From:	Kim Patten
To:	Lubliner, Nathan (ECY)
Subject:	comments on draft permit
Date:	Friday, January 17, 2014 1:16:03 PM
Attachments:	Comment on japonica for ecology jan 17 2014.docx

---

Nathan, Please find attached my comments on the eelgrass permit.

--

Kim Patten
WSU Long Beach Research and Extension Unit - Extension Professor
WSU Pacific County Extension Director
360-642-2031
pattenk@wsu.edu
WSU Extension programs and employment are available to all without discrimination. Evidence of non-compliance may be reported through your local Extension office or to the WSU Center for Human Right

Comments to: Washington State Department of Ecology

Re: DRAFT *ZOSTERA JAPONICA* MANAGEMENT ON COMMERCIAL CLAM BEDS IN WILLAPA BAY GENERAL PERMIT

From: Kim Patten, WSU Long Beach REU

Date: 1/17/2014

Comment on S4B. 10 m Buffer along all side of parcel boundary.

Below are 4 reasons I would like the Department of Ecology to reconsider this buffer

1) Economic hardship.

My farm: As a commercial clam grower with a small parcel of ground thickly covered by *Z japonica*, this buffer will prevent most of my ground from being farmed. I have a 160' by 200' parcel that is farmable (32,000 ft^2). This buffer removes 16,800 ft^2. My ground produces ~ 0.5 lbs/ft^2 every 4-5 years. I get paid $0.75/ lb. On ground with *japonica* my yields have been about half. This totals approximately $5,000 to $6,000 in crop loss. I think this is an unreasonable economic impact. The ground does not have drainage swales and there is little chance of "chemical trespassing."

All farms: Not being able to treat up to the buffer zone constitutes a taking of private revenue and right to farm. For every 1 foot of property line on a clam farm, a grower can lose ~ $10 of net revenue (assumes an average yield of 1 lbs/ft^2 of clams every 3 years, with the grower netting $1/ lbs and a 30% reduction in yield with Z. *japonica*). Using an example of a small 3.5 acre clam farm (1000' by 160') a grower would lose $23,000 (2320 ft of property line x $10/ft) every three years having to accommodate this buffer. This buffer would cost a small grower over $7,000 a year in lost revenue. This constitutes a very significant economic impact.

2) The 10 m buffer is poorly designed to protect off-site movement and is not based on science

The "10 m buffer" was developed from my research to measure off-site movement of imazamox. These results are presented in a graphic format map in the EIS. While it is true that we were able to measure imazamox 3 m away at a high enough concentration to be of concern, this does not infer that a 10 m buffer around the entire is an appropriate buffer.

This site was chosen to provide a worst case scenario. It contained a swale of standing water in the SE corner (~8 m by 20 m) that was ~ 15 cm deep. All the water from this pool slowly drained and focused into a narrow swale ~ 1 m wide. This pool was part of the treatment site and was intentionally oversprayed . We expected off-site movement along the drainage swale. We tracked it with a spray dye and by measuring imazamox in

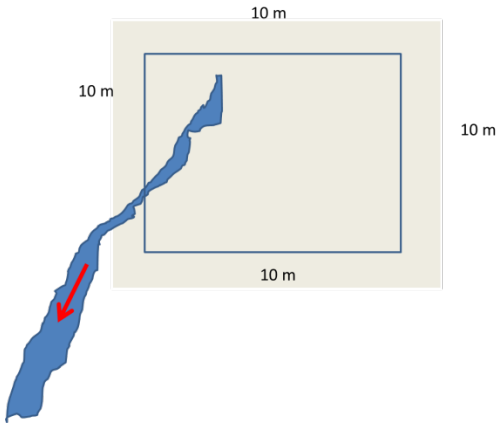
the water when the dye reached the off-track monitoring sites. This allowed us to target how far off-site movement would occur when there was a direct over-spray in a swale that drained off-site. That data suggested 10 m would be a good safety buffer in those conditions (drainage end of the site, in a swale). It does not indicate that a 10 m safety buffer needs to be placed around the entire site. Data from the other directions (west side) indicate imazamox concentrations were not high enough to warrant any buffer. Data based on control of *Z japonica* from this site and the dozen of plots I've done over the past 6 years suggest that unless you have sprayed in standing water and have off-site movement of water in a swales you are not going to see off-site control of eelgrass. Since this permit does not allow treatment of swale areas with standing water, even this off-site concern is minimized.

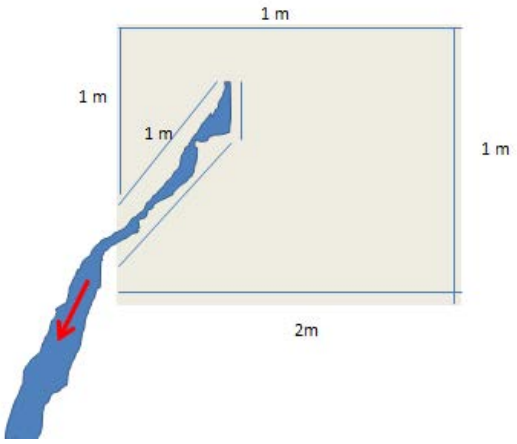
I think it is very prudent to have a 10 m buffer along all property edges where there are swales draining off-site. This should be in the direction of swale drainage and be limited to the zone where that swale exists. If the property drains along one small swale, put the 10 m buffer at that location and a 1 m buffer elsewhere along the treatment zone.

I think it is overly onerous to inflict considerable economic hardship based on a poorly made inference that is not supported by data.

Below are two examples of buffers. The left one is the Department of Ecology's recommendation. The second is an alternative I would suggest. With the Ecology buffer, the swale is likely to get some imazamox in it since the permit just says don't spray swales. But there will always be some drainage into a swale from the subtending edges. A 10 m buffer along all the edges won't offer any protection and off-site movement could occur. On the right is my proposed buffer. There is a small buffer along the internal swales that drain off-site, and a small buffer along the other edges, with a slightly larger one on the bottom edge. The swales are protected better and hence off-site movement would actually be less.

I would content that the example on the right would offer better protection than the proposed planned offered by Ecology. If would like to see a demonstration of how these two buffer zones would differ using a dye I would be happy to conduct a spray-dye demonstration and you can see for yourself.





3) Compromised IPM

This buffer zone is a poor IPM practice and will result in increased pesticide usage over time. Mature *Z. japonica* seeds drop in place and concentrate close to where they are produced. This untreated buffer zone allows for constant re-infestation of a clam farm and necessitates annual retreatment in perpetuity. Using the 3.5 acre farm example above, a grower would have 1.6 acres of untreated *Z japonica* that would supplying seeds to the 1.9 acres of *Z japonica*-free zone in the treated zone. The unintended consequence of this buffer zone is that there will likely be considerable more herbicide applied in Willapa Bay over the course of the next five years than if there was not a 10 m buffer. Since a clam bed would always be surrounded by 10 m swath of *Z japonica* constantly resupplying seed, it is likely to be quick re-infested every year. This seems like it would ultimately increase the opportunity of chemical trespassing over the time, not decrease it.

4) Legally messy

The inclusion of a 10 m buffer in this permit represents an unprecedented use of application buffers for control of an invasive species. In no other aquatic permit does Ecology include a treatment buffer zone. This includes the Aquatic Plant and Algae Management General Permit, Aquatic Invasive Species Management General Permit, Mosquito Control permit, Fish Management permit, or the Oyster Growers Permit. Why is this permit different? All these permits allow for pesticides to be used in water to control a pest, noxious weed or invasive species. If the concern is for preventing chemical trespassing, why don't these permits have buffer zones?

If the true reason for this buffer is to avoid the ecological and legal risks of chemical trespass, then the permit should specify that there should be no movement of imazamox off the site. This is not feasible, since trace amounts of imazamox would still move off-site with a buffer width of 100 m.

The use of a 10 m buffer in a NPDES permit for control of a listed noxious weed and non-native species also sets a dangerous legal precedent for all future NPDES permits for aquatic noxious weeds, or for control of any state-listed terrestrial noxious weed. It opens the door for any land owner to prevent the adjacent land owner from controlling the said noxious weed within 10 m of his or her property line. If I don't like chemical control of a noxious weed, I could use this permit to cite legal precedent and prevent my neighbor from controlling his or her weeds (terrestrial or aquatic). It opens all previous NPDES to now include a buffer. While one might think that this is obtuse reasoning, it is based on experience. The Moby Dick Hotel filed a lawsuit against the state and county for using herbicide for control of Class A noxious weeds on property adjacent to theirs. They claimed chemical trespass. This lawsuit cost the state and county considerable money, and delayed *Spartina* control. Do we really want to a repeat of this experience?

From:	Kim Patten
To:	Lubliner, Nathan (ECY)
Subject:	public comments
Date:	Wednesday, February 05, 2014 8:35:04 PM
Attachments:	patten comments to ecology npdes eelgrass feb 5 2014 .pdf

---

Nathan,
Please accept the attached additional comments.
Nice job the other day

--

Kim Patten
WSU Long Beach Research and Extension Unit - Extension Professor
WSU Pacific County Extension Director
360-642-2031
pattenk@wsu.edu
WSU Extension programs and employment are available to all without discrimination. Evidence of non-compliance may be reported through your local Extension office or to the WSU Center for Human Right

TO: Nathan Lubliner
Washington State Department of Ecology
PO Box 47696
Olympia, WA 98504-7696

FROM: Kim Patten, Extension Professor, WSU Long Beach

DATE: Wednesday, February 05, 2014

SUBJECT: **Comments on Proposed Permit**

The Washington State Department of Ecology (Ecology) is proposing to issue the *Zostera japonica* Management on Commercial Clam Beds in Willapa Bay General Permit.

Although I have already submitted comments, I would like to submit an additional comment. 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.

Comments on recent review 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).

Wading Shorebirds
There are few studies of wading shorebird utilization of seagrass habitat in the Pacific Northwest. Lamberson et al. (2011) observed shorebird utilization of Z. japonica and Z. marina in Yaquina Bay, with active foraging in Z. japonica beds. They found no statistically significant difference (P = 0.261) in the density of wading shorebirds between Z. marina and Z. japonica habitats and suggested that there is no evidence that birds will be negatively impacted by the presence of Z. japonica (Lamberson et al. 2011).

This study was not designed to make any inferences about the effects of *Z japonica* on shorebirds. As such, it is an incredulous stretch of reasoning to suggest a negative, positive or no relationship between these two species. Only a properly designed experiment (large-scale paired plots) can establish that relationship. We have these studies planned, but need approval of the NPDES to do so.

Aquaculture Interactions
In Washington State, the shellfish industry has been the dominant force behind the efforts to list Z. japonica as a noxious weed. Based on public comments (see http://www.ecy.wa.gov/programs/wq/pesticides/comments.html) there is a perception that the presence of Z. japonica interferes with culture of the non-native Manila clam (Ruditapes philippinarum) on graveled tide flats. White paper reports suggest shellfish growers in Washington are experiencing economic losses due to decreased production on shellfish

beds inhabited by Z. japonica (Fisher et al. 2011). However, due to insufficient information on the methods, numbers of replicate samples, and statistical testing, the validity of the scientific conclusions about the degree of impact of Z. japonica on Manila clams could not be evaluated. Fisher et al. (2011) did not examine alternative hypotheses for decreased Manila clam production (e.g., ocean acidification, indirect grazing pressure); therefore a clear cause and effect relationship between the presence of Z. japonica and hypothesized declines in Manila clam production has not been demonstrated. Only a single study has evaluated the impact of Z. japonica presence on Manila clam production. Tsai et al. (2010) concluded that Manila clam condition (measured as meat dry weight) was reduced in the presence of Z. japonica. The difference in clam meat weight between Z. japonica presence and absence was about 100 mg (Tsai et al. 2010; J. Ruesink pers. comm.). Assuming a 40 mm adult Manila clam weighs about 600 mg (Tsai et al. 2010), this is about a 17 % decrease in meat weight. Clam shell growth was not affected by Z. japonica presence and plots with Z. japonica had increased clam recruitment relative to removal plots (Tsai et al. 2010). Consequently, the presence of Z. japonica appears to affect Manila clam production; however, the economic implications have not been evaluated. Recent work in Korea concluded that mechanical Manila clam harvest stimulated Z. japonica sexual reproduction and that the seagrass beds recovered within about 1 year of disturbance (Park et al. 2011). That study suggests that Z. japonica is resilient to and may even benefit from low frequency (annual) destructive Manila clam aquaculture harvest. Consequently, it appears possible that Z. japonica and Manila clam aquaculture can coexist.

The results by Fisher that they claim as being invalid are based on my data. They claim inadequate replicated and poorly cited methods as reasons these studies are not valid. The original was easily available for them to cite. We used four sites, with up to 20 replications of paired plots per site. The results found a significant yield depression on clams. Work since then has validated these effects and is attached.

The second study they site is by Tsai. They suggest her differences were inconsequential in terms of real weight differences. While that may or may not be true, that study was done on small plots by hand pulling eelgrass, over a short time. It does not represent the long-term consequence of *japonica* removal on a large scale. Our resent data suggest that the impacts are very real and not insignificant. We have expanded that research to include oysters and have found the same effect. See attached.

Migratory Waterfowl Foraging Habitat

Nineteen bird species in the Pacific Northwest are listed by Phillips (1984) as Z. marina consumers. The use of Z. japonica as foraging habitat for migratory waterfowl species is also well known (Baldwin and Lovvorn 1994a, b; Lamberson et al. 2011). A study of the feeding habits of waterfowl in Boundary Bay, British Columbia, found that Z. japonica comprised the largest fraction of the diet for all species (brant, American widgeon, northern pintail, and mallard) except green-winged teal (Baldwin and Lovvorn 1994a). Although Z. marina also comprised a large proportion of the brant diet (41 %), it was a relatively minor component (\5 %) in the diets of the other species. The preferential consumption of Z. japonica was attributed to its greater accessibility over the course of the tidal cycle, the higher energy content of its leaves, and easier manipulation of its smaller leaves and rhizomes (Baldwin and Lovvorn 1994a).

Brant are also undergoing a distribution shift that has been linked to changes in habitat availability along the Pacific Coast (Wilson and Atkinson 1995; Ward et al. 2005). If populations of Z. marina decline in brant wintering areas along the Pacific Coast (Ward et al. 2005), the importance of Z. japonica.

This is a good summary of what is known. However, it fails to consider the bigger ecosystem question of foraging budgets – how much eelgrass is needed to feed all the waterfowl in Willapa Bay? I have addressed that issue with a foraging budget analysis. Those results, which Ecology has, indicate more than adequate *japonica* would be available for waterfowl regardless of what is control on growers' beds.

Methods for *Z. japonica* Control

We were unable to identify any peer-reviewed studies describing the effect of imazamox or Clearcast on marine or estuarine phytoplankton, benthic microalgae, macroalgae, or seagrass. Federal and state resource agencies and citizen groups have expressed concerns about the potential for herbicide application to cause unintended impacts to non-target organisms such as Z. marina and listed endangered species (ESA) such as salmonids (http://www.ecy.wa.gov/programs/wq/pesticides/comments.html). Preliminary field-based testing indicates that downstream Z. marina is negatively impacted by the herbicide applications to Z. japonica beds (J. Gaeckle, pers.obs.). Chemical control measures applied to Z. japonica would therefore most likely result in loss of the native seagrass Z. marina. Due to the protection measures afforded Z. marina under the MSA and other federal and state regulations, mitigation could be required for any loss of Z. marina that occurred as a result of Z. japonica control activities.

These are interesting comments on two accounts.
1) The EPA registration of imazamox requires impact data on not just algae, but a large list of other organisms. Based on those data, EPA gave imazamox its most safe rating. These authors suggest there is no data and therefore we should assume the worst. Dr. Kaldy has suggested that imazamox has deleterious effects on phytoplankton. If that is true, then one needs to consider the pelagic nature of phytoplankton, benthic microalgae, and macroalgae. Any impact from imazamox would be short-term and ecologically inconsequential. Our replicated plot trials on macroalgae, which is included in the Risk Assessment, cited by these authors, would suggest that imazamox has no effects. Furthermore data presented by Ecology at the public meeting in South Bend confirms that at the exposure rates found in the bay, phytoplankton toxic should not be a concern.

2) They cite themselves for personnel observation of one research plot that they saw of mine, yet they fail to include the data. Ecology has details of that study and concerns of downstream movement are addressed in the permit.

Recommendations
We recommend the following actions to fill some of the existing data gaps and help provide resource managers with the information they need to balance complex trade-offs between economic development and the risks of ecosystem degradation.

1. *Conduct a risk/benefit analysis as suggested by Beck et al. (2008) to determine whether further regulatory action is warranted with regard to Z. japonica.*
2. *Conduct independent, peer-reviewed research using rigorous experimental design and statistical analysis procedures to evaluate:*
    a. *efficacy of proposed herbicide applications*
    b. *potential impacts of herbicides to target and nontarget marine/estuarine primary producers (e.g., Z. marina, planktonic and benthic microalgae and macroalgae)*
    c. *potential for herbicide to persist in estuarine food chains.*
3. *Conduct a cost–benefit analysis to determine where specific management actions (e.g., eradication efforts) are most likely to be effective. Incorporating economic considerations into the management of non-native species may influence optimal management strategies (Buhle et al. 2005; Williams and Grosholz 2008).*
4. *Investigate the environmental impacts of both chemical and non-chemical Z. japonica control efforts on native benthic communities, waterfowl foraging opportunities, fisheries habitat utilization and other components of affected ecosystems. To date this has received little consideration.*
5. *Document the ecosystem services (e.g., fisheries habitat utilization, shoreline stabilization, carbon sequestration, etc.) provided by Z. japonica. In particular, there is a need to investigate the potential use of Z. japonica by spawning herring, juvenile salmonids, and other commercial and recreationally important fisheries species.*
6. *Identify the major dispersal pathways for Z. japonica and the relative importance of vegetative versus sexual reproduction in the establishment of new colonies.*
7. *Model the colonization potential of Z. japonica based on physiological tolerances (e.g., temperature, salinity, nutrients, etc.) and dispersal mechanisms.*
8. *Develop and evaluate alternative aquaculture practices that can coexist with seagrass.*

These are all good suggestions. Some of them (1,2 and 3) have been done by me (which I consider to be independent; these studies are pending submission to peer-review). Others can't be done unless Ecology approves the NPDES. One can not conduct research on items 4, 5, 6 and 8 on small 20' x 20'replicated plots. These can only be done using large-scale paired plots. We have set those experiments up and have year-before-treatment data. We are waiting for the NPDES to get year-of- treatment and year-after-treatment data. In summary: yes we need more information to support control of *Z. japonica* in Willapa Bay and elsewhere. However, there is already a good enough data set existing to justify Ecology's approval of the NPDES. This will allow us to proceed to address the concerns raised by this paper and other citizens.

2013 Project Report to WDFW

IPM for Burrowing Shrimp and Japanese Eelgrass in Willapa Bay

Kim Patten, Nick Haldeman, Scott Norelius WSU LB REU
Jacob Moore, WGHOGA – collaborator; Brett Dumbauld, USDA- collaborator

Progress by objective:

Objectives 1 to 6 not related to *Z. japonica* and not included.

Objective 7) *Impact of Z. japonica to tidal ecology:* In 2013 we established 3 paired plots just south of Oysterville (see aerial map below). These plots were used to establish baseline data for the 2014 spray plots. The plots were initially used to collect data to statistically validate the proposed eelgrass monitoring plan in the NPDES. This was a separate project conducted by Dr. Grue, UW. Using these same paired plots, our team collected systematic data on elevation, percent coverage by *Z. marina*, *Z. japonica* and macroalgae, sediment pH, sedimentation rates, gypsum-block dissolution rates, and water fowl usage. These 2013 data sets (see Table 6) will be used to compare against parallel data sets being gathered in 2014 and 2015 following *Z. japonica* control with imazamox. An additional 6 paired plots were established to just monitor the impacts of *Z. japonica* removal on green sturgeon foraging. These plots were required to be in a different site in order to assure there was site fidelity to green sturgeon. The size of the paired plots ranged from 0.4 to 3 acres. Baseline foraging data in shown in Table 8.

Additional work was done to assess the impact of *Z. japonica* removal on growth of Manila clams, the harvest efficiency of commercial clam diggers, and Pacific oyster production.

Clams: For clams, 14 replications of 15' by 15' plots with thick *Z japonica* at 2.5' to 4' tidal elevation off Oysterville were treated with imazamox @ 16 oz/ac on 6/29/13. 1 ft^2 plots were harvested on 10/22/13 and the resulting clams were sorted by age class based on growth rings. Analysis of variance was run on mean clam dimension by age class within each replication. If there were <5 clams per age group then data for that replication or its matched pair were not used in the analysis. There were only enough clams in the 2, 3 and 4 year-old age classes for statistical analysis. For two, three and four year-old clams, n= 5, 9 & 11, respectively. For those age brackets, clams were larger and had greater growth on plots where *Z. japonica* was treated with imazamox than plots left untreated (Table 9). Similar trends were noted for 1 and 5 year old clams (Figure 9). These plots were also used to assess harvest efficiency. Nine 1 m^2 replicated paired plots were harvested by a commercial clam digger on 11/1/13. At harvest time, the *Z japonica* had mostly senesced. The time to harvest a plot, the weight of clams picked and the number of clams missed was recorded. Removal of *Z. japonica* reduced the number and weight of missed clams and the percent of commercial clams missed at harvest (Table 10). There was no difference in time to harvest a plot, but there was a trend for reduced time to harvest a clam (seconds/clam).

These results can help assess the economic impact of *Z japonica* on clam production and harvest. They indicate that the annual reduction in growth is at least 15% during the early years of a clam's life. A 45% differences in accumulative size would be noted after 3 years. In addition, there is an 8% increase in the amount of clams missed by commercial harvesters, and it takes a ½ second longer to harvest each clam (p=0.1). At 20 clams/ft^2 (~ 1 lbs/ft^2) it could take an additional 121 hours to harvest an acre of *Z. japonica*-infested clam bed than one where it was

removed. There would also be an additional ~ 3,500 lbs of commercial clams on that acre that were left unharvested, compared to where *Z japonica* was removed. Cumulatively this would mean an ~ $48,000 loss per acre of total harvestable clams (45% reduction of 1 lbs/ft^2 = 19,600 lbs/ac @ $2.45 wholesale price), an additional labor cost to harvest of ~ $3,000/ac (121 hours @ ~$24/hr piece work for 3.5 hrs/tide cycle), and a loss of $8,000/ac in deferred return due clams missing during harvest (8% unharvested commercial clams @ 1 lb/ft^2 =~ 3,500 lbs clam/ac valued @ $2.45/lb). The $8,000/ac in deferred returns could be realized in the subsequent harvest in two years. The net value of that $8,000 to the grower, however, would be reduced by ~ $400. This assumes 5% loss/yr on the invested value of $8,000 less the increase in net value of the unharvested clams of ~ $400 (3,500 lbs of mature clams growing 5% /yr = extra 172 lbs @ $2.50/lb). Based on these data and market assumptions, an infestation of a good clam bed by *Z. japonica* in Willapa Bay would result in a net loss to the grower of ~ $50,000/ac each crop cycle.

Oysters: Two oyster beds off Stackpole with moderate infestations of *Z. japonica* were treated (625 ft^2 plot) with imazamox on 6/28/13 (See Photo 1). Paired plots (treated and untreated) were harvested 11/14/13 (n=6 for Wiegardt, n=3 for Sheldon). 30 single oysters per plots were harvested from Wiegardt's and 60 per plot from Sheldon's. Total shell weight and meat weight were recorded for each batch. *Z. japonica* reduced net production of oysters at both sites, but there was only a significant difference at the Wiegardt site (Tables 11 & 12). It should be noted that the eelgrass was not as thick at Sheldon's and the oysters were smaller and more variable. Although the meat to shell ratio was greater for the treated than untreated sites, that difference was very minor. If these results are indicative of what a moderate infestation of *Z japonica* can do to an oyster bed, there could be a considerable economic impact. For example, if we assume a little over 2 oysters /ft^2 there would be ~100,000 oyster/ac. This is a decrease of ~ 1100 lbs of meat/ac (14% crop loss). At $3/lb (assumes whole price of $24/gallon of shucked oysters and 8 lbs/gal), this is a net loss of >$3,000 in just one year of a three to four year growth cycle. It does not include losses of nonsaleable oysters that don't make grade because of poor condition. The person who commercially sucked these oysters from these plots noted that many from the eelgrass were not fat enough to make grade (Ken Wiegardt, personnel communication). This observation of difference in fatness was confirmed when we subsequently harvested 20 single oysters from each plot and determined their condition index (CI). The CI for the imazamox treated and untreated was 6.7 and 5.7, respectively, (significant at P>0.04.).

Table 9. The growth rate of different age Manila clams as a function of *Z japonica* treatment in 2013.

Treatment	Clam dimension (mm)					
	2 year-old clams		3 year-old clams		4 year-old clams	
	Length	Width	Length	Width	Length	Width
Z japonica- untreated	16.6	22.2	28.5	21.5	36.0	27.0
No *Z. Japonica* - treated	19.8	26.6	33.0	24.8	37.6	28.4
T Test treatment Prob(F)	0.0004	0.0001	0.0011	0.0006	0.0679	0.0400

14 replications of 15' by 15' plots with thick *Z. japonica* at 2.5' to 4' tidal elevation off Oysterville were treated on 6/29/13. 1 ft^2 plots were harvested on 10/22/13. Clams were sorted by age class based on growth rings. Analysis of variance was run on mean clam dimension by age class within each replication. If there were <5 clams per age group then data for that replication or its matched pair were not used in the analysis. For two, three and four -year-old

clams, n= 5, 9 & 11, respectively.

Figure 9. Compare growth rate and sizes of different ages of clams as a function of *Z. japonica* treatment in 2013 (mean ± std. error across all clams within that age class).

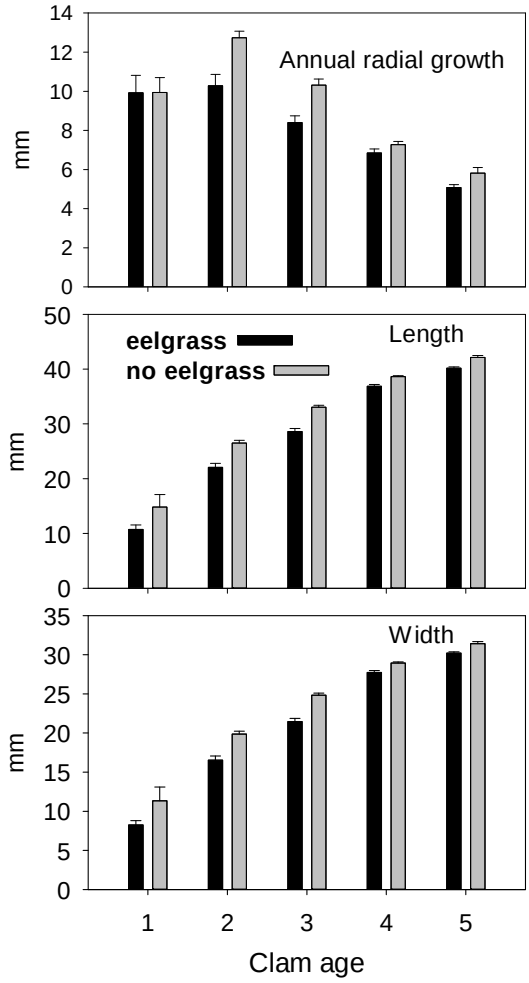


Table 10. The commercial harvest efficiency of hand digging Manila clams as a function of *Z japonica* treatment in 2013.

Treatment	Commercial clam harvest (1 m^2)					
	# clams missed	Wt of clams missed (grams)	% of total commercial clams harvested	Total wt of harvested clams (grams)	Seconds to harvest a m^2	Seconds /clam
Z japonica- untreated	6.4	116	87	760	162	3.3
No Z. Japonica - treated	4.3	79	95	1129	161	2.7
T Test treatment Prob(F)	0.05	0.05	0.0011	ns	ns	0.1

9 replicated harvest 1 m^2 off Oysterville on paired replicated plots on 11/1/13, harvested by a commercial clam digger. Plots originally had thick *Z. japonica* and were treated on 6/29/13. At harvest time the *Z. japonica* was most senesced. The time taken to harvest a plot, the weight of clams picked, and the number of clams missed was recorded.

Table 11. The yield of Pacific oysters as a function of *Z japonica* treatment in 2013 (Wiegardt bed- Stackpole)

Treatment	Total (shell+meat) wt (g)/ oyster	Meat wt (g) /oyster (g)	Meat weight/total shell wt ratio ± std. error
Untreated	211±6	33.3±1.3	0.15±0.004
Treated	241±10	38.8±1.9	0.16±0.002
	*	*	ns

± Std. Err.
* treatment significantly different @ 5% level by T test

Table 12. The yield of Pacific oysters as a function of *Z. japonica* treatment in 2013 (Sheldon bed- Stackpole)

Treatment	Total (shell+meat) wt (g)/ oyster	Meat Wt (g) /oyster (g)	Meat weight/total shell wt ratio ± std. error
Untreated	189±13	23.9±1.9	0.13±0.004
Treated	192±19	27.3±2.0	0.14±0.004
	ns	ns	*

± Std. Err.
* treatment significantly different @ 5% level by T test

Photo 1. Treated plot one month after treatment