2.1 Project Proponent

At the request of the Willapa-Grays Harbor Oyster Growers Association (WGHOGA), the Washington State Department of Ecology (Ecology) is proposing to develop a general permit under the National Pollutant Discharge Elimination System (NPDES) for the control of the state-listed class C noxious weed *Zostera japonica* (Japanese eelgrass) on commercial clam beds (excluding geoducks) in Willapa Bay, Pacific County, Washington. This permit will authorize *Z. japonica* control activities that result in the discharge of the aquatic herbicide imazamox and marker dyes into Willapa Bay. Ecology issues general permits in place of a series of individual permits when the permitted activities are similar. Agencies, organizations and individuals that receive coverage under the general permit must comply with the terms and conditions of the permit.

2.2 Purpose and Objectives of the Proposal

WGHOGA has requested a NPDES general permit for the purpose of allowing chemical treatment of *Zostera japonica* with the herbicide "imazamox" on commercial clam beds in the Willapa Bay tide flats. The objectives of the proposal are to:

- Facilitate the commercial cultivation and harvest of clams on Willapa Bay tide flats by reducing obstructions and other effects caused by the presence of *Z. japonica*.
- Maintain beneficial uses of State waters.

2.3 Location

Willapa Bay is located in the southwestern corner of the Washington coast, within Pacific County. It is Washington's largest outer coast estuary: approximately 38 km long and 8 km wide, and approximately 88,000 acres in surface area at high tide, with 45,000 acres of tidelands. Willapa Bay is almost fully enclosed by the North Beach Peninsula, a 30 km-long barrier spit formed by the northward deposition of Columbia River sediments (Gringas et al. 2000, Cohen et al. 2001, and WGHOGA 2006, all as cited in ENVIRON Corporation 2012).

Less than 15% of the estuary is deeper than 7 m with half of the surface area exposed at low tide. There are 26,028 acres of tidelands privately-owned or leased for commercial shellfish culture.

2.4 Description of Manila Clam Aquaculture

The Manila clam (*Venerupis philippinarum*) was introduced to the west coast of North America in the 1930s and 1940s. There is speculation as to exactly how the Manila clam was introduced, whether it was in ballast water or in shipments of oyster seed from Japan. The majority of Willapa Bay's Manila clam production comes from farming on privately-owned or leased tidelands. During the initial years of commercial harvest, the beds were managed to produce a self-sustaining amount of clams. By the 1970s, predator exclusion nets were employed to increase yields. In the 1980s, growers began to occasionally supplement natural sets with hatchery-raised juvenile clams (Dewey 2013). In order to increase natural recruitment and survival of hatchery seed, the substrate is often enhanced with gravel/shell (Thompson 1990). This method was initially developed in Willapa Bay in the mid-1970s by WDFW when it used gravel to enhance a recreational harvest area on the west side of Long Island. The substrate provides an optimal recruitment surface as well as protection from predators.

Clam crops are grown on a 3- to 5-year rotation depending on the substrate and the desired size of mature product. Natural recruitment is sometimes supplemented with hatchery seed. Ideally, clams that have reached the proper size are harvested and two to four smaller age-classes will be left in the substrate to grow and mature in subsequent years. The vast majority of clams are harvested by hand using short-handled rakes, although there have been efforts to develop mechanical harvesters. Obstacles for the clam diggers are tidal restrictions and Z. *japonica*. When the substrate is turned over to expose the clams so they can be picked up, *Z. japonica* roots hold the substrate together so the harvester has to manually break it apart and dig through the root to find the clams. This process takes more time and results in the loss of some clams. When there is no root, the substrate falls into small chunks easily, exposing all the harvestable clams. *Z. japonica* roots have also proven to be an impediment to mechanical harvest trials (personal communication with WGHOGA members, various dates).

Clams are collected in plastic mesh bags and allowed to purge (i.e., expel sand and mud from the inner part of the bivalve) before processing/packaging.

Under desired bed conditions, approximately one pound of clams is produced in each square foot of clam bed. This is dependent on location within the tidal zone, current/food flow, bed drainage characteristics, and other variables. Any disruptions in current flow acts to alter recruitment, feeding, and growth conditions of the clam crop. Bed drainage impacts not only affect crop recruitment, but also the ability to efficiently harvest the crop (Spencer et al. 1991). *Z. japonica* affects bed drainage by trapping silt and slowing the flow of water from intertidal zones on outgoing tides.

2.5 Socioeconomics

The economic impact analysis to Willapa Bay shellfish growers associated with the invasion of Z. japonica is summarized below from Fisher Bradley and Patten (2011) with more recent input from Brian Sheldon, Owner, Northern Oyster Company (October 14, 2013).

Willapa Bay shellfish growers have experienced economic impacts in the last 10 to 15 years due to the invasion of *Z. japonica*. Shellfish growers report that the extensive growth of *Z. japonica* interferes with shellfish production in areas that were formerly unvegetated mud flats and sand flats used for shellfish culture. In particular, they state that *Z. japonica* has colonized intertidal zones formerly used for Manila clam culture to such a degree and density in some locations as to prevent effective shellfish planting and harvesting. In an experiment that included both gravel additions and eelgrass control, they found that in the presence of gravel, *Z. japonica* reduced juvenile clam abundance (Ruesink et al., in review). Clam size, quality (meat weight vs. shell weight), density, and recruitment levels are all higher in areas with little to no *Z. japonica* versus areas of dense *Z. japonica* (Fisher Bradley and Patten 2011). *Z. japonica* reduces the number of juvenile and adult manila clams (Patten et al. 2012), total clam production (Patten et al. 2012), clam growth rate (Patten et al. 2012), and clam condition (Patten et al. 2012, Tsai et al. 2010). In a five-year study following the impact of *Z. noltii* colonization in France, Tu Do et al. (2012) found that manila clams, cockle and blue mussels all but disappeared from fully colonized sites, and cockle fitness declined. The Washington State University Cooperative Extension Office in Long Beach, Washington projected net income based on mean yield of clams with and without *Z. japonica* and estimated that dense *Z. japonica* decreases the net return for clam production by approximately 44%, which is a net profit loss of approximately $4,000 per acre per year (Fisher Bradley and Patten 2011). Taylor Shellfish Company abandoned 800 acres of clam beds due to the invasive *Z. japonica* (personal communication with Eric Hall, Willapa Division Manager, Taylor Shellfish Company, October 4, 2013), resulting in an annual loss of about $3.2 million profit.

The negative effect of *Z. japonica* on clam quality may be due to reduced food delivery (decreased water flow to mudflats has been reported up to 40%), or sub-lethal effects of poor environmental conditions (Tsai 2010 as cited in Fisher Bradley and Patten 2011). Recent studies suggest that *Z. japonica* harbors increased numbers of organisms that predate on clams and clam seed (Patten 2013 and Ruesink 2013). In a study on the differences in benthic invertebrates that occurred with *Z. japonica* removal using an herbicide in Willapa Bay, Booth and Rassmussen (2011) found twice the level of the *Phyllodocida* and *Spionida* polychaetes in the vegetated plot compared to the treated plot. These genera of polychaetes are known to predate young clams. One of the major impacts of *Z. japonica* on shellfish is likely due to its effects on the sediment. *Z. japonica* changes the benthos from a net nitrogen source to a net sink (Larned 2003), increases dissolved organic matter (Hahn 2003), total organic matter (Harrison 1987, Lee et al. 2001, Posey 1988), and accumulation of fine sediments (Posey 1988, Patten et al. 2012). This accumulation of silts and organics creates a thicker surface muck layer (Posey 1988). There is also short-term nighttime anoxia in the shallow waters retained by the eelgrass during low tides, due to plant respiration and organic matter mineralization (sulfate reduction) (Clavier et al. 2011). This may result in an increase in surface sediment and rhizosphere sulfide (Clavier et al. 2011, Rosenberg 1991) to a level detrimental to some benthic organisms, including bivalves (Clavier et al. 2011, Tu Do et al. 2012, Vinther et al. 2008; Booth and Heck 2009). These conditions, if short-term, may not be overtly toxic to Manila clams, but will reduce their glycogen levels (Kozuki et al. 2012) and cause them to dwell closer to the surface, where they are more susceptible to crab predation (Munari 2012). Reduced sediment condition can also result in increased manganese levels, potentially to a level that is neurotoxic to clams (Beirao and Nascimento 1989, Tsutsumi 2006). Finally, just the increase in sediment silt composition alone may dramatically suppress Manila clam growth (Melia et al. 2004), or bury the supplemental surface gravel (Patten et al. 2012) used for clam production in many Pacific Northwest estuaries.

Biofouling from drift algae can cause anoxia and crop loss in Manila clams (Adams et al. 2011). In Willapa Bay, growers report increased problems from drift algae at sites that are colonized by *Z. japonica*. Although there is no research specifically on *Z. japonica*, artificial *Ruppia maritima* and *Z. marina have* been noted to increase drift algae coverage of sediment (Bostrom and Bonsdorff 2000). Disease and parasites are biotic stressors that diminish shellfish populations

(Gillespie et al. 2012). Short-term anoxia could enhance these stressors. *Z. noltii* colonization in France, for example, increased the trematode assemblages infecting cockle four-fold, and may be partially accountable for the decline in cockle fitness (Tu Do et al. 2012).

Dissolved oxygen levels are lowered in *Z. japonica* beds during nighttime. (http://www.ecy.wa.gov/programs/sea/aquaculture/japonicaeelgrass.html)

There are approximately 6,000 acres of tidelands owned by commercial shellfish growers in Willapa Bay that are suitable for clam cultivation (Shellfish Grower estimations 2012). Out of the 6,000 acres growers have reported that approximately 1,100 are currently in production, approximately 3,000 acres are presently laying fallow due directly to colonization by *Z. japonica* (WGHOGA member survey 2012), and there are approximately 1,900 acres where clams are considered a secondary crop.

To determine a value for the approximately 3,000 acres that are out of production due to *Z. japonica* colonization, an average yield for this combination of previously cultivated and uncultivated lands is estimated at 0.4 lb/sq ft. Based on a 4-year harvest cycle, this results in an annual economic impact of approximately 31 million dollars (3,000 acres x 43,560 sq ft/acre x 0.4 lb/sq ft x $2.40/lb/4) (Email communication from Brian Sheldon, November, 2013).

As of 2012, there were approximately 1,100 acres in commercial production in Willapa Bay (WGHOGA member survey 2012). These acres are capable of producing a higher clam yield density due to active cultivation, averaging 1 lb/sq ft. It was found that *Z. japonica* colonization can reduce clam density by an average of 44% (Fisher Bradley and Patten 2011). Based on a 4-year harvest cycle, the estimated losses for ground in production is approximately $12.6 million annually (1,100 acre x 43,560 sq ft/acre x 44% x 1 lb/sq ft x $2.40/lb/4), assuming that all 1,100 acres are being impacted by *Z. japonica*.

If it is assumed that the 3,000 acres currently out of production due to *Z. japonica* colonization, and the 1,100 acres currently in production would be cultivated if free of *Z. japonica*, then the total estimated annual economic loss in gross sales is $43.6 million. For hand harvest of Manila clams in Willapa Bay, growers report a 5% crop loss due to difficulty of finding and removing clams in *Z. japonica* beds, and an extra $0.05/lb in cleaning cost (Patten 2012; see Washington State Department of Ecology 2013).

It is estimated that it would take about six years to control *Z. japonica* on both the commercial clam beds currently in production as well as the clam beds not currently in production due to *Z. japonica* colonization. Initially it is predicted that growers would focus on removing *Z. japonica* from beds currently in cultivation (approximately 1,100 acres), followed by control of *Z. japonica* on beds currently out of production due to Z. japonica colonization (approximately 3,000 acres)(Email communication from Brian Sheldon, November, 2013).

Washington State has recognized the importance of the shellfish industry by designating shellfish rearing, cultivation and harvesting as a beneficial use to be protected in the State Water Quality Standards (WAC 173-201A-030[2][b][iii]). The Washington State Shoreline Management Act

(SMA) (RCW 90.58) Shoreline Use Standards also identify aquaculture as a beneficial use of the State's shorelines (WAC 173-26-241[3][b]):

> *Properly managed, it can result in long-term over short-term benefit and can protect the resources and ecology of the shoreline. Aquaculture is dependent on the use of the water area and, when consistent with control of pollution and prevention of damage to the environment, is a preferred use of the water area. Local government should consider ecological conditions and provide limits and conditions to assure appropriate compatible types of aquaculture for the local conditions as necessary to assure no net loss of ecological functions*.

In a bill that passed both the House and Senate unanimously (ESHB 2819, February 18, 2002), the Washington State Legislature re-emphasized the importance of the shellfish industry in this State:

> *The legislature declares that shellfish farming provides a consistent source of quality food, offers opportunities of new jobs, increases farm income stability, and improves balance of trade. The legislature also finds that many areas of the State of Washington are scientifically and biologically suitable for shellfish farming, and therefore the legislature has encouraged and promoted shellfish farming activities, programs, and development with the same status as other agricultural activities, programs, and development within the State*.

And in *Willapa-Grays Harbor Oyster Growers Association v. Pollution Control Hearings Board et al*. (July 19, 2002), Thurston County Superior Court found that there is an overriding public interest to protect the oyster growers and the rural communities in which they are located from adverse economic impact.

2.6 Regulatory Status and Regulatory Control

2.6.1 Regulatory Requirements for Commercial Shellfish Aquaculture

Pursuant to Section 404 of the Clean Water Act (CWA), the U.S. Army Corps of Engineers (Corps) is responsible for administering a regulatory program that requires permits for certain activities in waters of the United States, including wetlands. Under Section 404, the Corps regulates the discharge of dredged or fill material into waters of the U.S. Activities requiring Corps authorization that are similar in nature and have minimal individual and cumulative environmental impacts may qualify for authorization by a general permit, such as a nationwide permit (NWP). On February 21, 2012, the Corps issued 50 nationwide permits, including NWP 48 which authorizes commercial shellfish aquaculture activities. The Seattle District issued regional conditions for the 2012 NWPs on March 18, 2012.

Under Section 401 of the CWA, an activity involving a discharge into waters of the U.S. authorized by a Federal permit (such as NWP 48) must receive water quality certification (WQC) from the appropriate certifying agency or Tribe. Ecology makes Section 401 certification decisions for activities on non-Tribal lands within the State, including Willapa Bay where *Z. japonica* control methods are proposed.

Some local jurisdictions (cities and counties) may also require a permit for commercial shellfish aquaculture under the development regulations of their local Shoreline Master Program (SMP). Members of WGHOGA operate their commercial shellfish farms in compliance with the Pacific County and Grays Harbor County SMPs.

2.6.2 Regulatory Status of *Z. japonica* as a Noxious Weed

Washington State Department of Fish and Wildlife (WDFW). The WDFW Priority Habitats and Species designation is the agency's primary means of transferring fish and wildlife information from its resource experts to those local and State entities that can protect habitat through their regulatory actions. Although the Priority Habitats and Species program is not a WDFW regulatory program, other agencies use the WDFW database to write conditions and mitigation requirements in their regulatory programs to protect these habitats and species.

Until 2011, WDFW did not specify species of *Zostera* on its Priority Species and Habitat list, instead simply referring to native species throughout the document. In 2011, WDFW changed the listing, from simply *Zostera* to *Z. marina* in order to clarify that it is not the intent of WDFW to protect non-native species.

Washington State Department of Ecology (Ecology). Eelgrass is designated critical saltwater habitat in the Shoreline Master Program Guidelines which implement the Shoreline Management Act.

Ecology recently affirmed that city and county Shoreline Master Programs should not protect *Z. japonica* as critical saltwater habitat now that it is listed a Class C noxious weed (see WSNWCB, below) where it occurs throughout the state, and is revising its aquaculture guidance for local governments to make this clear (Washington State Department of Ecology 2013).

Washington State Noxious Weed Control Board (WSNWCB). The State weed board is responsible for developing the State annual noxious weed list. Their decisions define eradication or control actions for public and private landowners. In January 2013, the WSNWCB listed *Z. japonica* as a Class C noxious weed in all areas of the State. Under a Class C listing, there is no requirement for landowner control, unless a County Noxious Weed Control Board decides to “select” the plant for control on its local noxious weed list (RCW 17.10.090). At the time of this writing, no counties selected *Z. japonica* for control.

Western States. *Z. japonica* is a Class A weed in California. A-rated noxious weeds are prohibited from entry into California, for sale within the state, and are subject to eradication. Since the early 2000s, there has been an ongoing eradication program for *Z. japonica* in California (Muir 2011; and Williams 2007).

The state of Oregon does not presently list *Z. japonica* as a noxious weed. However, information on the internet indicates that some government agencies recognize *Z. japonica* as non-native and invasive in that state (Nugent 2005, ODFW).

2.6.3 Regulatory Requirements for Physical or Mechanical Control of *Z. japonica*

Washington State Department of Fish and Wildlife (WDFW) Requirements for Z. japonica Control. RCW 77.115.010(2) limits application of WDFW regulatory powers with respect to private-sector cultured aquatic products. The limitation prevents WDFW from requiring a Hydraulic Project Approval permit to regulate the planting, growing, and harvesting of clams and other shellfish grown by private aquaculturalists (AGO 2007 No. 1, January 4, 2007).

The Hydraulic Code Rule pertaining to eelgrass (WAC 220-110-250) is being revised at the time of this writing. The current WAC language defines eelgrass as *Zostera spp*. In the new proposed draft rule, seagrass will replace "eelgrass" as a saltwater habitat of special concern and be defined to include *Zostera marina*, *Ruppia maritima*, and *Phyllospadix* species.

Washington State Department of Natural Resources (WDNR) Requirements for Z. japonica Control. WDNR manages State-owned aquatic lands in conformance with constitutional and statutory requirements. The agency is mandated to provide a balance of public benefits for all citizens of the State, including encouraging direct public use and access; fostering water-dependent uses; ensuring environmental protection; and generating revenue when consistent with other benefits (RCW 79.105.030 and WAC 332-30).

In exercising its leasing authority, WDNR is directed to consider the natural values of State-owned aquatic lands as wildlife habitat, natural area preserve, representative ecosystem, or spawning area prior to leasing, and withhold or protect from leasing lands that it finds to have significant natural values (RCW 79.105.210[3]). The Washington State Legislature recognized that marine aquatic plants have inherent value and provide essential habitat (RCW 79.135.400). Personal harvest limits and commercial harvesting prohibitions of aquatic plants are defined on State-owned and private aquatic lands (RCW 79.135.41). However, WDNR, as with all State agencies, is explicitly directed by law to control the spread of noxious weeds through integrated pest management practices (RCW 17.10.145).

Commercial shellfish growers who cultivate clams on State-owned land in Willapa Bay should contact the WDNR Aquatics District Office for the area in which new *Z. japonica* management methods are proposed and forward information related to environmental review and permitting for the activity to the WDNR SEPA Center. A noxious weed removal project on State-owned tidelands may require a State Aquatic Land Use Authorization.[3]

[3] There are very few leased State tidelands in Willapa Bay used for commercial clam aquaculture. Of the approximately 6,000 acres of tidelands suitable for clam cultivation in the bay, it is estimated that there are presently fewer than 50 acres (less than 1%) on State-owned tidelands (personal communication with Brian Sheldon, Northern Oyster Company, September 18, 2013).

Washington State Department of Ecology (Ecology). Ecology's Shorelands and Environmental Assistance (SEA) Program administers the Washington Shoreline Management Act (Chapter 90.58 RCW) in partnership with local governments. Local shoreline master programs must protect shoreline ecological functions, provide for public enjoyment of public shores and waters, and plan for and foster all reasonable and appropriate uses. Local programs must be approved by Ecology and consistent with the Shoreline Management Act and its regulations. Ecology has recently clarified that shoreline programs should not protect invasive, non-native species such as *Z. japonica*. At the time of this writing, WAC 173-26-221 identifies eelgrass as a critical saltwater habitat and does not differentiate between native and non-native species. Aquaculture use standards (WAC 173-26-241[3][b][i][C]) state that "Aquaculture should not be permitted in areas where it would result in a net loss of ecological functions, adversely impact eelgrass...." Ecology interprets “eelgrass” in this context as referring to only *Z. marina*, native eelgrass.

Ecology's Water Quality and SEA Programs also administer the State Water Pollution Control Act (Chapter 90.48 RCW). Under this authority, Ecology must balance competing beneficial uses including aquatic life use, shellfish harvesting, recreation, wildlife habitat and harvesting, commerce and navigation, boating, and aesthetics. Per RCW 90.48.445, the program must not issue permits that burden noxious weed control efforts. Due to the listing of *Z. japonica* as a noxious weed, and because of the economic impact that it is having on manila clam growing operations in Willapa Bay, Ecology's Water Quality Program has drafted an NPDES general permit that would allow for the control of *Z. japonica* on commercial clam beds using the herbicide imazamox. The findings of this Environmental Impact Statement will be considered when Ecology decides whether to issue the permit.

Ecology-issued Clean Water Act Section 401 Water Quality Certification. This requirement is triggered 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 waters of the U.S., non-isolated wetlands, or excavation in water or non-isolated wetlands.

Local Regulatory Requirements for Z. japonica Control. Depending on the proposed physical or mechanical management activity for aquatic invasive species, local jurisdictions (City or County governments) may require a Shoreline Conditional Use permit, or Shoreline variance for activities in or near shorelines of the state under the Shoreline Management Act (Chapter 173-27 WAC). Each local government has adopted local implementing regulations for shoreline management. These vary somewhat from one another. RCW 90.58.030 and WAC 173-27-040 exempt noxious weed control from needing a Shoreline Substantial Development Permit (SDP). If a Shoreline Conditional Use permit or variance is required, Ecology must review and approve these local permit decisions.

Federal Regulatory Requirements for Z. japonica Control. Shellfish growers who wish to implement physical and/or mechanical management measures for *Z. japonica* may need Federal permits and/or Federal environmental review if this activity is proposed on Federal lands or would receive Federal funding.[4] Federal permits and environmental reviews may include:

- National Environmental Policy Act (NEPA) review. NEPA applies to all major Federal actions, any project requiring a Federal permit, receiving Federal funding, or proposed on Federal land. NEPA is similar to Washington's SEPA.
- Endangered Species Act (ESA) Section 7 consultation with the U.S. Fish and Wildlife Service (USFWS)[5] and/or National Oceanic and Atmospheric Administration (NOAA)/National Marine Fisheries Service (NMFS).[6] The ESA lists many salmon, steelhead, and bull trout populations and other aquatic biota as threatened or endangered for special protection in Washington waters. These listings may affect aquatic invasive species management projects in the State. 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/conservation/endangered.
- U.S. Army Corps of Engineers Section 404 Clean Water Act permit for discharge of dredged or fill materials into waters of the United States, including wetlands. Nationwide Permit 48 is a general Section 404 permit that authorizes commercial shellfish activities.
- U.S. Army Corps of Engineers Section 10 Rivers and Harbors Act permit for any structures or work in navigable waters of the United States. No structures are proposed for *Z. japonica* control. The Nationwide Permit 48 also includes Section 10 authorization.
- U.S. Coast Guard Private Aids to Navigation (PATON) permit to establish and maintain, discontinue, change, or transfer ownership of lights, signs, etc. that serve, or will serve, as private aids to navigation. No new private aids to navigation or alteration of existing aids to navigation in Willapa Bay are proposed to implement *Z. japonica* physical or mechanical management measures.

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4 There are no known commercial clam beds on Federal lands within Willapa Bay, and no known programs that would make Federal funds available to commercial shellfish growers in the bay (personal communication with Brian Sheldon, Owner, Northern Oyster Company, October 14, 2013).

5 USFWS has jurisdiction over Federally-listed terrestrial mammals, birds, non-anadromous fish, bull trout, birds, amphibians, reptiles, insects, and plants. NOAA/NMFS has jurisdiction over Federally-listed marine mammals, anadromous fish, saltwater fish, and sea turtles.

6 NOAA/NMFS does not have an official written policy regarding *Z. japonica*. However, the Pacific Coast Groundfish Fishery Management Plan does contain language about the species in its definition of Seagrass Habitat Area of Particular Concern. Based on Executive Order 13112 that formed the National Invasive Species Council, NMFS does not promote the spread of invasive plants.

2.6.4 Regulatory Requirements for Chemical Applications

Washington State Department of Ecology (Ecology) Requirements for Chemical Applications. Since 2002, Ecology has regulated herbicide application under general NPDES/State Waste Discharge permits instead of site-specific administrative orders. The special condition section of Ecology's general pesticide permits contains mitigations for herbicide use. Mitigations include such things as notifications, application timing windows, treatment buffers to protect non-target vegetation, preparation of management plans called Discharge Management Plans, monitoring, and other special provisions to help protect the environment from the regulated action.

Under the proposed "*Zostera japonica* Management on Commercial Clam Beds in Willapa Bay" NPDES General Permit, Washington State has made a tentative decision to allow the use of imazamox in Willapa Bay for the purpose of controlling *Z. japonica* on commercial clam beds for a period of 5 years. Ecology intends to issue coverage under this NPDES general permit to licensed pesticide applicators. Each Permittee (licensed pesticide applicator) must have a sponsor to receive coverage under the permit. The permit defines a sponsor to mean an individual or an entity (business) that has the legal authority to make a decision to apply herbicide to its clam beds. A sponsor is typically a commercial clam grower with a vested or financial interest in the control of *Z. japonica* on its property. The sponsor may hire or contract with a licensed applicator to apply pesticides or the applicator may be the sponsor or a staff member of the sponsor's business. Entities such as a consortium of individual growers cannot be sponsors under this permit.

The NPDES general permit Fact Sheet, a companion document to the proposed "*Zostera japonica* Management on Commercial Clam Beds in Willapa Bay" General Permit, provides the legal and technical basis for permit issuance (WAC 173-226-110). The Draft "*Zostera japonica* Management on Commercial Clam Beds in Willapa Bay" General Permit and the Fact Sheet are incorporated by reference into the FEIS. The imazamox *Screening-Level Ecological Risk Assessment of the Proposed Use of the Herbicide Imazamox to Control Invasive Japanese Eelgrass (Zostera japonica) in Willapa Bay, Washington State* prepared by ENVIRON International Corporation (November 2012) is also incorporated by reference into this FEIS. The Screening-Level Risk Assessment was prepared for Washington State University to help support the research conducted by that University in its investigation of imazamox to manage *Z. japonica* on Willapa Bay estuarine tidelands.

Washington State Department of Agriculture (WSDA) Requirements for Chemical Applications. WSDA is Washington's lead agency for the regulation of pesticides, and issues private, commercial, and other licenses required for the application of pesticides. The WSNWCB is an agency within the WSDA, and it receives administrative and funding support from WSDA.

WSDA classifies all aquatic herbicides as "restricted use." Only trained and certified applicators or people under their direct supervision can legally purchase and apply aquatic herbicides in Washington. Most aquatic pesticide treatments occur under joint NPDES and State Waste Discharge permits administered by Ecology.

Laws and Codes that Apply to Chemical Applications. The Washington State Water Pollution Control Act (Chapter 90.48 RCW) states that issuance of permits for using herbicides and surfactants registered under State or Federal pesticide control laws to control aquatic noxious weeds "shall be subject only to compliance with: Federal and State pesticide label requirements; the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act; the Washington Pesticide Control Act; the Washington Pesticide Application Act; and the State Environmental Policy Act," subject to several enumerated exceptions.

Local Regulatory Requirements for Chemical Applications. Some local jurisdictions (City or County governments) may require a Shoreline Substantial Development permit, Shoreline Conditional Use permit, or variance for chemical applications in or near Shorelines of Statewide significance under the jurisdiction of the Shoreline Management Act (Chapter 173-27-WAC). Each local government has local implementing regulations that vary somewhat from one another. Shellfish growers should check with Pacific County regarding their Shoreline permitting requirements before treating clam beds with imazamox for the management of *Z. japonica*.

EPA Statutory Requirements for Pesticides

EPA regulates pesticides under four major statutes:

1. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. § 136 et seq.).
2. Federal Food, Drug, and Cosmetic Act (FFDCA) (21 U.S.C. Chapter 9).
3. Food Quality Protection Act (FQFA) (7 USC §136).
4. Clean Water Act (CWA) (33 U.S.C. 1251 et seq.).

- **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 a EUP, Section 24(c) or a Section 18 emergency exemption.
- **FFDCA** authorizes EPA to set tolerances, or maximum legal limits, for pesticide residues in food. Tolerance requirements apply equally to domestically-produced and imported food.
- **FQFA** fundamentally changed the way that EPA regulates pesticides. Some of the major requirements include stricter safety standards, especially for infants and children, and a complete reassessment of all existing pesticide tolerances.
- **CWA** (1972 and later modifications [1977, 1981, and 1987]) established water quality goals for navigable waters of the United States. A 2011 court ruling directed EPA to require National Pollutant Discharge Elimination System (NPDES) permits for aquatic pesticide applications under the CWA. EPA delegated responsibility for administering the 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. Also see the "*Zostera japonica* Management on Commercial Clam Beds in Willapa Bay" General Permit Fact Sheet for more information about regulations and authorities supporting imazamox application to State waters.

EPA requires extensive data as part of its registration review and approval process, requiring more than 120 studies before granting a registration for most pesticides used in food production (imazamox is used on food products). EPA tiers these study requirements to the intended use and certain properties of the pesticide. The studies allow EPA to assess risks to human health, domestic animals, wildlife, plants, surface and groundwater, beneficial insects, and other environmental effects. When new evidence arises to challenge the safety of a registered pesticide, EPA may take action to suspend or cancel its registration and revoke the associated tolerances.

EPA Ecological Risk Assessments. EPA conducts an Environmental Fate and Ecological Risk Assessment (EFED) for each active ingredient during the pesticide registration process. EPA used the most sensitive toxicity endpoints from surrogate test species to estimate treatment-related direct effects on acute mortality and chronic reproductive, growth, and survival endpoints. In general, categories of acute toxicity ranging from "practically nontoxic" to "very highly toxic" have been established for aquatic organisms based on lethal concentration (LC50) values, terrestrial mammals based on lethal dose (LD50) values, avian species based on LC50 values, and non-target insects based on LD50 values for honey bees.

EPA Human Health Risk Assessments. Federal law requires detailed evaluation of pesticides to protect human health (www.epa.gov/pesticides/factsheets/riskassess.htm). In 1996, Congress made changes to strengthen pesticide laws through the Food Quality Protection Act (FQPA), which require EPA to consider:

- *A new safety standard*: FQPA strengthened the safety standard that pesticides must meet before EPA approves their use. EPA must ensure with a reasonable certainty that no harm will result from the legal uses of the pesticide.
- *Exposure from all sources*: In evaluating a pesticide, EPA must estimate the combined risk from that pesticide from all non-occupational sources such as:
    - Food Sources
    - Drinking water sources
    - Residential sources
- *Cumulative risk*: EPA is required to evaluate pesticides in light of similar toxic effects that different pesticides may share, or a “common mechanism of toxicity.” EPA is developing a methodology for this type of assessment.
- *Special sensitivity of children to pesticides*: EPA must ascertain whether there is an increased susceptibility from exposure to the pesticide to infants and children. EPA must build into their risk assessment an additional 10-fold factor of safety to ensure the protection of infants and children, unless it is determined that a lesser margin of safety will be safe for infants and children. The use of the extra 10-fold factor of safety for children is in addition to the traditional 100-fold factor of safety for human health. To further increase protections for infants and children, EPA now requires registrants to conduct acute, sub-chronic, and developmental neurotoxicity studies. EPA also updated the set of test guidelines for development of data on reproductive and developmental effects.

The FQPA requires EPA to set tolerances or grant exemptions for all the ingredients in a pesticide product that is used on food. A tolerance is the maximum amount of pesticide chemical residue that can be in or on a food product or feed commodity. EPA must determine that the levels of the chemical proposed in the tolerance are "safe." Safe means a reasonable certainty of no harm to human health. An exemption from a tolerance is issued when EPA determines that the total quantity of the pesticide chemical in or on the food will present no hazard to public health. Generally, other ingredients in pesticide formulations are not pesticidally active themselves and are exempt from the need for a tolerance determination so long as they do not present a hazard to public health.

Reduced-Risk Herbicides. The EPA Office of Pesticide Program's Conventional Reduced-Risk Program expedites the review and regulatory decision-making process of conventional pesticides that pose less risk to human health and the environment than existing conventional alternatives. Reduced-risk pesticides typically have one or more of the following advantages over existing conventional pesticides:

- Low impact on human health
    - Very low mammalian toxicity
    - Toxicity generally lower than currently-registered higher risk conventional pesticides
    - Can displace chemicals that pose potential human health concerns
    - Reduce exposure to pesticide handlers and post-application exposure
- Lower toxicity to non-target organisms (birds, fish, plants)
    - Very low toxicity to birds, honey bees, fish
    - If toxicity is similar to conventional herbicides, than lower exposure potential
    - Potential toxicity/risk is capable of mitigation
- Low potential for groundwater contamination
- Lower use rates or fewer applications than conventional pesticides
- Low pest resistance potential (for example, reduced risk pesticides may have a new mode of action)
- Compatibility with integrated pest management (IPM) practices.

EPA considers imazamox a reduced-risk herbicide. The reduced-risk designation applies to only certain uses of a particular pesticide and may not include all labeled uses for that product. In the case of imazamox, there are two potential exceptions: effects to the native eelgrass *Z. marina*, and the single mode of action of the herbicide as an acetolactate synthase (ALS) inhibitor. Target species can become ALS-resistant within 3 or 4 generations. Remedies for these potential limitations include observing buffers specified in the draft NPDES Permit, and ongoing research for additional *Z. japonica* management tools.

2.7 The Proposed Action and Alternatives

Alternative methods for the control of *Zostera japonica* are in the Determination of Significance and EIS Scoping Notice dated October 3, 2012. These methods are limited to actions that may be taken by shellfish growers on their commercial clam beds in Willapa Bay. An Ecology NPDES general permit to allow the application of imazamox to commercial clam beds in Willapa Bay is required to implement the preferred alternative for *Z. japonica* management (an Integrated Pest Management approach), or the use of chemical methods only.

The action that triggered preparation of this FEIS is the Ecology proposal to issue a NPDES general permit for a term of five years for the chemical management of *Z. japonica* on commercial clam beds in Willapa Bay. Ecology determined that applications of imazamox to manage *Z. japonica* may result in significant environmental impacts, resulting in the evaluation of the potential impacts of the proposed action in an EIS.

This FEIS identifies and analyzes reasonable alternatives to chemical control, probable significant environmental impacts, and potential mitigation measures for each alternative, including chemical control methods. The Draft EIS was made available for public review and comment. Ecology has taken these comments into consideration both during preparation of the FEIS and in making the decision regarding the NPDES general permit for application of imazamox.

Most current management practices used by Willapa Bay shellfish growers focus on reducing density and seed production in existing *Z. japonica* meadows in commercial clam beds. Since *Z. japonica* was first discovered in Washington waters, there has been little action taken to manage its growth and spread outside of commercial shellfish beds. In part, this was due to all *Zostera* species being designated as Priority Habitat and Species (PHS) by the Washington Department of Fish and Wildlife (WDFW). Previously, all species in this genus were considered by regulatory agencies to be equally desirable and were therefore protected. WDFW removed the *Z. japonica* protected status in 2011.

The potential impacts and mitigation measures for each alternative are described in Chapter 3. The information provided will be used by decision makers to evaluate the reasonable alternatives and appropriate mitigating conditions for the proposed chemical applications. The alternatives evaluated include:

1. The No action Alternative – Continuing Existing Management Practices.
2. Use of Chemical Methods Only.
3. Use of an Integrated Pest Management (IPM) approach with adaptive management principles (the preferred alternative).

The FEIS also includes a section (2.7.4) on Other Alternatives Considered and Eliminated from Detailed Evaluation.

Analysis and Comparison of Alternatives

Washington State Environmental Policy Act. The rules (Chapter 197-11 WAC) implementing the State Environmental Policy Act (Chapter 43.21C RCW) require an EIS to describe and present the proposal (or preferred alternative, if one exists) and alternative courses of action. Reasonable alternatives are actions that could feasibly attain or approximate the objectives of the proposal, but at a lower environmental cost or decreased level of environmental degradation. The word "reasonable" is intended to limit the number and range of alternatives, as well as the amount of detailed analysis for each alternative. The level of detail is to be tailored to the significance of environmental impacts, and one alternative may be used as a benchmark against which to compare the other alternatives. The EIS may indicate the main reasons for eliminating some alternatives from detailed study. The guidelines also require that the No Action Alternative shall be evaluated and compared to other alternatives (WAC 197-11-440[5]).

Washington State Surface Water Quality Standards. Washington State surface water quality regulations and standards (RCW 90.48; Chapter 173-201A WAC) provide authority to Ecology 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.

The FEIS will analyze each alternative for:

- The extent to which the approach may detract from beneficial use of Willapa Bay.
- Potential adverse environmental impacts.
- Potential adverse human health impacts, particularly for chemical control methods.
- The effectiveness of the method in controlling *Z. japonica*.

2.7.1 Alternative 1: No Action − Continue Existing *Z. japonica* Management Practices

Under the No Action Alternative, shellfish growers would continue to manage the growth of *Z. japonica* on Manila clam beds as they do now through a combination of physical, manual and cultural methods.

Mechanical and manual control methods are not discriminatory between *Z. japonica* and *Z. marina*. *Z. japonica* management by mechanical or manual methods may result in the removal of *Z. marina* where mixed beds of native and non-native eelgrass occur on commercial clam beds

Mechanical and manual control methods do not result in pesticide discharge and the resulting environmental impacts to Willapa Bay.

Z. japonica management methods currently ongoing in Willapa Bay include:

Manual Disruption/Removal: Cultural Control Methods. The majority of clams are harvested by hand with short-handled rakes. Manila clams reside within 1 to 4 inches beneath the surface of the substrate. During clam excavation, the substrate is raked and tilled in a manner that disrupts the Z. *japonica*. Only small areas are harvested at a time─approximately 0.02 acre per tide cycle for a standard digging crew of 6 to 12 individuals (personal communication with WGHOGA members, December 2012). *Z. japonica* plants are not removed to an upland disposal site in this practice.

After clam harvest, Z. *japonica* is suppressed for a short period of time before re-growth occurs. Re-growth of roots and rhizome fragments along with seed germination the following season causes Z. *japonica* to fully reestablish within one year (personal communications with WGHOGA members, various dates).

Harrowing. This method involves pulling a solid tooth, loose tooth, spring tooth, or disc harrow over clam beds with a boat at high tide, or with a vehicle/tractor at low tide. The harrow disrupts the foliage of *Z. japonica* and tears loose a percentage of root and rhizome structure. The damaged plants are suppressed for a period of time before re-growth and seed germination occurs during the same or following season. Growth rates of Z. *japonica* increase, and harrowing becomes ineffective by early summer (personal communications with WGHOGA members, December 2012). Alternatively, a heavy steel bar (channel bar) can be dragged across *Z. japonica* beds at low tide to strip stems and some root and rhizome structure from the sediment.

Following harrowing the incoming tide may move plant fragments to new locations. There is a possibility that the plant fragments released from harrowing Z. japonica may initiate colonization elsewhere in Willapa Bay as some nuisance plants can be spread through plant fragments (Ecology 2004).

Harrowing can only be conducted when the beds support no clam crop and when no natural recruitment of clams is occurring. Manila clams are grown on a 2- to 4-year rotation with recruitment occurring from May to November. The bulk of recruitment occurs in July and August. This combined with needing to harrow only during low tides during the spring and summer severely limits the flexibility of this control method.

Harrowing is effective in disrupting seedlings and subduing re-growth of perennial rhizomes for a short time. One grower who has invested large amounts of funds and effort to develop an array of harrowing equipment and other methods to control *Z. japonica* since 1999 stated that several years ago he felt like he could maintain at least a portion of his farm with these methods. However, for the past several years, he saw *Z. japonica* colonizing his beds from one direction, to colonizing from all directions. Based on his experience he does not believe he can control *Z. japonica* any longer using these methods alone (personal communication with John Heckes, Owner Heckes Clam Farms, August 2013).

Mechanical Removal. A modified street sweeper (4-ft wide roller with stiff bristles) is mounted on a tractor and applied to Z. *japonica* beds. The rotating brush disrupts the Z. *japonica* with a scraping motion causing severe foliar damage and uprooting approximately 40% of root/rhizome structure (personal communication with Ken Wiegardt, Farm Manager, Wiegardt and Sons Oyster Co., September 17, 2013). *Z. japonica* is subdued for one season but then re-grows, due to residual roots/rhizomes in the sediment. This system is labor- and equipment-intensive, as a retrofitted tractor must be transported to the site and operated. The targeted seagrass (*Z. japonica*) quickly builds up on the bristles and must be cleaned out by hand. This system cannot be used on clam beds that are actively growing or recruiting a crop. Mr. Wiegardt does not believe he can effectively use this method alone to control *Z. japonica* on his beds.

2.7.2 Alternative 2: Chemical Control Methods Only

Under the Chemical Control Alternative, existing manual and mechanical methods of *Z. japonica* management would be discontinued, and Willapa Bay shellfish growers would apply the herbicide imazamox to their commercial clam beds for control of *Z. japonica*. The characteristics of imazamox and its effects are briefly and concisely described in this FEIS without overly technical information. This summarized information is based primarily on technical review found in the *Screening-Level Ecological Risk Assessment of the Proposed Use of the Herbicide Imazamox to*

Control Invasive Japanese Eelgrass (Zostera japonica) in Willapa Bay, Washington State (ENVIRON International Corporation, November 2012). Additional detailed technical supporting information can be found in that document.

Shellfish growers have proposed application of the EPA-registered aquatic labeled herbicide imazamox to control *Z. japonica* on commercial clam beds in Willapa Bay. Imazamox was selected as the herbicide of choice after research trials conducted by the Washington State University Long Beach Extension Office, under WSDA Experimental Use Permits, showed the herbicide to be effective at controlling dewatered *Z. japonica* plants with minimal impacts to nearby native eelgrass (*Z. marina*) beds. Currently, imazamox has a marine/estuarine label from the EPA, one of only three aquatic herbicides with this use designation. EPA also considers imazamox to be a reduced-risk herbicide. To further investigate the use of imazamox to manage *Z. japonica* in the marine/estuarine environment, Washington State University contracted with ENVIRON International Corporation of Seattle to develop the Screening-Level Risk Assessment cited above.

The American Cyanamid Corporation (acquired by BASF – The Chemical Company in 2000) first introduced imazamox in Europe in 1995. The EPA granted a conditional registration for imazamox in the United States in 1997, and an unconditional registration Section 3 label in 2001. In 2003, imazamox received an "exemption for tolerance" designation from the EPA. The exemption waives all food residue tolerance requirements for food or feed products treated with imazamox, including fish, shellfish, crustaceans, and irrigated crops. Imazamox is the first and only organic pesticide to receive a tolerance exemption. All active formulations of imazamox are registered to BASF. In Washington State, the herbicide is registered as Clearcast®.

Clearcast® is considered a selective herbicide. In general, monocots like *Z. japonica* are more effectively controlled with Clearcast® than dicots[7]. Applicators may apply imazamox into the water for the control of submersed vegetation, or spray it directly onto emergent plants. However, application to emergent plants typically requires the use of an adjuvant (i.e., an agent that modifies the effect of other agents). The label allows application to plants when the water is drawn down as occurs during low tide when *Z. japonica* is typically fully exposed. The shellfish grower's proposal is to apply Clearcast® directly to exposed *Z. japonica* using a backpack sprayer, or working from an all-terrain vehicle (ATC) or other ground-based machine using a single hand-held nozzle or boom sprayer, rather than to inject the herbicide into the water column. No adjuvants are proposed for this type of application.

[7] Monocotyledons are flowering plants in which seedlings typically have a single embryonic leaf known as a "cotyledon." True grasses, true grains, pasture grasses, sugar cane, and bamboo are representative monocots. Monocots are easily recognized by the long parallel veins in their leaves, whereas dicot plant leaves have a complex netted vein pattern.

Imazamox is a systemic herbicide that is rapidly absorbed into the foliage and moved throughout the plant via phloem and xylem tissues. It concentrates in the actively growing portions of roots and shoots. Imazamox inhibits plant growth within the first 24 hours after application, though visual symptoms appear about one week after treatment with symptoms evident first on new growth. Susceptible plants develop a yellow appearance or general discoloration and eventually die or suffer severe growth inhibition. For emergent applications, BASF claims that Clearcast® is rainfast within one hour of application.

The maximum label rate for foliar broadcast applications is four quarts per acre, or 1 pound (16 oz) active ingredient (a.i.) per acre. For foliar spot applications, the maximum rate is up to 5% by volume. Clearcast® applied at a rate of 16 oz a.i. per acre has been shown to be effective at controlling *Z. japonica*. Field trials indicate efficacy can be achieved at the 16 oz a.i./ac rate with no adjuvants under normal application conditions. Efficacy at this rate may be compromised if applications are made at sites that do not fully drain at low tide. For this reason, it is important that treatments occur in the early stages of *Z. japonica* growth (April to late June), before the plant canopy becomes so thick that it impedes offsite drainage. Applicators must coordinate treatment activities with appropriate tidal phases to allow sufficient dry time (ENVIRON, 2012). A minimum of one hour dry time before the incoming tide reaches a treated area is required to ensure maximum efficacy. Increased dry time may increase efficacy.

The Clearcast® label allows multiple applications during the annual growth season, but the label does not specify retreatment intervals of the maximum amount of active ingredient that can be applied each growing season. Repeated use of herbicides with the same mode of action can lead to herbicide-resistant plants. Application of imazamox should be limited to one application per season per treated area in the proposed NPDES general permit.

As with the other alternatives, the potential environmental and health effects of chemical methods of *Z. japonica* management are evaluated in Chapter 3.

2.7.3 Alternative 3: Preferred Alternative for Management of *Zostera japonica*: Integrated Pest Management (IPM) with Adaptive Management Principles

The preferred alternative is to use an integrated pest management (IPM) approach for the management of *Z. japonica* on commercial clam beds. This approach would combine crop rotation timing,[8] harvest activities, and selected existing control practices (described above under the No Action Alternative) with chemical applications of the herbicide imazamox. The efficacy of imazamox combined with shellfish cultural activities and general integrated pest management practices should reduce the interval at which imazamox applications will be necessary; i.e., it is expected that it will not be necessary for commercial clam farmers to apply imazamox to the

[8] "Crop rotation timing" as it applies to clam aquaculture refers to the activity of harvesting mature clams, then waiting for the next clam seed size to grow to a harvestable size.

same bed every year under this alternative. The IPM approach relies on the use of imazamox in order for the other control methods to be commercially viable (personal communication with WGHOGA members, August 2013).

EPA defines 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 the EPA website http://www.epa.gov/opp00001/factsheets/ipm.htm).

Ecology's proposed NPDES general permit will require that applicants develop Discharge Management Plans (DMPs) for the use of imazamox to manage *Z. japonica* on commercial clam beds in Willapa Bay. The DMPs will serve as the IPM plans.

2.7.4 Other Alternatives Considered and Eliminated

Several alternative methods for freshwater weed management are described in Ecology's *Draft Supplemental EIS: Assessments of Aquatic Herbicides* (July 2000). These methods are not reasonable or feasible for use in a saltwater environment with a commercial clam crop present in the substrate occupied by *Z. japonica*. These methods are described below but not analyzed in detail in this Environmental Impact Statement (in accordance with WAC 197-11-440[5]).

Manual Removal/Disposal to an Upland Site. Manual removal involves removing the entire *Z. japonica* plant from the substrate by hand using tools such as shovels, rakes and knives to loosen the substrate and facilitate removal. The plants would be disposed on an upland site, away from clam beds. *Z. japonica* plants are best removed when exposed by low tide; otherwise, divers or snorkelers would have to be employed while water levels are high and plants are submerged. This would substantially increase the cost of removal. Workers may use bags, wheel barrows, hand carts, boats, barges, and/or motorized vehicles to transport plants away from removal sites. This work would generate turbidity, and would result in the removal of sediments that cling to the root/rhizome structure of *Z. japonica* plants, as well as benthic organisms that live in these sediments.

Manual removal is generally only suitable for small populations (i.e., less than 0.05 acres) of mature plants. Seeds and recently sprouted plants (2,000-6,000/m^2) (Britton-Simmons 2010) are small and difficult to see and remove effectively. Manual removal of *Z. japonica* is very labor-intensive, time consuming, and expensive. For example, an eradication project in Humboldt Bay, California required 48 volunteers working a total of 259 person hours to remove 0.07 acre of Z. *japonica* (Schlosser 2007).

Manual control of extensive beds of *Z. japonica* plants on a commercial scale of multiple acres is likely infeasible. Seeds and rhizomes from unmanaged acreages can repopulate hand-pulled areas. *Z. japonica* produces viable seed that are spread throughout Willapa Bay by the tide.

Populations of *Z. japonica* spread and become dense perennial colonies due to sprouting from the rhizomal network (Fisher Bradley and Patten 2011).

Bottom Barriers/Covering. A bottom barrier, also called a benthic barrier or a bottom screen, would cover the sediment or substrate like a blanket. It would be analogous to using landscape fabric under bark chips to prevent weeds on an upland site. Barriers block light and limit water/oxygen circulation from plants and algae.

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 the barrier upwards into the water column. Many different materials have been used for bottom barriers, such as burlap, plastics, perforated black Mylar®, and woven synthetics. There are also some commercial bottom barrier products available; however, even the most porous materials can billow due to sediment gas buildup (Gunnison and Barko, 1989 and 1990).

Fishing gear, anchors, vandalism, or storms can damage bottom barriers. Any tears in the fabric will reduce their efficacy. Wave or tidal action limits their use in Willapa Bay, which regularly experiences tidal swings of 8 to 11 feet and strong sustained winds that can generate 2- to 5-foot surface waves. This combination of tidal regimes and wave action make anchoring bottom barriers in Willapa Bay difficult and impractical. Past trials using bottom barriers over small areas to eradicate ghost shrimp have resulted in these barriers becoming dislodged and lost even when extreme measures have been taken to secure them to the bottom (Personal communication Patten 2012b, Wiegardt 2004).

While bottom barriers are effective at killing vegetation, they are not selective, and also kill native eelgrass, macroalgae, shellfish and benthic organisms. Scientists briefed members of the Tahoe (California) 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 populations resulted in 100% mortality of the clams within 28 days (Hamel 2011).

In practice, for logistical and economic reasons, bottom barriers would only be effective for eradication projects where there are small areas or patches of vegetation to cover, where barriers could later be removed, and where the barriers would not cover the clam crop. Bottom barriers are one of the most expensive methods for aquatic vegetation control if used in a large-scale application. There are few small populations of *Z. japonica* in Willapa Bay, and large-scale application of bottom barrier is neither cost-effective nor desirable given their non-selectivity to plants and animals. Cost estimates for bottom barrier material in freshwater applications range from $0.22 to $1.25 per square foot.

Temperature Manipulation. Temperature manipulation typically includes the application of heated vapor (steam), actively combusting fuel (flame), or hot foam to targeted plants with a hand-held wand or boom. The duration of application depends on the intensity and penetration required to achieve efficacy.

The Waipuna™ Hot Foam System is designed for “spot” weeding, trimming and general landscape vegetation management. The capacity of systems like these is limited and not aligned with commercial-scale control of Z. *japonica* on 5 to 50 acres. Due to the size and weight of the hot foam system, special vehicles would be required to deliver the system to remote clam beds. The cost and logistical requirements associated with this system make it a nonviable option for commercial clam farmers. This type of control method would kill clam crops, clam seed, and other benthic invertebrates.

The optimum time to treat *Z. japonica* is in the spring before it goes to seed. At this time of year, the clam crop is closest to the surface, and therefore would be most vulnerable to damage by a temperature manipulation method of *Z. japonica* control.

Flame weeding is the use of an open flame, typically fueled with propane, to suppress or kill weeds. The objective of flame weeding is not to burn the plant tissue but rather to vaporize water within the plants cells. The vaporized water expands to burst or decompose the cell wall. This causes terrestrial weeds to dry up and begin to die within a few hours to a day. Flame treatment does not effectively kill perennial weeds; terrestrial grasses and larger broadleaf weeds usually recover within one year of treatment. Flame weeders are designed for killing seedlings and weeds that establish in cracks between paved surfaces (Cornell University). If this control method were applied to *Z. japonica* on commercial clam beds, it would only be effective on the upper plant parts (not the roots), and it would also kill clam crops, clam seed, and other benthic invertebrates. If clam necks are damaged by heat (or freezing), these injuries often lead to a slow decomposition of the clam tissue causing them to eventually die over an extended period of time (personal communication with Brian Sheldon, Owner, Northern Oyster Company, October 11, 2013). These types of injuries have resulted in massive crop losses (approximately 80%) from commercial clam beds in Willapa Bay.

Mechanized Cutting and Harvesting: Mechanical weed cutters cut aquatic plants several feet below the water surface. Plant roots and rhizomes are not removed by cutting and harvesting. Unlike mechanical harvesting, cut plants are not collected while the machinery operates. Cutting generates floating plants, seeds, and fragments. It would be nearly impossible to collect and remove *Z. japonica* plants, seeds and fragments from the water to prevent them from drifting onshore, or re-rooting or seeding at new locations, with the result that this method may exacerbate the problem rather than contribute to the management of *Z. japonica* populations.

Cutters and harvesters are designed for use in freshwater environments. Willapa Bay is a saltwater, open marine environment known for severe weather conditions common to the outer Washington coast. Bottom topography is inconsistent, and there are many submerged holes, undulating surfaces, etc. Machines used for cutting and harvesting freshwater aquatic plants are not resistant to corrosion and the type of wear and tear that occurs in a saltwater environment. It is likely that the useful life of these machines would be greatly reduced in the saltwater; with the result that there would be more mechanical failures that could potentially release fuels and/or lubricants into marine waters.

Due to the low profile of *Z. japonica* plants, and their thin, flexible leaves, it is unlikely that the mechanical cutters described above would be effective. It would be very difficult to consistently cut *Z. japonica* close to the sediment/water interface. Due to the lack of control (i.e., removal) of the root and rhizome structure, plants would quickly re-sprout as cutting is similar to mowing a lawn; many subsequent cuttings are required during the growing season. Cutting at the sediment surface would generate turbidity, damage clam crops, clam seed and other benthic and epi-benthic organisms. In addition, mechanical cutters/harvesters could potentially harm fish and invertebrates caught in the path of the cutting blades or removed from the water by the harvester.

Suction Dredging (Diver Dredging): Diver dredging is a method whereby divers wearing Self Contained Underwater Breathing Apparatus (SCUBA) use hoses attached to small dredges to vacuum plant material out of the sediment. The purpose of diver dredging is to remove all parts of the aquatic plant, including the roots. The use of the suction dredge is slow, labor intensive, and expensive. Removal rates by an experienced diver vary from 0.25 acre per day to one acre per day (Washington State Department of Ecology 2004).

Use of a suction dredge is practical and up to 90% effective for clearing plants from small areas and from areas containing obstructions. Removal can be very selective for an area and for a species; however, turbidity that occurs during the procedure tends to obscure visibility resulting in less effective removal.

Due to the high cost of suction dredging, this method is not considered a reasonable alternative to IPM or chemical methods of *Z. japonica* management. Further, suction dredging would be an undesirable method on commercial clam beds within Willapa Bay as juvenile clams and clam seed would also be removed (along with sediments and benthic organisms), thereby resulting in significant economic losses.

Rotovation: Rotovation for the control of aquatic vegetation is performed using agricultural tilling machines. Rotating blades churn 7 to 9 inches deep into the bottom substrate to dislodge and damage plant foliage and roots. Rotovation appears to stimulate the growth of aquatic plants, so it would not be an effective tool to manage excessive growth of nuisance species such as *Z. japonica* (Washington State Department of Ecology 2004). Due to an increase in plant biomass during summer months, plants must be cut by some other means before rotovation. Otherwise, long leaves and stems tend to wrap around the rototilling head.

The amount of area that could be rotovated per day can range from 2 acres to less than one acre depending on plant density, time of year, bottom obstructions, and weather conditions. Imprecise tracking of rotovated areas could result in incomplete removal of target plants, ultimately minimizing the effectiveness of this method and long-term control.

Rotovation would disrupt the benthic structure and biology of Willapa Bay sediments. This technique would physically damage or kill the clam crop as well as macrofauna living in or residing on the substrate (bivalves and crustaceans).

Equipment used for rotovation is not designed for saltwater environments; therefore, it would have a limited useful life, which could result in mechanical failures that could potentially release fuels and lubricants into marine waters.

Biological Control: Biological control (biocontrol) is the purposeful introduction of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biocontrol agents must be living organisms so 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. Scientists conduct extensive research before releasing any biocontrol organisms to help ensure that these organisms are host-specific, thereby minimizing the chance that they may harm the environment in other ways.

Even when successful, a classical biocontrol 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, and the cycle continues.

Biocontrol is most suited for non-native organisms not closely related to indigenous beneficial species. It is not suitable for organisms with many related members that are of economic or environmental importance, because the biocontrol agent may attack related species as well as the targeted pest. *Z. marina* eelgrass native to Willapa Bay is closely related to *Z. japonica* and shares some of the same intertidal habitat, and therefore would be at risk of adverse effects if biocontrol were implemented.

At this time, there are no known potential biological control agents for *Z. japonica*.

2.8 Comparison of Environmental Impacts

Table 2.8-1 presents a comparison of the environmental impacts of the three alternatives for each element of the environment considered in this limited-scope, programmatic FEIS. Readers are encouraged to review more detailed information in Chapter 3 regarding the impacts summarized in Table 2.8-1 for a more complete, “in-context” understanding of these issues, including citations.

Table 2.8-1. Comparison of the environmental impacts of the alternatives.

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred − Integrated Pest Management
Sediments	Manual and/or mechanical methods of removing *Z. japonica* adds to turbidity on incoming tides. These activities occur in small areas (approximately 3 acres), at times associated with harvest (approximately 0.02 acre per tide cycle).	Minor (if any) sediment disturbance would occur with chemical applications made using backpack sprayers, or working from all-terrain vehicles (ATVs) using a hand-held nozzle or boom sprayer; however, more frequent chemical applications may be required without other concurrent methods of *Z. japonica* control. Imazamox is highly water-soluble and adheres poorly to all soil types, particularly sediments with low organic content such as those in Willapa Bay. Sediment disturbance that occurs during clam harvest would continue to occur; however, sediment disturbance due to mechanical means of *Z. japonica* control would be discontinued. Removal of *Z. japonica* from commercial clam beds would eliminate the sediment-trapping function of this seagrass. No impacts to upland soils are anticipated if label instructions and permit conditions are followed.	The sediment-disturbing effects of existing *Z. japonica* management practices would continue, and the temporary minor turbidity effects associated with imazamox applications would occur at separate times. Removal of *Z. japonica* from commercial clam beds would eliminate the sediment-trapping function of this seagrass.
Air Quality	Manual methods of *Z. japonica* control occur primarily during harvest. There are vehicle emissions to the air associated with the transport of workers to	There are vehicle emissions to the air associated with the transport of workers to the clam beds. Vehicle exhaust emissions to the air from	Emissions to the air would be slightly higher than with Alternative 2, as the new trips associated with imazamox applications would be added to

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred − Integrated Pest Management
	the clam beds. Transport and operation of mechanical equipment for *Z. japonica* control also results in gasoline and diesel emissions to the air. Vehicle emissions from these sources are minor in the context of well-circulated air within Willapa Bay, adjacent to the Pacific Ocean.	herbicide application would depend on the method of imazamox application: backpack sprayers or working from ATVs. In either case, the quantity of emissions would be insignificant in the context of overall air quality in Willapa Bay due to excellent circulation. The frequency of imazamox applications would be limited by the NPDES general permit, not to exceed one treatment per year per clam bed. Imazamox is odorless; therefore, applications should be undetectable to off-site observers. Imazamox would be applied on private tidelands normally located well away from any public gathering locations; therefore, there should be little to no exposure to the public or other bystanders. The aquatic formulation of imazamox is considered to be non-volatile and relatively non-toxic by inhalation. There should be little to no inhalation exposure to the applicator during applications in the aquatic environment. The imazamox label does not require the applicator to wear any special personal protective gear other than chemical-resistant gloves when applying Clearcast®. Aerial applications and application when the	existing trips for manual and mechanical control. Similar to other alternatives, vehicle exhaust emissions would not be expected to reach a level of air quality concern. Similar to Alternative 2, applications of the odorless herbicide imazamox should be undetectable to off-site observers. Similar to Alternative 2, no adverse impacts to applicators are anticipated during aquatic applications of imazamox.

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred – Integrated Pest Management
		wind speed is above 10mph will not be allowed, reducing potential for exposure to the public or other bystanders.	
Surface Water	Does not result in the discharge of imazamox into Willapa Bay. There are short-term, localized occurrences of turbidity associated with manual and mechanical methods of *Z. japonica* management: • Manual removal during harvest disrupts approximately 0.02 acre of substrate per tide cycle. • Harrowing and other mechanical removal methods disrupt up to about 3 acres per tide cycle.	Minor (if any) turbidity would occur on incoming tides as a result of imazamox applications made using backpack sprayers or working from ATVs using a single hand-held nozzle or boom sprayer. Localized occurrences of turbidity associated with existing mechanical means of *Z. japonica* management (e.g., harrowing, sweeping) would not occur under the Chemical Methods Only alternative. Removal of *Z. japonica* may reduce near shore turbidity levels over time as silt trapped by this seagrass is allowed to flow out from the bay during natural tide/ wave/wind cycles. Imazamox would be temporarily present and breaking down in marine surface waters of Willapa Bay. The half-life of imazamox in the presence of light is 6.8 hours. The proposal to apply this herbicide to *Z. japonica* on low tides when the plants are exposed and mostly dewatered will: • Optimize photolytic degradation. • Function more like terrestrial herbicide applications, optimizing adherence to *Z. japonica* (i.e., applications will not be	The Integrated Pest Management alternative would have surface water effects similar to both Alternative 1 and 2: • Localized increases in turbidity associated with existing management practices would continue • Imazamox would be temporarily present and breaking down in marine surface waters of Willapa Bay.

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred – Integrated Pest Management
		made directly into water). • Minimize the persistence of imazamox in the water column due to shallow depth and constant, powerful tidal movement within Willapa Bay. Imazamox is highly soluble in water, particularly at the pH levels commonly found in Willapa Bay (7.3 to 7.6). Tidal flux will provide a constant and reliable rinsing effect that will dilute the herbicide and move it off-site. No significant adverse effect on dissolved oxygen (DO) in the bay is anticipated, since plants treated with a systemic herbicide (like imazamox) generally die back slowly after treatment, and the tidal exchange will have a diluting effect.	
Plants	Roots, rhizomes and seeds disrupted in one location may be distributed by the tide to other sites. Physical and manual control methods are not species specific so there will be some amount of *Z. marina* affected on-site using these methods. Alternative 1 is not expected to	Systemic herbicide applications of imazamox would kill the upper portions of *Z. japonica* plants as well as their roots and rhizomes that would be left in sediments to deteriorate in-place. While risks to non-target aquatic vegetation are of concern, no effects to the native eelgrass *Z. marina* were observed when it was covered with 20 to 30 cm of water, or at a distance of 6 meters from the spray zone during field testing and monitoring (ENVIRON 2012). Similarly, no effects to unicellular algae or	Existing manual and mechanical methods would control the upper vegetative growth of *Z. japonica* plants, while systemic herbicide applications of imazamox would kill not only the upper portions of the plants but also roots and rhizomes that would be left in sediments to deteriorate in-place. The integrated approach may

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred – Integrated Pest Management
	have a significant impact on off-site *Z. marina*.	macroalgae were observed during field tests. The herbicide imazamox is toxic to *Z. marina* when it is directly sprayed. Ecology expects treated commercial clam beds containing Z. marina, as a mixed eelgrass bed with Z. japonica, will be removed. Ecology expects that *Z. marina* growing off of the treatment site will not be significantly impacted if effective mitigation is employed.	minimize the frequency of imazamox applications to achieve the desired level of *Z. japonica* management. As indicated in alternatives 1 and 2, some *Z. marina* growing on-site would be controlled. Alternative 3 is not expected to have a significant impact on off-site *Z. marina* if effective mitigation is used.
Animals (including T&E Species)	Existing *Z. japonica* management practices disturb sediments and therefore disturb benthic invertebrates. Some organisms likely perish during manual and mechanical removal methods, though these areas are likely re-colonized by other members of the same species shortly afterwards. Growers report that it is unlikely that significant impacts to baitfish spawning occur as a result of manual or mechanical *Z. japonica* management measures, conducted at low tide, because shellfish growers recognize the appearance of herring spawn and avoid it.	The EPA (2008) *Environmental Fate and Ecological Risk Assessment* prepared for imazamox found that the chronic risk of imazamox to invertebrates is negligible. No adverse impacts to baitfish are anticipated since imazamox is practically non-toxic to fish, and permit conditions will limit applications to a period of time within the U.S. Army Corps of Engineers in-water work window for forage fish (USACE 2012) to avoid removing *Z. japonica* stems that may be used as spawning substrate until after eggs have hatched. Similarly, no toxic effects to finfish are anticipated. At the highest imazamox concentration tested, there were no observed acute adverse effects to fish or aquatic invertebrates. The herbicide does not	Benthic disturbance would continue to occur, though potentially to a lesser degree than with Alternative 1 since chemical control under the Integrated Pest Management approach may reduce the frequency of intensive mechanical management measures. For the same reasons as those described for Alternative 1 and 2, no significant adverse impacts to baitfish would be expected with the Integrated Pest Management approach. For the same reasons as those described for Alternative 1 and

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred − Integrated Pest Management
	Harrowing that occurs at high tide using a boat may impact baitfish spawn. Manual and mechanical removal of *Z. japonica* upper plant parts may diminish shelter for juvenile salmonids at some tidal elevations, though studies indicate they show no preference for *Z. japonica* over bare tide flats, but do prefer to remain in and around *Z. marina* in deeper areas. Temporary removal of Z. japonica shoots on clam beds, approximately 1,100 acres, is not likely to significantly impact waterfowl forage opportunities. No significant adverse impact to mammals is anticipated as a result of continuing existing manual and mechanical methods of *Z. japonica* control. Mammals are rarely seen on commercial clam beds.	bioconcentrate in fish; they adsorb and rapidly excrete the herbicide. Ecology does not anticipate any significant chronic exposures of imazamox to fish or estuarine animals in Willapa Bay due to large tidal exchanges that will dilute the herbicide. Based on the response of fish to imazamox, the potential for bioaccumulation and/or biomagnification in the aquatic food chain is considered low. Chemical removal of *Z. japonica* upper plant parts may diminish shelter for juvenile salmonids at some tidal elevations, though studies indicate they show no preference for *Z. japonica* over bare tide flats, but do prefer to remain in and around *Z. marina* in deeper areas. No significant toxic effects to birds (including waterfowl) are expected with chemical methods of *Z. japonica* control using imazamox. The herbicide is slightly-to-practically non-toxic to birds on an acute oral basis and on a sub-acute dietary basis. No adverse impact to migratory waterfowl foraging requirements is anticipated with treatment of approximately 3,000 acres of clam beds to control *Z. japonica*, since it is estimated that, after treatment and waterfowl foraging are accounted for, more than 7,000	2, no significant adverse impacts to finfish would be expected with the Integrated Pest Management approach. For the same reasons as those described for Alternative 1 and 2, no significant adverse impacts to birds (including waterfowl) would be expected with the Integrated Pest Management approach. For the same reasons as those described for Alternative 1 and 2, no significant adverse impacts to wild animals would be expected with the Integrated Pest Management approach. For the same reasons as those described for Alternative 1 and 2, no significant adverse impacts to threatened, endangered, or candidate species (including green sturgeon) would be expected with the Integrated Pest Management approach.

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred − Integrated Pest Management
		acres of unmanaged *Z. japonica* would remain in Willapa Bay. Ecology believes that exposure risk to wildlife from spraying imazamox treatments on commercial clam beds would be transient and minimal. As an acetolactate synthase (ALS) inhibitor, imazamox has low toxicity toward animals, likely because the ALS biochemical pathway does not exist in animals. Ecology does not anticipate any direct adverse impacts to threatened or endangered (T&E) animal species from applications of imazamox to commercial clam beds in Willapa Bay due to lack of toxicity to aquatic and terrestrial animals. No significant impact to the food source and habitat requirements of Federally-listed or State Priority species is anticipated as a result of reducing or eliminating *Z. japonica* from approximately 3,000 acres of clam beds, since it is estimated that, after treatment and waterfowl foraging are accounted for, more than 7,000 acres of unmanaged *Z. japonica* would remain in Willapa Bay. It is unlikely that imazamox would pose a risk to adult green sturgeon for the following reasons: • Imazamox is practically non-toxic to fish because the acetolactate synthase (ALS)	

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred – Integrated Pest Management
		inhibitor pathway does not exist in animals. • The herbicide will be applied to dewatered plants, not directly into water, and Willapa Bay has excellent tidal flushing. • Observations indicate that green sturgeon feeding pits may occur less frequently in areas with *Z. japonica* (Corbett Faist Lindley and Moser 2011) (Fisher Bradley and Patten 2011).	
Aesthetics	Existing *Z. japonica* management practices result in no significant adverse impact to the aesthetic condition of Willapa Bay: • Small-scale, short-term activities occur on privately-owned or leased tidelands designated for clam aquaculture, at times concurrent with harvest. • These areas are not highly visible to the public.	Imazamox applications would occur at a different time than harvest. Certified applicators would visit commercial clam beds wearing a backpack sprayer or working from an ATV using a single hand-held nozzle or boom sprayer. The herbicide would be applied during a low tide, and the applicator would leave the site within approximately 5 hours or less. Commercial clam beds should not receive imazamox applications more frequently than once per year. The optimum time for imazamox treatments is spring, before substantial growth of *Z. japonica* plants; therefore, no significant quantity of dead plant material would be expected to appear on the tide flats or become suspended in surface water. Treated plots of tide flat could be returned in appearance to how they looked prior to	Workers would be present on application sites with approximately the same frequency as Alternative 2, to perform manual practices during harvest plus separate site visits for imazamox applications. If mechanical methods of *Z. japonica* management were used in addition, workers would be present on the clam beds for three separate activities: harvest, harrowing (or similar activity), and spraying. If the benefit of IPM methods results in less frequent need for imazamox applications, the amount of dead plant material left on the tide flats by this alternative would be

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred – Integrated Pest Management
		colonization by *Z. japonica*.	approximately comparable to Alternative 2. It may be possible to return clam beds to their appearance prior to *Z. japonica* colonization.
Recreation	Existing practices of *Z. japonica* management have no impacts to recreational opportunities as they are small-scale activities that occur on privately-owned or leased tidelands used for clam aquaculture.	The imazamox aquatic label does not include any swimming restrictions. The Clearcast® product has not been found to irritate eyes or skin and is practically non-toxic to mammals. Imazamox has no fishing or fish consumption restrictions. Therefore, its use should have no effect on recreational fishing within Willapa Bay.	Similar to Alternatives 1 & 2, the Integrated Pest Management alternative would have no adverse impacts to recreational opportunities in Willapa Bay.
Navigation	Existing practices of *Z. japonica* management have the potential to produce floating wrack within Willapa Bay.	The application of imazamox to commercial clam beds in Willapa Bay would not interfere with boating or navigational routes because these applications will occur at a time when the tide flats are exposed and not navigable. Die-back will occur early in the season as a result of imazamox applications made in spring and early summer, before *Z. japonica* plants reach their full vegetative growth. This may reduce the quantity of vegetative material that breaks off and forms floating "wrack" in Willapa Bay during the fall, thereby reducing boating hazards.	As with Alternatives 1& 2, there would be no impacts to navigation as a result of the Integrated Pest Management alternative. There may actually be a benefit in the form of reduced plant material that would break off in the fall and form dense floating "wracks" that interfere with navigation in the bay at that time of year.

Elements of the Environment	Alternative 1:No Action, Continue Existing Practices	Alternative 2: Chemical Methods Only	Alternative 3: Preferred − Integrated Pest Management
Human Health	There is some degree of risk of injury related to use of hand rakes for harvest and mechanical methods of *Z. japonica* management; however, growers use experienced field crews on an on-going basis, which minimizes these risks due to familiarity. No risk of chemical exposure or toxicity.	Imazamox is an acetolactate synthase (ALS) inhibitor. ALS herbicides demonstrate low toxicity toward animals, likely because the ALS biochemical pathway does not exist in animals. Because rat toxicity testing showed that imazamox was practically non-toxic to mammals on an acute basis, no significant human health concerns have been identified for application of this herbicide where humans may come into contact with it. Similarly, there was no evidence of carcinogenicity in rat or mouse studies, and imazamox was negative in a number of genotoxicity studies. Based on these findings, EPA designated imazamox as *not likely to be carcinogenic to humans*. EPA granted a conditional registration for imazamox in 1997 and an unconditional registration Section 3 label in 2001. In 2003, imazamox received an "exemption for tolerance" designation from EPA. This exemption waives all food residue tolerance requirements for potential food or feed uses of imazamox, including fish, shellfish, crustaceans, and irrigated crops. Imazamox is the first and only organic pesticide to receive a tolerance exemption. This means that EPA determined the total quantity of imazamox in or on food presents no hazard to public health.	As with Alternative 1, the risk of injury related to manual and mechanical methods of *Z. japonica* control would also be a factor with the Integrated Pest Management approach. As with Alternative 2, there would be no human health concern with the use of imazamox.

2.9 Cumulative Impacts

2.9.1 Actions Considered as Cumulative Impacts

In addition to direct and indirect effects, cumulative effects are those that could result from the combined incremental impacts of multiple actions over time. This analysis considers effects of other past, present, and reasonably foreseeable proposals. Thus, this FEIS will consider the potential cumulative impacts of Imazamox applications combined with:

- Mechanical and manual removal of *Z. japonica*.
- Effects of the proposed imazamox discharge with the existing discharge of imazapyr for *Spartina* control.
- The use of imidacloprid to control burrowing shrimp in Willapa Bay.
- The potential to discharge carbaryl under the *Willapa-Grays Harbor* Oyster Growers Association NPDES Permit.

Mechanical and manual removal of Z. japonica. The additive effects of mechanical and manual removal of *Z. japonica* combined with imazamox treatment is addressed by the discussion of Alternative 3, the integrated pest management option, in this FEIS.

Effects of the proposed imazamox discharge with the existing discharge of imazapyr for Spartina control. The acreage of *Spartina* in Willapa Bay has been steadily decreasing in Willapa Bay so that in 2012 approximately 1.3 solid acres remain (Washington State Department of Agriculture 2013). It is anticipated that the level of *Spartina* infestation in Willapa Bay will continue to decrease with projections for 2013 and 2014 at 0.8 acre and 0.4 acre, respectively. The reported amount of imazapyr discharged for *Spartina* control in Willapa Bay for 2012 was approximately 0.75 pound of active ingredient (data from Aquatic Noxious Weed Management General Permit Reporting). The amount of imazapyr expected to be discharged into Willapa Bay in the future under the Aquatic Noxious Weed Management General Permit should continue to decrease if projections of *Spartina* infestation are correct (Washington State Department of Agriculture 2013). Timing of imazapyr treatments generally are from June 1 through October 31. This results in potential overlap of imazapyr discharge and imazamox discharge only during the month of June.

The mode of action for imazapyr is as an ALS inhibitor, in the same family of chemicals as imazamox (Ecology 2014). Both chemicals are applied to dewatered plants and are rapidly diluted by tidal exchange. Based on the limited overlap in the timing of discharge and the anticipated use of less than one pound of imazapyr, Ecology does not anticipate that the discharge of imazapyr and imazamox concurrently in Willapa Bay will increase the likelihood of non-target impacts to vascular plants such as *Zostera* spp.

The request for permit development to allow the use of imidacloprid to control burrowing shrimp in Willapa Bay. An application has been submitted for the use of imidacloprid to treat burrowing shrimp (ghost shrimp and mud shrimp) on commercial clam and oyster beds in Willapa Bay and Grays Harbor. There are currently no known studies that address additive or synergist effects of imazamox and imidacloprid. Imazamox and imidacloprid have completely different toxic modesof-action, where imazamox is an ALS inhibitor which acts on a biochemical pathway that does not occur in animals and imidacloprid is neonicotinoid insecticide.

Aside from conducting specific toxicological studies, the assessment of additive or synergistic risk can be addressed by evaluating the potential for combined exposure. Scientists have collected extensive water concentration information for imidacloprid. Felsot and Ruppert (2002) treated small plots (approximately 20 feet square) with imidacloprid. They collected water and sediment samples directly in the treated plots or at various distances along a transect from the plots. They collected water samples on the flood tide in 2 cm of water (initial samples, and 14 and 28 days after treatment). They also collected sediments during low tides when the sediment was exposed. Typically, imidacloprid was detected in first tidal flush water after application (concentrations peaked 10 minutes post-flow), but was not detected in samples collected 30 and 40 minutes after the first flush tide. Felsot and Ruppert (2002) did not detect imidacloprid in water samples collected 15 and 152 m (approximately 50 and 500 feet) from the plot the day after application. The authors attributed the rapid dissipation of imidacloprid to dilution, and concluded that 99% of the applied chemical dissipated from the small plots within 24 hours. At a distance of 152 m (approximately 500 feet) along a transect from the plot in the direction of tidal flow, imidacloprid levels peaked within 10 minutes after the tidal waters reached that location, but within 30 minutes, no residues were detected. Nor were any residues detected for a month following the treatment when sampling finished.

Larger scale trials (5 to 10 acres) were also conducted as part of the imidacloprid sampling and analysis plan (SAP) (Hart Crowser 2013). The vast majority of imidacloprid (89 to 98%) was transported off-site within the first 24 hours after application, and 30 to 90% of the remaining imidacloprid was bound to the sediment 24 hours post-treatment. The remaining imidacloprid in the pore water dropped one degree of magnitude within 24 hours and another degree of magnitude within 14 days.

Similar to imidacloprid, imazamox rapidly dissipates from the ecosystem. The lowest effect level for imazamox is 10 to 40 ppb for 120 hours static test for algae, diatom and aquatic vegetation, and the no effect level (96 hour exposure) for aquatic invertebrates is 94,000 to 122,000 ppm (ENVIRON 2012). Imazamox dilutes in the leading edge of the water column 1 order of magnitude every 24 hours (60 ppb to 6 ppb) (ENVIRON 2012).

Until studies are conducted regarding the potential additive or synergistic effects of imidacloprid and imazamox, a cautionary approach of utilizing a treatment window could be employed to avoid any potential for adverse effects. A 96-hour delay for imidacloprid application after imazamox application would result in a co-exposure scenario (short-time exposure within the top 2 cm of leading edge of the tidal water) of imazamox at approximately 0.006 ppb. This is approximately 4 to 5 orders of magnitude lower than the lowest effect level of imazamox for a 120-hour exposure for aquatic species, and 6 to 7 orders of magnitude lower than the worst-case exposure rate expected from imidacloprid (200 to 1,000 ppb) (Hart Crowser 2013). With this margin of safety with imazamox (after 96 hours), and this difference in concentration after 96 hours between imazamox and imidacloprid, it is unlikely that there would be any chemical synergy or additive effects between these two chemicals. If future studies demonstrate a lack of additive or synergistic effects through the combined presence of these chemicals in the environment, then the treatment window could be reduced or eliminated.

The potential to discharge carbaryl under the Willapa-Grays Harbor Oyster Growers Association NPDES Permit. Carbaryl is currently permitted for discharge in Willapa Bay under the Oyster Growers Association NPDES Individual Permit. Carbaryl is an insecticide in the carbamate family of chemicals. The Oyster Growers Association NPDES permit limits carbaryl discharge from July 1 through October 31.

Studies in the Palix River area of Willapa Bay where carbaryl was applied at either 5 pounds per acre or 7.5 pounds per acre resulted in concentrations of 35 to 68 ppm immediately after treatment (WDF and Ecology 1992). Twenty-four hours after treatment, carbaryl concentrations had fallen to 0.65 – 3.94 ppm, and at 16 to 59 days after treatment carbaryl concentrations were less than 0.02 ppm. No studies found irreversible physiological impacts to aquatic plants due to carbaryl applications (WDF and Ecology 1992).

Imazamox rapidly dissipates from the ecosystem. The half-life of imazamox in the presence of light is 6.8 hours (ENVIRON 2012). The lowest effect level for imazamox is 10 to 40 ppb for 120 hours static test for algae, diatom and aquatic vegetation, and the no effect level (96 hour exposure) for aquatic invertebrates is 94,000 to 122,000 ppm (ENVIRON 2012). Imazamox dilutes in the leading edge of the water column 1 order of magnitude every 24 hours (60 ppb to 6 ppb) (ENVIRON 2012). Imazamox discharge is proposed to be limited to April 15 through June 30.

The treatment windows in the proposed *Z. japonica* Management on Commercial Clam Beds in Willapa Bay Permit and the Oyster Growers Permit will provide a separation of permitted carbaryl discharge and the proposed imazamox discharge. A 96-hour delay for carbaryl application after imazamox application would result in a co-exposure scenario (short-time exposure within the top 2 cm of leading edge of the tidal water) of imazamox at approximately 0.006 ppb. This is approximately 4 to 5 orders of magnitude lower than the lowest effect level of imazamox for a 120-hour exposure for aquatic species. Instituting a 96-hour separation between imazamox discharge and carbaryl discharge would make additive effects between the two chemicals unlikely.

2.9.2 Actions Not Considered as Cumulative Impacts

Potential expansion of permit authority to other aquatic lands and testing of alternative herbicides to treat *Z. japonica* are not being considered in the cumulative impacts analysis. Ecology does not know where expansion of future use may be considered or what other chemicals may be researched for *Z. japonica* control, making them speculative and outside the scope of this proposed action.

2.10 Benefits/Disadvantages of Reserving the Proposed Action for Some Future Time

Opinions are varied regarding the benefits and disadvantages of reserving until some future time applications of imazamox to manage *Z. japonica* on commercial clam beds in Willapa Bay. For those who either don't want pesticide use in Willapa Bay or support the proliferation of *Z. japonica* for its habitat value, postponing chemical applications on commercial clam beds would allow *Z japonica* to remain largely unmanaged in Willapa Bay. The benefits are that no additional pesticides will be put into Willapa Bay and *Z. japonica* populations won't be greatly altered.

Many consider the body of research on *Z. japonica* to be lacking sufficient evidence to determine whether it poses an ecological risk or a benefit. Under this line of thinking, more research is necessary before determining whether to follow through with the proposed action. For a list of research needs surrounding *Z. japonica* in Washington State, see the Science Panel Summary (Ecology 2013). The benefit of postponing the proposed action is a reduction in the uncertainty surrounding *Z. japonica* ecological function.

Z. japonica has been designated a Class C noxious weed in Washington State. Class C weeds are typically common and widespread. Rather than requiring control of these plants, most County Weed Boards simply offer advice to landowners about the most effective control methods. A County Weed Board may require landowners to control a Class C weed if it poses a threat to agriculture or natural resources by selecting the class C weed for control within the county (Washington State Noxious Weed Control Board, *Weed* Laws). Postponing the proposed action would limit the control options for this class C noxious weed.

For commercial shellfish growers, there would be disadvantages to delaying the proposed action. The longer *Z. japonica* remains un-managed on commercial clam beds, the more potential for reduced clam yields and negative economic impacts. See section 2.5 for a discussion of socioeconomic impacts.

3.0 Affected Environment, Potential Impacts, and Mitigation Measures

The Determination of Significance and Environmental Impact Statement Scoping Notice issued by Ecology on October 3, 2012 identified the following areas for discussion:

1. The potential environmental impacts of various management methods for the control of the state-listed noxious weed Japanese eelgrass (*Zostera japonica*) in Willapa Bay.
2. Any potential human health effects from controlling Japanese eelgrass.
3. The efficacy of the various management methods on managing Japanese eelgrass.
4. Impacts of Japanese eelgrass on the environment and infrastructure if it is not managed.

The efficacy of the alternative management methods is discussed in Chapter 2, Section 2.7. The efficacy of imazamox treatments in research trials conducted under Experimental Use Permits are also described below in the subsection titled "Shellfish Grower Concerns re: *Z. japonica*." The potential environmental impacts of management methods, potential human health effects, and the impacts of Japanese eelgrass if not managed are discussed in Section 3.2 below.

3.1 Biological Background Information

This section summarizes the results of scientific studies performed by scientists with a range of experience from post-graduate students and doctoral candidates, to agency staff and consultants with decades of experience. The research was performed for various purposes that range from dissertations, to advancement of the body of knowledge in scientific journals, to a response to shellfish industry concerns.

No attempt is made in the summaries below to delve into methods used, to express judgment regarding the comparative credibility of the various biological investigations, or to persuade reviewers which conclusions are the most factually correct. Rather, this summary of available literature describing the values and detriments of *Zostera japonica* is intended to present a balance of information from which reviewers may draw their own conclusions in relation to the proposed action: issuance of a NPDES general Permit for chemical management of *Z. japonica* on commercial clam beds in Willapa Bay.

It is difficult to assess the effects of *Z. japonica* on biological community interactions because some species use *Z. japonica* as food or habitat, some species are negatively affected in density or performance, and some have no response at all. This complicates assessment of the overall impact of *Z. japonica* since whether it is harmful or beneficial depends on the species of concern or affected group (Mach et al. 2010).

3.1.1 Washington's Marine/Estuarine Vascular Plants

There are two species of eelgrass found in Washington, the highly valued and protected native eelgrass (*Zostera marina*), and an introduced Asian eelgrass (*Zostera japonica*). Common names for *Z. japonica* include Japanese eelgrass, dwarf eelgrass, Asian eelgrass, duck grass, and narrow-bladed eelgrass (Mach et al., 2010). Washington's two eelgrass species grow on muddy or mixed sand and mud sediments in protected estuarine waters (Phillips 1984). Unlike freshwater systems where there are numerous aquatic vascular species, there are few marine/estuarine vascular species worldwide.

Washington's two eelgrass species are seagrasses in the family *Zosteraceae*. Seagrasses are flowering plants found in brackish or marine waters that form highly productive ecosystems. Seagrasses grow in protected coastal waters in both temperate and tropical areas and provide food, shelter, and nursery areas for many fauna. Scientists refer to seagrasses as "ecosystem engineers" because they partly create their own habitat by slowing down water flow. This increases sedimentation while roots and rhizomes stabilize sediments. As discussed in detail in Phillips (1984), Pacific Northwest seagrasses (both native and introduced) perform the following functions:

- *High production and growth*: Seagrasses grow rapidly and form highly productive ecosystems.
- *Food and feeding pathways*: Seagrasses are a direct food source for many organisms as is the detritus produced by decaying seagrass biomass.
- *Shelter*: Seagrasses serve as nurseries and create habitat for various fauna including commercially important Pacific Northwest species such as Pacific herring, striped sea perch, English sole, Dungeness crab, and several species of juvenile salmon.
- *Habitat stabilization*: Seagrass leaves reduce water velocity and the roots and rhizomes bind and stabilize sediments.
- *Nutrient effects*: Seagrasses provide organic material, aid in sediment/substrate nutrient cycling and release, and improve water quality through production of oxygen and adsorption of nutrients.

The attributes described above may have a positive or a negative impact on estuaries that were historically partially unvegetated prior to colonization by seagrass. As an "ecosystem engineer," the non-native *Z. japonica* is creating change in the ecosystem and environment of Willapa Bay.

There are about 50 to 60 species of seagrasses worldwide, but according to the Global Invasive Species Database, *Z. japonica* is the only documented invasive seagrass. However, Willette and Ambrose (2009) have documented Halophila stipulacea behaves as an invasive seagrass species. Scientists report that in general, seagrass beds are declining worldwide for several reasons including nutrient runoff and sea level rise (Thom et al. 2011).

3.1.2 Life History of *Zostera japonica*

Phillips (1984) provides a comprehensive overview of Pacific Northwest eelgrass life history and ecology (both *Z. marina* and *Z. japonica*). Whether *Z. japonica* is annual or perennial depends on latitude, elevation on the intertidal zone, and weather conditions. The *Flora of North America* describes *Z. japonica* as an annual, rarely perennial plant. However, the written findings of the Washington State Noxious Weed Control Board (WSNWCB) indicate that it is an annual to perennial herbaceous plant with creeping, perennial rhizomes (Haynes 2000 as cited in the 2011 WSNWCB written findings). Harrison and Bigley (1982) describe *Z. japonica* as an annual, or a short-lived perennial in British Columbia (B.C.) waters, and Harrison (1982a) reported that its location in the intertidal zone determined whether individual *Z. japonica* plants were annual or perennial. Low intertidal populations were partly, or wholly perennial with leafy shoots present year-around. Mid-intertidal plants were annual with only a few leafy shoots overwintering. Phillips (1984) found that plants in more exposed locations tended to be annual and set many seeds. Less exposed plants are perennial and rely more on vegetative reproduction.

In Yaquina Bay, Oregon, *Z. japonica* persists year-around (Larned 2003; and Kaldy 2006). These authors found that above-ground biomass varied seasonally, with maximum above-ground biomass present in late summer and early fall. Phillips (1984) described *Z. japonica* as a facultative perennial in the Pacific Northwest. Thom (2000), as cited in Dumbauld and Wyllie-Echeverria (2003), noted that *Z. japonica* is predominantly an annual with high seed production in its northern introduced range. However, during warmer years in northern locations and in coastal estuaries, it persists as a perennial. In Willapa Bay, *Z. japonica* is a perennial (personal communication with Dr. Kim Patten, Washington State University Cooperative Extension Office, Long Beach, Washington 2012).

The growth habits and life cycle of *Z. japonica* also seem to depend on latitude, tidal elevation, and weather. In his review paper on west coast eelgrass, Phillips (1984) concluded that on the Pacific coast of North America, *Z. japonica* has distinct life-history strategies that depend on latitude, intertidal gradients, water temperatures, salinity, light, grazing, erosion, and wave action.

In southern British Columbia waters, Harrison (1982b) determined that *Z. japonica* is an opportunistic species that colonizes large areas by seedlings that mature, flower, and set seed within a 6- to 7-month life cycle. *Z. japonica* overwinters as buried seeds and germinates from seeds between March and May (Harrison and Bigley 1982; and Harrison 1982b). It typically flowers in late July and August (Harrison 1982b), but also reproduces vegetatively through rhizomatous cloning. Maximum above-ground biomass occurred in British Columbia in August and September (Harrison 1982b). Seed set occurs in early autumn with most shoots senescing before November, except in habitats sheltered from storms. In sheltered environments, some short vegetative shoots may overwinter (although those shoots often died the following spring).

Kaldy (2006) describes very different growth and flowering habits of this species in Oregon compared to conditions that occur in southern British Columbia.[9] He studied the autecology of *Z. japonica* in Yaquina Bay along the central Oregon Coast. Unlike in British Columbia waters where up to 70% of the shoots flower each year, Kaldy (2006) observed 10% of the shoots flowering in October 2001 and only 2% of the population flowering in late summer of 2002.

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[9] The north/south geographic difference of a few hundred miles, possible changes in plant morphology, and climate fluctuations that have occurred in the intervening period of time (20+ years) between the Harrison 1982 and Kaldy 2006 studies may account for their different observations.

In even more southern latitudes (e.g., California), plants flower in March, produce seed in April and May, and decay as water temperatures exceed 27º Centigrade (Phillips 1984).

In a two-year life cycle study of *Z. japonica* in southern British Columbia, Harrison (1982b) observed that *Z. japonica* is more vigorous (produced more biomass and flowering shoots) in more submerged locations than in more exposed sites higher on the intertidal zones. He speculated that competition from the more robust-appearing native eelgrass, *Z. marina*, might limit the growth of *Z. japonica* in the lower intertidal and subtidal zones.

Shafer et al. (2011) looked at the effect on photosynthesis of chronic low salinity, similar to what may be found in an estuary. Their data showed that *Z. japonica* in Coos Bay, Oregon and Padilla Bay, Washington were best adapted to intermediate salinities and could tolerate long term salinities ranging from 5-35. The authors concluded that the effect of salinity on photosynthesis does not seem to be a strong selective force for *Z. japonica*. *Z. japonica* has an optimal photosynthetic physiology at 20° C and a salinity of 20 (Kaldy and Shafer 2012).

A study by Kaldy and Shafer (2012) addressed the effects of chronic extreme temperature and salinity stress on *Z. japonica* from Padilla Bay, Washington and Coos Bay and Yaquina Bay in Oregon. The authors found that chronic low salinity when combined with high temperatures resulted in a negative effect on *Z. japonica* shoot survival. It was suggested that *Z. japonica* can tolerate short-term extreme thermal stress (tidal exposure) but not the chronic exposure presented in the experiment.

3.1.3 Distribution of *Zostera japonica*

Z. japonica is native to Asia, specifically the far east of the Russian Federation, China (Hebei, Liaoning, and Shandong), Japan, Korea, Taiwan, and Vietnam (WSNWCB 2011). Its native range includes tropical and sub-tropical latitudes, but scientists generally regard *Z. japonica* as a temperate species (Lee 1997; and Shin and Choi 1998, as cited in Ruesink et al. 2010). In parts of its native range on western Pacific shores, *Z. japonica* is declining, but it is increasing where introduced (Lee 1997 as cited in Ruesink et al., 2010).

People believe that *Z. japonica* entered northern Puget Sound in the 1930s along with shipments of Japanese oyster spat,[10] although its presence was not officially documented in the region until approximately 20 years later. People speculate that shippers used *Z. japonica* as packing material for Japanese oyster stock with eelgrass being disposed into the water, and/or that *Z. japonica* seed may have hitchhiked on oyster shipments from Japan to the area. The first documented presence of *Z. japonica* on the Washington Coast occurred in 1957 (Fisher Bradley and Patten 2011). In the 1980s, *Z. japonica* rapidly expanded from Willapa Bay to Oregon estuaries, north and south from Samish Bay into British Columbia, and throughout Puget Sound (Mach et al.

[10] Oyster spat is the spawn or larval stage of an oyster.

2010). Scientists do not know if *Z. japonica* established through a single introduction or multiple introductions.

Z. japonica distribution on the west coast of North America now extends from British Columbia to Humboldt Bay, California (WSNWCB 2011). Currently, *Z. japonica* is widespread within Washington waters from areas along the Canadian – USA border; San Juan Island Straits; north, central, and south Puget Sound; Hood Canal; and the Washington coast (Willapa Bay and Grays Harbor). Fisher Bradley and Patten (2011) list specific locations of the occurrence of *Z. japonica* within these areas.

Fisher Bradley and Patten (2011) report *Z. japonica* presence in Willapa Bay from the mid-1950s. The authors note that populations did not expand until about 1998 at which time populations "exploded and aggressively carpeted many areas of Willapa Bay." Monitoring conducted in Willapa Bay by Ruesink et al. (2010) confirmed that substantial increases in eelgrass have occurred on historically unvegetated tide flats, although they reported that this increase in eelgrass was from the upslope expansion of *Z. marina* rather than an increase in *Z. japonica*. The authors reported that *Z. japonica* densities did not change between 2004 and 2007. However, they agree that *Z. japonica* populations have increased in Willapa Bay in the five decades since its introduction.

3.1.4 Distribution of *Zostera japonica* within Intertidal Zones

Growth patterns of native (*Z. marina*) and non-native *Z. japonica* along the intertidal zones likely result from wave energy and shoreline slope (Mach et al., 2010). With steep topography, there is a distinct distribution with *Z. japonica* occurring in the high tidal zone, no vegetation in the mid-tidal zone, and native eelgrass in the low tidal zone. With flat topography, such as occurs in Willapa Bay, (Mach et al. 2010, Shafer et al. 2013) there can be overlapping distribution with *Z. japonica* occurring in the high tidal zone, a mix of Japanese and native eelgrass in the mid-tidal zone, and native eelgrass in the low tidal zone. A mosaic distribution sometimes occurs with *Z. japonica* only in the high tidal zone, patchy mid-tidal zone with native eelgrass in a dominantly *Z. japonica* zone or the opposite. Mosaic distribution occurs less frequently than the other two distribution patterns. Britton-Simmons et al. (2010), as cited in Mach et al. (2010), noted that there is evidence that the lower edge of *Z. japonica* distribution is not variable and concluded that it is variation in the native eelgrass up-shore tidal limit that causes the patterns of co-occurrence between the two species. Another hypothesis is that differences in thermal optima may help to explain differences in vertical zonation between *Z. japonica* and *Z. marina* (Shafer et al. 2013). In North America *Z. japonica* is warm water adapted and *Z. marina* is cold water adapted. *Z. japonica* has an optimal growth temperature of 20° C while *Z. marina* grows best at temperatures between 6 and 13° C.

Z. japonica occupies areas in Willapa Bay from MLLW (0 feet elevation) to deeper waters. Fisher Bradley and Patten (2011) observe, "Where 20 years ago it [*Z. japonica*] inhabited areas approximately between 4 feet and 7 feet MLLW, it now grows at the approximate MLLW (0 ft) tidal elevation occupying vast monotypic beds." The authors also observed that in Willapa Bay, *Z. japonica* appears to colonize intertidal hillocks that are at an elevation that does not initially support native eelgrass. (See Fisher Bradley and Patten [2011] includes photographs of extensive

Z. japonica beds in Willapa Bay.) However, Harrison and Bigley (1982) reported extensive *Z. japonica* beds earlier in Willapa Bay (pre-1982). They said "all substrates except those with excessive clay or gravel support dense populations." The authors also observed large beds of *Z. japonica* in Gray's Harbor in the early 1980s. Ruesink et al. (2010) reported that as of 1997, *Z. japonica* occupied 7.7% of the Willapa Bay's total area of 35,700 hectares (ha), and native eelgrass occupied 9.6% of the total area. The authors report that about half of Willapa Bay is exposed on extreme low tides.

3.1.5 Comparison of *Zostera japonica* and Native Eelgrass (*Zostera marina*)

Baldwin and Lovvorn (1994) concluded that *Z. japonica* has many characteristics of a successful invader; i.e., the species is small and heavily invests in reproductive strategies. In Boundary Bay on the Washington/British Columbia border, *Z. japonica* seed germinates in the spring in mid-to-low intertidal areas denuded by storms. In contrast, native eelgrass overwinters as perennial rhizomes and shoots at low intertidal to sub-tidal elevations with limited storm exposure. In British Columbia, *Z. japonica* produces many seeds, whereas the more robust native eelgrass relies heavily on vegetative resources (rhizomes and shoots) for overwintering. The authors hypothesize that native eelgrass is confined to lower tidal elevations because it appears to have a lower resistance to desiccation than does *Z. japonica* and Harrison (1982) agrees. However, a study comparing the photosynthetic responses of the two species to desiccation did not support their hypothesis (Shafer et al. 2007). Instead, native eelgrass, *Z. marina*, showed greater tolerance for desiccation and recovery than *Z. japonica*, even though *Z. marina* typically grows lower on the intertidal than *Z. japonica*. Shafer et al. (2007) concluded that there is some evidence that the smaller leaves, and more rapid leaf turnover in *Z. japonica* may account for its ability to grow successfully on a more exposed environment (i.e., higher on the intertidal). A study by Shafer and Kaldy (2014) suggested that *Z. japonica* leaf tissue is more photosynthetically efficient than *Z. marina* leaf tissue. They concluded, from the data, that light limitation did not did not limit the distribution of *Z. japonica* in the intertidal. *Z. japonica* is high light adapted and taken with optimal leaf growth at warm temperatures, may allow for colonization of the high intertidal where *Z. marina* is restricted by desiccation stress (Shafer and Kaldy 2014).

People generally differentiate *Z. japonica* from native eelgrass by the length and width of its leaves. *Z. japonica* plants are typically smaller with narrower and shorter leaves than the more robust looking native eelgrass. Native eelgrass leaves can reach lengths of 1.5 m or more, but *Z. japonica* leaves typically only grow to 30 cm in length (Vavrinec et al. 2012). Although the two species look dissimilar most of the time, leaf length and width in both species varies with depth. In intertidal beds, *Z. marina* can be stunted and resemble *Z. japonica* (Harrison and Bigley 1982). Yang (2011) reported that native eelgrass shoots in sandy, more wave-exposed beds tend to be short and fine, but in protected areas, its shoots are long and wide.

The best way to differentiate between the two species is by their sheaths (Environment Canada 2002). Native eelgrass has an entire tube-like sheath. When the lower leaves are slowly pulled in opposite directions, the sheath will tear. The sheath of *Z. japonica* consists of two overlapping flaps that do not tear when the lower leaves are pulled apart. Within Willapa Bay, researchers report that *Z. japonica* is easy to distinguish by morphological characteristics only (personal communication with Dr. Kim Patten, Washington State University Cooperative Extension Office, Long Beach, Washington 2012).

Z. japonica grows much more densely than native eelgrass. In Yaquina Bay, Oregon, Kaldy (2006) recorded 11,000 shoots per square meter (m^2) of *Z. japonica* during the summer, with a winter minimum of 1,500 shoots m^2. In Willapa Bay, a more northern location, Ruesink (2010) recorded maximum shoot numbers of 3,500 m^2 of *Z. japonica*. In contrast to the very high stem numbers of *Z. japonica*, stem densities of native eelgrass in Yaquina Bay were much lower. In a study of native eelgrass, Kaldy and Lee (2007) observed a minimum of 55 shoots m^2 in April and maximum of 89 shoots m^2 in June 2003. In 2002, they observed a maximum of about 130 shoots m^2. In Willapa Bay, Thom et al. (2011) citied densities of native eelgrass that ranged from 39.5 to 71.3 shoots m^2, but Ruesink, et al. (2006) reported higher native eelgrass densities of 105 to 162 shoots per m^2 in their study of both eelgrass species. Variation is likely attributable to weather, seasonal, and geographic differences.

3.1.6 Effects of *Zostera japonica* on Native Eelgrass (*Zostera marina*)

There is both anecdotal and scientific evidence that the presence of *Z. japonica* can facilitate the migration and establishment of native eelgrass into higher intertidal zones than it normally occupies. Fisher Bradley and Patten (2011) noted, "Willapa Bay researchers and oyster growers have observed that the establishment of *Z. japonica* in the middle intertidal range has caused changes in sediment composition and water retention, facilitating the spread of *Z. marina* into shallower waters than it would normally be found." Ruesink et al. (2010) sampled 14 transects in Willapa Bay at two time periods, four years apart, and found that native eelgrass moved up-shore into areas normally occupied by *Z. japonica*. The authors speculated that this migration to a higher intertidal zone was caused by *Z. japonica* retaining water, thereby physically altering the upper intertidal zone to mimic a lower tidal elevation; i.e., making the habitat more suitable for native eelgrass migration into higher tidal elevations (excerpted from WSNWCB written findings, Fisher Bradley and Patten 2011). Tsai et al. (2010) demonstrated that the presence of eelgrass reduced water flow by up to 40% in vegetated test plots in Willapa Bay and concluded that this led to water retention within the plots. Porter et al. (2000) looked at the plaster of paris (gypsum) dissolution method used in the Tsai (2010) study and found that the gypsum – dissolution technique is not a universal device for calculating 'water motion' They found that problems arose when the gypsum-dissolution method was used in highly fluctuating or mixed flow environments while calibrated under steady flow conditions.

In an evaluation of threats to native eelgrass (*Z. marina*) beds in Washington, Thom et al. (2011) considered *Z. japonica* to be the primary non-native invasive species of concern to native eelgrass populations:

> *Although Z. japonica is common, it appears to be having a limited effect on the native Z. marina. Case studies in the region show that Z. marina has a competitive advantage because of its size and its ability to hold space. There is some evidence that Z. japonica is increasing in cover and distribution. Therefore, we consider the magnitude and extent of the threat to be medium, but increasing. Once Z. japonica is removed it appears that Z. marina can re-colonize the space.*

Others also speculated that it was unlikely that *Z. japonica* would displace native eelgrass beds (Harrison and Bigley 1982), concluding that native eelgrass populations appear to have the robustness and ability to maintain their niche against *Z. japonica*. Thom et al. (2011) also reported, however, that the uncertainty about *Z. japonica* as a stressor is high, which the authors concluded to mean that the extent of *Z. japonica* effects on native eelgrass are unknown and could be higher than currently thought.

Merrill (1995) conducted a small study in Padilla Bay, Washington to compare the effect of *Z. japonica* on the growth of native eelgrass. He measured the leaf growth and new shoot recruitment of native eelgrass in the presence and absence of *Z. japonica* and found inhibition of both during the latter half of his study in competitive plots. He concluded that the presence of *Z. japonica* could inhibit the establishment of native eelgrass in restoration sites.

Others, such as Mach et al. (2010), believe that because Washington's two eelgrass species occupy different niches in the intertidal zone, there is reduced opportunity for direct competition. They report that in areas where the two species overlap, neither dominates (e.g., the presence of both species did not cause a decrease in the biomass or density of either species).

Bando (2005) reached a different conclusion than Mach et al. (2010) about eelgrass interspecies competition. In her Willapa Bay study, both eelgrass species experienced substantial reductions in above-ground biomass in mixed species plots compared to above-ground biomass in single-species plots (see also Bando 2006). In the absence of disturbance, native eelgrass outcompeted *Z. japonica*. However, in a disturbed environment, *Z. japonica* responded positively to disturbance, and native eelgrass responded negatively. She recorded a 14-fold decrease in *Z. marina* biomass and an 11-fold increase in *Z. japonica* biomass within disturbed plots and concluded that *Z. japonica* had a massive competitive advantage in disturbed plots. Disturbance also decreased the maximum number of inflorescences per flowering shoots in *Z. marina* (6-fold decrease), but increased flowering shoot production in *Z. japonica* by 19 fold. She concluded that disturbance and interactions with *Z. japonica* are factors in the decline of *Z. marina* in the Pacific Northwest.

Mach et al. (2010) noted that Bando conducted her research at only one site in Willapa Bay, and results from this site may not be applicable to other sites.

A Korean study of the effects of clam harvesting on *Z. japonica* in its native range supported Bando's results about disturbance. Park et al. (2011) monitored above and below-ground biomass of *Z. japonica* before 2003 and after a Manila clam harvesting event that removed all above-ground biomass in spring 2004. The authors found that *Z. japonica* reproductive shoot density and reproductive efforts increased the first year after clam harvesting compared to pre-harvesting levels. Further, *Z. japonica* produced reproductive shoots for approximately three times longer after the disturbance than before the disturbance. The below-ground biomass was also significantly higher than the biomass prior to the clam harvest. The authors concluded that disturbance tends to promote more sexual and asexual reproduction in *Z. japonica*.

3.1.7 Effects of *Zostera japonica* on Nutrient Cycling

In Yaquina Bay, Oregon, the presence of *Z. japonica* altered nitrogen cycling in the estuary. Larned (2003) hypothesized that this could lead to reductions in nutrient availability. Unvegetated sediments colonized by *Z. japonica* switched from functioning as net sources to net sinks of inorganic nutrients. Nitrate and ammonium fluxes in native eelgrass beds were twice that of *Z. japonica* beds. Mach et al. (2010) concluded from a different study in Washington State that there is conflicting evidence of nutrient use by *Z. japonica* that makes it difficult to draw any conclusions about its effect on nitrogen cycling.

Scientists believe that nitrogen is the major limiting nutrient in marine waters. However in Pacific Northwest estuaries there is little evidence for nitrogen limitation in seagrass. Kaldy (2006) concluded that Z. marina in Yaquina Bay, Oregon is unlikely to be nutrient limited. In Yaquina Bay, water column and sediment nutrients were always greater than the reported requirements for seagrasses (Kaldy and Lee 2007). Yaquina Bay summer nutrient concentrations were due to coastal upwelling, while winter nutrient inputs were dominated by nitrogen fixing trees such as Red Alder (Alnus rubrum) in the watershed (Brown and Ozretich 2009).

3.1.8 Relationship of *Zostera japonica* Control to State Sediment Management Standards

The aquatic sediment standards (chapter 173-204 WAC) protect aquatic biota and human health. Under these standards, Ecology may require a Permittee to evaluate the potential for the discharge to cause a violation of sediment standards (WAC 173-204-400). Readers may obtain additional information about sediments at the Aquatic Lands Cleanup Unit website www.ecy.wa.gov/programs/tcp/smu/sediment.html

The antidegradation and designated use policies of the SMS 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 (WAC 173-204-120).”

Marine sediment quality standards (WAC 173-204-320) do not list a numeric standard for imazamox.

The EPA Environmental Fate and Ecological Risk Assessment prepared for imazamox found that the herbicide has low sorption potential and should not bind to sediments (EPA 2008).

Imazamox is highly water-soluble (4,424 mg/L) and adheres poorly to all soil types. The organic carbon absorption (coefficient) of imazamox is 5 to 143 ml/g. Sorption is typically less in sediments with low organic content, such as those within Willapa Bay (ENVIRON 2012). Based on these chemical characteristics, imazamox is not expected to persist in the sediment.

EPA did not require chronic testing of imazamox for invertebrates because the estimated environmental concentration did not exceed 1% of the lowest LC_{50} (concentration at which 50% lethality occurs), making the chronic risk of imazamox to invertebrates negligible. The EC_{50} values (maximal effect concentration of 50%) for the daphnid and mysid organisms are greater than 122 ppm and 94.3 ppm, respectively. These values are well in excess of the maximum in-water label rate of 500 ppb for imazamox. Based on this data imazamox is not expected to harm benthic invertebrates.

Even though imazamox is not expected to persist in the sediment, the proposed NPDES general permit should require additional sediment testing to assess imazamox levels and persistence in treated estuarine sediments to ensure that the herbicide does not persist in Willapa Bay sediments at concentrations that harm plant growth in desired species (such as the native eelgrass, *Z. marina*).

3.1.9 Importance of *Zostera japonica* to Juvenile Salmon

Researchers tracked the movement of 17 juvenile Chinook hatchery salmon, implanted with microacoustic tags, in an enclosure that encompassed several habitat types in Willapa Bay (Semmens 2008). Habitat types within the enclosure included *Z. marina*, *Z. japonica*, bare ground, oyster beds, and *Spartina*. The juvenile salmon spent most of their time in deeper water over native eelgrass patches, rather than in the other habitats. The author speculated that the salmon preferred native eelgrass to the other habitats because it provided better cover from predators and better foraging opportunities. Native eelgrass was taller with wider stems than *Z. japonica* (and therefore provided more structure), and grew in deeper water, which may be why the Chinook preferred native eelgrass beds to the *Z. japonica* beds in more shallow water. The authors' state: "The apparent similarity in habitat capacity provided by non-native eelgrass and oysters suggests that the common practice of assuming that native and non-native eelgrasses are ecologically equivalent may unduly burden the aquaculture industry during efforts to implement 'salmon-friendly' management practices." Predators killed all fish within days of release. (Belted kingfisher, great blue heron, and great egret were observed in the enclosure, but there were no fish present except for the salmon.) All predation events occurred while the fish were over open ground.

In Grays Harbor young of year chum salmon were sampled and found at the highest densities in aquatic vegetation bed habitats. The greatest densities of chum salmon were measured from February through May (Sandell et al. 2013). This study did not separate out the aquatic vegetation habitat into *Z. marina*, *Z. japonica* or mixed seagrass beds.

3.1.10 Shellfish Grower Concerns

Some Washington shellfish growers, predominantly those farming in Willapa Bay, report that *Z. japonica* is interfering with shellfish production (particularly Manila clam culture). This has caused growers to collaborate with the Washington State University Cooperative Extension Office to discover new management methods for *Z. japonica* control on shellfish beds. Manila clams (*Venerupis philippinarum*) represent a significant portion of the shellfish industry in Willapa Bay, where Ruesink et al. (2006), as cited in Tsai et al. (2010), reports that Manila clam harvests are increasing by 6% each year. At the same time, *Z. japonica* populations have expanded and occupy about 9% of Willapa Bay (Ruesink et al. 2006 as cited in Tsai et al. 2010) − up from 7.7% in 1997 as reported in Ruesink et al. (2010). A suitable tidal elevation for Manila clam cultivation is + 0.6 m to + 1.2 m above MLLW. *Z. japonica* has colonized these formerly unvegetated intertidal zones used for Manila clam culture in Willapa Bay, interfering with shellfish planting and harvesting, and reducing yields (Fisher Bradley and Patten 2011). Growers typically harvest clams about 3 to 5 years after seeding, using raking and hand removal techniques. Dense *Z. japonica* makes harvesting difficult. A normal aquaculture clam density is about 125 adult clams (>40 mm shell length) per m^2 (Tsai et al. 2010). The density of clams where *Z. japonica* is present varies with eelgrass density and other site conditions, but is estimated at a 44% reduction when compared to sites where *Z. japonica* is not present (Fisher Bradley and Patten 2011).

In studies conducted in Willapa Bay, the presence of *Z. japonica* reduced both clam condition and the dry weight of the clam meat (Tsai et al. 2010). The authors hypothesized that the negative effects of *Z. japonica* on clam condition may be because of reduced food delivery to clams rearing in eelgrass beds or from poor environmental conditions caused by dense vegetative cover. They observed that clams in the eelgrass plots were closer to the surface than clams in non-vegetated or harrowed research plots, although oxygen levels appeared adequate in all plots. *Z. japonica* affected clam growth and condition; however, the presence of Manila clams did not affect eelgrass growth. A study by Irlandi (1994) conducted on *Mercenaria mercenaria* (hard clam) in seagrass beds (*Halodule wrightii* and *Zostera marina*) showed that when clams were placed in 99% vegetated and 23% vegetated beds, clams recovered from the 99% vegetated beds were nearly double what was recovered from 23 % vegetated beds. This reduction in clam recovery in the 23% vegetated seagrass beds was thought to represent increased predation intensity. In a study by Irlandi and Peterson (1991) the authors concluded that food depletion did not occur as a result of a reduction in flow velocities under seagrass canopies.

Recent work suggests that the alteration of habitat caused by *Z. japonica* has altered the basic food chain so that algal types necessary to sustain shellfish and other native species are being replaced by habitat that supports other types of biota (personal communication with Dr. Richard Wilson, 2012, while developing a proposal for field work to assess the impact of *Z. japonica* in Willapa Bay). Additionally, the type of biota found in *Z. japonica* beds is more aligned with the needs of certain worm species (polychaete worms) that prey on shellfish seed (Ferraro and Cole 2011). Kaldy et al. (2002) reports that in seagrass dominated systems the largest contributors to total ecosystem net primary production is macroalgae and microalgae. Seagrasses are extremely productive but not many consumers directly utilize them alive or as detritus (Morgan and Kitting 1984). They investigated further what made the seagrass system so productive and concluded that epiphytic algae contribute a large fraction of the carbon fixed in seagrass beds. However, the authors noted that epiphytes may play a larger role in semitropical environment than in temperate systems. In temperate, sub-tropical and tropical systems epiphytic algae is shown to produce organic matter equal to, or in excess of that produced by their seagrass hosts (Moncrieff and Sullivan 2001).

To help document impacts of *Z. japonica* on shellfish beds, the Willapa-Grays Harbor Oyster Growers Association contracted with ENVIRON International Corporation and Washington State University Cooperative Extension (WSU Extension) to prepare a "white paper" titled *Invasion of Japanese eelgrass,* Zostera japonica *in the Pacific Northwest: A preliminary analysis of recognized impacts, ecological functions, and risks* (Fisher Bradley and Patten 2011). WSU Extension scientist Dr. Kim Patten has been conducting trials of imazamox in Willapa Bay each year since 2007 under WSDA Experimental Use Permits. The "white paper" documents the results from some of his unpublished research trials and summarizes other relevant literature.

Dr. Patten compared the number and weight of Manila clams on imazamox-treated beds (no *Z. japonica* present on the beds after treatment). He found that the number and weight of clams was higher at four of the five treated locations, and significantly higher at three locations. He saw variable results with soft shell clams, with three of the five sites showing higher abundance in the herbicide-treated beds, but two sites showing higher abundance in the beds with *Z. japonica*. In other unpublished information, Dr. Patten reported increased summer length gain and clam weight, and clam quality (meat weight/shell weight) on beds where he removed *Z. japonica*, relative to vegetated beds. He reported variable results with clam set.

The average decrease in yield of clams on a cultivated bed was found to be 44% (Fisher Bradley and Patten 2011). Based on a 4-year harvest cycle, and on an average harvest density of 1 lb/sq ft for cultivated ground, the estimated gross loss from one acre of clam ground per year is approximately $11,500 (43,560 sq ft/acre x 1 lb/sq ft x 44% x $2.40/lb/4). There were an estimated 1,100 acres of commercial clam beds in active cultivation in Willapa Bay in 2012 (WGHOGA member survey 2012). A 44% loss from these beds results in a gross economic loss of approximately $12.6 million (1,100 x $11,500), assuming all 1,100 acres under cultivation are fully impacted by Z. japonica. There are an additional 3,000 acres of tidelands owned by commercial shellfish growers that are suitable for the cultivation of manila clams that are presently lying fallow due to *Z. japonica* colonization (WGHOGA member survey 2012). These lands are a combination of previously cultivated and uncultivated beds that would yield a lower clam density at an estimated 0.4 lb/sq ft. These beds have become economically unfeasible to harvest due to *Z. japonica*, so are essentially a 100% loss each year they are not farmed. Annual losses for these beds are estimated to be approximately $31 million (3,000 acres x 43,560 sq ft/acre x 0.4 lb/sq ft x $2.40/lb/4) based on a 4-year harvest cycle. This results in a combined gross economic loss to shellfish growers of approximately $43.6 million.

The calculations for economic loss assume that all suitable acreage for clam aquaculture is being fully impacted by *Z. japonica* and that commercial clam growers would cultivate all suitable clam aquaculture grounds. The price of $2.40/lb was given as the average wholesale price of manila clams (Sheldon 2013 email communication).

Because of their growing concern about *Z. japonica* impacts to shellfish farming, some growers initiated a change in the regulatory status of *Z. japonica* in Washington, by submitting requests to the WSNWCB to list *Z. japonica* as a noxious weed (proposals submitted in 2010 and 2011). Testimony from some commercial shellfish growers at the WSNWCB public hearing in 2011 highlighted their concerns about the negative impacts to shellfish growing areas. A representative from Taylor Shellfish Company testified that 800 acres of their clam farmland in Willapa Bay has "turned into a wasteland of mud and muck." Taylor Shellfish Company said that it had to abandon this portion – 80% – of their 1,000-acre farm because of *Z. japonica* colonization. Representatives from the Northern Oyster Company and the Willapa-Grays Harbor Oyster Growers Association asserted, "*Japonica* is an invasive that is decimating our land. It reduces natural seed setting, degrades meat yield, provides cover for predators, is smothering the beds and trapping sediment resulting in a tremendous loss in crops." Shellfish growers Wiegardt and Sons, Inc. testified, “The infestation of *japonica* has cost us ten full-time positions.” Northern Oyster Company: “Our records show that we had to reduce sales by 32% between 2010 and 2012, and will continue to be forced to decrease sales annually due to direct impacts caused by *japonica* infestation. We were on track to achieve our crop production forecast levels, but *japonica* caused us to level off at about 50% of forecast amounts, and is now acting to reduce even that 50% crop production level."

Tim Morris, former president of the Willapa-Grays Harbor Oyster Growers Association, in a letter, that asked Ecology to develop a permit to allow the use of imazamox to manage *Z. japonica*, provided the following reasons why *Z. japonica* impacts aquaculture. "It [*Z. japonica*] has carpeted what used to be mostly bare sandy bottom tidelands where we have historically cultivated shellfish. …*japonica* is causing large impacts now and continues to expand its coverage further into the bay…The invasive isn't constrained to only our farms, and is causing the same damages to all State- and Federally-managed tidelands as well."

3.1.11 Positive Impacts associated with *Zostera japonica*

As noted in the description of seagrasses at the beginning of this section, both *Z. marina* and *Z. japonica* fulfill many of the same food, shelter, and habitat functions. Mach et al. (2010) concludes that it is difficult to assess the effect of *Z. japonica* on community interactions when some species use it for food or habitat, it affects others negatively in density or performance, and some species have no response to *Z. japonica* presence. However, there is scientific literature that discusses positive effects of *Z. japonica* in its introduced range.

Increased Species Diversity. Species diversity and the abundance of fauna are typically greater in seagrass beds than in unvegetated areas (Phillips 1984). In Coos Bay Oregon, Posey (1988) reported that species richness was higher within *Z. japonica* patches that he monitored as compared to adjacent unvegetated areas. The densities of several common organisms also changed within eelgrass beds with some common animals showing increases within the patches while other species declined or had no significant correlation with eelgrass cover. The author noted that the increased species richness and other changes found in *Z. japonica* beds are consistent with similar biological effects associated with other seagrasses, and concluded that there was a general positive effect of *Z. japonica* colonization on local diversity and animal abundances in Coos Bay. There is minimal information documenting the pre-colonization natural conditions in terms of diversity and species content in Willapa Bay. Concern about the lack of pre-colonization data in regard to historic tideland conditions and their ecological value was expressed at The Science and Management of *Zostera japonica* in Washington workshop for State agencies, June 18-19, 2013 (Washington State Department of Ecology 2013).

Epibenthic Organisms. Thom et al. (1995) as cited in Mach et al. (2010) showed that populations of invertebrate grazers were similar on *Z. japonica* to those on *Z. marina*.

Waterfowl Food Source. *Z. japonica* can be a food source for waterfowl at some locations. Because it grows higher on the intertidal zone than *Z. marina*, it provides easier feeding access for dabbling ducks. Baldwin and Lovvorn (1994) concluded that in Boundary Bay near the Canada/U.S. border, *Z. japonica* provides feeding habitat for migratory waterfowl such as Brant, American widgeon, and mallard. Some waterfowl species fed preferentially on *Z. japonica* over the native eelgrass at this site. The authors also determined that *Z. japonica* leaves had a higher caloric value than native eelgrass leaves although they did not find any caloric differences between the rhizomes of the two species. Phillips (1984) also noted that black brant geese use *Z. japonica* as a food source.

In Willapa Bay, Dr. Kim Patten reported in unpublished research cited in Fisher Bradley and Patten (2011) that there was no appreciable amount of *Z. japonica* in the gullet contents of waterfowl examined. At least one local duck hunter challenges Patten's findings (R. Barkhurst, written testimony to the WSNWCB), with anecdotal evidence that 90% of widgeon taken in his blinds on Willapa Bay had *Z. japonica* in their gullets and other dabbling duck species contained significant amounts. At an informational meeting held in December 2012, Mr. Barkhurst displayed photographs that showed waterfowl feeding on *Z. japonica* in Willapa Bay in fall 2012.

Spawning Substrate. Scientific literature studying the use of *Z. japonica* as spawning substrate for forage fish is lacking and was recognized as an area where further research was needed (Ecology 2013). It has been observed that *Z. japonica* provides spawning surface for forage fish such as herring. Forage fish are small fish that provide a significant food source for larger fish such as salmon. One biologist has observed the use of middle intertidal beds of *Z. japonica* as egg-deposition substrate by Grays Harbor and Willapa Bay stocks of Pacific herring during the February-March spawning season (Daniel E. Penttila, Salish Sea Biological, letter of comment to Ecology on draft NPDES permit development, October 23, 2012). In Willapa Bay, Mr. Penttila, a fish biologist, found herring eggs on *Z. japonica* beds just inshore of the native *Z. marina* beds in the area north of Oysterville, Willapa Bay. WDFW field reports between 2000 and 2003 documented herring eggs attached to Japanese eelgrass in Stackpole Harbor along the eastern shore of the North Beach peninsula (WDFW, unpublished data, as cited in ENVIRON 2012).

In 2004 at Yaquina Bay, Oregon an Oregon Department of Fish and Wildlife report documented two separate episodes of herring spawn, in February and March, on *Z. japonica* that was estimated to represent approximately 17.5 tons and 41 tons of herring respectively (Matteson 2004). Matteson (2004) observed that *Z. japonica* did not retain eggs well. The density of eggs on *Z. japonica* was reduced after one day and no observation of bird predation occurred causing the author to conclude that the loss was likely due to eggs being washed free of the spawning substrate.

Competition with Burrowing Shrimp. Previous research reported eelgrasses can reduce numbers of burrowing shrimp (ghost shrimp and mud shrimp) that are also problem species for shellfish growers (Feldman et al. 2000; and Harrison 1987 as cited in Fisher Bradley and Patten 2011). It was thought that the roots and rhizomes of both *Z. marina* and *Z. japonica* inhibit/exclude burrowing organisms, and conversely, that burrowing shrimp could reduce the growth of eelgrass. It was concluded in the 1987 and 2000 studies that sediment turnover and water turbidity caused by ghost shrimp reduced the shoot growth of *Z. japonica* compared to areas without shrimp.

It was also observed that burrowing shrimp impeded *Z. japonica* expansion by reducing seedling survival in areas where they are present in Willapa Bay (Dumbauld and Wyllie-Echeverria unpublished manuscript as cited in Feldman et al. 2000). With shrimp recruitment now beginning to reoccur in large numbers, they are now observed to inhabit areas where *Z. japonica* is present. Recruitment into Willapa Bay for the approximate decade prior to 2012 had been greatly diminished. Reduced shrimp populations may have allowed substrates to stabilize, which facilitated the eco-engineering actions of *Z. japonica*.

The reduction in burrowing shrimp populations between approximately 1998 and 2011 correlates with the significant expansion of *Z. japonica*. Past information demonstrates that where burrowing shrimp inhabit tide flats, sea grasses and other species are displaced depending on shrimp density. With the shrimp recruitment cycle now apparently on the upswing, it may be possible to learn more about any affect *Z. japonica* might have on discouraging or preventing shrimp colonization of tide flats (personal communication with Brian Sheldon, Northern Oyster Company, October 1, 2013).

Patten suggests that conclusions about the relationship between burrowing shrimp and *Z. japonica* may be more site-specific. He suggests three scenarios to consider when looking at impacts: 1) the control of shrimp at a particular site may stabilize tide flat substrate and allow *Z. japonica* to colonize the newly stabilized area within one year; 2) heavily populated shrimp ground surrounded by dense *Z. japonica* ground will quickly become colonized by *Z. japonica* within two years due to high seed pressure; and 3) heavily populated shrimp ground not adjacent to *Z. japonica* will remain clear of *Z. japonica*. The question of whether shrimp inhabit *Z. japonica* ground to an extent equal to bare ground needs further investigation. It is also of interest that shrimp constantly bury and unbury *Z. japonica* seeds, which may prolong seed germination during the summer. It has not yet been determined whether this slows the speed at which *Z. japonica* colonizes shrimp beds (personal communication with Kim Patten, Ph.D., Washington State University Cooperative Extension Office, Long Beach, October 15, 2013.)

3.2 Elements of the Environment

Ecology's Water Quality Program and Shorelands and Environmental Assistance (SEA) Program administer the State's Water Pollution Control Act (Chapter 90.48 RCW). Under this authority, Ecology must balance competing beneficial uses, and avoid contamination or other alteration of the physical, chemical or biological properties of waters of the state. Alterations to be avoided include:

- Change in temperature, taste, color, turbidity, or odor.
- Discharges likely to create a nuisance or render such waters harmful, detrimental or injurious to public health, safety or welfare.
- Discharges likely to create a nuisance or render such waters harmful, detrimental or injurious to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses.
- Discharges likely to create a nuisance or render such waters harmful, detrimental or injurious to livestock, wild animals, birds, fish or other aquatic life (RCW 90.48.020).

The proposed action and alternatives are evaluated in relation to the elements of the environment listed below in order to address the RCW 90.48 criteria, with the following exceptions:

- The estuarine waters of Willapa Bay are not used as drinking water by humans or livestock.
- The estuarine waters of Willapa Bay are not used as commercial or industrial process waters.
- Agricultural uses of the waters of Willapa Bay are limited to commercial shellfish aquaculture.

Mitigation Defined

As defined by the Washington State Environmental Policy Act (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.
6. Monitoring the impact and taking appropriate corrective measures.

Mitigation measures that could be implemented by shellfish growers and/or that would be required by the NPDES general permit for proposed use of the herbicide imazamox to control invasive Japanese eelgrass (*Z. japonica*) in Willapa Bay, Washington, are listed following the description of potential impacts to each element of the environment below.

General mitigation strategies to minimize potential impacts associated with the use of aquatic herbicides are included in the General Conditions of the proposed NPDES permit. The Special Conditions listed in the proposed NPDES permit provide specific mitigations to reduce the potential impacts of imazamox applications.

3.2.1 Sediments

Willapa Bay is dominated by mudflats. The physical structure is shaped by dynamic natural forces including large tidal ranges, strong currents, and heavy runoff (Day et al. 1989, cited in U.S. Department of the Interior, U.S. Fish and Wildlife Service 1997).

The bay has extensive, gradually-sloping, intertidal flats with small, shallow channels connecting to larger, deeper ones that expedite the cyclic flows of tides. The flats in the southern end of the bay have a fine silty substrate accumulated from upland sediments of rivers and streams flowing into the bay. The upper layer of fine sediments may be regularly resuspended by strong currents, wave action, rainfall on exposed mudflats, biological activity on or below the surface (such as that associated with burrowing shrimp), or human activities (such as boating and aquaculture). Further north in the bay where currents are stronger, bare tidal flats collect less silty material and tend to have coarser, sandier bottoms (USDI/USFWS 1997).

Field studies demonstrate that *Z. japonica* acts to trap finer and easily re-suspended silt/sediment that would otherwise be carried out of the estuary through natural tide, current, and wind actions (Fisher Bradley and Patten 2011). Removing *Z. japonica* from tide flats allows silt to be removed, returning the tide flats to a coarser sand/sediment mix.

In the marine intertidal mudflats, where imazamox would be applied to control Japanese eelgrass, the pH of sediments and sediment pore water range from 7.3 to 7.6 in Willapa Bay (Wilson and Partridge 2007, as cited in ENVIRON 2012). Willapa Bay sediments also have low organic carbon content (ENVIRON 2012).

Potential Impacts. Under Alternative 1 (No Action), manual disruption/removal, harrowing, and/or other mechanical methods of removing some portion of *Z. japonica* plants may temporarily result in an increase in turbidity. These activities occur in small areas (approximately 3 acres), at times associated with harvest (approximately 0.2 acre/tide), for limited durations of time due to tidal cycles.

Under Alternative 2 (Chemical Methods Only), imazamox would be applied to *Z. japonica* while these plants are exposed at low tide. Minor (if any) sediment disturbance would occur at the time of treatment with proposed methods of application: backpack sprayers, or working from all-terrain vehicles using a hand-held nozzle or boom sprayer. Sediment disruption that occurs during harvest would continue to occur; however, mechanical means of *Z. japonica* control (e.g., harrowing, sweeping) would be discontinued, with the result that there would be an overall reduction in the periodic occurrence of sediment disruption on the commercial clam beds. Chemical methods only (Alternative 2) may require more frequent applications of imazamox than Alternative 3.

Imazamox dissociates at pH of 5 and 7; thus, it would be in an ionic state in the Willapa Bay estuary, highly soluble and highly unlikely to persist. Site-specific studies were conducted to clarify its environmental persistence and to identify environmental exposure concentrations (EECs) in water and sediments. The resulting data suggest that imazamox would have very low to low persistence in the Willapa Bay environment where the proposed applications would occur (ENVIRON 2012). The EPA Environmental Fate and Ecological Risk Assessment prepared for imazamox found that the herbicide has low sorption potential and should not bind to sediments (EPA 2008).

Imazamox is highly water-soluble (4,424 mg/L) and adheres poorly to all soil types. The organic carbon absorption (coefficient) of imazamox is 5 to 143 ml/g. Sorption is typically less in sediments with low organic content, such as those within Willapa Bay. Imazamox breaks down primarily through photolysis with a half-life of 6.8 hours. The proposed application of imazamox to *Z. japonica* exposed during low tides should lead to rapid breakdown of the herbicide since this method will maximize light exposure. The results of sediment testing on plots treated in May 2012 revealed that average imazamox concentrations in both sediment and eelgrass tissue 24 hours after treatment were 5.9 and 1,016 µg/kg, respectively (ENVIRON 2012).

Ecology expects no impacts to upland soils surrounding Willapa Bay from the application of imazamox products to commercial clam beds in tide flat areas. Label information, such as controlling droplet size, will help applicators control off-target drift when using application equipment.

Under Alternative 3 (the Integrated Pest Management Approach), the temporary sediment-disturbing effects of manual *Z. japonica* management practices would continue, and the temporary minor effects to sediments of imazamox applications would occur at separate times. The combination of *Z. japonica* management methods under Alternative 3 (existing practices combined with herbicide applications) would be most effective at controlling the growth and spread of the invasive eelgrass.

Mitigation Measures. No sediment mitigation measures are required for the continuation of existing *Z. japonica* management practices under Alternative 1.

Under Alternative 2 or 3, the NPDES general permit may require additional sediment testing to assess imazamox levels and persistence in treated estuarine sediments to ensure that imazamox does not persist in Willapa Bay sediments to the extent that its presence may harm plant growth in desired species (such as the native eelgrass, *Z. marina*). EPA concluded in its risk assessment of imazamox that if the herbicide does persist in sediments, it is unlikely to present any risk to fish, invertebrates, birds or mammals (EPA 2008).

Applicators must follow all mixing and loading procedures indicated on the herbicide label to prevent spills on unprotected soil. In the event of a spill, applicators will be required to follow spill response procedures outlined in the NPDES general permit.

Proposed NPDES general permit conditions would restrict imazamox applications to conditions when the wind speed is 10 miles per hour or less, and the use of aircraft for imazamox applications will be prohibited. These permit conditions will minimize or avoid the risk of off-target drift onto upland soils or vegetation.

3.2.2 Air Quality

There are no major industrial sources of air pollution around the Willapa Bay estuary. The predominant onshore winds and winter storms assure an almost constant circulation of air from the Pacific Ocean. Temperature inversions that might trap smoke or other pollutants are rare in this area (U.S. Department of the Interior, U.S. Fish and Wildlife Service 1997).

Potential Impacts. Under Alternative 1 (No Action), there would be gasoline or diesel emissions to the air associated with the transport and operation of mechanical equipment on Willapa Bay clam beds. If only manual methods of *Z. japonica* removal were used during harvest, emissions associated with the transport of workers to the site and harvested clams away from the site would be more attributable to harvest than to *Z. japonica* control. In either scenario, vehicle exhaust emissions associated with continuing existing practices would constitute no change in existing air quality conditions in the area.

Under Alternative 2, gasoline or diesel exhaust emissions to the air would depend on the method of imazamox application (backpack sprayer, or working from all-terrain vehicles using a single hand nozzle or boom sprayer), and travel to/from application sites. In either case, vehicle exhaust emissions associated with trips to/from clam beds for imazamox applications once per season (or less) would not significantly increase emissions to the air or adversely affect air quality in the Willapa Bay area due to excellent wind circulation.

Emissions to the air under Alternative 3 would be slightly higher than with Alternative 2, as the new trips associated with imazamox applications would be added to existing trips for harvest and mechanical control methods. Similar to the other alternatives, vehicle exhaust emissions associated with Alternative 3 would not be expected to reach a level of air quality concern.

Imazamox is odorless; therefore, applications under Alternative 2 or 3 should be undetectable to off-site observers.

Imazamox would be applied on private tidelands normally located well away from public gathering locations; therefore, there should be little to no exposure to the public or other bystanders.

The aquatic formulation of imazamox is considered to be non-volatile and relatively non-toxic by inhalation. There should be little to no inhalation exposure to the applicator during an aquatic application. The herbicide label does not require any personal protective gear other than a long-sleeved shirt and long pants, shoes and socks, and chemical-resistant gloves when applying Clearcast®.

Mitigation Measures. No air quality mitigation measures are required for the continuation of existing *Z. japonica* management practices under Alternative 1.

Under Alternative 2 or 3, it would be the responsibility of the applicator to select appropriate application equipment and treat commercial clam beds only during appropriate environmental conditions when wind speed, temperature, and tidal elevation would minimize the risk of spray drift, to avoid off-target dispersion. It would be a violation of the FIFRA label and the proposed NPDES general permit for the applicator to not follow label directions. The permit will also prohibit any aerial applications (such as by airplane or helicopter).

To help prevent human exposure, the proposed NPDES general permit required to implement Alternative 2 or 3 specifies shoreline posting requirements to notify the public about treatments.

3.2.3 Surface Water

The Willapa Bay drainage basin is approximately 1,865 square kilometers (km^2), encompassing a total of nine rivers and several sloughs that drain into the bay. Riverine input has a significant influence on circulation and water exchange in Willapa Bay (Jennings et al. 2003 as cited in ENVIRON 2013). The main tributaries to the bay are the North, Willapa, and Naselle Rivers. The Palix River is a minor contributor to the mean daily runoff.

Willapa Bay is generally considered to be among the most biologically productive estuaries of the Pacific Coast of the United States. Unpolluted water and good circulation account for this productivity and resulting commercial and recreational benefits (WDF and Ecology 1992). Principal water quality factors of Willapa Bay are shown in Table 3.2-1.

Table 3.2-1. Willapa Bay water quality parameters (WDF and Ecology 1992).

Feature	Range of Values
Temperature	3° C to 20.4° on the Willapa River; 7.2° C to 17.4° C at Toke Point; high of 21.4° C at the WDF Shellfish Laboratory at Nahcotta.
Dissolved Oxygen	Generally above 6 mg/L; occasionally levels of 5 mg/L are recorded in the Willapa River; usual summer levels are 6 to 8 mg/L.
Salinity	Ranges from 7.5 ppt on the surface to 25 ppt at 20 feet at the same time and place; salinities near the entrance to the Bay are 30 ppt or more.
Turbidity	2 to 30 JTU in the open bay, with averages of 6.6 JTU on the surface and 8.0 JTU at 20 feet.

Sediment pore water in the Willapa Bay marine intertidal mudflats, where imazamox would be applied, has a pH range from 7.3 to 7.6 (ENVIRON 2012).

There are generally two high and two low tides in Willapa Bay within each 24-hour period. The tidal range is large, at times exceeding 10 feet. The average difference between the high and low tide ranges from 8.1 to 10.3 feet, with an average tidal prism of 4.8×10^8 cubic yards and an average tidal flow discharge of 25,000 cubic yards per second.

Potential Impacts. There are short-term, localized occurrences of turbidity where manual removal during harvest, harrowing, and other mechanical removal methods are used to control *Z. japonica* under Alternative 1. Manual removal during clam harvest disrupts approximately 0.02 acre of substrate per tide cycle. Harrowing and other mechanical removal methods disrupt up to about 3 acres.

Under Alternative 2, localized occurrences of turbidity associated with mechanical means of *Z. japonica* management (e.g., harrowing, sweeping) would not occur. There would be minor (if any) turbidity on incoming tides as a result of imazamox applications made using backpack sprayers, or working from all-terrain vehicles using a single hand nozzle or boom sprayer.

Under Alternative 2 or 3, photolytic degradation and dilution will be the primary sources of imazamox dissipation in aquatic environments. The key degradation pathway is photolysis (break down in the presence of light). The half-life of imazamox in the presence of light is 6.8 hours (ENVIRON 2012). Degradation proceeds via microbial action to carbon dioxide. Factors such as water depth, water clarity, vegetative cover, and season of application (e.g., available sunlight) influence the rate of photolytic degradation. The half-life of imazamox in the marine environment is not a static situation; however, it is less than a few hours as a result of dilution with the incoming tide, or until the tidal flush. Worst case, 400 ppb dissipates to <100 ppb in less than 5 minutes after the first flush. Assuming 1 to 2 hours of dry time prior to tidal inundation, the half-life would be approximately 2 hours (personal communication with Kim Patten, Ph.D., Washington State University Cooperative Extension Office, Long Beach, October 15, 2013). Some dispersion of imazamox into non-treatment areas through surface water conveyance may occur under Alternative 2 or 3 depending on several environmental factors such as size of the treatment area, wind, circulation patterns, currents, drainage swales and channels. Applying imazamox during low tides when *Z. japonica* plants are dewatered will function more like a terrestrial herbicide application, optimizing adherence to target plants. Due to the shallow depth and constant, powerful tidal movement of Willapa Bay waters, it is highly unlikely that imazamox would persist in the water column. EPA (2008) concluded that even if imazamox does persist at greater water depths, it still is unlikely to present a risk to fish, invertebrates, birds, or mammals.

With at least one hour of dry time between imazamox application and tidal inundation, *Z. japonica* plants would take up some of the herbicide and some breakdown by photolysis will occur prior to dispersion.

Solubility data for imazamox indicate that the herbicide is highly soluble in water, particularly at the pH levels commonly found in Willapa Bay waters. Tidal flux will provide a consistent and predictable rinsing effect that will dilute applied herbicide residues and move them off-site. Herbicide residues will be most concentrated in the leading edge of the tidal flow.

Patten and Haldeman (2012) as cited in ENVIRON 2012 characterized imazamox concentrations after an application in Willapa Bay conducted under an experimental use permit (WSEUP No. 12003). They treated a sandy sediment site with a 16 ounces per acre rate of Clearcast®, 20 minutes before low tide (-2.6 feet), using a backpack sprayer. They described the site as dry except for a tidal drainage swale and several isolated pools. Following treatment, they collected water samples in tidal pools and swales within the treated site, in the tidal swale draining the site during ebb tide, and on the shore side of the plot during flood tide. To ensure that the off-site sample locations or times of sampling occurred where and when concentrations were highest, they added a blue dye to the water in the outgoing drainage swale immediately after treatment and to the leading edge of the incoming tidal water as it moved across the site. Sampling times at each collection site during the ebb tide corresponded to times when the peak of the dye was most concentrated for that location. The results are summarized in Figure 3-1 below taken from the report. Results are reported in parts per billion (ppb).

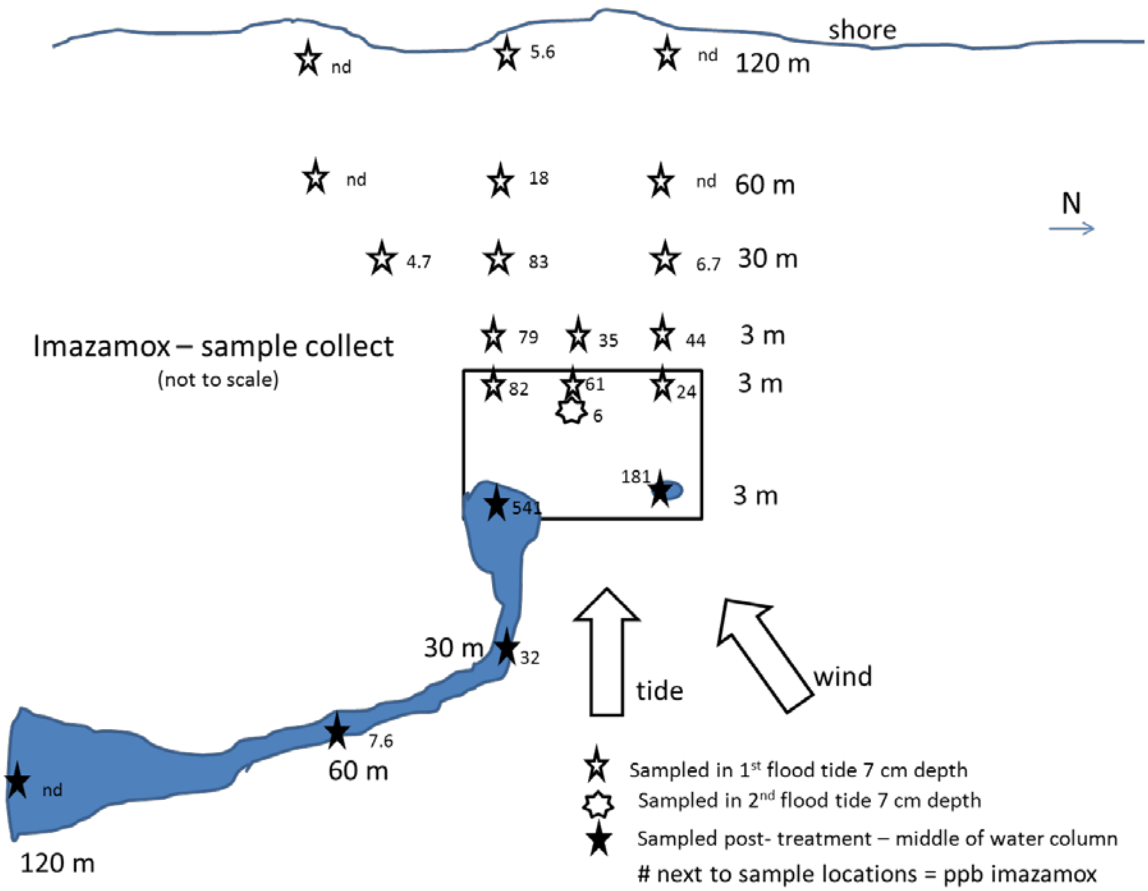

Figure 3-1. Imazamox concentrations in Willapa Bay following an application 20 minutes before low tide (Patten and Haldeman 2012).

On-site concentrations of imazamox were higher, but quickly diluted as the tide moved over the treated site. Imazamox moved off-site in both the ebb and flood direction.

Ecology expects that as a systemic herbicide, imazamox should have minimal impact under Alternative 2 or 3 to dissolved oxygen levels in a treated water body. Plants generally die back slowly after treatment with systemic herbicides, due to biological oxygen demand from decomposing plants typically occurring over weeks rather than days. Any increased concentrations of plant nutrients in water treated with imazamox due to nutrient release from decomposing vegetation should be diluted by the large tidal flows in Willapa Bay.

Mitigation Measures. No surface water mitigation measures are required for the continuation of existing practices of *Z. japonica* management under Alternative 1.

To mitigate imazamox dispersal and to facilitate plant uptake (treatment efficacy) under Alternative 2 or 3, the proposed NPDES general permit should require that imazamox applications precede tidal inundation by at least one hour to allow “dry time” for plant uptake of the herbicide. Longer exposure would allow the plants more time to "take up" the systemic herbicide. Applying imazamox to plants exposed at low tide also assures that herbicide applications occur during maximum light exposure to optimize photolytic degradation.

Because imazamox moved both up slope and down slope with the tide in the Patten and Haldeman (2012) Willapa Bay trial described above, the permit should require native eelgrass (*Z. marina*) monitoring in both ebb and flood tide drainage from treated beds to determine whether treatment will harm off-site native eelgrass (*Z. marina*).[11]

EPA regards IPM (Alternative 3) as meeting technology-based effluent limits for aquatic pesticide application (see the EPA general permit). The EPA general permit requires all applicants to file a Notice of Intent (NOI), and to develop and implement *Pesticide Discharge Management Plans* that include comprehensive IPM practices. EPA also requires any State-issued aquatic pesticide NPDES permits to be at least as stringent as its general permit. Therefore, Ecology's proposed NPDES general permit will require that applicants develop *Discharge Management Plans* (DMPs) for the use of imazamox to manage *Z. japonica* on commercial clam beds in Willapa Bay. The DMP will serve as the IPM plan.

Appendix D of the proposed NPDES permit for the proposed action sets out the minimum standards and guidelines for DMP development.

A 1997 Integrated Pest Management Law requires all State agencies that have pest control responsibilities to follow the principles of integrated pest management. 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.

[11] Note: the Clearcast® label allows irrigation to occur with treated freshwater when the water concentration of imazamox is $\leq$ 50 ppb. That means that the manufacturer does not expect any toxicity to plants at an irrigation water concentration of 50 ppb or less.

While this law applies to the activities of agencies as they manage noxious weeds and pests on their own lands and properties, the principles of this law are sound and Ecology has incorporated these IPM principles into its aquatic pesticide NPDES general permits.

The Washington State Surface Water Quality Standards (SWQS) also encourage entities to develop integrated pest management plans, particularly for long-term or ongoing activities. The SWQS "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…."

3.2.4 Plants

Two sources were reviewed to obtain descriptions of existing vegetation in Willapa Bay: 1) the *Supplemental Environmental Impact Statement: Use of the Insecticide Carbaryl to Control Ghost and Mud Shrimp in Oyster Beds of Willapa Bay and Grays Harbor* (WDF and Ecology 1992); and 2) the *Environmental Assessment: Control of Smooth Cordgrass (Spartina alterniflora) on Willapa National Wildlife Refuge, Ilwaco, WA* (U.S. Department of the Interior, U.S. Fish and Wildlife Service 1997).

Plankton. Little information is available to describe plankton populations in Willapa Bay. The phytoplankton, planktonic algae, is probably made up of diatoms, dinoflagellates, and microflagellates. These algae are an important source of food for clams, oysters, and zooplankton (WDF and Ecology 1992). Indications are that *Z. japonica* may be displacing naturally-occurring plankton populations as it ecoengineers areas it inhabits so as to alter the make-up of the biota (personal communication with Kim Patten, Ph.D., Washington State University Cooperative Extension Office, Long Beach, October 15, 2013).

Seagrasses. One of the largest seagrass (eelgrass) meadows in the Pacific Northwest occurs in the protected estuarine waters of Willapa Bay. Hedgpeth and Obrebski (1981, as cited in USDI/USFWS 1997) describe an eelgrass community as "a whole system of growth, catchment of detritus, support of microbial associations, source of oxygen by day and deprivation by night, the mainstay of small crustacea, and modifier of current and sedimentation patterns and nutrient regimes." Wyllie-Echeverria and Hershman (1994, as cited in USDI/USFWS 1997) listed six major functions of seagrasses from Wood et al. (1969): 1) stabilize bottom sediments; 2) slow and retard current, prompt sedimentation, and inhibit resuspension of organic and inorganic matter; 3) provide shelter and substrate (for other organisms); 4) provide grazing and detrital food pathways; 5) support high productivity; and 6) cycle nutrients internally.

In Willapa Bay, *Z. marina* generally occurs in the lower intertidal and subtidal; whereas, *Z. japonica* is generally abundant on the middle to lower intertidal mudflats. See additional information in Section 3.1, Biological Background Information.

Native Saltmarsh Vegetation. Native saltmarsh vegetation in the upper tidal flats includes pickleweed (*Salicornia virginica*), jaumea (*Jaumea carnosa*), saltgrass (*Distichlis spicata*), seaside arrowgrass (*Triglochin maritimum*), tufted hairgrass (*Deschampsia caespitosa*), and saltmarsh bulrush (*Scrirpus maritimus*) (Sayce 1993 and Zipperer 1996, as cited in USDI/USFWS 1997). There are about 500 acres of native saltmarsh on the Willapa National Refuge multiple locations within Willapa Bay). The location and quantity of native saltmarsh vegetation elsewhere within Willapa Bay is not reported in the sources reviewed.

Exotic Spartina Marsh Vegetation. Similar to *Z. japonica*, *Spartina* (cordgrass) may have been introduced to the West Coast as packing material for oyster shipments coming from the East Coast in the 1890s (Frenkle and Kunze 1984, as cited in USDI/USFWS 1997). *Spartina* may have been intentionally planted to create a blind for waterfowl hunting, or to help prevent shoreline erosion on State or Federal lands. Historic files located at the Pacific County Historical Society Museum contain a sale brochure in which *Spartina* was advertised for sale for use in creating waterfowl hunting blinds[12]. Typical of Pacific Northwest estuaries, the geologically-young Willapa Bay, with its relatively high tidal range, has characteristically large expanses of mudflats that are susceptible to *Spartina* invasion. *S. alterniflora* in Willapa Bay represents the largest *Spartina* infestation in the State of Washington (Washington State 1993, as cited in USDI/USFWS 1997). The rate of spread of *Spartina* is geometric; that is, the quantity of growth each year increases based on the increased amount of *Spartina* from the previous year. In 1945, 4.5 acres of *Spartina* were present; 432 acres in 1982; 2,400 acres in 1990 (Marks 1995, as cited in USDI/USFWS 1997); and 4,700 acres in 1996. Stiller and Denton (1995, as cited in USDI/USFWS 1997) noted that at current expansion rates, without effective management, *Spartina* threatened to occupy most of the intertidal habitat in Willapa Bay within 40 years.[13] As of 2013, *Spartina* has been eradicated to an approximate combined area of less than a few acres with single plants now spread over a large area of the estuary (Washington State Department of Agriculture 2012).

Potential Impacts. The impacts of continuing existing *Z. japonica* management practices under Alternative 1 would be localized and temporary. Fragmentation of roots and rhizomes that occurs with hand-pulling during clam harvest results in re-growth within one year. Harrowing and other forms of mechanical removal disrupt the foliage and tear loose a percentage of root and rhizome structure. The damaged plants are suppressed for a period of time before re-growth, and seed germination occurs during the same or following season. Roots, rhizomes and seeds disrupted in one location can be distributed by the tide to other sites, potentially exacerbating the spread of *Z. japonica*. Control practices under alternative 1 are non-discriminatory and may result in the removal of some *Z. marina* where it occurs as an intermixed bed with *Z. japonica*.

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[12] Wildlife Nurseries and Game Farm, Oshkosh, Wisconsin brochure: *How to Attract and Hold Game*.

[13] The *Spartina* expansion estimate reflects an unmanaged condition. The U.S. Department of the Interior, Fish and Wildlife Service implemented a long-term integrated pest management approach in the late 1990s to eradicate *Spartina alterniflora* on Willapa National Wildlife Refuge and surrounding tidelands in Willapa Bay.

Under Alternative 2, the effectiveness and selectivity of imazamox would be dependent upon application rates and plant growth stages. Dr. Kim Patten (WSU Cooperative Extension Office, Long Beach, Washington) has conducted research trials on *Z. japonica* in Willapa Bay under an Experimental Use Permit (EUP), and has determined that imazamox is effective in controlling the growth of *Z. japonica* when imazamox is applied to plants exposed at low tide. The results of one of the research trials are summarized as follows: Imazamox (0.14 kg active ingredient per hectare) was applied on May 27, 2010 (-2.2 tide at 8 to 8:30 am at approximately 2.5 ft tidal height) to a 100 ft by 100 ft section of tide flats that were colonized with *Z. japonica*. At the time of treatment, the percent of ground coverage by **both** *Zostera* species ranged from 2% to 95% with a mean of 20%. Thirty days after treatment, the percent on-site *Z. japonica* control was 100%. The off-site *Z. japonica* control on the flood side of the treatment zone was zero. Similarly, there were clean lines differentiating treated and untreated locations on the south and north of the plot (ENVIRON 2012).

Application of the systemic herbicide imazamox would kill the upper portions of *Z. japonica* plants as well as their roots and rhizomes, which would be left in the sediment to deteriorate in-place.

The fate of *Z. marina* sprayed within the treated zone in the ENVIRON 2012 trial varied by location. Sparse *Z. marina* not covered by water (i.e., not within a drainage swale) was 100% affected (eliminated). *Z. marina* directly sprayed but covered by < 10 cm of standing pooled water was reduced by 57%, and there was no effect on *Z. marina* if it was covered by 20 to 30 cm of water. There was no measured effect of imazamox on *Z. marina* in the drainage swale beyond 6 meters from the treated zone (ENVIRON 2012).

Risks to non-target aquatic vegetation are of concern with the use of imazamox, given that the herbicide provides broad-spectrum control of plant growth.

A portion of off-site *Z. marina* beds should be underwater at the time of treatment. There may also be *Z. marina* on the treated clam beds, but mostly in lower elevation swales or channels that applicators would avoid spraying since clams do not grow in these areas and the proposed permit should limit spraying directly into them. *Z. japonica* would have a minimum of one hour to take up the herbicide, and some herbicide would degrade before the flood tide washed herbicide residues off the clam bed.

Impacts to native salt marsh plants are not expected since they occur in the upper portion of the tideflats.

EPA was not certain whether the maximum in-water label concentration of 500 ppb imazamox would adversely affect aquatic unicellular algae since the maximum concentration tested on algae during the registration process was 40 ppb. However, subsequent to the EPA process, Federal aquatic scientists Netherland et al. (2009) assessed imazamox for efficacy against eight species of green and blue-green algae at imazamox concentrations of 100, 200, and 500 ppb active ingredient in a two-week exposure laboratory experiment. The authors did not observe a response to the different rates of imazamox or any algal species selectivity. They did not recommend further testing of imazamox for potential as an algaecide because it did not demonstrate any algaecidal activity.

Exposure to imazamox during research trials conducted on Willapa Bay did not indicate any effects on algae in treated clam beds (personal communication with Dr. Kim Patten 2012). Dr. Patten also indicated that unlike eelgrass, which is rooted, macroalgae are transient on shellfish beds. Ecology believes that effects on algae from treatment of *Z. japonica* with imazamox are unlikely to occur.

Alternative 3 is expected to achieve the maximum effectiveness in *Z. japonica* management, with comparable effects to other plants as those described above for Alternative 2. Existing manual and mechanical methods would suppress the upper vegetative growth of *Z. japonica* plants, while systemic herbicide applications of imazamox would kill not only the upper portions of the plants but also roots and rhizomes, which would be left in sediments to deteriorate in-place. This integrated approach is expected to minimize the frequency of imazamox applications to achieve the desired level of *Z. japonica* management.

Mitigation Measures. No plant mitigation measures are required for the continuation of existing *Z. japonica* management practices under Alternative 1.

Under Alternative 2 or 3, the proposed NPDES general permit should restrict timing of imazamox treatments to occur between April 15 and June 30 in any year for which the permit is in effect. *Z. japonica* plants begin their active growth period in the Spring, which is typically the best season to achieve the optimum treatment results. For example, in a number of earlier tests completed by Dr. Kim Patten (WSU Long Beach Extension Office), a higher rate of application (32 fluid oz/acre) was required for >90% control of Japanese eelgrass in the fall compared to a much smaller rate (4 to 8 fluid oz/acre) in the spring and summer when conditions were dry and only small plants were present (ENVIRON 2012). Based on trials conducted by Dr Kim Patten (WSU Long Beach Extension Office) good results require a minimum dry time between tide cycles of one hour post application. Longer dry times may increase efficacy.

There are distinct differences in the physical appearance of *Z. japonica* and *Z. marina*. Applicators should avoid spraying directly into significant drainages containing *Z. marina* on commercial clam beds.

The proposed NPDES permit should require monitoring studies to determine what buffer distance is sufficient to protect off-site *Z. marina* from lethal and sub-lethal effects of spraying imazamox on commercial clam beds. Until a buffer width validation study is completed; based on the ENVIRON 2012 study, which saw no measured effect of imazamox on *Z. marina* in the drainage swale beyond 6 meters from the treated zone, a default buffer of 10m should be employed. To ensure that the buffer distances remain effective in various locations throughout Willapa Bay, monitoring for herbicidal effects beyond the proposed buffer should be done. If the proposed permit is adopted, Ecology should work with permittees to select appropriate study sites, and oversee the monitoring. Data evaluation would be conducted by the permittee, a team of scientists from natural resource agencies and Ecology. If monitoring study data indicate ecologically significant negative effects to off-site *Z. marina* populations from imazamox treatment, Ecology has the option to modify the permit to change the buffer distance or terminate the permit.

The imazamox label describes treatment mitigations to reduce spray drift to avoid potential impacts to off-site, non-target plants. It will be the responsibility of the applicator to select appropriate application equipment and treat only during appropriate environmental conditions (wind speed, temperature, and tidal elevation) to avoid off-target dispersion. It would be a violation of the FIFRA label and the NPDES general permit for the applicator to not follow label directions. The proposed permit will also prohibit any aerial applications (e.g., by airplane or helicopter).

The proposed NPDES general permit will limit the application of imazamox to one application per season per treated area. Due to the high efficacy of imazamox, particularly when combined with existing shellfish cultural practices and general integrated pest management practices (Alternative 3); commercial shellfish growers may be able to apply imazamox less often than once per season to achieve the desired level of control.

3.2.5 Animals

Willapa Bay has diverse wildlife resources. Seventeen species of amphibians and reptiles, 51 species of mammals, and more than 200 species of birds (resident and migratory) are known to use Willapa National Wildlife Refuge lands and associated waters (U.S. Fish and Wildlife Service 1991, as cited in USDI/USFWS 1997). The *NEPA Environmental Assessment for Control of Smooth Cordgrass* (Spartina alterniflora) *on Willapa National Wildlife Refuge* (USDI/USFWS 1997) and two other sources were reviewed to obtain descriptions of existing vertebrate and invertebrate animals that use Willapa Bay: 1) the *Supplemental Environmental Impact Statement: Use of the Insecticide Carbaryl to Control Ghost and Mud Shrimp in Oyster Beds of Willapa Bay and Grays Harbor* (WDF and Ecology 1992); and 2) *Screening-Level Ecological Risk Assessment of the Proposed Use of the Herbicide Imazamox to Control Invasive Japanese Eelgrass* (Zostera japonica) *in Willapa Bay, Washington State* (ENVIRON International Corporation, November 2012).

Zooplankton. Zooplankton, planktonic animals, include the larvae of many benthic animals, as well as species that are planktonic their entire lives. Dungeness crab (*Cancer magister*) larvae appear in the Willapa Bay zooplankton in the spring; other zooplankton includes oyster larvae, clam larvae and copepods (WDF and Ecology 1992).

Benthic Invertebrates. Benthic invertebrates in Willapa Bay are limited to species that are tolerant of wide variations in salinity and temperature. The distribution of these species is also dependent upon sediment type. Several polychaete worm species are common in the mud and silt bottoms of the bay. Blue mussels (*Mytilus edulis*) and barnacles are common on solid surfaces such as rocks, piling, and oyster shell. All Willapa Bay tide flats and shallow channels seaward of the highway river crossings are Areas of Major Biological Significance (AMBS)[14] for Dungeness crab and Pacific oysters (WDF and Ecology 1992).

Commercial shellfish within Willapa Bay include four cultured species and six wild species. Pacific oyster (*Crassostrea gigas*), Kumamoto oyster (*Crassostrea sikamea*), Manila clam (*Venerupis philippinarum*), and geoduck (*Panopea abrupta*) are cultured by shellfish growers. The bay supports wild stocks of quahog or hardshell clam (*Arctica islandica*), softshell clam (*Mya arenaria*), native little neck (*Protothaca staminea*), cherrystone clams (*Mercenaria mercenaria*), and Dungeness crab (*Cancer magister*) (ENVIRON 2012).

Oyster culture has traditionally been Willapa Bay's principal marine fishery. The Willapa Bay wild Dungeness crab fishery also contributes to one of Pacific County's most important industries (WDF and Ecology 1992).

Baitfish. Herring, smelt and anchovies also use Willapa Bay and are a source of food for larger fish, including salmon. The south arm of Willapa Bay near Oysterville and the west side of Long Island are listed as AMBS for herring spawning (WDF and Ecology 1992). There is a small (single boat) baitfish fishery in Willapa Bay.

Two stocks of Pacific herring (*Clupea pallasii*) reportedly spawn in Willapa Bay and Grays Harbor between mid-January and early April. Herring deposit transparent, adhesive eggs on intertidal and shallow subtidal *Zostera* spp. and marine algae. These eggs typically hatch in 10 to 14 days. Eggs may be deposited anywhere between the upper limits of high tide to a depth of -40 feet, though most spawning takes place between 0 and -10 feet (WDFW 2011). *Z. japonica* typically grows much higher in the intertidal (0.1 to 1.5 m Ruesink et al. 2010) than the preferred spawning depth of herring. Further, most growth and germination of *Z. japonica* begins in the spring, after the typical herring spawn. Herring prefer to spawn at a lower elevation than *Z. japonica* prefers to live (0 ft to -10 ft) (WDFW 2011). Perennial *Z. marina* grows at the preferred spawning elevation for herring.

Documented spawning grounds for Pacific herring occur along the inner shoreline of the North Beach peninsula (Stick and Lindquist 2009, as cited in ENVIRON 2012). WDFW field reports between 2000 and 2003 documented herring eggs attached to Japanese eelgrass in Stackpole Harbor along the eastern shore of the North Beach peninsula (WDFW, unpublished data, as cited in ENVIRON 2012).

Finfish. Tributaries to Willapa Bay provide spawning grounds for salmon and trout. They migrate through Willapa Bay at various times of the year, and use the bay as a nursery area much

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[14] "AMBS" is a U.S. Fish and Wildlife Service habitat designation, comparable to the more contemporary term Essential Fish Habitat.

of the year (WDF and Ecology 1992). See section 3.1.9 for a discussion of the importance of *Z. japonica* to juvenile salmon. Anadromous salmonid distribution and utilization within Willapa Bay tributaries is described in detail in ENVIRON (2012; Table 2-4). Species include Chinook salmon (*Oncorhynchus tshawytscha*), Coho salmon (*O. kisutch*), steelhead (*O. mykiss*), chum salmon (*O. keta*), and bull trout (*Salvelinus confluentus*) (migration only).

Green sturgeon and white sturgeon are found in Willapa Bay. Sturgeon feed on smaller fish and benthic invertebrates such as ghost shrimp, amphipods and mollusks. Ecology has designated the deeper channels of southern Willapa Bay, the Willapa River and the Naselle River as AMBS for sturgeon. Willapa Bay also supports a white sturgeon commercial fishery (WAC 220-40-03100J).

Juvenile lingcod utilize Willapa Bay, and flat fish use the bay as a nursery area. The Willapa River between Range Point and South Bend is designated as an AMBS for starry flounder (WDF and Ecology 1992).

Birds. Willapa Bay is an important feeding and resting area for a large variety of birds. The Willapa National Wildlife Refuge (9,600 acres of Federal land and open water, and 10,000 acres of State-owned tidelands and water) was established for the protection of habitat for wintering and migrating aquatic birds including ducks, geese, brant, swans, shorebirds, and wading birds. Use of the Willapa Bay estuary by loons, grebes, cormorants, herons, bitterns, ducks, geese, brant, plovers, sandpipers, dunlin and other shorebirds is of special significance, because Willapa Bay is one of ten major wintering and resting areas for waterfowl and shorebirds along the Pacific Flyway. As a major flyway stopover point and staging area, Willapa Bay is of critical importance for fuel replenishment for migrating aquatic birds: they depend on the abundance of mudflat invertebrates, seagrasses, native saltmarsh plants, and associated invertebrates for food. The birds tend to feed mostly in the high intertidal mudflats, which are the first areas available as the tides recede, and the last ones covered by incoming tides (USDI/USFWS 1997).

The numbers of waterfowl and shorebirds are lowest in summer, highest in spring and fall, but remain relatively high throughout the winter (USDI/USFWS 1997). Peak migration through Willapa Bay occurs between mid-April and early May. Later migrants are present until the end of May (Slater Museum of Natural History 2011). Many areas in Willapa Bay have been mapped as AMBS for several waterfowl and shorebird species (WDF and Ecology 1992).

The distribution of ducks within Willapa Bay was modeled by the National Wildlife Refuge (ENTRIX 2003, as cited in ENVIRON 2012). The hierarchy of distribution according to mid-winter aerial waterfowl surveys was: South Bay (47.1%), East Bay (28.6%), North Bay (18.8%0, West Bay (4.2%), and Peninsula (1.2%). Brandt geese (*Branta bernicla*) peak in abundance in Willapa Bay in the spring at approximately 6,900 birds (Moore et al. 2004, as cited in ENVIRON 2012).

Mammals. Marine Mammals such as harbor seals and gray whales have been observed in Willapa Bay. Harbor seals use channels for swimming and feeding and haul out on several isolated sandbar areas within the bay, designated as AMBS (WDF and Ecology 1992). Other marine mammals generally use the deeper, more saline water of the north end of the bay (USDI/USFWS 1997).

Few mammals use the high intertidal mudflats where *Z. japonica* and *Spartina* occur. River otter may venture into channels on the mudflats in search of fish. Small mammals such as shrews, mice, or voles live in native saltmarsh vegetation and may be present in the high intertidal area above regular tidal inundation.

Threatened, Endangered, and Protected Species. Threatened and endangered (T&E) species and species of concern are those species that have been given special legal and/or protection designations by Federal and State government resource agencies. A species federally-listed as endangered is one that is in danger of extinction throughout all or a significant portion of its range. A species federally-listed as threatened is one likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. A species of concern is one for which status information suggests that the species is not abundant, and for which additional information is sought (ENVIRON 2012).

Use of Willapa Bay by T&E aquatic species is primarily limited to the listed species of salmonids in the Columbia River system that may dip into the bay, and the green sturgeon which is known to regularly use the bay as sub-adults. Pacific eulachon (*Thaleichthys pacificus*) are not known to regularly use Willapa Bay and the bay is not designated as critical habitat for the species. In addition, several coastal avian species listed as sensitive, candidate, or State-monitor species are common to Willapa Bay and other areas where Japanese eelgrass occurs (ENVIRON 2012) (see Table 3.2-2). Other State candidate species that occur in Willapa Bay and on adjacent lands include the Pacific harbor porpoise (*Phocoena phocoena*), Brandt's cormorant (*Phalacrocorax penicillatus*), and pileated woodpecker (*Dryocopus pileatus*) (USDI/USFWS 1997, and WDFW 2013).

Table 3.2-2. List of threatened or endangered species that may occur in Willapa Bay, Pacific County, and that could potentially be exposed during imazamox treatment of *Z. japonica* (WDFW 2008 in ENVIRON 2012).

General Taxon		**Species**	**Status**		
			State	Federal	County
Vertebrates	Fish	Green sturgeon	N	T	X
		Eulachon	C	T	X
		Bull trout	C	T	X
		Chinook salmon	C	T	X
		Chum salmon	C	T	X
		Coho salmon	C	T	X
		Steelhead trout	C	T/E	X
Avifauna and Mammals	Marine Birds	Brown Pelican	E	D	X
		Marbled murrelet	T	T	X
		Short-tailed albatross	C	E	X
		Snowy plover	E	T	X
	Marine Mammals	Killer whale	E	E	X
		Steller (Northern) sea lion	T	T	X

T = Threatened, E = Endangered, C = Candidate for listing, D = Delisted due to recovery, N = Not designated.

The southern distinct population segment of green sturgeon is Federally-listed as threatened, but is not a State-listed species. Green sturgeon are found along the western coast of the USA, Canada, and Mexico. They are present in Willapa Bay, but do not spawn in Washington waters. According to a National Oceanic and Atmospheric Administration (NOAA) website, the principal factor in the decline of the green sturgeon on the west coast is reduction of the spawning area to a limited section of the Sacramento River.

> *Willapa Bay, along with the Columbia River and Grays Harbor, is one of the estuaries where green sturgeon concentrate in summer. Generally, green sturgeon are more abundant than white sturgeon here (Emmett et al. 1991). Catches have declined from 3,000-4,000 fish per year in the 1960's to few or none in recent years (WDFW 2002a). Much of this is probably due to reduced size limits and seasonal and area closures.* (http://www.nmfs.noaa.gov/pr/pdfs/statusreviews/greensturgeon.pdf)

One of two nesting colonies of western snowy plovers (*Charadrius nivosus nivosus*) in Washington State was identified on Leadbetter Point. Small groups of plovers nest on the beach west of the mouth of Willapa Bay and on a small island off the point. Federally proposed critical habitat for the plovers occurs on the ocean beach at Leadbetter Point (USDI/USFWS 1997).

One plant species Federally-listed as threatened may occur in freshwater wetlands, ponds, or lakes in the vicinity of Willapa Bay: water howellia (*Howellia aquatilis*) (USDI/USFWS). This species does not occur in the estuarine environment occupied by *Z. japonica*.

Potential Impacts. The EPA (2008) risk assessment conducted for imazamox did not anticipate that use of this herbicide for aquatic weed control would exceed the agency's acute Level of Concern (LOC) for avian, mammalian, fish, and aquatic invertebrate listed species. EPA did not rule out chronic risk for aquatic fish and invertebrates since there are no EPA reviewed and approved chronic toxicity data on fish and invertebrates. However, based on the large tidal fluxes in Willapa Bay (dilution of herbicide), and the low sorption potential of imazamox (should not bind to sediment), it would be unlikely that fish and invertebrates would experience chronic exposure to imazamox from treatments in Willapa Bay (EPA 2008).

Benthic Invertebrates. Existing practices used for *Z. japonica* management under Alternative 1 disturb sediments and therefore disturb benthic invertebrates. Some organisms likely perish during manual and mechanical removal methods, but other members of the species likely re-colonize these areas when disturbed sediments are restabilized during subsequent tidal cycles.

For implementation of Alternative 2, EPA did not require chronic testing of imazamox for invertebrates because the estimated environmental concentration did not exceed 1% of the lowest LC_{50} (concentration at which 50% lethality occurs), making the chronic risk of imazamox to invertebrates negligible. The EC_{50} values (maximal effect concentration of 50%) for the daphnid and mysid organisms are greater than 122 ppm and 94.3 ppm, respectively. These values are well in excess of the maximum in-water label rate of 500 ppb for imazamox. Benthic invertebrate disturbance would still occur during harvest, but to a lesser degree with Alternative 2 than with Alternative 1.

Under Alternative 3, benthic disturbance would continue to occur with manual and mechanical methods of *Z. japonica* control, though potentially to a lesser degree than with Alternative 1 since chemical control under Integrated Pest Management practices may reduce the frequency of intensive mechanical management measures.

Baitfish. It is unlikely that significant impacts to baitfish spawning occur under Alternative 1 (or would occur under Alternative 3) as a result of manual and mechanical *Z. japonica* management practices, due primarily to shellfish grower training in how to recognize herring spawn, awareness of the importance of avoiding disturbance, and the relatively small areas over which manual and mechanical *Z. japonica* removal methods occur.

Imazamox applications under Alternative 2 or 3 would be practically non-toxic to fish (EPA 2008). Permit conditions will limit imazamox applications to a period of time within the U.S. Army Corps of Engineers in-water work window for forage fish (USACE 2012) to avoid removing *Z. japonica* stems that may be used as spawning substrate until after eggs have hatched.

Finfish. Manual and mechanical removal of *Z. japonica* upper plant parts under Alternative 1 or 3 may diminish shelter for juvenile salmonids at some tidal elevations, though researchers

(Semmens 2008) found that juvenile salmon spent most of their time in deeper water over native eelgrass patches, rather than in the other habitats (see FEIS Section 3.1.9). Alternative 2 would be even more effective than Alternative 1 in suppressing the vegetative growth of *Z. japonica*, and therefore may have a similar or greater effect on juvenile salmonid habitat.

No toxicity effects to finfish are expected under Alternative 2 or 3. At the highest imazamox concentration tested, there were no observed acute adverse effects to fish or aquatic invertebrates. EPA did not require chronic toxicity testing for fish because the estimated environmental concentration did not exceed 1% of the lowest LC_{50}, making the chronic risk of imazamox to fish negligible. According to the EPA, imazamox does not bioconcentrate in fish, and concentrations in fish following aquatic applications were below the limit of quantification. Ecology does not anticipate any significant chronic exposures of imazamox to fish or estuarine animals in Willapa Bay due to large tidal exchanges that will dilute the herbicide (Hamel 2012).

Information from fish studies showed that imazamox has a low potential for bioconcentration due to its low octanol/water partition coefficient (Kow <1). Fish adsorbed and rapidly excreted imazamox, and tissue concentrations declined to less than quantifiable limits during the first 24 hours of the depuration process. Based on imazamox behavior in fish, the potential for bioaccumulation and/or biomagnification in the aquatic food chain is low (Hamel 2012).

Birds. Continuing existing manual and mechanical methods of *Z. japonica* management under Alternative 1 should have no known significant adverse impact to waterfowl foraging requirements.

Under Alternative 2 or 3, imazamox is slightly-to-practically non-toxic to birds on an acute oral basis and on a sub-acute dietary basis. The LC_{50} for sub-acute avian dietary assays was >5,573 ppm, and there were no bird mortalities observed during avian toxicity testing. Avian reproductive studies showed the NOEC (No Observed Effect Concentration) and LOEC (Lowest Observed Effect Concentration in ppm of active ingredient) to be >2,000 ppm for mallard and northern bobwhite quail. Waterfowl are likely to be the most exposed type of birds, since they swim, drink, and feed on Willapa Bay and its tributaries, and may ingest treated vegetation. However, imazamox is relatively non-toxic to birds, water concentrations should not exceed 500 ppb (and will likely be much less and for only a short duration), and imazamox does not bioaccumulate or persist in well-lighted waters. Therefore, Ecology does not expect any direct adverse impacts to birds from treatments of imazamox applied to *Z. japonica*.

Reduction in *Z. japonica* in Willapa Bay due to chemical methods of management (Alternative 2) or integrated pest management methods (Alternative 3) will reduce the available acreage of waterfowl forage. USDA estimated approximately 12,000 acres of moderate to heavy-density *Z. japonica* in Willapa Bay in 2007 (see FEIS Figure 1-1). This did not include any acres with thinly populated *Z. japonica*, nor does it include any increase in acres or density of *Z. japonica* since 2007 (see the shellfish growers estimate of *Z. japonica* distribution in FEIS Figure 1-2). Migratory waterfowl foraging budgets for *Z. japonica,* presented in Appendix A to this FEIS, estimate that approximately 1,600 acres of *Z. japonica* may be needed for waterfowl forage. If shellfish growers control *Z. japonica* on the 3,000 acres of currently un-cultivated clam beds in

Willapa Bay, it is estimated that there would be more than 7,000 acres of unmanaged *Z. japonica* within the bay.

A study from Yaquina Bay Oregon found that *Z. marina* and possibly *Upogebia*/mudflat habitat supported significantly greater bird densities than *Z. japonica* for the four bird groups examined (Frazier et al. 2014). For waterfowl in particular *Z. marina* showed bird densities that were significantly greater than that of *Upogebia*/mudflat, *Neotrypea*/sandflat and *Z. japonica* habitats (Frazier et al. 2014). In Yaquina Bay ducks, coot, and geese foraged on *Z. japonica* primarily at mid-tide when *Z. marina* was flooded or at high tide when *Z. japonica* was flooded but shallow (Frazier et al. 2014).

A study in Yaquina estuary, Oregon conducted by Lamberson et al. (2011) commented on the concern that shorebirds would be impacted by *Z. japonica* supplanting the *Neotrypea* (burrowing shrimp)/sand habitat. They concluded that there were no significant differences between *Z. japonica* and *Neotrypea* /sand habitat for any metric of bird use studied. Based on these studies it is unlikely that shorebirds will be affected under any of the alternatives being considered. Interactions between shorebirds and *Z. japonica* were identified as an area that needed further research (see Washington State Department of Ecology 2013).

Mammals. No significant impact to mammals is expected under Alternative 1. In general, mammals are very rarely seen on commercial clam bed tide flats. Raccoon have been observed eating crustaceans and clams on commercial clam beds, and blacktail deer have been seen on the tide flats, though not seeming to graze. Elk have been seen occasionally grazing on freshly grown salt marsh plants in the high intertidal zone (personal communications with WGHOGA members, various dates).

Raccoon and bird species use sight as one means of locating clams and to harvest other food sources. *Z. japonica* can impede the use of sight by covering the tide flats with a dense mat of stem. This, in turn, may make it more difficult for tideland foragers to locate food sources.

No significant adverse impact to mammals is expected as a result of imazamox applications to *Z. japonica* under Alternative 2 or 3. EPA did not require wild mammal testing for imazamox because rat toxicity testing showed that imazamox was practically non-toxic to mammals on an acute basis. Acetolactate synthase (ALS) inhibitor herbicides demonstrate low toxicity toward animals. This is likely because the ALS biochemical pathway does not exist in animals. Ecology believes that exposure risk to wild mammals from the use of imazamox on commercial clam beds would be transient and minimal.

Imazamox concentrations detected in the Patten and Haldeman (2012) Willapa Bay trial described above in the *Surface Water* section should not pose any risk to animal species since the LC_{50} of the most sensitive aquatic animal is >100 ppm (orders of magnitude higher than the exposure from a *Z. japonica* treatment where concentrations were in ppb).

Threatened, Endangered and Protected Species. The EPA (2008) aquatic risk assessment for imazamox only identified a level of concern for endangered plants. There are no endangered plants on the Willapa Bay tide flats where shellfish growers currently implement manual and mechanical methods of *Z. japonica* management, and where shellfish growers propose to apply imazamox. The native eelgrass *Z. marina* is a WDFW priority species, and therefore protected. The potential effects to *Z. marina* from imazamox applications to commercial clam beds in Willapa Bay are discussed above under *Plants*.

No significant adverse impact to Federally-listed or State Priority animal species is expected under Alternative 2 or 3. Ecology does not anticipate any direct adverse impacts to threatened or endangered animal species from applications of imazamox to commercial clam beds in Willapa Bay, due to low imazamox use rates and lack of toxicity to aquatic and terrestrial animals. Acetolactate synthase (ALS) inhibitors target a biochemical pathway that exists in plants, but not in animals. No significant impact to the food source and habitat requirements of Federally-listed or State Priority species is anticipated as a result of controlling *Z. japonica* on approximately 3,000 acres of currently un-cultivated clam beds, since, after accounting for waterfowl forage requirements, it is estimated that more than 7,000 acres of unmanaged *Z. japonica* would remain in Willapa Bay (see FEIS Appendix A).

Because imazamox is practically non-toxic to fish, the herbicide will be applied to dewatered plants, Willapa Bay has excellent tidal flushing, and unpublished research suggests that green sturgeon feed less in areas of *Z. japonica* (Fisher Bradley and Patten 2011); it is unlikely that the application of imazamox would pose a risk to adult green sturgeon present in Willapa Bay.

WAC 173-226-140 requires that Ecology submit all draft NPDES general permits for Federal agency review and recommendations. Federal agencies include the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and any other Federal agency upon their request. Ecology also solicited input from Federal resource agency scientists while drafting the *Z. japonica* permit. Issuance of the Ecology NPDES general permit for imazamox applications to commercial clam beds in Willapa Bay, Washington, does not have a Federal nexus that would trigger formal ESA consultation with the Services. National Marine Fisheries Service (NMFS) staff said in a communication to Ecology, "As the permit is issued solely by the State, there is no formal nexus, and therefore NMFS will not be issuing a legal opinion on the permit. We have offered, and will assist, in providing technical input to Ecology as it relates to this permit and any potential interactions it has with our trust species, but lacking a formal Federal nexus, our role will be in providing technical assistance and feedback only (email communication with Jeff Fisher, NMFS Southwest Washington Branch Chief, 2012)."

Mitigation Measures. Shellfish growers managing *Z. japonica* under any alternative will avoid any direct or indirect harm to species listed as threatened, endangered, or candidates for listing under the Endangered Species Act.

Under Alternative 2 or 3, the proposed NPDES general permit would limit the imazamox application period to daylight hours during the period April 15 through June 30 in any year in which the permit is in effect, and would only allow one application per season per treatment area (commercial clam bed). This application window would occur after the herring spawning season in Willapa Bay. The application window is also within the in-water work window (March 2 –

October 14) allowed by WDFW in their Hydraulic Project Approval program to avoid sensitive life cycles of fish within Willapa Bay.

To address the concern of whether imazamox applications to *Z. japonica* on Willapa Bay clam beds would pose a threat to waterfowl populations on the Pacific Flyway, a preliminary foraging budget was developed based on the amount of *Z. japonica* in Willapa Bay, the amount of *Z. japonica* consumed by waterfowl, and the total waterfowl usage in Willapa Bay during peak migration. The two methods used to develop this model are described in Appendix A of this FEIS. The analysis estimates that the amount of *Z. japonica* available in Willapa Bay is several orders of magnitude greater than what would be consumed, even with implementation of the proposed action.

EPA has implemented an Endangered Species Protection Program (ESPP) to identify all pesticides that may cause adverse impacts to threatened/endangered species, and to implement measures that will mitigate these impacts. When the ESPP identifies an adverse impact, it requires use restrictions to protect these species at the County level. EPA specifies these use restrictions on the product label or by distributing a County-specific Endangered Species Protection Bulletin. Bulletins are enforceable under FIFRA.

3.2.6 Aesthetics

Affected Environment. Willapa Bay has access to three distinct bodies of open water: the Willapa River, the bay and the Pacific Ocean. The area has spectacular views of sandy beaches, dune grasslands, coastal pine forests, and wildlife (Port of Willapa Harbor 2013).

Willapa Bay has a relatively undeveloped shoreline, with low-density residential use and homes set back from the high salt marsh and shoreline edge. Most of the community development is in the south end of the bay. Commercial clam beds are minimally visible, with the exception of a few sapling stakes and PVC pipes that mark the boundaries of individual beds. There are few racks or other infrastructure on the clam beds that would create the appearance of commercial aquaculture when the tide flats are exposed at low tide (personal communication with Brian Sheldon, Owner, Northern Oyster Co., October 11, 2013).

Clam harvest of a particular bed occurs approximately once every 1 to 4 years, depending on the particular growth characteristics of the bed. Harvest of an average-sized bed generally takes 1 to 3 months working 3 to 5 hours per day during low tides. After harvest, workers and equipment are not present on the clam bed again for 1 to 4 years, other than to occasionally visit the site to survey crops, maintain the beds, inspect for pests, control pests, and assure that bed markers are intact (personal communication with Brian Sheldon, Owner, Northern Oyster Company, October 11, 2013).

Potential Impacts. Existing *Z. japonica* management practices under Alternative 1 do not have a significant adverse affect the aesthetic condition of Willapa Bay, as these are small-scale historic activities and occur on privately-owned or leased tidelands for clam aquaculture. Existing practices are short-term, and often associated with harvest. Clam beds are privately held, and thus are not highly visible to the public.

Under Alternative 2 (Chemical Methods Only), imazamox applications would occur at a different time than harvest. Certified applicators would visit commercial clam beds to be treated wearing a backpack sprayer, or working from an all-terrain vehicle utilizing a single hand nozzle or boom sprayer. The herbicide would be applied during a low tide, and the applicator would leave the site within approximately 5 hours or less. Because applications are proposed to be made in the spring before substantial growth of *Z. japonica* plants, no significant quantity of dead plant material would be expected to appear on the tide flats or to become suspended in surface water. Once killed, *Z. japonica* roots would decompose over time. Treated plots of tide flat could be returned in appearance to how they looked prior to colonization by *Z. japonica*.

Under Alternative 3, workers would be present on application sites with approximately the same frequency as Alternative 2 for harvest and separate site visits for imazamox applications. If existing mechanical methods of *Z. japonica* management were used in addition, workers would be present on the clam beds for three separate activities: harvest, implementing existing mechanical control methods, and spraying. If using IPM methods results in less frequent need for imazamox applications as anticipated, the amount of dead plant material left on the tide flats by Alternative 3 would be approximately comparable to Alternative 2. These areas are not highly visible to the public.

As with Alternative 2, it may be possible under Alternative 3 to restore clam beds to their appearance prior to *Z. japonica* colonization.

Mitigation Measures. No mitigation measures for aesthetics are required for the continuation of existing *Z. japonica* management practices under Alternative 1.

The proposed NPDES general permit would limit imazamox applications to the period between April 15 and June 30 in any year for which the permit is in effect. Since *Z. japonica* dies back during winter months, the biomass will still be low this early in the growing season, which will minimize the amount of dead vegetative material that will result from imazamox treatments. This will help minimize the quantity of plant material in the "rack" of vegetative debris that naturally forms in Willapa Bay in the fall each year. A condition of the proposed NPDES general permit would be that no site can be treated more frequently than once per season.

3.2.7 Recreation

Affected Environment. Willapa Bay, the rivers flowing into it and the surrounding hills offer a variety of outdoor recreation activities. Traditional hunting, fishing and shellfish gathering opportunities attract both local residents and visitors. Activities include hunting elk, deer and waterfowl; digging razor clams; freshwater and saltwater fishing, including sturgeon and salmon fishing. Willapa Bay has been recognized for its ecotourism opportunities with bird watching, kayaking, and water trails. The 180 square mile estuary contains abundant wildlife, forests, and historic sites. Willapa Bay is a place that naturalists, boaters, and historians enjoy as a year-around destination (Port of Willapa Harbor 2013).

The Willapa National Wildlife Refuge encompasses four separate areas within Willapa Bay: the southern units (Lewis, Porter Point, and Riekkola); and the Long Island, Leadbetter Point, and

Cape Shoalwater units. The Refuge allows camping on Long Island, a popular kayaking destination, which has five primitive campgrounds and hiking trails. Because of shallow water depths, large tidal ranges, swift currents, frequent high winds, and changeable weather patterns in the bay, recreational boating opportunities are limited. Paddling (kayaking, canoeing) mostly occurs in shallow waters near shorelines. While there are some opportunities to fish deeper channel waters for Dungeness crab and white sturgeon, these activities normally occur closer to the few public boat launch sites. Salmon fishing opportunities occur in the Willapa River at the north end of Willapa Bay. Recreational clamming within the bay is limited to public lands Waterfowl hunting and wildlife viewing are primarily land-based and occur along the dike and saltmarsh areas of the Refuge's southern units and tidal flats adjacent to the Leadbetter Point unit (U.S. Department of the Interior, U.S. Fish and Wildlife Service 1997).

The Willapa Bay Water Trail stretches around the bay with connections to the shoreline, providing views of sandy beaches, dune grasslands, coastal pine forests, and wildlife (Port of Willapa Harbor 2013). The Water Trail provides information on public bay access points where kayaks, canoes, and other small water craft can be hand-launched for travel around the bay. Near shore areas can be accessed when incoming tides cover the tide flats with enough water so that boats can be paddled over these shallow areas. *Z. japonica* stem acts to make it more difficult for shallow water paddlers to maneuver near shore. Silt fines trapped in the *Z. japonica* are resuspended through mild wave action, resulting in turbidity in the shallows so that boaters cannot view the bottom. Boating in Willapa Bay is further impacted by *Z. japonica* fouling paddles and propellers. Loose floating *Z. japonica* "wrack" can get taken up into engine water intakes where it causes damage due to overheating or mechanical problems.

Swimming is not a significant attraction for visitors to Willapa Bay, with summertime water temperatures ranging between 50 and 65 degrees Fahrenheit. The large tidal ranges, swift currents, frequent high winds, and changeable weather patterns in the bay are also deterrents to open-water swimming.

Potential Impacts. Existing *Z. japonica* management practices under Alternative 1 have no negative impacts to recreational opportunities within Willapa Bay, as they are small-scale activities that occur on privately-owned or leased tidelands used for clam aquaculture. These areas are normally located well away from public gathering areas. People don't tend to walk on the clam beds as most are remote and are recognized as private farm lands.

The imazamox aquatic label does not include any swimming restrictions to be imposed under Alternative 2 or 3. Ecology believes that no swimming restrictions or advisories following applications of Clearcast® are appropriate in the NPDES general permit because Clearcast® has not been found to irritate eyes or skin and it is practically non-toxic to mammals.

Imazamox has no fishing or fish consumption restrictions. Therefore, its use under Alternative 2 or 3 should have no effect on recreational fishing in Willapa Bay.

Mitigation Measures. No mitigation measures for recreation are required for continuation of existing *Z. japonica* management practices under Alternative 1.

Since no adverse impacts to recreation are associated with imazamox applications to commercial clam beds under Alternative 2 or 3, no mitigation measures are proposed.

3.2.8 Navigation

Affected Environment. Willapa Bay has a well-established system of U.S. aids to navigation, including entrance lights, channel lights, lighted buoys, day-beacons on pilings and dolphins, jetty lights, range lights, yellow can and red nun buoys (U.S. Coast Guard 2013).

Near shore areas dominated by *Z. japonica* growth tend to be more turbid, making it more difficult to see the bottom. The turbidity results partially from silt that has been trapped by *Z. japonica* stem being resuspended into the water column by normally-occurring wave action as tidal waters inundate the higher near shore areas.

In autumn and early winter, the majority of the above-ground biomass of *Z. japonica* dies and breaks free from the substrate, collecting as floating debris referred to as "wrack." This wrack can pose hazards to recreational and commercial boat traffic within Willapa Bay, as described above in Section 3.2.7. *Z. japonica* stem density is at its peak between June and October. The thick stem density interferes with navigation by becoming tangled in propellers and plugging motor water intakes.

Potential Impacts. No negative impacts to navigation would be anticipated with continuation of existing *Z. japonica* management practices (Alternative 1), as these result in small-scale, temporary removal of plant parts.

Under Alternative 2 or 3, the application of imazamox to commercial clam beds in Willapa Bay would not interfere with boating or navigational routes, because these applications will occur at a time when the tide flats are exposed and not navigable. Die-back will occur early in the season as a result of applications between April 15 and June 30 in any year for which the NPDES general permit is in effect, before *Z. japonica* plants reach their full vegetative growth.

Mitigation Measures. No mitigation measures for navigation are required for the continuation of existing *Z. japonica* practices under Alternative 1.

Since no adverse impacts to navigation are indicated associated with imazamox applications to commercial clam beds under Alternative 2 or 3, no mitigation measures are proposed.

3.2.9 Human Health

Affected Environment. The Pacific County Board of County Commissioners serves as the local board of health, with responsibility for all matters pertaining to the preservation of the life and health of people within its jurisdiction.

The Pacific County Public Health and Human Services Department (PCPHHSD) collects, analyzes, and reports information related to the overall health status of the County. The Department uses data from a variety of sources to prepare and disseminate reports that describe general health status, behavioral health, youth health, and risk factors, access to health care and a number of other topics. Individuals, agencies, and organizations use PCPHHSD data to identify community needs, develop and plan programs, prepare grant requests, and measure program effectiveness. The South County office of PCPHHSD is located in Long Beach, Washington (Pacific County Health and Human Services Department 2013).

Potential Impacts. There is some degree of risk of injury related to the use of hand rakes and mechanical methods of *Z. japonica* management under Alternatives 1 or 3. Growers use experienced field crews on an on-going basis, which minimizes these risks due to familiarity.

The mechanism of action of an herbicide is defined as the biochemical and/or physical method by which it has been engineered to kill or suppress the growth of specific plants. Imazamox is an acetolactate synthase (ALS) inhibitor. ALS herbicides demonstrate low toxicity toward animals, likely because the ALS biochemical pathway does not exist in animals. Rat toxicity testing showed that imazamox was practically non-toxic to mammals on an acute basis (ENVIRON 2012). For this reason, no significant human health concerns have been identified related to chemical applications under Alternative 2 or 3.

Table 3.2-3 below summarizes some of the toxicity endpoints used for evaluating potential health risks to humans determined by EPA-approved toxicity texting during the imazamox registration process.

Table 3.2-3. Toxicity studies for imazamox in mammals (Hamel 2012).

Acute Toxicity Studies for Imazamox			
Study	**Organism**	**Results**	**Toxicity Category**
Acute oral toxicity – single dose (LD_{50})	Rat	>2,121mg active ingredient/kg of body weight	
Acute inhalation	Rat	>6.3 mg/L	IV
Acute dermal	Rabbit	>4,000 mg/kg b.w.	III
Acute dermal sensitization	Guinea pig	Not a sensitizer	
Primary dermal irritation	Rabbit	None-to-slightly irritating	IV
Primary eye irritation	Rabbit	Slight-to-moderately irritating	III

Subchronic Effects			
28-day dermal	Rat	NOAEL[15] 1,000 mg/kg body weight/day	No systemic toxicity at the HDT (highest dose tested)
13-week feeding study	Rat	NOAEL>20,000 ppm	No systemic toxicity at the HDT
90-day feeding study	Dog	NOAEL>40,000 ppm	No systemic toxicity at HDT
Chronic Effects			
Tests indicate no oncogenic or teratogenic potential and no reproductive toxicity at the highest doses tested and negative activity in four mutagenicity studies.[16] There were no effects on organs associated with endocrine function.			

Collective organ weight data and histopathological findings from the two-generation rat reproductive study, as well as from the sub-chronic and chronic toxicity studies conducted in two or more animal species demonstrate no apparent estrogenic effects or effects on the endocrine system. There is no information available that suggests that imazamox would be associated with endocrine effects (Hamel 2012).

The New York State Department of Health determined after reviewing the EPA toxicity data that imazamox was moderately irritating to rabbit eyes; however, they concluded that the aquatic formulation, Clearcast® (proposed for use in Willapa Bay) was not very irritating. They also concluded that neither the active ingredient nor the formulated product were very irritating to rabbit skin, and did not cause dermal sensitization when tested on guinea pigs (Hamel 2012).

Imazamox did not cause any observable toxicity in sub-chronic or chronic feeding studies with laboratory animals at high doses. There was no evidence of carcinogenicity in either the rat or

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15 NOAEL = No observable adverse effect level.

16 Toxicity Category III – Harmful if absorbed through skin. Causes eye irritation. Avoid contact with skin, eyes, or clothing. Wash thoroughly with soap and water after handling. Avoid breathing dust. Remove contaminated clothing and wash before reuse.

mouse studies, and imazamox was negative in a number of genotoxicity studies. Based on these findings, EPA designated imazamox as *not likely to be carcinogenic to humans*.

In a 2011 assessment of imazamox, the Thurston County Health Department used a 9 mg/kg/day dose of concern to assess risk for both short- and long-term human exposures to imazamox. The County Health Department calculated the potential exposure to adult applicators of the aquatic formulation of imazamox to be at least 600 times less than the dose of concern (rated low in hazard).

EPA granted a conditional registration for imazamox in 1997 and an unconditional registration Section 3 label in 2001. In 2003, imazamox received an "exemption for tolerance" designation from EPA. This exemption waives all food residue tolerance requirements for potential food or feed uses of imazamox, including fish, shellfish, crustaceans, and irrigated crops. Imazamox is the first and only organic pesticide to receive a tolerance exemption. This means that EPA determined the total quantity of imazamox in or on food presents no hazard to public health. EPA considers imazamox to be a reduced-risk pesticide with both terrestrial and aquatic uses.

Mitigation Measures. No human health mitigation measures are required for the continuation of existing *Z. japonica* management practices under Alternative 1.

While no mitigation for potential impacts to human health with implementation of Alternative 2 or 3 are indicated by the results of testing the herbicide imazamox, proposed NPDES general permit special conditions include the following measures that will be protective of human health:

- Permit coverage requires imazamox to be applied by a State-licensed applicator with an aquatic endorsement.
- Aerial application of imazamox is prohibited.
- Ecology will post pre-treatment plans on the NPDES permit webpage (http://www.ecy.wa.gov/programs/wq/pesticides/eelgrass.html) to notify the public prior to imazamox applications.
- All corners of the proposed imazamox application sites must be posted to notify users of the application.

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Appendix A: Preliminary Foraging Budget for Migratory Waterfowl

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Preliminary Foraging Budget for Migratory Waterfowl

To address a potential concern whether imazamox applications to *Z. japonica* on Willapa Bay clam beds would pose a threat to waterfowl populations on the Pacific Flyway, a foraging budget was developed based on the amount of *Z. japonica* in Willapa Bay, the amount of *Z. japonica* consumed by waterfowl, and the total waterfowl usage in Willapa Bay during peak migration. Two methods were used in this model: one based on data used in a study of eelgrass consumed by brant in Humboldt Bay (Moore 2002), and the other based on data used for a landscape budget for waterfowl developed in Puget Sound (Lovvorn and Baldwin 1996). The discussion that follows shows that these foraging budgets conservatively overestimate the amount of *Z. japonica* consumed by dabbling ducks, and that the amount available in Willapa Bay is several orders of magnitude more than what would be consumed.

Z. japonica Area in Willapa Bay

USDA surveyed eelgrass (*Z. japonica* and *Z. marina*) in Willapa Bay in 2006/2007 (Draft EIS Figure 1-1). USDA estimated approximately 12,000 acres of moderate to heavy density *Z. japonica*. This did not include any acres with thinly populated *Z. japonica*, nor did it include any increase in acres or density of *Z. japonica* since 2007. A less conservative mapping of *Z. japonica* polygons suggests that there are presently approximately 18,000 acres of *Z. japonica* in Willapa Bay (Draft EIS Figure 1-2). This expanded acreage value considers *Z. japonica* expansion trends and reported observations from various clam farmers, Jacob Moore (Willapa Grays Harbor Oyster Growers Association Project Coordinator), and Washington State University (Long Beach Research and Extension Unit) reports.

Z. japonica Dry Weight Data

Top growth of *Z. japonica* was sampled by Dr. Kim Patten (WSU Cooperative Extension Office, Long beach, Washington) monthly from September to November, in 1 ft2 quadrats at 40 locations in Willapa Bay. Leaves were dried and recorded as grams dw/m2. Moderate to thick density *Z. japonica* averaged ~ 0.1 to 0.2 kg dry weight/m2 (405 to 812 kg dry wt/ac). Based on these data, there are approximately 5 to 15 million kg dw of *Z. japonica* available for forage in Willapa Bay (0.1 kg dw/m2 X 4,046 m2/ac X 12,000 ac to 0.2 kg dw/m2 X 4,046 m2/ac X 18,000 ac). For the calculations in the consumptive model and the energy model presented below, the more conservative value of 0.1kg dw/m2 of *Z. japonica* will be used.

Consumptive Use Model

This model uses brant as a surrogate for all waterfowl known to consume *Zostera* spp. This is based on a MS thesis by J. Moore (2002) in Humboldt Bay, California. Mr. Moore determined that brant consume ~100 g dw of *Z. marina*/day. Since brant are approximately twice the body weight of dabbling ducks (3.5 lbs vs. 1 to 1.75 lbs), the smaller dabbling duck species are assumed to eat approximately 50 g dw of *Zostera* spp./day. Assuming waterfowl usage for Grays Harbor and Willapa Bay is approximately equivalent, there are approximately 20,000 dabbling ducks present in Willapa Bay during October and November (Baldwin and Lovvorn 1994). These values can then be combined to obtain the *Zostera* spp. consumed in Willapa Bay during peak migration (20,000 ducks/day X 0.05 kg *Zostera* spp./day X 60 days= 60,000 kg). This much forage can be obtained on approximately 150 acres of *Z. japonica*. If the number of foraging ducks is quadrupled to 80,000, and their foraging time doubled to 120 days, their consumptive requirement would be for approximately 1,200 acres of *Z. japonica* (80,000 ducks x 120 days x 0.05 kg/day = 480,000 kg *Z. japonica*). During October 2012 to January 2013, 542 brant were identified in Willapa Bay (USFWS 2013). This value can be used to calculate the *Zostera marina* consumed during peak migration (542 brant/day X 0.1kg *Zostera*/day X60 days = 3,252kg). This much forage can be obtained on approximately 8.13 acres of *Z. japonica*. Assuming that mass density of *Z. marina* is similar to the mass density of *Z. japonica*, 8.13 acres of the 10,000-15,000 acres of *Z. marina* is needed by brant.

Energy Model

Lovvorn and Baldwin (1996) developed landscape models for waterfowl that included *Z. japonica*. They based their calculations on the energy requirements of dabbling ducks. Widgeon and other waterfowl use approximately 630 thousand joules (KJ)/day of energy. The energy requirements of 20,000 dabbling ducks for 60 days would be (630 KJ/day X 20,000 ducks X 60 days) approximately 756,000 MJ from forage in Willapa Bay. Lavvorn and Baldwin (1996) report that *Z. japonica* contains 18,145 KJ/kg dry weight, but that only about 50% of that is utilized for energy. This equals 3641.4 MJ/ac for *Z. japonica* (0.5 X 18 MJ/kg dw X 0.1 kg dw/ m2 X 4,046 m2/ac). Because the density of *Z. Japonica* declines in the fall, there would be less energy later in the season. An average density across the migration season would be approximately 0.1 g dw/m2 which gives an energy value for *Z. japonica* of 3,641 KJ/ac. One acre of *Z. japonica* could therefore theoretically support about 100 ducks over 60 days of foraging ((3641 MJ/ac) ÷ (630 KJ/day/duck X 60 days)). To fulfill the energy requirements of 20,000 dabbling ducks would require 200 acres of *Z. japonica*. If the number of ducks is quadrupled to 80,000 ducks feeding, and their foraging days are doubled to 120, representing 9.6 million duck days, then about 1,673 acres would be required for the approximately 6,048,000 MJ of total energy required to feed those ducks.

Discussion

Both of the models used above are conservative. They assume that all food/energy for all ducks would be derived from *Z. japonica*. Based on the data presented in Lovvorn and Baldwin (1996), this is not the case, with widgeon in Boundary Bay deriving only 43% of their diet from the intertidal. In the Lovvorn and Baldwin (1996) study, *Z. japonica* leaves provided 84.8%, 48.3%, 72.3% and 1.7% of the intertidal diet of widgeon, pintail, mallard, and teal, respectively. This study assumed that no *Z. japonica* root biomass would be available for consumption, and that all the energy would be derived from leaves. Dabbling ducks do eat rhizomes of *Z. japonica*, especially pintail and mallard with 24.33% and 39.0% of their diet being rhizome, respectively (Lovvorn and Baldwin 1996).

The models also assume that there has been no increase in *Z. japonica* since 2007. Subsequent mapping, Google Earth satellites imagery, and shellfish farmer/research observation indicate that there may have been significant increases in *Z. japonica* in several locations in the bay since 2007. Even if these budgets are conservative and greatly overestimate the amount of *Z japonica* consumed by dabbling ducks, that amount is several orders of magnitude less than what is available in Willapa Bay. If the most conservative estimates of all the data are used in the models, then they suggest about 1,600 acres of *Z. japonica* are required to support the migratory waterfowl that use Willapa Bay. Based on these models, management of *Z. japonica* on clam production ground would leave enough *Z. japonica* remaining to support waterfowl usage. Using the 2007 *Z. japonica* data of 12,000 acres, assuming 1,600 acres are needed for waterfowl forage, and up to 3,000 acres of clam beds would be managed to reduce *Z. japonica* (personal communication with WGHOGA members, December 2012), there would still be approximately 7,000 acres of unmanaged, unconsumed *Z. japonica* beds in Willapa Bay.

Appendix B:

Responsiveness Summary

Non-Project Environmental Impact Statement

Zostera japonica Management on Commercial Clam Beds in Willapa Bay

March 26, 2014

Introduction

Responsiveness Summary

Non-Project Environmental Impact Statement

Zostera japonica Management on Commercial Clam Beds in Willapa Bay

March 26, 2014

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 *Zostera japonica (Z. Japonica)*. The *Z. japonica* Management on Commercial Clam beds in Willapa Bay 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 *Z. japonica* management, the probable significant adverse and beneficial environmental impacts of these alternatives, and their relation to existing policies, rules and regulations. This DEIS analyzed three possible alternatives.

1) No Action–Continuing Existing Management Practices

2) Use of Chemical Methods Only

3) Use of an Integrated Pest Management (IPM) Approach with Adaptive Management Principles.

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

Ecology encouraged the public to comment on the DEIS and the draft permit. A comment period was open from January 2, 2014 until February 15, 2014. Ecology held a workshop and public hearing in South Bend Washington on February 1, 2014. Comments are listed by number below Table 1. Comment originators are listed in Table 1 with the coordinating comment numbers referenced. Response to comments and any resulting changes to the draft follow each summarized comment. The original full text of the comments are available on Ecology's webpage at: http://www.ecy.wa.gov/programs/wq/pesticides/eelgrass/commentsFeb2014.html

Section 1: List of Commenters and Comment Numbers

Table 1: Commenters

Commenter Name	Affiliation	Comment Number
Ross Barkhurst	Washington Waterfowl Association	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 51
Tim Visel	Interested Party	58
Kim Patten	WSU Extension-Long Beach	59
Dan Penttila	Salish Sea Biological	15, 29, 52, 53, 54, 55, 56, 57
Rob Kavanaugh	Interested Party	2, 4, 7, 12, 17, 18, 19, 20
Steven Spencer	Shoalwater Bay Tribe	65, 66, 67, 68, 69
Richard Wilson, Ph.D.	Bay Center Mariculture Co.	13, 21, 22, 23, 24
Jerry Johannes	Interested Party	2, 25, 26, 27, 29
Curt Stephens	Ocean Park Resort	30
Kristin Swenddal	Washington State Department of Natural Resources (DNR)	60, 61, 62, 63
Laura Hendricks	Sierra Club	1, 2, 3, 4, 8, 9, 12, 20, 26, 31, 32, 33
Kim W. Kratz, Ph.D.	National Oceanic and Atmospheric Administration (NOAA)	34, 35
John McCabe	Interested Party	28, 36, 37, 38, 40, 41, 42, 43, 44
Jim Kaldy	Interested Party	14, 45, 46, 47, 48, 49, 50, 70, 71, 72, 73, 74, 75, 76, 77, 78
Cameron Jimmo	Northwest Environmental Defense Center	2, 16, 39, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89
Pat Rasmussen	World Temperate Rainforest Network	64

Comments and Responses

General Comments

Comment 1: *The Risk Assessment for imazamox done by Environ does not adequately describe how waterfowl forage and consume eelgrass, particularly Z. japonica, in Willapa Bay.*

> **Response:** The Screening-Level Ecological Risk Assessment of the Proposed Use of the Herbicide Imazamox to Control Invasive Japanese Eelgrass (*Z. japonica*) in Willapa Bay, Washington State is not an Ecology document. It has been posted to the Ecology website to allow for easy public access to the document.

Comment 2: *Impacts to Pacific Brant and chum smolt are not adequately characterized. Prevention or mitigation of damage to native eelgrass is not proposed.*

> **Response:** Ecology feels that the DEIS adequately characterizes potential impacts to Pacific Brant and that the Preliminary Foraging Budget for Migratory Waterfowl provided in Appendix A indicates that there is sufficient forage available, even after accounting for removal of *Z. japonica* on commercial clam beds.
>
> DEIS section 3.1.9 discusses impacts to juvenile salmon. Ecology will add the information and reference given below.
>
> **Changes:** In 2012, chum salmon (all unmarked YOY) were found at highest densities at aquatic vegetation bed habitats, though they were also at high densities off gravel/cobble/sand beach sites (particularly Damon Point, just North of the estuary mouth) and sand and mud flats, in that order.
>
> Chum salmon were present at high densities from February to May (in June, only four chum were captured), after which all chum salmon had migrated to sea, in keeping with their life history.
>
> **From: Grays Harbor Juvenile Fish Use Assessment: 2012 Annual Report,** Prepared for the Chehalis Basin Habitat Work Group; **February, 2013**
>
> Prepared by: Todd Sandell, James Fletcher, Andrew McAninch, and Micah Wait
>
> **Wild Fish Conservancy Northwest**
>
> **http://wildfishconservancy.org/projects/grays-harbor-juvenile-salmon-fish-community-study/WFCGraysHarbor2012Report_final.newplots.pdf**
>
> Information will be added from: Frazier et. al. 2014. Intertidal habitat utilization pattern of birds in a Northeast Pacific estuary. Wetlands Ecology and Management. 22:1

Comment 3: *The loss of carrying capacity of Willapa Bay for many species, including green sturgeon is not addressed.*

Response: Imazamox is not expected to reduce the carrying capacity of Willapa Bay for green sturgeon for the following reasons:

1. Imazamox is practically non-toxic to fish

2. Imazamox has not been shown to bio-accumulate in fish.

3. Field data indicates that green sturgeon feeding pits may occur less frequently in areas of *Z. japonica* (Corbett, Faist, Lindley, Moser 2011) (Fisher Bradley and Patten 2011).

Comment 4: *Appendix A: Preliminary Foraging Budget for Migratory Waterfowl does not properly characterize the forage requirements of migratory waterfowl in Willapa Bay as it fails to account for other reductions in Z. japonica as well as consumption of rhizomes.*

Response: The preliminary foraging budget is an estimation of the *Z. japonica* acreage needed to support migratory waterfowl on Willapa Bay. The DEIS acknowledges that waterfowl consume rhizomes as part of their diet; however, Dr. Patten did not include rhizomes in his calculation. If rhizomes were included in the foraging budget, it would increase the calories available to waterfowl on a per area basis thereby reducing the acreage required to support migratory waterfowl in Willapa Bay. By not including rhizomes the foraging budget underestimates the calorie density of *Z. japonica*.

Comment 5: *Accurate mapping of Z. japonica and Z. marina populations in Willapa Bay are lacking.*

Response: The 2006/2007 USDA map provided as Figure 1-1 is the most accurate map currently available.

Comment 6: *Public tidelands need to receive more protection than private tidelands.*

Response: The only scenario where public tidelands could be covered under the proposed permit is through a DNR lease to a commercial clam farmer. Ecology does not provide extra provisions or protections for leased lands in the permit. It is up to DNR and the Lessee to determine how to manage leased lands in respect to management of noxious weeds.

Comment 7: *Brant wintering beds occur over mixed eelgrass beds and should be accounted for in the EIS.*

Response: Ecology feels that conditioning the permit to allow control of *Z. japonica* on commercial clam beds only will mitigate the indirect impacts to waterfowl. Imazamox has an EPA toxicity rating of practically non-toxic to birds and is not expected to have direct toxic effects on waterfowl.

Comment 8: *We have had no opportunity to participate in the drafting process or in workshops where a thorough exchange of facts, studies, and observations could take place.*

Response: Ecology held two public comment periods when determining whether to proceed with permit development. Those comments can be found here: http://www.ecy.wa.gov/programs/wq/pesticides/eelgrass/historical.html

As a result of these comment periods, Ecology determined to reduce the scope of the permit from all shellfish beds statewide to commercial clam beds (excluding geoduck) in Willapa Bay only.

The public had the opportunity to provide scoping comments for the Environmental Impact Statement.

Ecology held an informational public meeting in December of 2012 to discuss development of the draft permit and listen to concerns.

During draft permit development Ecology worked with DNR and WDFW to help develop the Buffer Validation Study that is included as Appendix B in the Fact Sheet.

Ecology conducted a workshop and public hearing on February 1, 2014 in South Bend as well as a 45 day comment period that ran from January 2, 2014 through February 15, 2014, to solicit comments on the draft permit documents. Ecology will use the comments obtained during the 45 day public comment period to make necessary changes to the Draft NPDES Permit and Draft EIS.

Comment 9: *The EIS fails to include meaningful precautions, limitations and cumulative effects.*

Response: Ecology feels that the conditions and mitigations proposed in the EIS will provide protection from direct toxic effects to vegetation off of commercial clam beds. Imazamox has an EPA toxicity rating of practically non-toxic to animals and is not expected to have direct toxic effects to animals.

Ecology feels that it has adequately addressed cumulative impacts in section 2.9 of the DEIS.

Comment 10: *I oppose chemical control of Z. japonica and Z. marina based on the current draft NPDES and EIS.*

Response: Thank you for your comments. The permit regulates the use of imazamox to manage the state listed class C noxious weed *Z. japonica* in Willapa Bay only. The legislature has directed Ecology to develop permits for noxious weed management. Ecology attempts to strike a balance between beneficial uses of a water body when developing aquatic pesticide permits. This permit took Ecology several years to develop and required the development of a non-project DEIS. Ecology worked with natural resource agency scientists as well as academic scientists when developing the permit. Based on the DEIS Ecology included mitigations within the permit to reduce potential ecological impacts to Willapa Bay.

Comment 11: *The mud flats were never bare. They used to have large oyster reefs on them.*

> **Response:** The reference to bare tide flats is referring to the fact that they were un-vegetated and is meant to describe them as not having aquatic vegetation present.

Comment 12: *The authors failed to document concisely both the beneficial and negative impacts on the environment from Z. japonica.*

Comment 13: *It is felt that the full extent of the negative impacts to the habitat by the invasive Japanese eelgrass is incomplete or not adequately stated in the draft environmental impact statement.*

Comment 14: *The EIS should include a valuation of potential positive benefits (e.g. ecosystem services such as nutrient removal, pH amelioration, etc.) of Z. japonica in the socioeconomic impacts section.*

Comment 15: *Any consideration of permitting eradication measures triggered by this permit must include a cost/benefit/risk analysis to determine whether or not the economic value of the exotic shellfish commodity produced thereby is of sufficient value to justify the conversion of wide areas of estuarine tideflat habitat, of ecological value to a wide range of native species, to a chemically-supported monoculture for a single industry, as opposed to those estuarine habitats being of more societal value when left in their existing condition.*

Comment 16: *The potential positive impacts of Z. japonica, such as the benefit to native eelgrass populations, should be considered before allowing additional control methods.*

> **Response:** The DEIS examines impacts from the proposed action, management of *Z. japonica* on commercial clam beds in Willapa Bay using the herbicide imazamox. The alternatives examined look at no action (status quo), chemical only and IPM approach. The no action alternative discusses current management practices, which allow for management of *Z. japonica* on commercial clam beds in Willapa Bay using physical and mechanical methods. The decision that the DEIS is informing is whether to allow for chemical management of *Z. japonica*; not the broader question of whether *Z. japonica* should be managed. The question of whether *Z. japonica* should be managed was answered from a state agency regulatory point of view with the listing of *Z. japonica* as a class C noxious weed. It is for these reasons that including further discussion of impacts from *Z. japonica* is outside the scope of the DEIS.

Comment 17: *The DEIS/NPDES does not conform to either the legislative intent of SEPA or the Clean Water Act.*

> **Response:** Thank you for your comment. Ecology feels that it is following the process and intent provided by SEPA and the Clean Water Act.

Comment 18: *Claims that shellfish growers are experiencing economic damage due to Z. japonica are unsubstantiated.*

> **Response:** The socioeconomic discussion in the DEIS is given as an example of how one beneficial use of the water is being impacted by *Z. japonica*. Ecology feels that impacts to commercial clam aquaculture have been demonstrated, although an independent economic impact analysis has not been conducted. The impact to commercial aquaculture from *Z. japonica* is supported by the state listing of *Z. japonica* as a class C noxious weed. That being said, demonstrating economic loss is not a necessary step in developing an NPDES permit.

Comment 19: *We are concerned about the issue of depleting shellfish beds by overstocking with exotic manila clams thus creating smaller less desirable and marketable clams.*

> **Response:** Commercial clam bed properties are independently owned or leased properties that are privately managed for commercial aquaculture. A discussion of overstocking of manila clams on privately managed commercial aquaculture beds is outside of the scope of the proposed action discussed in the DEIS.

Comment 20: *Research from UWs Escheria, National Estuarine Research Reserve, Dr. Bulthuis and Dr. Deborah Shafer should be included in the EIS.*

> **Response:** Thank you for your comment.
>
> Dr. Sandy Wyllie-Echeverria is cited in the DEIS on pages 71, 81 and 91.
>
> Dr. Doug Bulthuis is cited in the DEIS through the Washington Department of Ecology. 2013. The Science and Management of *Zostera japonica* in Washington: A Meeting for State Agencies. June 18-19, 2013. Olympia, WA.
>
> http://www.ecy.wa.gov/programs/sea/aquaculture/japonicaeelgrass.html.
>
> Dr. Deborah Shafer is cited on page 74 of the DEIS.

Comment 21: *It should be noted (and emphasized) in the final documents the fact most shellfish growers hold deeded title to (i.e. own) the intertidal areas they raise shellfish on and thus pay taxes just as would an upland farm owner.*

> **Response:** Ecology has noted that the commercial clam beds that may be covered under the draft permit are privately owned or leased properties being actively managed for commercial clam production.

Comment 22: *It should be made clear that the area that would be treated is only a small percent of the total which has been taken over by Japanese eelgrass.*

> **Response:** The DEIS identifies that in the most recent Z. japonica survey from 2006/2007 approximately 12,183 acres of Z. japonica were surveyed (Figure 1-1). Commercial clam growers in Willapa Bay have identified approximately 6,000 acres as suitable for clam culture. What is not completely clear is how many of the potential 6000 acres that are suitable for clam cultivation will be actively managed for clam production and of that acreage being farmed how much overlaps with Z. japonica distribution.

Comment 23: *Efficacy of imazamox on Z. japonica has been demonstrated and imazamox has been shown to have a light touch on the environment.*

Response: Thank you for your comment.

Comment 24: *More content should be added to the EIS to characterize the benthic sedimentary environment and the spread of the invasive species.*

Response: Ecology feels that impacts to the benthic environment from *Z. japonica* have been adequately characterized based on the available science.

Comment 25: *The use of the word "infest" and "infestation" needs to be stricken from the fact sheet and the EIS.*

Response: *Z. japonica* is a state listed class C noxious weed. In the context of noxious weed control, uses of the word infest or infestation is appropriate. Ecology understands that the terms infest and infestation has negative connotations and that not everyone agrees with the listing of *Z. japonica* as a class C noxious weed. Ecology will review the use of infest and infestation in the DEIS.

Comment 26: *The EIS should address the impact that removing Z. japonica will have on global warming and climate change.*

Response: The proposed action is the use of imazamox to manage *Z. japonica* on commercial clam beds. It is not anticipated that impacts to climate change would occur with use of imazamox to manage *Z. japonica*. Analysis of climate change impacts are out of the scope of the DEIS.

Comment 27: *It is problematic that Brian Sheldon is listed as an Author and Principal Contributor of the EIS.*

Comment 28: *This EIS is very biased in favor of the Willapa-Grays Harbor Oyster Growers Association.*

Response: It is common practice, and allowable under WAC 197-11-420, for Ecology to ask proponents of permit development to write the DEIS. In this instance, the Willapa Grays Harbor Oyster Growers Association (WGHOGA) requested permit development. Ecology required the WGHOGA to develop the DEIS and Brian Sheldon as a representative of the WGHOGA had a role in the development of the DEIS. However, the DEIS is an Ecology document and will meet our standards.

Comment 29: *The recent study by Shafer, Kaldy and Gaeckle should be included as a reference in the EIS.*

Response: Thank you.

Change: The reference will be added.

Comment 30: *I hope all of the questions addressed in the linked article are being carefully addressed.*

http://www.caseinlet.org/uploads/Zostera_japonica-Shaferetal2013Zjaponicamanagement.pdf

> **Response:** The eight areas recommended for further research in the linked paper are identified as data gaps that would be useful for making decisions on *Z. japonica* management. However, the research has not been conducted for many of the topics identified and Ecology uses the best available science to guide decision-making.

Comment 31: *The EIS is inadequate and leaves out important peer reviewed science.*

> **Response:** The public comment period for the DEIS is to solicit input on what needs to be included in the EIS. Ecology will modify the DEIS to include relevant references based on comments received during the public comment period.

Comment 32: *The EIS should mention the fact that one of the Puget Sound Partnership's goals is to increase eelgrass by 20%. Herring spawning medium will also be removed even though an increase in herring biomass is also a Puget Sound Partnership management goal.*

> **Response:** Puget Sound Partnership management goals for eelgrass and herring are for Puget Sound waters. The proposed permit would only cover *Z. japonica* management in Willapa Bay.

Comment 33: *The EIS does not include a cumulative impacts analysis which should have included the effects from the current spraying of Imazapyr, Glysophate and Carbaryl in Willapa Bay.*

> **Response:** This section is included in the DEIS as section 2.9.1.

Comment 34: *NMFS recommends the SEPA EIS discuss direct and indirect effects of current Z. japonica physical removal practices (on commercial clam beds) on Z. marina in Willapa Bay.*

> **Response:** Ecology agrees.
>
> **Change:** It will be noted that current mechanical and physical process are non-discriminatory between *Z. japonica* and *Z. marina*. Current *Z. japonica* management results in loss of *Z. marina* where mixed beds of native and non-native eelgrass occur and physical/mechanical management practices are occurring.

Comment 35: *NMFS suggests including a statement regarding current Z. marina presence within commercial clam beds.*

> **Response:** Ecology is not aware of any surveys or mapping that describes the presence of *Z. marina* on commercial clam beds in Willapa Bay. Further, many commercial clam beds will have varying amounts of the native and non-native eelgrass present and distribution patterns will vary among beds. The occurrence of *Z. japonica* and *Z. marina* in the intertidal has been discussed along with the suitable locations for Manila clam culture. Based on these discussions, Ecology feels that decision makers and the public can infer the potential types of *Z. marina* distribution that may occur on commercial clam beds in Willapa Bay.

Comment 36: *WA DOE notes that "Washington State has made a tentative decision to allow the use of imazamox in Willapa Bay for the purpose of controlling Z. japonica on commercial clam beds for a period of 5 years."*

> **Response:** The determination to begin permit development constitutes a tentative decision to allow the use of imazamox in Willapa Bay for the purpose of controlling *Z. japonica* on commercial clam beds. A decision on whether to issue the permit will not occur until after the final EIS is issued and reviewed.

Comment 37: *WA DOE's intended permit to destroy eelgrass meadows can reasonably be qualified as an attempt to engage in 'take' (i.e. harass, harm) under the Endangered Species Act. WA DOE appears in a hurry to kill eelgrass meadows and stresses legitimacy of such action in considerable part on the basis of a clearly fragile classification as a noxious weed.*

> **Response:** *Z. marina* and *Z. japonica* are not ESA listed species in Willapa Bay. Designation of *Z. japonica* as a Class C noxious weed was through the Washington State Noxious Weed Control Board and is a separate process from NPDES Permit development.

Comment 38: *WA DOE appears to be acting as an economic development authority with regards to the shellfish industry.*

Comment 39: *Apart from economic interests, Ecology does not address why additional control methods are needed or how that need outweighs other environmental interests.*

> **Response:** Ecology received a request for permit development, which Ecology is required to respond to. As a result of the state listing of *Z. japonica* as a class C noxious weed Ecology must follow RCW 90.48.445. This justification is provided in the fact sheet on page 11: RCW 90.48.445 Aquatic Noxious Weed Control - Water quality Permits In 1991, the Washington State Legislature directed Ecology to issue or approve water quality permits for use by federal, state, and local government agencies and licensed applicators for the purpose of using, for aquatic noxious weed control, herbicides and surfactants registered under state or federal pesticide control laws. Aquatic noxious weed means an aquatic weed on the state noxious weed list adopted under RCW 17.10.080. The legislature also specified that the issuance of these permits was subject only to compliance with federal and state pesticide label requirements, FIFRA requirements, the Washington Pesticide Control Act, the Washington Pesticide Application Act, and the State Environmental Policy Act (SEPA) (with some exceptions for *Spartina* projects).
>
> The Legislature further stated that Ecology may not use this permit authority to otherwise condition or burden weed control efforts and that permits are effective for five years, unless the applicant requests a shorter duration.

Comment 40: *WA DOE continues to repeat the obvious misinformation of "Shellfish aquaculture in Willapa Bay began in approximately 1849". In recent years, WA DOE has repeatedly been corrected in this regard. Anything remotely resembling aquaculture on Willapa Bay did not occur before the end of the 19th century with the importation for grow-out of Eastern oysters (Crassostrea virginica) from the U.S. East Coast.*

> **Response:** Thank you for your comment. Ecology understands that the industry has evolved and aquaculture practices have changed over time. The timing of when aquaculture began in Willapa Bay does not impact the proposed permit.

Comment 41: *In the DEIS, the claim, "Natural recruitment is sometimes supplemented with hatchery seed" is certainly backwards. Commercial clam growers in Washington State today usually rely on hatchery seed and welcome natural recruitment as an ancillary bonus.*

> **Response:** Thank you for your comment. Ecology is relying on information reported by the commercial clam growers for this information.

Comment 42: *The DEIS should stress that clam and oyster cultivation plots can exist side-by-side at the same elevation on Willapa Bay, that some oyster beds can readily be converted to clam beds, that the elevation of clam beds is not necessarily higher than that of oyster beds.*

> **Response:** The proposed action is for management of *Z. japonica* on commercial clam beds in Willapa Bay using the herbicide imazamox. The definition of commercial clam bed given in Appendix A of the draft permit is what defines where the proposed action could occur.

Comment 43: *Although eelgrass is rather common on clam beds in Washington State, never once have I heard a worker complain about it.*

> **Response:** Thank you for your comment.

Comment 44: *I find it difficult to expect a pesticide applicator working a large area to immediately stop spraying when gusts occur or the wind speed happens to increases above 10 mph in the course of his work.*

> **Response:** The requirement for the 10mph wind limitation is given in RCW 90.48.445 (1)(a)(iv).

Comment 45: *Citations to unpublished "white papers "that have not undergone peer review should not be considered with the same level of confidence as published citations.*

The following papers should be included in the EIS:

- *Shafer, D.J., Kaldy, JE, Sherman, TD, Marko KM. 2011. Effects of salinity on photosynthesis and respiration of the seagrass Zostera japonica: a comparison of two established populations in North America. Aquatic Botany 95: 214-220.*
- *Kaldy, JE, Shafer DJ. 2012. Effects of salinity on survival of the exotic seagrass Zostera japonica subjected to extreme high temperature stress. Botanica Marina. DOI 10.1515/bot-2012-0144.*
- *Shafer, DJ, Kaldy, JE, Gaeckle JL. 2013. Science and management of the introduced seagrass Zostera japonica in North America. Environmental Management DOI 10.1007/s00267-013-0172-z*

- *Shafer, DJ, Kaldy JE. 2014. Comparison of photosynthetic characteristics of the seagrass congeners Zostera marina L. and Zostera japonica Ascher. & Graeb. Aquatic Botany 112: 91-97.*

  Response: Ecology agrees that peer reviewed science should receive more weight than unpublished white papers and personal communications. Citations and a note about whether they are peer reviewed and published, white papers or personal communications are given in the Readers Guide on page d of the DEIS. This notification about references also mentions that these three types of citation are not equal in terms of scientific rigor.

  Change: The papers that are suggested for inclusion will be reviewed and included in the EIS.

Comment 46: *The economic impact analysis (publication 14-10-002 provided as part of the EIS package) only assess how the fees and costs associated with the NPDES permitting process would influence the shellfish growers.*

> **Response:** That is correct. The Small Business Economic Impact Analysis (EIA) is required during development of general permits when small businesses can apply for coverage under the permit. The purpose of the EIA is to investigate how the draft permit would impact businesses and their cost to comply with the NPDES Permit. Per the EIS: *This analysis only estimates the additional costs borne by expected permittees resulting from compliance with the requirements of the general permit.*

Comment 47: *An independent economic analysis would be beneficial to the process.*

> **Response:** An independent economic analysis would be beneficial for a more accurate assessment of the socioeconomic impacts surrounding *Z. japonica* management. However, requiring development of an independent economic analysis is outside the scope of the DEIS (See comment # 14).

Comment 48: *The statement about persistence in the marine environment is unsubstantiated. I think it would be prudent to consider monitoring for imazamox and its degradation products.*

> **Response:** Persistence in marine sediments will be looked at as part of the Buffer Width Study (Fact Sheet Appendix B) that Ecology is asking the proponents of permit development to conduct. Ecology’s primary concern is build up of imazamox in sediments to a level that is herbicidally active. Excluding photolytic degradation from the equation; imazamox in the water column is expected to be rapidly diluted as a result of tidal exchange, resulting in concentrations that are not herbicidally active. Further, imazamox has an EPA toxicity rating of practically non-toxic to fish, birds, mammals, terrestrial invertebrates and aquatic invertebrates.

Comment 49: *In my opinion the susceptibility of phytoplankton, microphytobenthos (MPB) or unicellular microalgae (or macroalgae) to Imazamox has not been adequately evaluated. I think it would be reasonable to consider monitoring or evaluating phytoplankton and MPB (or sediment microalgae) response to Imazamox.*

Comment 50: *Pg 91, section 3.2.4, second paragraph. See comments above. The literature suggests that there is increased microalgal production associated with seagrass beds. Stable isotope data as well as empirical production estimates indicate that microalgal production accounts for >60 of the total primary production (Morgan and Kitting 1984 L&O 29: 1066-1077; Moncreiff et al. 1992. Marine Ecol Prog. Sers. 87: 161-171, Moncreiff and Sulivan 2001 Mar Ecol Prog. Sers. 215: 93-106; Kaldy et al. 2002 Estuaries 25: 528-539). This type of work has not been conducted in the PNW, which is further reason to require monitoring of the microalgal community.*

> **Response:** Available data is adequate to base a permit decision on. Through permit development Ecology is tasked with balancing beneficial uses of the water body. Impacts to phytoplankton, MPB and unicellular microalgae are expected to be minimal, localized and transitory based on available imazamox toxicity studies on algae and the special conditions included in the permit limiting treatments to once per year and limiting the location of treatments to commercial clam beds only.

Comment 51: *The discussion on herring spawning does not adequately address the long term impact that removal of spawning substrate would have.*

> **Response:** Use of *Z. japonica* as a spawning substrate was identified as an area that needed further research during the June 2013 meeting on the Science and Management of *Zostera japonica* in Washington: A Meeting for State Agencies. It is not clear whether spawning substrate is a limiting factor in Willapa Bay for herring spawning. Ecology has made use of existing information and studies that are already available. Ecology has limited the potential application of imazamox to commercial clam beds only in Willapa Bay.

Comment 52: *The management significance of the now-widespread observations of herring eggs on Zostera japonica within Washington State is that the plant should now be added to the list of near-shore marine plants that comprise "documented herring spawning habitat" and, by that measure, be afforded <u>no-net-loss</u> protection by the WAC Hydraulic Code Rules, the state Growth Management Act, and the state Shoreline Management Act, all of which have herring spawning habitat conservation language within them.*

> **Response:** Adding *Z. japonica* to WAC Hydraulic Code Rules, the state Growth Management Act, and the state Shoreline Management Act is outside of the scope of EIS development.

Comment 53: *So far as I am aware, there have been no suggestions of consideration of full and previously -proven mitigation for proposed damage to Zostera japonica beds by this proposal.*

> **Response:** *Z. japonica* is a state listed class C noxious weed. *Z. japonica* is not included in the WDFW Priority Species and Habitat list. Ecology is Revising its Shoreline Master Program guidance to local governments. The revised guidance will clarify that invasive, non-native species should not be protected under local shoreline master programs. The DEIS and Draft Permit will not be considering mitigation for *Z. japonica*.

Comment 54: *Peer-reviewed studies, by impartial researchers not associated with the shellfish industry, should be undertaken to document the salmonid-food communities within the plant's beds, compared to adjacent unvegetated-control middle intertidal mudflats.*

> **Response:** Ecology has made use of existing information and studies already available. Ecology feels that it has adequate information to base a permit decision on.

Comment 55: *The proposal to purposely eradicate a carbon-fixing estuarine marine plant species would seem to obviously run counter to any goal of alleviating ocean acidification.*

> **Response:** The proposed action is the use of imazamox to manage *Z. japonica* on commercial clam beds. It is not anticipated that impacts to ocean acidification would vary significantly with use of imazamox to manage *Z. japonica* relative to management through physical or mechanical methods which currently occur.

Comment 56: *If an NPDES permit is eventually issued, it must also include suitable mitigation measures to compensate for those losses of ecological functions brought about by the removal of Z. japonica on commercial clam beds.*

> **Response:** Mitigation can occur in multiple forms, and does not require replacing lost eelgrass. Ecology feels that the Special Conditions proposed in the Draft Permit provide suitable mitigation through restrictions on the application of imazamox.
> Mitigation is defined in WAC 197-11-768:
> 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.
> 6. Monitoring the impact and taking appropriate corrective measures.

Comment 57: *Alternatives to eradication by broad-cast herbicide applications must be investigated before permitting, including those regions of the world where eradication of Z. japonica is not considered necessary or appropriate.*

> **Response:** Reasonable alternatives to herbicide use were discussed as part of the alternatives analysis in the DEIS.

Comment 58: *Many turn of the century shellfish researchers wrote about the negative impacts of eelgrass to shellfish – more current work reflects a bias regarding Sapropel – organic matter trapped by eelgrass that lowers pH. These acidic high sulfur bottoms are highly toxic to shellfish veligers - many such habitats are started by eelgrass during periods of high heat and few storms.*

Response: Thank you for the information.

Comment 59: *It has come to my attention that concerned citizens are citing a recent paper as a scientific basis to deny this permit. For that reason, I would like to address several of the issues brought up in this paper.*

Science and Management of the Introduced Seagrass Zostera japonica in North America. 2013. Deborah J. Shafer, James E. Kaldy and Jeffrey L. Gaeckle. Z japonica. Environmental Management 52 (4).

Response: Comment noted.

Comment 60: *The proposed application of Imazamox needs to be clearly defined- What are the specific types of clam aquaculture? Does it apply to existing and/or new aquaculture or areas that could be good shellfish growing areas not currently in use?*

Response: The proposed action as described in the Draft Permit and Draft EIS would cover all commercial clam operations. This would include existing operations as well as new aquaculture areas so long as they fit the definition of commercial clam bed as defined in Appendix A of the Draft Permit.

Comment 61: *The evidence of economic and ecological concerns needs to be sufficiently detailed. The draft EIS states that farmed areas have been abandoned because of Zostera japonica growth but this hasn't been substantiated or documented. There is also conflicting information in the draft EIS regarding the impacts of Zostera japonica on clam beds as well as the potential effects of Imazamox on the native Zostera marina and other vulnerable species.*

Response: The DEIS examines impacts from the proposed action, management of *Z. japonica* on commercial clam beds in Willapa Bay using the herbicide imazamox. The alternatives examined look at no action (status quo), chemical only and IPM approach. The no action alternative discusses current management practices, which allow for management of *Z. japonica* on commercial clam beds in Willapa Bay using physical and mechanical methods. The decision that the DEIS is informing is whether or not to allow for chemical management of *Z. japonica*; not the broader question of whether *Z. japonica* should be managed. The question of whether *Z. japonica* should be managed was answered from a state agency regulatory point of view with the listing of *Z. japonica* as a class C noxious weed.

Ecology feels that the impacts of *Z. japonica* on clam beds as well as the potential effects of Imazamox on the native *Z. marina* and other vulnerable species has been adequately addressed in the DEIS.

Comment 62: *The scientific research results and studies used to support the EIS must undergo rigorous peer review and be appropriately referenced.*

> **Response:** Ecology agrees that more weight must be given to peer reviewed research relative to white papers and personal communications. Citations and a note about whether they are peer reviewed and published, white papers or personal communications are given in the Readers Guide on page d of the DEIS. This notification about references also mentions that these three types of citation are not equal in terms of scientific rigor.

Comment 63: *The information in the EIS has implications for proposed applications of Imazamox on Zostera japonica outside of the scope of the EIS in areas that would expand the footprint of existing shellfish farms or in areas beyond Willapa Bay commercial clam farms, or for influencing the noxious weed classification of Zostera japonica in Washington.*

> **Response:** If expansion of the permit were considered for use of imazamox on *Z. japonica* outside of the scope of the EIS, in areas that would expand the footprint of areas beyond Willapa Bay commercial clam farms, then the SEPA process would be revisited. Modification of the permit to include new areas outside of Willapa Bay would require that an Addendum to the EIS or Supplemental EIS be developed to look at the potential environmental impacts of that expansion. Permit modification and development of new SEPA documents would go through the public review process.
>
> Looking at the potential for the EIS to be used as justification in noxious weed classification is outside the scope of the DEIS.

Comment 64: *A full analysis of the ecosystem services of non-native eelgrass must be made.*

> **Response:** An analysis of available science has been included in the DEIS to address ecosystem services of *Z. japonica*. Ecology has made use of existing information and studies already available.

Comments on Specific Sections of the DEIS

Comment 65: *Page 9: Figure 1-2 misrepresents the northwest portion of Willapa Bay. Eelgrass is not abundant in that area. Graphic appears to make Zostera japonica distribution larger than it really is. The polygon in the very northwest encompasses not only mudflats but high salt marsh and dune areas. There are only a few small patches of Zostera japonica within the above mentioned polygon.*

> **Response:** Figure 1-2 was meant to provide a map of where *Z. japonica* occurs but is not intended to define abundance. This map was developed largely through observation of *Z. japonica* distribution while working on the tide flats. It is possible that *Z. japonica* distribution is not that abundant in the area described or that distribution has changed since the map was developed. For a better indication of abundance see Figure 1-1. Figure 1-2 was included to indicate that *Z. japonica* distribution in Willapa Bay is thought to be expanding by some.

Comment 66: *Page 14/Table 1.5-1Testing of surface waters should also be conducted rather than just sediments and not just around the area treated. Just like imazamox, carbaryl was touted as having a short half life and supposedly broke down quickly in sunlight. However, after the NPDES permit was issued, carbaryl was detected year after year on the Shoalwater Bay Reservation and at the Tokeland marina within 12-48 hrs of applications.*

Response: With rapid dilution occurring as a result of tidal exchange, imazamox is not expected to occur at herbicidally active concentrations off of the commercial clam beds. Ecology proposed a 10m buffer around the property boundaries of commercial clam beds to protect against impacts to adjacent properties. If herbicidally active concentrations of imazamox are moving off of the commercial clam beds the Buffer Width Study (Fact Sheet Appendix B) should confirm that. Non-herbicidally active concentrations of imazamox moving off of commercial clam beds are not expected to have impacts to other organisms as imazamox has an EPA toxicity rating of practically non-toxic to invertebrates, mammals, birds and fish.

Comment 67: *There is no mention in the EIS that landowners on Willapa Bay could possibly be subjected to chemical trespass as a result of imazamox applications.*

Response: Ecology agrees that chemical trespass is a possibility under the proposed action. The 10m buffer required around property boundaries was included to addresses chemical trespass. The only expected effect of chemical trespass is herbicidal activity, due to imazamox having an EPA toxicity rating of practically non-toxic to animals.

Comment 68: *Page 32 (WAC 173-26-241[3][b]): "Properly managed, it can result in long-term over short-term benefit and can protect the resources and ecology of the shoreline. Aquaculture is dependent on the use of the water area and, when consistent with control of pollution and prevention of damage to the environment, is a preferred use of the water area.*

I'm not so sure the introduction of non-native species (spartina, Japanese eelgrass and manila clams), especially invasive ones, by the oyster growers is what is meant by "Properly managed". What is actually happening in Willapa Bay might be considered by some to be contradictory to WAC 173-26-241[3][b].

Response: Thank you for your comment

Comment 69: *Page 99 "Charadrius alexandrinus nivosus" should be "Charadrius nivosus nivosus" Federal Register / Vol. 77, No. 10 / Tuesday, January 17, 2012 / Proposed Rules Page 2244*

Response: The change will be made as suggested.

Change: *Charadrius alexandrinus nivosus" will be changed to "Charadrius nivosus nivosus" on page 99.*

Comment 70: *Pg 70, 4th paragraph. Halophila stipulacea is a second seagrass species that some researchers consider to be "invasive".*

Response: Ecology agrees. *Halophila stipulacea* is considered an invasive species in the Mediterranean and Caribbean Oceans per: Willette and Ambrose. 2009. The distribution and expansion of the invasive seagrass *Halophila stipulacea* in Dominica, West Indies, with a preliminary report from St. Lucia. Aquatic Botany. 91: 137-142.

Change: The information and citation will be added.

Comment 71: *Pg 71. Recent publications have described optimal temperatures for growth and photosynthesis of Z. japonica. See references above.*

> **Response:** Ecology will review: Kaldy, JE, Shafer DJ. 2012. Effects of salinity on survival of the exotic seagrass *Zostera japonica* subjected to extreme high temperature stress. Botanica Marina. DOI 10.1515/bot-2012-0144.
>
> **Change:** Information will be added to describe optimal temperatures for growth and photosynthesis of *Z. japonica*.

Comment 72: *Pg 73, section 3.1.4. See zonation description in Shafer et al. 2014.*

> **Response:** The reference will be reviewed and incorporated.
>
> **Change:** Information will be added to describe zonation.

Comment 73: *Pg 73, section 3.1.5. See comparison of photosynthetic parameters of Zj and Zm Shafer and Kaldy 2014.*

> **Response:** The reference will be reviewed and incorporated.
>
> **Change:** Information will be added to describe photosynthetic parameters.

Comment 74: *Pg 75, first paragraph, last sentence. Statement about 40% reduction in water flow. The plaster of paris dissolution method does not reliably quantify water flow. Clearly the presence of seagrass reduces water flow but the magnitude of the reduction is not well constrained. See Porter et al. 2000 for further explanation. (Porter et al. 2000 Gypsum dissolution is not a universal integrator of 'water motion'. Limnology and Oceanography 45: 145-158).*

> **Response:** The reference will be reviewed and incorporated.
>
> **Change:** Information will be added to describe limitations of the plaster of paris dissolution method.

Comment 75: *Pg 76. First full paragraph. "In her PhD dissertation…intertidal eelgrass habitats". It is not clear how this paragraph relates to the section, since this was clearly the Dr. Bando' s opinion and not the research on interactions.*

> **Response:** Ecology agrees with the commenter.
>
> **Change:** The paragraph referred to by the commenter will be removed.

Comment 76: *Pg 76, section 3.1.7. Statement that nitrogen is primary limiting nutrient. While this is true in many temperate estuaries particularly along the Atlantic coast of North America it is not necessarily true in PNW estuaries that receive high ambient loads of nitrogen from coastal upwelling as well as from watersheds dominated by nitrogen fixing Red alder (Alnus rubra) (Brown and Ozretich 2009 cited above). There is little evidence for seagrass N limitation based on C:N:P ratios in PNW estuaries (Kaldy 2006 Carbon, nitrogen, phosphorus and heavy metal budgets: how large is the eelgrass sink in a temperate estuary Mar Poll Bull 52: 332-356; Kaldy & Lee 2007 Aquatic Botany 87: 116-126), where plants tend to have >2% leaf N and sediment nutrient concentrations above the limitation threshold of about 100 µM.*

Response: Thank you for the references. The references will be reviewed and incorporated.

Change: Information will be added to describe evidence for the lack of nitrogen limitation for seagrasses in PNW estuaries.

Comment 77: *Pg 78, section 3.1.10, second paragraph. "Recent work suggests … habitat that supports other biota". This statement appears to be based on a letter report by Dr. Richard Wilson that was provided during a previous public comment period. The peer reviewed literature indicates that seagrasses enhance microalgal production that supports shellfish. Several studies have concluded that microalgal production in seagrass beds accounts for >60% of the total ecosystem primary production (Morgan and Kitting 1984 L&O 29: 1066-1077; Moncreiff et al. 1992. Marine Ecol Prog. Sers. 87: 161-171, Moncreiff and Sulivan 2001 Mar Ecol Prog. Sers. 215: 93-106; Kaldy et al. 2002 Estuaries 25: 528-539). Microalgae fix more carbon than the seagrass because they have higher photosynthetic rates, lower light saturation points and the seagrass blades provides more surface area for the microalgae (e.g. diatoms) to colonize than mudflat. Additionally, work from the Atlantic coast suggests that there is a positive relationship between seagrass presence and hard clams (Irlandi 1994 Oecologia 98: 176-183, Irlandi and Peterson 1991 Oecologia 87: 307-318).*

Response: The papers will be reviewed and information added to the EIS.

Change: Information will be added to describe microalgae production on seagrasses.

Comment 78: *Pg 81, second full paragraph. Herring spawn has been documented on several occasions in Oregon estuaries by ODFW staff. ODFW staff have documented with maps the extent of spawn, and estimated the amount of spawn (tons) and the number of spawning fish. See citations in Shafer et al. 2013.*

Response: The reference will be reviewed and incorporated.

Change: Information will be added to describe herring spawn on *Z. japonica* in Oregon.

Comment 79: *Use of imazamox in conjunction with mechanical measures (Alternative 3) has the potential to damage native Z. marina, as well as remove a microcosmic ecosystem that Z. japonica creates.*

Response: Ecology agrees that *Z. marina* on commercial clam beds has the potential to be damaged and that ecosystem services provided by *Z. japonica* on commercial clam beds would be lost. Permit development requires Ecology to balance what are at times competing beneficial uses of the water body and aquaculture is a beneficial use. Also it should be noted that *Z. japonica* is a class C noxious weed and as such Ecology is not attempting to protect it.

The DEIS examines impacts from the proposed action, management of *Z. japonica* on commercial clam beds in Willapa Bay using the herbicide imazamox. The alternatives examined look at no action (status quo), chemical only and IPM approach. The no action alternative discusses current management practices, which allow for management of *Z. japonica* on commercial clam beds in Willapa Bay using physical and mechanical methods. The decision that the DEIS is informing is whether or not to allow for chemical management of *Z. japonica*; not the broader question of whether *Z. japonica* should be managed. The question of whether *Z. japonica* should be managed was answered from a state agency regulatory point of view with the listing of *Z. japonica* as a class C noxious weed.

Comment 80: *There also exists a concern that if the applicator errs in application that Z. marina plants will suffer.*

Response: If an applicator were to violate the FIFRA label for Clearcast® or conduct an application in a way that violates a condition of the permit it would result in a compliance violation of the permit and is enforceable by Ecology and third parties. All applicators operating under the proposed permit are required to have an aquatic pesticide applicators license, which are administered by the Washington State Department of Agriculture.

Comment 81: *Imazamox has the potential to mix with other pesticides and herbicides that are also used in the area, which has the potential to cause further damage. We cannot know the true potential risk of these interactions in nature without data gathered over the course of several years.*

Response: Please see DEIS section 2.9.1 for a discussion of this topic.

Comment 82: *Eelgrasses provide a foraging and spawning ground for various fish, potential cover from predators, as well as hunting grounds and important feeding habitats for migratory waterfowl.*

Response: Thank you for your comment.

Comment 83: *Ecology fails to disclose whether any endangered plant species under the ESA are present in Willapa Bay, whether any portion of Willapa Bay is under federal jurisdiction, and if so, how such species might be affected by the applicant's activity.*

Response: DEIS section 3.2.5 discusses endangered species use of Willapa Bay. One plant species Federally-listed as threatened may occur in freshwater wetlands, ponds, or lakes in the vicinity of Willapa Bay: water howellia (*Howellia aquatilis*) (USDI/USFWS). This species does not occur in the estuarine environment occupied by *Z. japonica*. This permit does not cover imazamox discharge on federal lands where the State does not have jurisdiction so a discussion of discharge to federal lands was not specifically discussed.

Comment 84: *The Final EIS should directly assess whether the permit would violate the ESA.*

Response: The information provided in the EIS is adequate for decision makers and the public to determine potential impacts to ESA listed species. The DEIS discusses ESA species (DEIS section 3.2.5) occurring in Willapa Bay as well as impact to those species in 3.2.4 and 3.2.5.

Comment 85: *The use of ATVs is likely to have significant impacts, including benthic disturbances that this alternative purports to diminish. Id at 14. This is particularly concerning when Ecology proposes no mitigation strategy to measure or document benthic disturbances under this alternative.*

Response: Potential benthic disturbances due to ATV use during application of imazamox to commercial clam beds would be of short durations and occur on privately owned or leased lands that are being managed for commercial aquaculture. Ecology does not anticipate impacts to benthic invertebrates from imazamox due to the EPA rating of practically non-toxic to invertebrates. For these reasons, Ecology has not proposed specific mitigations for benthic disturbances. However, the limitation on application of imazamox to one treatment per year will serve to limit benthic disturbances on commercial clam beds proposed for treatment.

Comment 86: *Herbicide-resistant plants are a serious concern. Ecology should enforce its proposed maximum of no more than one application per season per treated area.*

Response: Thank you for your comment. The permit limits application of imazamox to one treatment per year.

Comment 87: *Ecology should determine and announce the standards it plans to use in reviewing applicants' Discharge Management Plans (which it states will be used as the IPM plans). In particular, the current evaluation proposed on page 28 of the Draft Permit should be expanded to require an evaluation of all the environmental impacts discussed in the environmental impact statement under Table 1.5-1 and elsewhere (i.e., air quality, sediment, surface water, etc.).*

Response: Ecology will review Discharge Management Plans (DMP) for completeness according to Appendix D of the Permit. Permittees are encouraged to adopt relevant portion of the EIS in their DMP.

Comment 88: *Ecology needs to provide more information on what is meant by crop rotation timing and harvest activities.*

Response: Harvest activities involve removal of market size clams; this can vary based on the size of clam the grower is planning to sell. As stated: Crop rotation timing is defined as "the activity of harvesting mature clams, then waiting for the next clam seed size to grow to a harvestable size". Furthermore different clam beds grow clams at different rates based upon food supply, elevation and other clam bed characteristics. Most clams in Willapa Bay are harvested by hand raking, digging and mechanized digger.

Comment 89: *Nowhere in the environmental impact statement is it stated what a "harvestable size" is or how that activity will be monitored.*

Response: Unlike recreational clam harvesters that must follow WDFW size limits while harvesting clams, commercial growers can harvest clams at any size that they feel they have a market for. Harvestable clams sizes can range from 6-35 clams per pound with the majority harvested in the range of 17-24 clams per pound. Monitoring harvesting activities is outside the scope of the DEIS.