WRITTEN FINDINGS OF THE
WASHINGTON STATE NOXIOUS WEED CONTROL BOARD
September 2011; Updated October 28, 2013

Scientific name:	*Zostera japonica* Asch. & Graebn.
Synonyms:	*Zostera americana* den Hartog, *Zostera nana* Roth, *Nanozostera japonica* (Asch. & Graebn.) P. Toml. & U. Posl.
Common name:	dwarf eelgrass, narrow-bladed eelgrass, Japanese eelgrass, Asian eelgrass, duck grass
Family:	Zosteraceae
Legal Status:	Proposed for 2012 as a Class C noxious weed; listed as a Class C noxious weed *on commercially managed shellfish beds only* for 2012; listed as a Class C noxious weed (without modification) for 2013. Proposed as a Class C noxious weed *on commercially managed shellfish beds only* for 2014.

Note: *Zostera japonica* written findings primarily based on excerpted material from "Distribution and potential effects of a non-native seagrass in Washington State, *Zostera japonica* Workshop" (Mach et al., 2010) and "Invasion of Japanese eelgrass, *Zostera japonica* in the Pacific Northwest: A Preliminary Analysis of Recognized Impacts, Ecological Functions, and Risks" (Fisher et al., 2011). Additional sources have been used in the updated version.

Description and Variation:

Overall Habit:
Zostera japonica is an annual to perennial, aquatic, herbaceous plant (Haynes, 2000).

Roots/Rhizomes:
Z. japonica has creeping, perennial rhizomes, 0.5-1.5mm in diameter, and has two roots at each node (Haynes, 2000).

Stems:
Stems are mostly unbranched and 10-30 cm long (Hitchcock et al., 1969).

Leaves:
Leaves are alternately arranged and 2-ranked on stems (Hitchcock et al., 1969). Leaf sheaths are open, persistent, 3-5.5cm long and have 2 membranous flaps (Haynes, 2000). Leaf blade length noted as being up to 15 cm (Haynes, 2000), or 30cm (Kozloff, 2005) or 35 cm long (Guo et al., 2010) with a width of 1-1.5 mm. Leaves have 3 veins and obtuse or retuse tips (Haynes, 2000).

Flowers:
Inflorescences are 3-6 cm long and one-sided (Hitchcock et al., 1969). Flowers are monoecious and lack petals and sepals. Inflorescences have sessile staminate and pistillate flowers, alternating in two rows on a fleshy spadix (Hitchcock et al., 1969). The spadix has tiny flap-like marginal projections scarcely 1 mm long (Hitchcock et al., 1969). The spadix is surrounded by a tardily ruptured sheath (spathe) that is as wide as or wider than the leaves, with an obtuse, mucronate or rarely retuse tip (Guo et al., 2010). Pistillate

flowers have a 2 carpellary pistil, a 1.5-2 mm style and 2 stigmas and staminate flowers each have a single 1-celled anther (Hitchcock et al., 1969).

Fruits and Seeds:
Fruits are urticles, ellipsoid and beaked, 2.5 mm long and have one seed (Hitchcock et al., 1969).

Habitat:
Zostera japonica grows in intertidal marine waters (Haynes, 2000). "It generally occurs higher in the intertidal (0.1 to 1.5m mean lower low water [MLLW]) than native *Z. marina* (generally 0.6 m MLLW and below), colonizing open tidal mudflats and sandflats within sheltered bays and inlets of the Pacific Northwest (Ruesink et al., 2010)." (Excerpted from: Fisher et al., 2011) "There appears to be a limit to how far along the intertidal gradient *Z. japonica* populations may extend due to the narrow band of suitable habitat available along tidal elevations (Almasi and Eldridge, 2008). Dumbauld and Wyllie-Echeverria (2003) demonstrated that *Z. japonica* is also found in less saline portions of estuaries possibly due to decreased abundance of ghost shrimp (*N. californiensis*), which can reduce *Z. japonica* survival through sediment bioturbation."

Geographic Distribution:

Native Distribution:
According to the USDA GRIN database (USDA ARS, 2011), *Zostera japonica* is native to Asia, specifically the far east of the Russian Federation, China (Hebei, Liaoning and Shandong), Japan, Korea, Taiwan and Vietnam.

Distribution in North America:
"The northern extent of *Z. japonica* distribution is currently documented as English Bay on the BC mainland and Campbell River on Vancouver Island, however, its current northern extent into the Strait of Georgia is undocumented and likely extends further north than these locations. *Z. japonica*'s southern extent, which is more intensely monitored, currently extends to Humboldt, CA" (excerpted from Mach et al., 2010).

History and Distribution in Washington:
"*Zostera japonica* is thought to have been introduced to Washington State with shipments of Japanese oyster (*Crassostrea gigas*) spat in northern Puget Sound in the 1930s (Bulthuis et al., 2005; Mumford, 2007), and subsequently observed on the Washington State coast in 1957 (Posey, 1988; Harrison, 1982). *Z. japonica* may have been used as packing material for the Japanese oyster stock, with the eelgrass being dumped into bays after removal of the stock (Harrison and Bigley 1982 as cited by Merrill 1995); however, this cannot be confirmed definitively. It is also possible that seed which hitchhiked on the oyster shipments may also have been responsible for the introduction" (excerpted from Fisher et al., 2011).

Table 1. Excerpted from Fisher et al., (2011) provides a detailed account of *Zostera japonica*'s distribution along the Washington Coast and in the Puget Sound.

Region	**Location**	**County**	**Source**
Canada-USA border	Bellingham Bay	Whatcom	Harrison and Bigley, 1982
	Chuckanut Bay	Whatcom	Harrison and Bigley, 1982
	East of Ferndale	Whatcom	Gaeckle et al., 2009

	Birch Bay	Whatcom	Harrison and Bigley, 1982
	Semiahmoo Spit	Whatcom	Gaeckle et al., 2009
	Drayton Harbor	Whatcom	Gaeckle et al., 2009
	SE of Cherry Point	Whatcom	Gaeckle et al., 2009
San Juan-Strait of Juan de Fuca	Eastsound County Park (Orcas Island)	San Juan	Gaeckle et al., 2009
	North Side of Crane Island	San Juan	Gaeckle et al., 2009
	Picnic Cove	San Juan	Gaeckle et al., 2009
North Puget Sound	Padilla Bay	Skagit	BMNHC 2006, Gaeckle et al., 2009
	Samish Bay	Skagit	Gaeckle et al., 2009
	Similk Bay	Skagit	Gaeckle et al., 2009
	North Possession	Island	Gaeckle et al., 2009
	Useless Bay (Whidbey Island)	Island	Gaeckle et al., 2009
	Ebey's Slough	Snohomish	BMNHC 2006
	Hat Slough	Snohomish	BMNHC 2006
	Jetty Island	Snohomish	BMNHC 2006
	Tulalip Bay	Snohomish	Gaeckle et al., 2009
	Snohomish Delta N	Snohomish	Gaeckle et al., 2009
	Edgewater, Possession Sound	Snohomish	Gaeckle et al., 2009
	Kilisut Harbor	Jefferson	ENVIRON 2009
Hood Canal	Oak Bay	Jefferson	Gaeckle et al., 2009
	S. of Tala Point	Jefferson	Gaeckle et al., 2009
	E. of Squamish Harbor	Jefferson	Gaeckle et al., 2009
	N. of Thorndyke Bay	Jefferson	ENVIRON 2009, Gaeckle et al., 2009
	Dabob Bay	Jefferson	Gaeckle et al., 2009
	S. of Long Spit	Jefferson	Gaeckle et al., 2009
	Quilcene Bay	Jefferson	Gaeckle et al., 2009, USFWS 2009
	Toanados Peninsula	Jefferson	Gaeckle et al., 2009
	Dosewallips	Jefferson	Gaeckle et al., 2009
	N of Port Gamble	Kitsap	Gaeckle et al., 2009
	Warrenville	Kitsap	Gaeckle et al., 2009
	Anderson Cove	Kitsap	Gaeckle et al., 2009
	Stimson Creek	Mason	Gaeckle et al., 2009
	Annas Bay	Mason	USFWS 2009
	Lynch Cove	Mason	Gaeckle et al., 2009
	Forest Beach	Mason	Gaeckle et al., 2009
Central Puget Sound	Sinclair Inlet	Kitsap	USFWS 2009
	Agate Pass Bridge SE (Bainbridge Island)	Kitsap	Gaeckle et al., 2009
	Murden Cove (Bainbridge Island)	Kitsap	Gaeckle et al., 2009
	Quartermaster Harbor	King	BMNHC 2006

	Tramp Harbor (Vashon Island)	King	Gaeckle et al., 2009
	Paradise Cove (Vashon Island)	King	Gaeckle et al., 2009
	Poverty Bay	King	Gaeckle et al., 2009
	Dumas Bay	King	Gaeckle et al., 2009
	Piner Point (Maury Island)	King	Gaeckle et al., 2009
South Puget Sound	North Bay, Case Inlet	Mason	USFWS, 2009a
	Taylor Bay, Case Inlet	Mason	ENVIRON, 2009
	Harstine Island, Case Inlet	Mason	ENVIRON, 2010
	Totten Inlet	Thurston	ENVIRON, 2009
	Burley Spit, Carr Inlet	Pierce	Gaeckle et al., 2009
Washington Coast	Willapa Bay	Pacific	Harrison and Bigley, 1982; BMNHC, 2006
	Grays Harbor	Grays Harbor	Harrison and Bigley, 1982; BMNHC 2006

Biology:

Growth and Development:
Zostera japonica is a euryhaline species that photosynthesizes best under a salinity of 20 in estuaries of Washington and Oregon (Shafer et al., 2011). It typically forms dense patches of growth in the mid-to-high intertidal zone from around 0.1 to 1.5m mean lower low water (MLLW), though in some cases it extends into the lower intertidal zone (Ruesink et al., 2010).

Zostera japonica and *Zostera marina*

Patterns of growth of *Z. japonica* co-occurring with the native *Z. marina* are summarized in Mach et al. (2010) referring to Shafer (2007) as:
"1) Disjunct distribution – *Z. japonica* only in the high tidal zone, no vegetation in mid tidal zone, *Z. marina* only in the low tidal zone– steep topography [70% of sites]
2) Overlapping distribution – *Z. japonica* only in the high tidal zone, mix of *Z. japonica* and *Z. marina* in the mid tidal zone, *Z. marina* only in the low tidal zone – flat topography [30% of sites]
3) Mosaic distribution – A variation of the overlapping distribution pattern. *Z. japonica* only in the high tidal zone, patchy mid tidal zone with *Z. marina* in a dominantly *Z. japonica* zone or the opposite (with pronounced microtopography), *Z. marina* only in the low tidal zone [2 or 3 sites]."

"These patterns likely result from wave energy and shoreline slope, which could control the vertical distribution of *Z. japonica* (Shafer 2007). There is evidence that the lower edge of *Z. japonica* tidal distribution is not variable, and it is variation in *Z. marina*'s upshore tidal limit that causes the patterns of co-occurrence described above (Britton-Simmons et al., 2010)" (excerpted from Mach et al., 2010).

Anecdotally, "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" (excerpted from Fisher et al., 2011). Ruesink et al., (2010) sampled 14 transects in Willapa Bay on two time points four years apart and found *Z. marina* moved upshore into *Z. japonica* zones. Ruesink et al., suggested that this is caused by *Z. japonica* retaining water, thus physically altering the upper intertidal zone to mimic a lower tidal elevation (i.e., thereby making the habitat more suitable for native eelgrass migration into higher tidal elevations) " (excerpted from Fisher et al., 2011).

Growth rate was higher in transplant studies when *Z. japonica* was planted into plots with established *Z. japonica* versus plots in which vegetation had been mechanically removed, suggesting a facilitation mechanism (Tsai et al., 2010).

"In most cases in the Pacific Northwest region, there is little opportunity for direct competition between the two *Zostera* species because they occupy different niches in the intertidal zone (Shafer 2007). Where they do overlap, neither species is clearly competitively dominant, since biomass and density of both species are reduced in the presence of the other" (excerpted from Mach et al., 2010). "Although it is possible that *Z. japonica* and *Z. marina* negatively impact the growth of one another, it is unclear whether *Z. japonica* will ultimately expand farther into lower intertidal zones dominated by native *Z. marina* in all areas.

- "Competition with native eelgrass (*Z. marina*) appears to retard the spread of Japanese eelgrass (*Z. japonica*) into deeper waters where the two species are collocated (Ruesink 2010). At the microtopographical scale, *Z. marina* appears to be capable of preventing the establishment of *Z. japonica* in pools but does not establish on mounds (Hannam, 2013).
- Bando (2006) conducted transplant and removal experiments and found that following disturbance, *Z. japonica* performed better whereas *Z. marina* declined. *Z. japonica* also outcompeted *Z. marina* under these disturbed conditions, leading to the conclusion that in the interest of protecting the native species, leading to the recommendation that *Z. japonica* no longer be given protective status.
- "A study in Washington State by Bando (2006) found that disturbance substantially enhanced *Z. japonica* productivity and fitness while at the same time decreasing *Z. marina*'s performance. Bando (2006) cleared plots in the *Z. japonica* and *Z. marina* mixed tidal zones and measured plant growth back into the plots. *Z. japonica* recruited in first, and in the two years the study was run, *Z. marina* never recolonized. The authors suggested that *Z. japonica*'s success as an invasive species stems dually from its ability to persist in competition with *Z. marina* coupled with its positive response to disturbance" (excerpted from Fisher et al., 2011).

<u>Reproduction</u>:
"*Zostera japonica* reproduces vegetatively via rhizomatous (root) growth and also produces seeds. In the Almasi and Eldridge (2008) study, they observed that the strongest relationship to spread potential was associated with vegetative propagule survival. That is, when colonization habitat is not limited, vegetative propagation appeared to contribute more to the spread of established populations than propagation and spread through seed dispersal and germination" (excerpted from Fisher et al., 2011).

<u>Dispersal pathways</u>
Dispersal pathways of *Z. japonica* "include hitchhiking through recreational and commercial vessel traffic, dispersal of seeds passed through the alimentary tract of waterfowl, and natural seed and reproductive shoot dispersal mechanisms through drift" (excerpted from Fisher et al., 2011).

<u>Control:</u>
It is important to implement an early detection/rapid response (ED/RR) approach to new infestations of *Z. japonica* (Fisher et al., 2011), although Eicher (2006) reported that in California, early detection of *Z. japonica* is challenging due to the habitat it occupies is only exposed at tides of 2.0 ft MLLW or lower, the intertidal mudflats are not easily traversed and the narrow leaf blades can be easy to miss.

California Fish and Game note that the further spread of *Z. japonica* can be reduced by rinsing mud and debris from boats, gear, and boots before moving to a new site. It is important to make sure that rinsing occurs where runoff will not lead to storm drains and straight back to coastal waters. New sightings of Z. japonica should be reported to natural resource managers.

Further information about abiotic factors that affect plant physiology such as rhizome growth, growth rate, and seed germination may improve the ability to successfully manage *Z. japonica* (Shafer and Kaldy, 2013).

Response to Cultural Methods: None known.

Response to Mechanical Methods:
According to Eicher (2006), manual control efforts to remove *Z. japonica* from Humboldt Bay in California began in 2003. All *Z. japonica* was excavated by hand using shovels. Plant material, including mud, was sealed in heavy-gage garbage bags and taken by boat to the mainland for disposal at a landfill. This method was very labor intensive but reduced the area occupied by *Z. japonica* from 284 square meters in 2003 to 6.6 square meters of new patches in 2006. In 2010, three additional mechanical control methods were added to manual excavation to eradicate *Z. japonica* from Humboldt Bay sites (Ramey et al., 2011). First, approximately 30 patches were used to test efficacy of repeated flame heat treatment, but was stopped in late summer when it was deemed ineffective. Second, a total of 136 patches were covered with burlap from 2010 through 2011. Ramey et al., (2011) note that tarping must remain in place for several months to achieve eradication. Third, a new method of eradication was tested in October 2010 by placing heater cartridges into the substrate and heating the immediate surrounding area up to 100^{o}C, at which point thermocouples placed concentrically around the cartridge would trigger it to switch off. Efficacy of this treatment has not been reported at this time.

For tidelands managed for Manila clams, removing *Z. japonica* by hand may result in a lower recruitment of clams, which is attributed to major disturbance of the substrate. Harrowing early in the season may be more effective at removing accrued substrate and provide access of recruited clams to gravel surfaces (Tsai et al., 2010). It should be noted that *Z. japonica* populations in Korea appear capable of fully retuning to pre-disturbance levels following the harvesting of Manila clams in spring (Park et al., 2011). Thus, it is unlikely that mechanical removal of *Z. japonica* will provide lasting control.

Response to Herbicide:
Bulthuis and Shaw (1993) tested the herbicide glyphosate and it did not have a measurable effect at controlling *Zostera japonica.* They attributed lack of control may be due to water retained on the leaf surface, reducing absorption of the herbicide and the short exposure time before the tide returned. Trials are currently underway testing the efficacy of the herbicide imazamox on *Z. japonica,* which appears to provide very good control. Currently, the Department of Ecology (ECY) has limited its proposed National Pollutant Discharge Elimination System (NPDES) permit to apply imazamox herbicide only on commercially managed clam beds of Willapa Bay during a specific period of time in the spring, to reduce potential non-target effects on other organisms. This proposed permit, if adopted following a public comment period, could be available to commercial clam producers of Willapa Bay in spring of 2014.

Any aquatic herbicide application has to take place under Washington Department of Ecology's NPDES permits. Check the Washington Department of Ecology's website for information on aquatic pesticide permits: http://www.ecy.wa.gov/programs/wq/pesticides/index.html.

Biological Control Potential: There are no known biological controls for *Zostera japonica.*

Economic Importance

Detrimental:

Effects on shellfish production:

Fisher et al., (2011) note that the expansion of *Z. japonica* onto commercial shellfish beds has caused negative socioeconomic impacts in West Coast embayments by reducing shellfish yields and increasing management costs, especially along intertidal zones where Manila clams (*Ruditapes philippinarum*) are cultivated. It is possible that encroachment of *Z. japonica* onto public shellfish beds may reduce yield for recreational harvesters, but data are lacking (Fisher et al., 2011). Tsai et al., (2010) examined the effect of *Z. japonica* on Manila clam density, size, weight, and recruitment over a two-month period. They found a statistically significant reduction of clam condition (weight of dry meat per clam) in *Z. japonica* plots vs. removed or harrowed *Z. japonica* sites, with no significant effect on clamshell growth or recruitment.

Taylor Shellfish Company owns rights to just over one thousand acres of tidelands in the Oysterville area of Willapa Bay, of which 50 acres were enhanced by the addition of washed gravel at an estimated cost of $1M over 4-5 years. The result of this enhancement was an increase in Manila clams from 0.25 pounds per square foot to about one pound per square foot, which produced about 2M pounds of clams over a 3-year harvest cycle. During the height of their production and due to a labor shortage, the company leased some of its tidelands while it employed a salaried clam department manager and a full-time harvesting crew consisting of 6-7 employees that harvested clams during low tide and worked on gravel enhancements during high tide. Since the recent increase in *Z. japonica*, the enhancement area has been abandoned, as have additional efforts to amend other areas with gravel due to increased sedimentation. The company has also observed a decrease in natural recruitment and recruitment survival. Clam yields have dropped to approximately 0.10 pounds per square foot, and the company's projected yield of Manila clams on these grounds for 2013 is 30,000 pounds that will be mechanically harvested, not hand harvested, due to low clam density. (Eric Hall, pers. comm.)

According to U.S. Army Corps of Engineers reporting records, there are approximately 6,000 acres of suitable tidelands for commercial clam production in Willapa Bay. A 2012 survey of shellfish growers in Willapa Bay indicated that 2,800 acres of tideland were currently lying fallow due to infestations of *Z. japonica*, based on six survey responses. Fallowed acreage included both tidelands that had been actively cultivated for clams but then abandoned due to *Z. japonica* infestations or ground that became too infested to deliver a commercial quantity of clams. Adding to the loss of productivity of these fallowed clam beds is the fact that, at this time, shellfish growers do not have a means to treat the *Z. japonica* with herbicide and mechanical disturbance appears to stimulate growth of this invasive species. If all 2,800 acres were yielding a mean 0.4 pounds of clams per square foot prior to establishment of *Z. japonica,* and price per pound of clams was $2.40 (over a four-year cycle), then an estimate of economic loss is around $29M (2,800 acres * 43,560 sq. ft./acre * 0.4 lb./sq. ft. * $2.40/4). Firsthand experience harvesting clams in *Z. japonica* infested areas suggests that it is more difficult to locate and access the clams beneath the dense mats. There is an additional cost (est. $0.05/lb) to clean off the plant material and silt from the clams harvested from these areas. (Brian Sheldon, pers. comm.)

Reduction to water flow and tideland drainage

Dense mats of *Z. japonica* can slow water flow by up to 40% as compared to unvegetated mudflats (Tsai et al., 2010). The reduced water flow causes deposition of silt and detritus, which creates a thicker organic layer and can cause a rise in elevation (Fisher et al., 2011). Unvegetated tidelands periodically drain in the winter and are completely exposed during minus tides in the summer; however, areas dominated by *Z. japonica* have been observed retaining water of depths ranging from 0.25-0.5ft. (Fisher et al., 2011).

Fish:
A recent study suggests that feeding activity of the endangered species green sturgeon (*Acipenser medirostris*) is significantly reduced in tideflats covered in *Z. japonica* compared to the bare sand substrate in which their feeding pits are typically found (Corbett et al., 2011).

Beneficial:

Productivity:
Ruesink et al. (2006) estimated productivity of *Z. japonica* to be around 170 g dry wt m^{-2} yr^{-1}, contributing an additional 4,800 t per year, which was a 14% increase in annual primary productivity in Willapa Bay.

Benthic fauna:
Zostera japonica shares many of the attributes to *Z. marina* and other submerged aquatic vegetation that provides structure, cover, food, and spawning surfaces for many species of fish and invertebrate species (Shafer et al., 2013; Fisher et al., 2011; Mach et al., 2010). A study by Posey (1988) provided the unique opportunity to evaluate the overall impact on benthic infauna resulting from the colonization of *Z. japonica* onto what had previously been bare mudflats. Prior benthic surveys at specific sites in Coos Bay, OR, coupled with known establishment history of the introduced species were used to evaluate benthic faunal communities that were now coexisting with the *Z. japonica*. In general, Posey (1988) concluded that the establishment of *Z. japonica* in the midintertidal zone had a positive effect on benthic faunal communities. Habitat created by *Z. japonica* in Tillamook Bay, OR had greater species richness, abundance, and biomass of benthic macrofauna than *Z. marina* habitat or bare intertidal sand (Ferraro and Cole, 2012). With respect to feeding guilds, there were also greater abundances of deposit and facultative feeders in *Z. japonica* habitat. Its establishment onto bare, intertidal mudflats creates additional habitat for these organisms reliant on such submersed vegetation (Posey, 1988).

Fish:
Pacific herring have been observed depositing eggs onto on *Z. japonica* blades in coastal embayments and in Puget Sound (Daniel Penttila, written comments submitted to WSNWCB in 2012).

Birds:
Baldwin and Lovvorn (1994) note that *Z. japonica* provides a major food source for migrating and wintering waterfowl in the Fraser Delta and Padilla Bay in the Pacific Northwest. Several migrating birds, primarily widgeon, pintail, mallards, and, to a lesser extent, brant consume its seeds, leaves, and rhizomes. Furthermore, *Z. japonica* increases habitat for many of the invertebrates consumed by waterfowl. Greater consumption of *Z. japonica* over *Z. marina* may be attributed to its greater energy content and increased accessibility since it occurs at higher elevations in the tidelands (Baldwin and Lovvorn, 1994). In an assessment of bird usage of five intertidal habitat types in Yaquina estuary, OR, Lamberson et al. (2011) found no significant difference in bird uses between *Z. japonica* habitat and *Neotrypaea*/sand habitat, which the nonnative eelgrass has been replacing. They noted that mostly ducks and coots fed in actively growing *Z. japonica* beds; in the winter when the eelgrass had died off, shorebirds fed indiscriminately in both the *Z. japonica* habitat and the *Neotrypaea*/sand habitat.

Neutral:
Fish:
Shafer et al., (2013) note that there has only been one published study investigating the use of *Z. japonica* as habitat by fish. An enclosure study examining different intertidal habitat types indicated that Chinook smolts showed a preference to *Z. marina* over *Z. japonica* in Willapa Bay (Semmens, 2008). It was suggested that the wider and longer blades of *Z. marina,* and the deeper water in which it occurred, made it a better habitat in which to avoid predation.

Unknown:
Preliminary studies show several specific biotic and abiotic interactions with *Z. japonica* in the intertidal zone, but it is not entirely understood if these interactions result in positive, negative or neutral effects at this time, or what is the cumulative impact. Mach et al. (2010) note that the net effects of colonization of *Z. japonica* on formerly unvegetated tidelands on estuarine ecosystem function is not understood at this time.

Decomposition and Nutrient Cycling:
The two *Zostera* species differ in decomposition rates and nutrient concentrations. Nonnative *Z. japonica* decomposes at a faster rate than native *Z. marina* (Hahn 2003), and its tissue contains a lower ratio nitrogen to carbon than *Z. marina* (C.J. Harvey, unpubl. data *in* Ruesink et al., 2006). The impacts of the earlier source of detritus and its different nutrient concentrations upon benthic fauna is not yet understood (Mach et al., 2010).

Benthic microalgae:
The possible effects of *Z. japonica* on benthic microalgae is not known at this time (Mach et al., 2010).

Rationale for Listing:
Zostera japonica was listed as a Class C noxious weed for 2013 because it was recognized as a nonnative, difficult to control species that was negatively impacting the shellfish industry, regardless of beneficial functions it may provide in natural tidelands. A proposal to reinstate the modified listing (on commercially managed shellfish beds only) would make the listing more appropriate for county noxious weed control boards wanting to select it, survey its distribution, and require control. The modified listing would also preclude mandatory control of *Z. japonica* in areas outside of commercially managed shellfish beds, should a county noxious weed board select it for control.

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Note: Please refer to Mach et al., (2010) and Fisher et al., (2011) for excerpted citation references

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