Zostera marina and *Zostera japonica* Sensitive Habitat Inventory: a comparison of seagrass distribution and abundance 1995, 2002, and 2004 Blackie Spit 2004, Crescent Beach, Surrey, British Columbia

Prepared for : Friends of Semiahmoo Bay Society
June 2006

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Executive Summary

A field study of the distribution and abundance of *Zostera* beds was conducted in July and August 2004 at Blackie Spit, Crescent Beach, British Columbia. Protocols followed were those of the BC Coastal Eelgrass Stewardship Project. Field teams mapped intertidal and subtidal *Zostera* beds and conducted shoot density counts. Measurements of blades and counts of reproductive shoots were also conducted. Three zones of *Zostera japonica* ranged from the upper intertidal (zone 1) to the mid intertidal zone. Percent cover of *Z. japonica* ranged from 1-10 percent in zone 1, 75 percent in zone 2, and less than 25 percent in zone 3. Within zone 1, *Z. japonica* shoot densities were an average of 40.8/m^2 (116/m^2 STDV); and within zone 2, shoot densities were an average of 1,916/m^2 (1744/m^2 STDV). Within zone 1, large areas *of Z. japonica* were impacted by red, filamentous algae (*Grassilopsious sp.*) and high-density clusters of snails were present. *Z. japonica* and *Zostera marina* merged in a seaward transition zone. Three zones of *Z. marina* were documented. Percent cover of *Z. marina* ranged from 75 percent in zone 1, 51-75 percent in zone 2, and 11 – 25 percent in zone 3. *Z. marina* ranged from the low intertidal zone to the margin of the navigation channel dredge and was characterized by three zones, one intertidal zone and two subtidal zones. Within zone 1, *Z. marina* shoot densities were an average of 158.9/m^2 (56.6/m^2 STDV). These results revealed that the spatial area and distribution encompassed by the *Zostera* beds were different than that found in previous surveys conducted by the Canadian Wildlife Service 1995 (CWS) and the Fraser River Estuary Management Program (FREMP) 2002-2004.

One goal of this project was to provide baseline data of the *Zostera* beds to allow assessment of various impacts and ecological interactions at the Spit. This area is heavily used by commercial harvesters of ghost shrimp and also for recreational purposes. An assessment of these impacts and others associated with dredging activities and global climate change can be studied with this baseline data as a starting point. As well, ecological questions of interest include competition between the native (*Z. marina*) and non-native (*Z. japonica*) eelgrass species as well as the role of other invertebrate species in the colonization dynamics of *Z. japonica.*

A further goal of this project is to provide ground-truthed data for a comparison and assessment of different methodologies used to document *Zostera* beds in the Province of British Columbia. CWS and FREMP have conducted surveys of the *Zostera* beds in this area in 1995 and 2002-2004 respectively.

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Acknowledgements

Thank you to the Eve Bene Fund and White Rock and Surrey Naturalists' Society for the funding that has made this important work possible. Also, the GIS technical wizardry and advice of Brad Mason, Department of Fisheries and Oceans, and Suzanne Richer, Community Mapping Network was essential for plotting the maps and providing the framework for comparison.

Thanks to volunteers of Friends of Semiahmoo Bay Society for their many hours of hard work, enthusiasm, and expertise: Audrey Belotte, Greg Fee, Penny and Lori Schlechtleitner, Sharon Jeffrey, Viveka Ohman Ruth Caspell, A-Rocha Canada: Martyn Lings, Erin Ensing, Joanna Appenheimer; FOSBS: Marg Cuthbert and Dave Riley

We acknowledge and are grateful for the legacy of the hard working, dedicated citizens who have worked for decades to preserve this special place of Boundary Bay.

Disclaimer

Photo Credits

Ramona C. de Graaf, volunteer with quadrat
Sharon Jeffrey, subtidal eelgrass bed

Introduction and Rationale

Blackie Spit, Crescent Beach, Surrey, British Columbia is located with the Wildlife Management Area of Boundary Bay and is a high-use area for many recreation activities including: boating (sailing and motorized), sand castling, swimming, fishing, crabbing and sunbathing. Also, illegal shellfish harvesting is of concern. The subtidal area of the spit has been dredged for a navigational channel. Due to its proximity to both the ocean and a high-density human population, it is heavily used by citizens walking their dogs and habitat is likely impacted by these and other activities. Blackie Spit is an area where burrowing shrimp species are commercially harvested. Anecdotal evidence purports that the number of burrowing shrimp at Blackie Spit has recently decreased and the percent cover of *Z. japonica* has increased (L. Pollard pers. com.). This observation would seem to fit the assumption of decreased shrimp densities leading to an increase in percent cover of the exotic *Z. japonica* (Posey et al. 1991, Dumbauld and Wyllie-Echeverria 2003).

Complete and current information regarding the eelgrass habitat of Blackie Spit was lacking. A project to provide baseline data of *Zostera* habitat at Blackie Spit was seen as a high priority for assessment of human impacts and environmental changes as well as enabling informed management decisions with respect to stewardship and restoration.

Mapping of *Zostera* species has been conducted by various agencies over the past few decades throughout the Georgia Basin. Two mapping efforts in the Boundary Bay area include the Canadian Wildlife Service (CWS) survey of 1995 (Michael Dunn) and the FREMP aerial photo-interpretation project completed in 2002. In 2003, FOSBS initiated mapping of the *Zostera* beds in the Blackie Spit area and in 2004, continued a more intensive project for this area. All three of these efforts were undertaken using different scales (coarse v. fine) and methodologies making comparison of findings difficult. CWS undertook a coarse scale study where transect count data of distribution and density of the two *Zostera* species were then correlated to bathymetry to interpolate over the much larger spatial area of Boundary bay. This has resulted in a coarse-scale analysis of the local eelgrass habitat. The FREMP methodology utilized interpretation of aerial-photo interpretation of *Zostera* beds. The FOSBS methodology followed that of the BC Coastal

Eelgrass Stewardship Project. The FOSBS study is a fine-scale subtidal and intertidal mapping and monitoring of both *Z. marina* and *Z. japonica* habitats. The FOSBS study allows a “ground-truthing” of the larger, coarse scale surveys of CWS and FREMP.

Methods

The project used the protocols detailed in the Methods for Mapping and Monitoring Eelgrass Habitat in British Columbia (Precision ID 2002) and Methods for Mapping and Monitoring Japanese eelgrass (Zostera japonica) Habitat in British Columbia (Precision ID 2004). Zones are delineated by percent cover. Zone 1 is the most shoreward zone and subsequent zones are orientated seaward. GPS data were uploaded to the Community Mapping Network for projection within the Georgia Basin Habitat Atlas and the BC Eelgrass Atlas. GPS data were then interpreted defining eelgrass polygons. Eelgrass plant data was transcribed into Microsoft Excel.

When conducting *Z. japonica* shoot density counts in zone 1, all shoots were counted in a 50 cm x 50 cm quadrat. In zone 3, one quarter of the quadrat was sampled. Each team of two volunteers, utilized the upper left hand corner of the quadrat; and the quadrat was placed on the shoreward side of the 60 metre transect tape.

Results

Four days of survey effort were used to conduct the mapping and monitoring project and are summarized in Table 1.

Within each zone and for each *Zostera* species, percent cover, shoot densities, abundance of reproductive shoots, blade length, blade width, and leaf area index (LAI) are given in Tables 2 and 3. Both species of *Zostera* are present at Blackie Spit. Three zones of *Zostera japonica* are present and three zones of *Zostera marina*. *Z. japonica* ranges in the upper intertidal to a transition zone in the mid intertidal where both species occur . *Z. marina* beds are dominant in the low intertidal and extend into the subtidal where the bed has been limited by the dredged navigational channel. There were three zones of *Z. marina.*

Percent cover of *Z. japonica* ranged from 1-10 percent in zone 1, 75 percent in zone 2, and less than 25 percent in zone 3. Within the first *Z. japonica* zone, the filamentous red algae, *Gracilariopsis sps.*, is present and causes a loss of eelgrass as the shoots underneath this algae were found to be degraded. As well, within this zone, numerous high-density clusters of the snail *Batillaria attramentaria* were present. Within the most shoreward *Z. japonica* zone, three beds of approximately 51-75 percent cover were found. Due to time constraints, only two of these beds high density beds were mapped and the third lies to the south of the largest bed shown.

Z. japonica zone 1 is the largest area of eelgrass habitat. The zone is characterized by a percent cover of 1-10 percent, sparse shoots of an average of 10.2/m^2 (2.9 STDV) and reproductive shoots of 0.0075/m^2 (0.125 STDV). Zone 2 *Z. japonica* is a narrow bed characterized by a percent cover greater than 75 percent, dense shoots of an average of 1916/m^2 (1744 STDV), reproductive shoots of 41.6/m^2 (18.5 STDV), an average blade length of 19.7 cm (5.6 STDV), an average blade width of 1.4 mm (0.8 STDV) and an LAI of 52.8 x 10^^{4} mm^2/m^2 (Table 2). The two *Zostera* species merge in a transition zone which was avoided for shoot counts and mapping. Zone 3 Z. japonica is in this region of transition. Three zones of *Z. marina* are present with zone 1 being the most shoreward. Percent cover of *Z. marina* ranged from 75 percent in zone 1, 51-75 percent in zone 2, and 11 – 25 percent in zone 3. Zone 1 *Z. marina* is a narrow bed with less than 25 percent cover of Z. japonica. This bed is characterized by a shoot density of 158.9/m^2 (56.6 STDV), no reproductive shoots were present, an average blade length of 64.1 cm (16.1 STDV), an average blade width of 5.4 mm (0.7 STDV), and a LAI of 55.5 x 10^ ^{4} mm^2/m^2 (Table 3). Shoot densities were also calculated for a 0.25m^2 spatial area and are presented in Tables 2 and 3. The plant characteristics in zone 1 are typical of the *Zostera marina phillipsi* ecotype. Zone 2 was not uncovered by the tide during the time of the project and Zone 3 is completely subtidal. Further information with respect to tide heights and substrate characteristics are available from Friends of Semiahmoo Bay Society or on the Community Mapping Network Georgia Basin Habitat Atlas or the Eelgrass Atlas.

Table 1: Summary of dates and activities at Blackie Spit, Crescent Beach 2004

	Mapping	Monitoring
July 15, 2004	Z. japonica shoreward edge	
July 17, 2004	Z. marina intertidal and subtidal; Z. japonica intertidal	
July 30, 2004	Z. japonica zone 1	Z. japonica (zone 2) and Z. marina shoot density counts (zone 1)
August 15, 2004		Z. japonica zone 1 shoot density counts

Table 2: *Zostera japonica* abundance data. Blackie Spit, Crescent Beach 2004

Zostera japonica	Percent Cover	Shoots						
		Density/ $0.25\ m^2$ Average (STDV)	Reproductive/ $0.25\ m^2$ Average (STDV)	Density/ m^2 Average (STDV)	Reproductive/ m^2 Average (STDV)	Length (cm) Average (STDV)	Width (mm) Average (STDV)	LAI mm^2/m^2
Zone 1	22%	10.2 (29)	0.0075 (0.125)	40.8 (116)	0.03 (0.5)			
Zone 2	75%	479 (436)	10.4 (4.6)	1916 (1744)	41.6 (18.5)	19.7 (5.6)	1.4 (0.8)	52.8×10 ^4
Zone 3	<25%							

Table 3: *Zostera marina* abundance data. Blackie Spit, Crescent Beach 2004

Zostera marina	Percent Cover	Shoots						
		Density/ $0.25\ m^2$ Average (STDV)	Reproductive/ $0.25\ m^2$ Average (STDV)	Density/ m^2 Average (STDV)	Reproductive/ m^2 Average (STDV)	Length (cm) Average (STDV)	Width (mm) Average (STDV)	LAI mm^2/m^2
Zone 1	75%	39.7 (14.2)	0	158.9 (56.6)	0	64.1 (16.1)	5.4 (0.7)	55×10^4
Zone 2 - 3	51-75%							
Zone 3	11-25%							

The three studies had few similarities with respect to *Zostera* habitat at Blackie Spit. The FOSBS and CWS were the most similar in their documentation of extensive *Zostera* beds in the area surveyed. Figure 1 is a map of the *Zostera* beds produced from the 2004 FOSBS mapping and survey work plotted on the Community Mapping Network Georgia Basin Habitat Atlas (Boundary Bay Atlas) and Figure 2 is a map of the CWS survey. These results revealed that the *Zostera* habitat found by the two surveys were different. The CWS 1995 vegetation survey lists the entire area as 7.4% - 51-100% *Z. japonica*. As well, from the information on the Eelgrass Atlas, no actual transect (field work) was done at Blackie Spit by CWS and the information appears to be an interpolation from other transects in Boundary Bay likely at similar intertidal and subtidal depths. Both studies, however, confirms the presence of *Z. japonica* habitat. The CWS study does not document the presence of *Z. marina* habitat. Figure 4 is a composite of the three studies.

The FREMP study (Figure 3) shows the entire area surveyed in 2004 by FOSBS as unvegetated mudflat with the exception of a small spatial area of overlap of zone 1 *Z. marina* habitat.

In 2003, the FOSBS Eelgrass Conservation Initiative surveyed *Z. marina* within the 2004 FOSBS project area and shoot density counts were conducted (data not presented) (Figure 5). As well as in the north east section of Blackie Spit, the 2003 FOSBS survey shows the presence of *Z. marina* with shoot density counts where the FREMP study shows no eelgrass and the CWS study shows 4.02% blue-green algae with salt marsh.

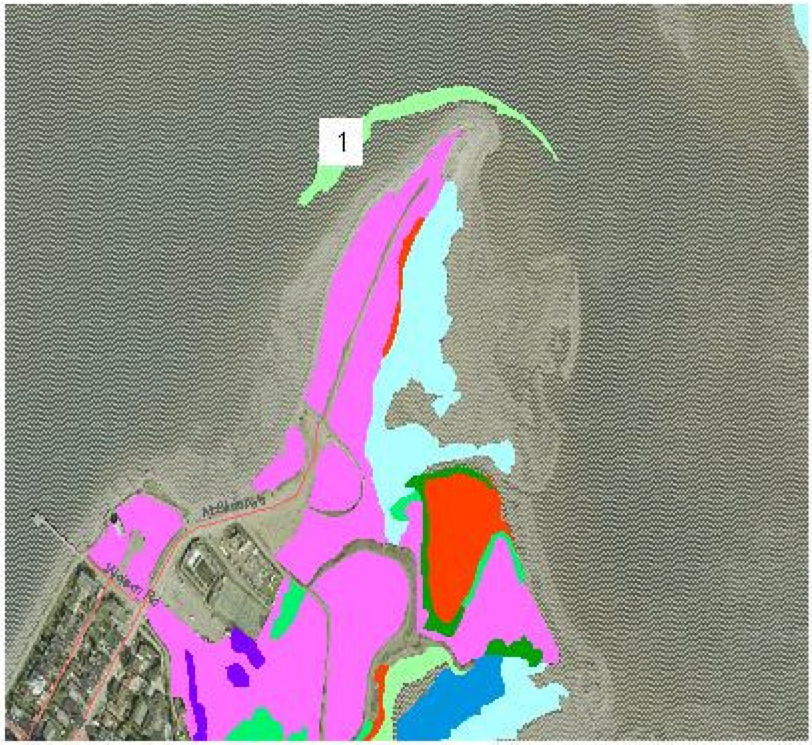
1. Zostera japonica, zone 1
2. Zostera japonica, zone 2-3
3. Zostera marina, zones 1-3

Figure 1: Results of FOSBS eelgrass survey at Blackie Spit, BC, 2004

The polygons represented are areas that were surveyed. More eelgrass is present at Blackie Spit but time did not permit an entire survey of the area.

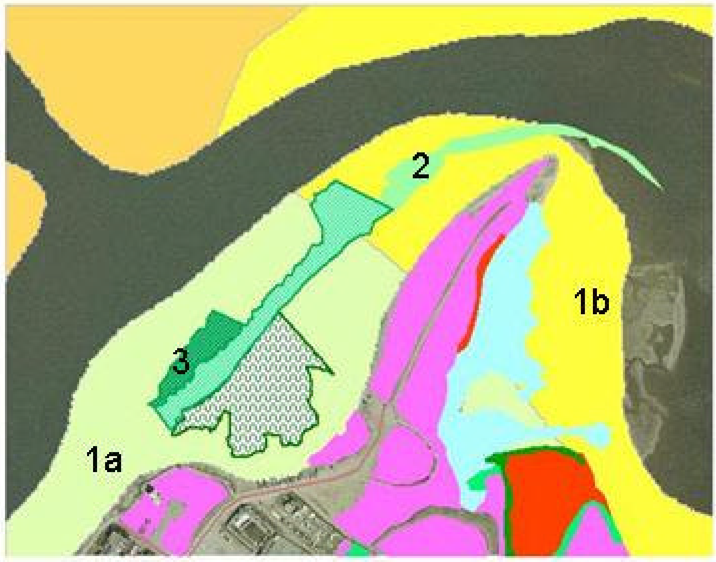
1. 7-100 Z. japonica
2. Blue-green algae

Figure 2: CWS eelgrass survey data as taken from the Georgia Basin Habitat Atlas, Community Mapping Network



1. Zostera

Figure 3: FREMP *Zostera* survey as taken from the BC Eelgrass Mapping Atlas, Community Mapping Network



1. CWS 1995 (showing only Z. japonica [1a] and blue-green algae [1b]
2. FREMP 2002 (Z. marina bed)
3. FOSBS 2004

Figure 4: Blackie Spit *Zostera* composite map of all three studies.

Figure 5: FOSBS 2003 Eelgrass mapping, Blackie Spit

Discussion

<u>Comparison of *Zostera* Habitat Surveys</u>

When contrasting the results of the FOSBS fine-scale study to the coarse scale studies of CWS and FREMP orthophoto interpretation and field survey, a finer resolution of *Zostera* species, densities, and spatial area is evident. Due to differing methodologies, it is very difficult to compare the results of the CWS and FOSBS projects. The most likely reason for the difference between the CWS and FOSBS study is that transects of *Zostera* habitat were not conducted in the same of Blackie Spit itself but the vegetation analysis was due to interpolation. Due to this methodology, it is unlikely that the CWS study accurately represented the *Zostera* habitat at Blackie Spit.

When comparing the 2002 FREMP polygons and the 2004 ground survey, the FREMP polygons under-represent the *Zostera marina* beds and large areas are labeled as "unvegetated". The reason for these differences may be the quality of the aerial photos and perhaps the tide height during the ground-truthing survey in 2004 was not favourable for a full analysis. As with any project, resources are limited and methodologies are adjusted to accommodate these constraints. Emphasis should be placed on ensuring that designated field days for ground-truthing are conducted during a favourable tidal height for estimating presence of *Zostera* species.

Overall, the FOSBS survey results provide the finest scale of *Zostera* habitat and it is recommended that this information be used for stewardship and management decisions for this high use and valuable habitat within the Wildlife Management Zone.

Mapping of this area should be continued every year or every two years to document the *Zostera* habitats. This area continues to be of high-use by local residents and pressure exists to allow more access to interest groups (dog-off lease) and to alter the diversity of organisms at Blackie Spit (Crescent Beach Ratepayers' Association snail removal request). Experiments should be conducted to further our understanding of the impacts of commercial harvest of benthic infauna species and biotic interactions among intertidal organisms on *Zostera* habitat.

<u>Implications of findings</u>

The implications of the differences in distribution and abundance of *Zostera* species found in the 2004 study versus the data from the 1995 and 2002 studies may be of high importance to managers of this area. If the data presented by the 1995 study, are correct, and using 1995 as a baseline, then over 9 years, *Z. marina* has dramatically increased in area as it was absent in the

CWS report. Looking at the 2002 FREMP study as the next temporal comparison of *Zostera* habitat, over 7 years both *Zostera* species were lost from the site, which is highly unlikely given the growth characteristics of these two species. If, however, these data sets from 1995 and 2002 are correct, investigating the reasons for the dramatic changes in *Zostera* percent cover and densities would warrant further study. There are various factors affecting the habitat at Blackie Spit including harvest of burrowing shrimp, invasion dynamics of *Z .japonica* and its interactions with other non-native invertebrate species, and the human impacts at this area.

Commercial Harvest Activities and *Zostera* Habitat

In order to maintain ecosystem function, it is important to investigate possible variables that may change or impact community structure of local mudflat and sandflat habitats. As has been seen in some regions of the west coast due to the invasive *Spartina anglica*, mudflat and sandflat habitats can be drastically altered by the colonization and rapid expansion of just one species. The results of this project provide a baseline from which experiments and surveys can be conducted to investigate changes to the *Zostera* beds due to a variety of factors. With respect to the commercial harvesting of burrowing shrimp species, a large number of studies have demonstrated that the presence of burrowing shrimp significantly reduces the abundance and distribution of seagrass species, lowers species diversity, and changes the community ecology of sites (Posey et al. 1991, Dumbauld and Wyllie-Echeverria 2003). In some areas of Oregon, for example, it has been shown that after an eelgrass bed has been compromised in some way, colonization of the sediment by burrowing shrimp generally occurs (Griffin 1997). Although burrowing shrimp do not readily colonize eelgrass habitat, once colonization does occur, the area becomes unsuitable for eelgrass, and burrowing shrimp have been termed a keystone species due to its role in altering community states (Griffin 1997). While a number of investigations on the west coast of North America have looked at the effects of the use of pesticides for shrimp removal on the ecology of seagrasses, the literature is lacking in studies examining the impact on seagrass habitats of commercial and/or recreational harvest of intertidal infauna such as burrowing shrimp and clams. The scientific literature does not address the issue of burrowing shrimp harvest or shellfish harvest impacts on eelgrass ecology. An investigation into the question of impacts of harvesting activities on seagrass habitat is warranted due to the lack of controlled studies on this particular question and the changes to the habitat that can result.

Ecological Interactions

Zostera japonica is a species of seagrass native to Japan that was introduced to western North America. *Z. japonica* has been noted in Boundary Bay for several decades. Generally, *Z. japonica* inhabits the high intertidal zone of mudflats and sandflats where it does not compete with the native *Zostera marina*. There is a transition zone in the mid and lower intertidal where mixed beds of *Z. marina* and *Z. japonica* can be found. Recently, a study has revealed a positive, facilitating interaction between the Asian hornsnail, *Batillaria attramentaria* and the mudsnail *Nassarius fraterculus* and *Z. japonica* due to indirect grazing and bioturbation (Wonham *et al* 2005). It appears that in areas of *B. attramentaria,* percent cover of *Z. japonica* increased (Wonham *et al* 2005). The biotic interactions among these three species should be considered in light of the interest of the Crescent Beach Ratepayers' Association to have vast numbers (up to 28 million) of intertidal snails removed from Crescent Beach. The impacts to eelgrass ecology locally by such an effort may result in a net loss of eelgrass habitat contrary to protection afforded to this habitat under the *Fisheries Act*.

References

Dumbauld, BR and S. Wyllie-Echeverria 2003. The influence of burrowing thalassinid shrimps on the distribution of intertidal seagrasses in Willapa Bay, Washington, USA. Aquatic Botany 77, 27 – 42.

Griffin, K. 1997. Eelgrass Ecology and Commercial Oyster Cultivation in Tillamook Bay, Oregon: A Literature Review and synthesis. Tillamook Bay National Estuary Project.

Posey, M.H, Dumbauld, B.R. and D.A. Armstrong 1991. Effects of a burrowing mud shrimp, *Upogebia pugettensis* (Dana) on abundances of macro-infauna. Journal of Experimental Marine Biology and Ecology 148 (2), 283-294.

Precision Identification 2002. Methods for Mapping and Monitoring Eelgrass Habitat in British Columbia (Draft #4)

Precision Identification 2004 Methods for Mapping and Monitoring Japanese eelgrass (*Zostera japonica*) Habitat in British Columbia (Draft #1)

Wonham, MJ, O'Connor, M, and CDG Harley 2005. Positive effects of a dominant invader on introduced and native mudflat species. Marine Ecology Progress Series 289: 109-116.