Z. marina Declines in San Juan County, WA
Westcott Bay Taskforce Mini-Workshop
26 July 2003

by

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Abstract

Zostera marina L. (eelgrass) is valuable nearshore resource that provides critical habitat for a number of marine and estuarine animals, including spawning substrate for Pacific herring, in the Puget Sound/ Georgia Basin. Washington State acknowledges this function and has established a policy of no net loss for eelgrass populations. Recent surveys indicate that more than 35 ac (14 ha) of this submerged habitat has disappeared from two documented Pacific herring spawn sties in northwest San Juan County, Washington. The conditions that caused the loss are presently unknown, however, there is concern that similar conditions could be occurring throughout the Puget Sound/ Georgia Basin. At both local and regional scales there is an immediate need to elucidate the reasons for the observed loss of habitat. The intent of this document is to (1) inform agencies and citizens on what is known about this loss of eelgrass stands and (2) assist in the development of a science-based program to identify the potential causes to ensure that similar losses, if preventable, do not occur throughout the region.

Introduction

Zostera marina L. (eelgrass) belongs to the group of submerged vascular plants collectively named seagrasses which grow in sub-arctic, temperate and tropical coastal marine and estuarine waters (den Hartog 1970; Phillips and Menez 1988). Depending on environmental conditions and the fitness of creeping rhizomes associated with sterile, vegetative shoots, *Z. marina* can form large prairies or stands in the Northern Hemisphere (den Hartog 1970; Tomlinson 1974). An annual seed rain from generative shoots also contributes to new growth within extant populations and allows these plants to colonize distant unvegetated “safe sites” in the near shore (Phillips et al. 1983; Harwell and Orth 2002). Perennial stands that include a yearly seed release are common in western North America (Phillips et al. 1983a; Wyllie-Echeverria and Ackerman 2003), however, annual stands are also present at some locations (Bayer 1979; Santamaria-Gallegos et al. 2000). In the Puget Sound Basin approximately 200 km^2 of *Z. marina* is distributed within coastal embayments or linearly along the shoreline (Berry et al, 2003). This vital habitat that sustains important migratory and resident animal species including Dungeness Crab (*Cancer magister*), black brant (*Branta bernicla*) and juvenile salmon (*Oncorhynchus* spp.) and is a spawning substrate for Pacific herring (*Clupea harengus pallasi*) (Phillips 1984; Simenstad 1994; Wilson and Atkinson 1995).

Owing to its overall importance to the ecosystem, Washington State has a no net loss provision to protect *Z. marina* resources (Fresh 1994; Hershman and Lind 1994). The State requires compensatory mitigation if proposed alteration of the near shore environment will result in an impact to extant *Z. marina* populations. The cost of restoring or mitigating seagrass within an impacted site is not trivial: Fonseca et al. (1998) estimate the average cost of restoring a damaged seagrass population to be approximately $91,000/acre. However, if the outcome of water or land-based human activity results in the removal or injury of a *Z. marina* stand, then a plan to restore habitat is mandated (Fresh 1994). If the loss cannot be explained, an inquiry must take place to determine if (1) human action contributed and therefore the responsible party or parties be held accountable and (2) the site can, once again, support healthy stands of *Z. marina*. The present document is the first step in an effort to determine the conditions that resulted in the relatively sudden loss of *Z. marina* resources at sites in San Juan County, Washington in 2003.

What Happened

The severe losses that occurred in Westcott and Garrison Bays (located on the northwest corner of San Juan Island; Figure 1) were discovered during the yearly Pacific herring spawn survey conducted by the Washington State Department of Fish and Wildlife (WDFW) in February 2003. The approximate location of these losses is shown in Figure 2. Because northern latitude populations (stands) of *Z. marina* begin to expand in late winter and early spring (Setchell 1929; Phillips et al 1983b), a second reconnaissance survey was undertaken in May 2003 to verify the February findings.

In preparation for this survey, results of the Washington State Department of Natural Resources, Submerged Vegetation Monitoring Project (SVMP) for the Westcott Bay site were reviewed. The Westcott Bay site was selected in the SVMP random sampling pool for 2000 and 2001 and bottom cover estimates and the mean maximum depth of plant growth are available for both years (Appendix A). Comparison between 2000 and 2001 reveals a decrease of approximately 24% in bottom cover and the depth at which plants were growing was reduced by approximately 2.3 m.

The survey team visited Westcott and Garrison Bays during maximum low water on 18 May (-1.0 m MLLW) and using aerial photos acquired by WDNR in 2001 searched for locations that formerly had *Z. marina* patches. In addition to inspecting sites from the surface by boat, the team also used a WDFW vegetation sampler. A small patch of *Z. marina* was located on the northwest side of Westcott Bay and patches were found on the northeast side of Garrison Bay. When compared to the number of patches visible in the 2001 aerial photo, bottom cover was much reduced. The team concluded that (1) an ongoing effort to census *Z. marina* in San Juan County, using similar protocol as the SVMP, include a survey of Westcott and Garrison Bays as soon as possible (2) other similar embayments in San Juan County should be surveyed in the same time frame and (3) effort be made to convene a scientific panel of experts to review the situation.

Significance of the Problem

Westcott Bay was re-sampled in June 2003 using the same protocol during 2000 and 2001 (see Berry et al. 2003) and preliminary results suggest that approximately 35 ac (14 ha) of *Z. marina* has disappeared (Figure 3). The loss in Garrison Bay is more difficult to quantify but when 2003 survey results are compared to WDNR's 1992 aerial photo of the site, *Z. marina* patches along the western side of the bay are absent (Figure 4).

While loss of valuable habitat results when *Z. marina* cover is reduced, conditions at Westcott and Garrison Bays are particularly troubling because known Pacific herring spawning sites are also lost (Lemberg et al 1997). On a larger scale, preliminary information from WDFW suggests that loss of *Z. marina* habitat may also be occurring at other documented herring spawn sites in San Juan County such as Blind Bay on the northern side of Shaw Island (Pentilla pers. com. 2003; Figure 5). It is also difficult to predict other impacts due to the cascade of changes in an ecosystem that could follow this rapid loss of *Z. marina* cover. Sudden loss of *Z. marina* cover following the wasting disease epidemic (i.e., lethal infection of the slime mold *Labyrinthula zosterae*) in the North Atlantic during the 1930's resulted in community shifts among benthic infauna in coastal embayments (e.g. Stauffer 1937). The impact to community structure caused by the loss of *Z. marina* in Westcott and Garrison Bays is unknown, but should be evaluated. An early warning signal of this shift might be the

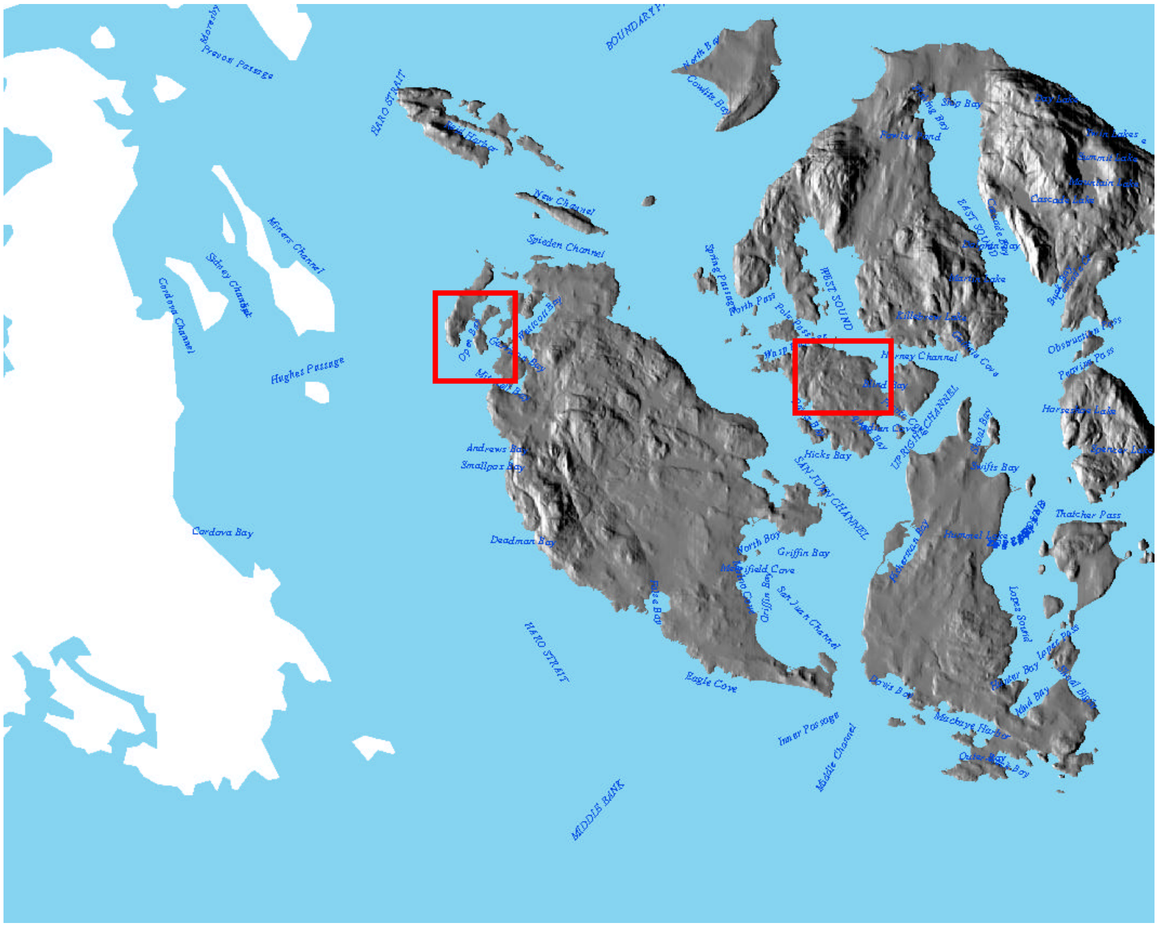

Figure 1. Westcott and Garrison Bays are located on the northwest corner of San Juan Island and Blind Bay is on the north side of Shaw Island, in San Juan County, Washington.

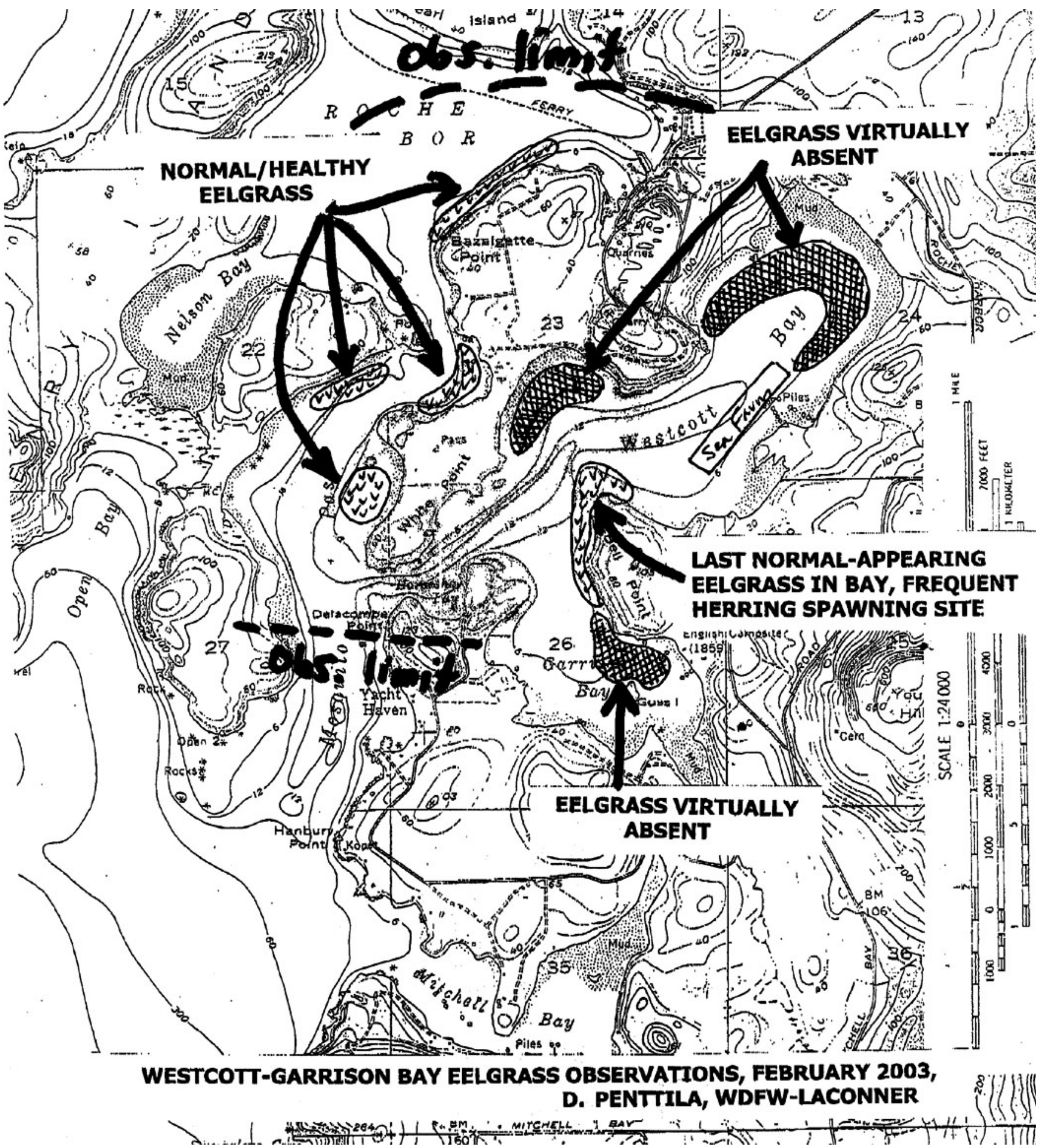

Figure 2. Hand-drawn map depicting the observations of *Z. marina* loss as noted by D. Pentilla, Washington State Department of Fish and Wildlife in February 2003.

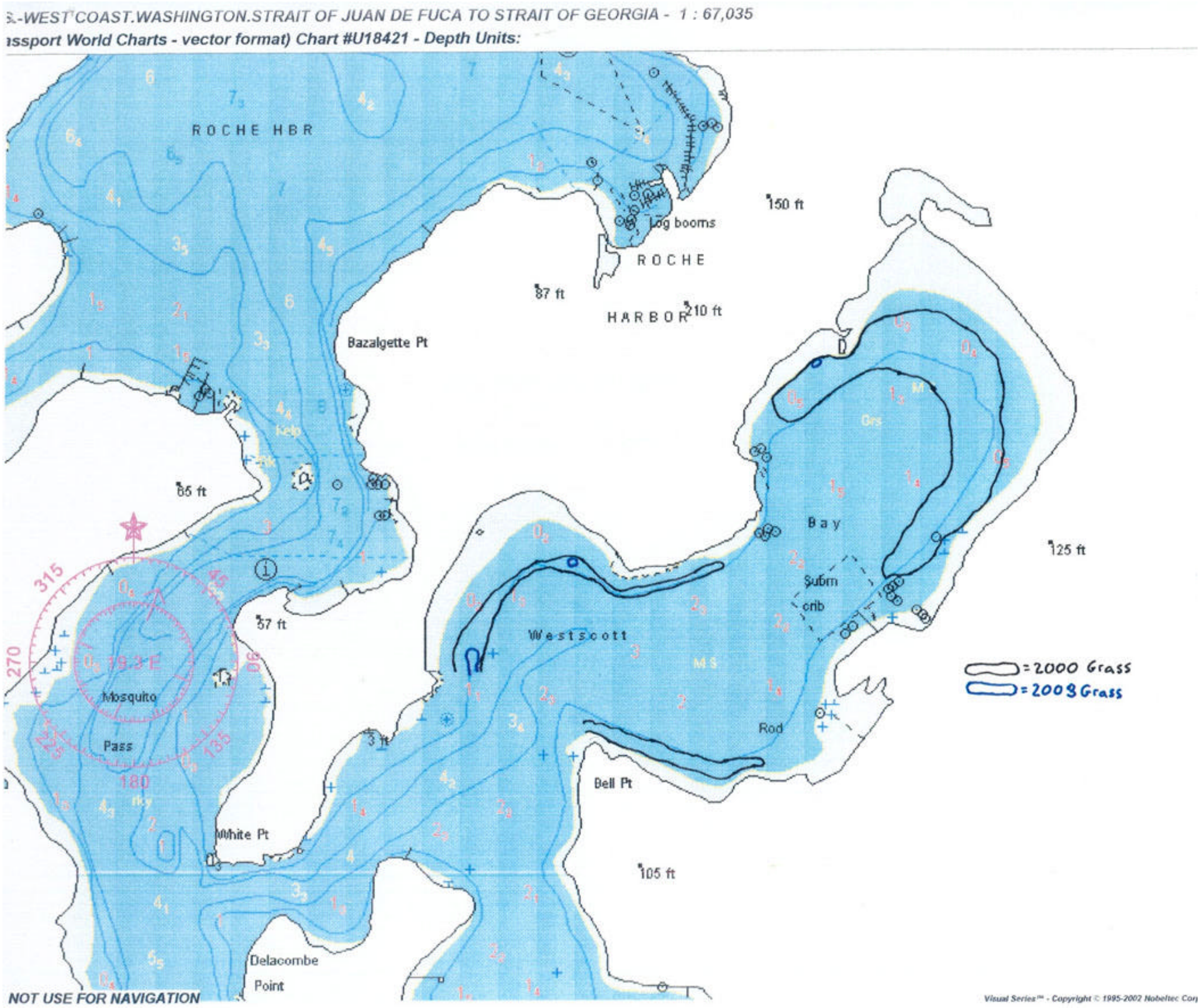

Figure 3. The preliminary hand-drawn polygons above compare the distribution of Z. marina Westcott Bay in 2000 and 2003. A final product will be available from the Friends of the San Juans by the third quarter of 2004.

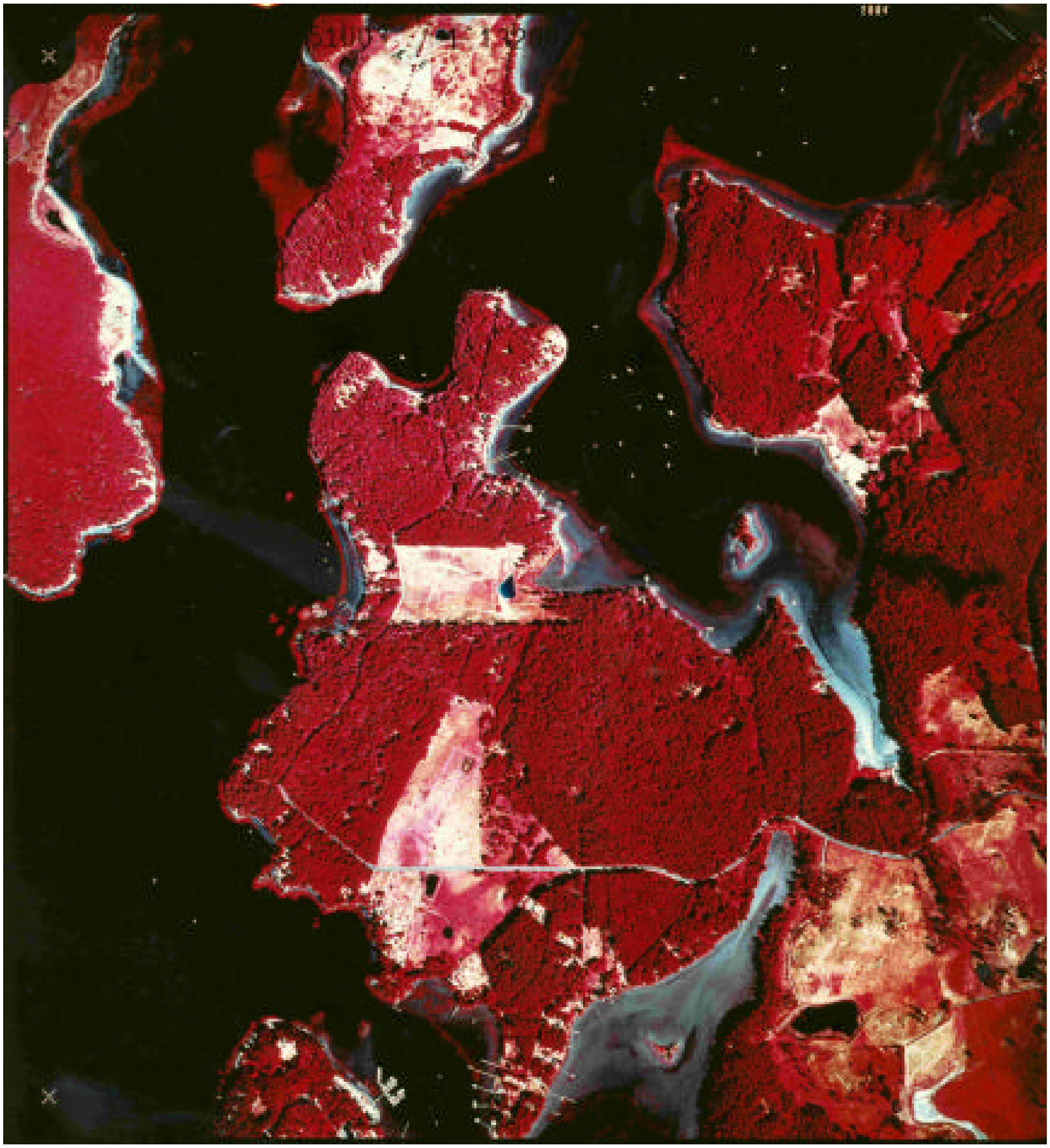

Figure 4. Color infrared aerial photo of Garrison Bay (the large bay in the center of the image) acquired in summer 1992 by the Washington State Department of Natural Resources. Patches of *Z. marina*, visible along the northern shore are absent in 2003 (See Figure 2).

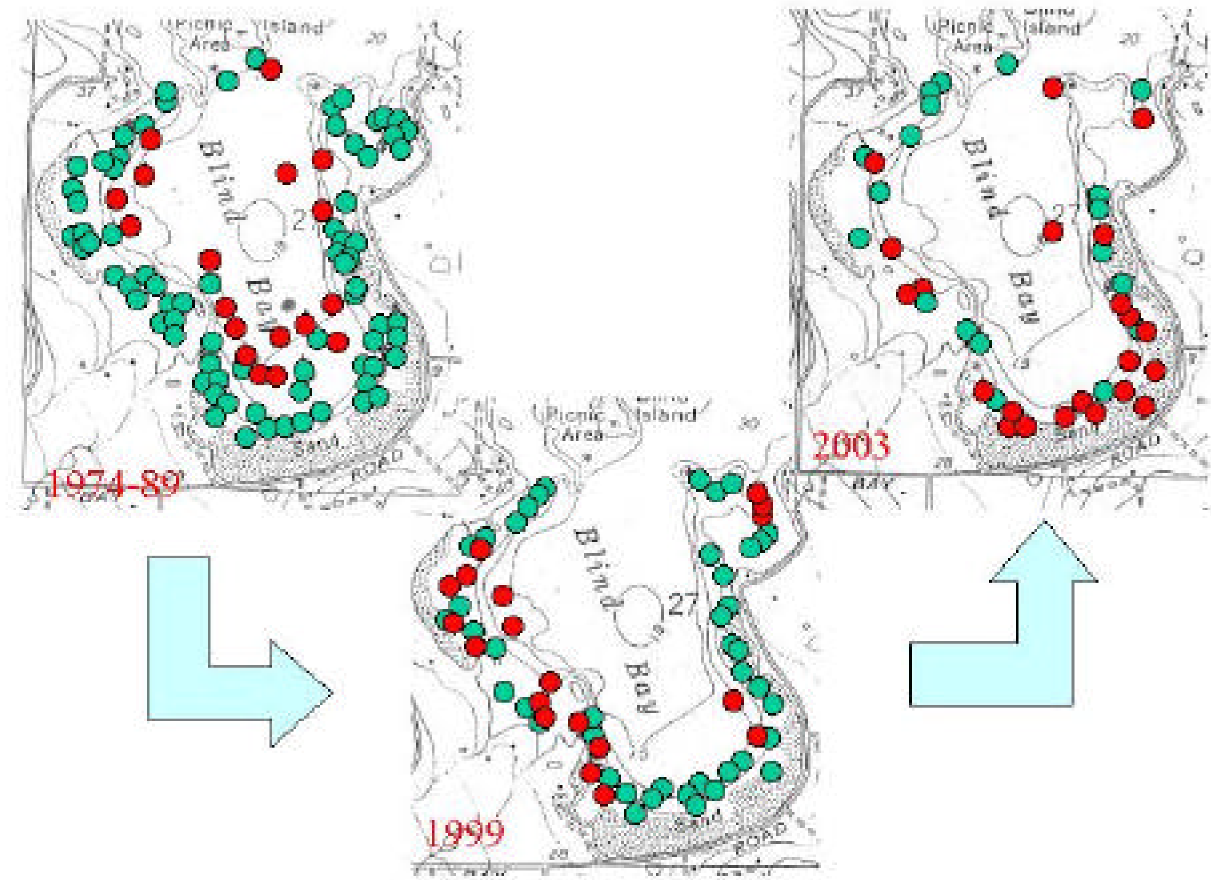

Figure 5. *Z. marina* distribution in Blind Bay, north side of Shaw Island (Figure 1) as observed by the WDFW Pacific herring spawn survey (Green circles = *Z. marina*; Red circles = No *Z. marina*).

observed loss of sea slugs (*Phyllaplysia taylorii*) which were once “thriving” on *Z. marina* leaves in both Westcott and Garrison Bays and are “not common elsewhere on San Juan Island” (Figure 1; Dethier and Ferguson 1998; Dethier pers. com. 2003). .

Possible Explanations

An array of human-induced and natural events can fragment or completely remove seagrass plants with the disappearance being either chronic or acute (Short and Wyllie-Echeverria 1996). Westcott and Garrison Bays are relatively sheltered embayments that are not often subjected to severe storms hence larger wave events known to destroy large areas of seagrass dominated sand in tropical regions (reviewed in Short and Wyllie-Echeverria 1996). Disturbance events such as disease and anoxia could have occurred and both are known to rapidly destroy and fragment *Z. marina* stands in northern temperate regions (Short et al. 1986; Muehlstein 1992; Plus et al. 2003). Human-induced events that produce sharp declines of the magnitude found in Westcott Bay can be related to the release of a toxic compound such as oil or eutrophication associated the watershed activities of farming and residential expansion along the waterfront (Short and Burdick 1996; Hemminga and Duarte 2000). The preliminary investigations on 18 May did not provide any clear explanation for the loss of *Z. marina* cover. Consequently, a mini-workshop involving regional experts was scheduled to discuss loss of *Z. marina* in Westcott and Garrison Bays and recommend a course of action.

Mini-Workshop

0n 26 July 2003, ten regional experts (Appendix B) met first for a survey of *Z. marina* conditions in Westcott and Garrison Bays during maximum low water (-0.4 m MLLW) and then for a workshop at Roche Harbor Resort on San Juan Island. In a discussion of the extent *Z. marina* of loss in Westcott and Garrison Bays, participants were informed that three detailed *Z. marina* surveys were conducted at Westcott Bay between 1998 and 2001 (Dethier and Ferguson 1998; Berry et al. 2003). When the results from these surveys are woven into a single theme the most plausible scenario is that of a gradual decline which then accelerated in 2002-03 and led to severe local depletion.

Dethier and Ferguson (1998) do not provide bottom cover estimates but their observations support the hypothesis of a gradually declining populations in both Westcott and Garrison Bays: (1) “Eelgrass was found in a virtually continuous band around the shallow subtidal zone of Westcott and Garrison Bays.”; (2) Density “was patchy at fourteen of the twenty sites in which eelgrass was present.”; (3) “..two property owners (one in Westcott and one in Garrison) independently commented that the eelgrass used to come further onto the shore than it does at this time.” and (4) *Z. marina* “consistently” grew adjacent to the shadow cast by over-water structures in the bays. Taken in concert these observations suggest that while intertidal populations of *Z. marina* were declining, subtidal populations were thinning. The SVMP survey revealed that approximately 45 ac (18 ha) of *Z. marina* cover was growing in Westcott Bay in 2000 (Figure 3), an amount that was reduced a year later by 24% and then was virtually eliminated in 2003. This sequence strongly suggests that the *Z. marina* population in Westcott Bay ceased to be self-sustaining at some point between 1998 and 2000, began to thin, and then crashed in 2003.

Workshop participants agreed that (1) the above scenario requires further examination and verification and (2) detailed examination should begin at other locations, especially those with similar geomorphological features to determine the geographic scope and magnitude of other possible declines in the region. Toward this end the following tasks were given priority:

- Compare results from the ongoing 2003 survey at other sites in San Juan County to existing historical data.
- Define the consequences of *Z. marina* loss as it pertains to loss of ecological services for important resident and migratory species such as juvenile salmon, Dungeness crab, Pacific herring and black brant.
- Re-sample transects established by Nyblade (1977) and Dethier and Ferguson (1998) to characterize the potential change in infaunal communities since the decline accelerated.
- Characterize the present state of Westcott and Garrison Bays as habitable sites for *Z. marina* by sampling environmental parameters such as temperature, salinity, light, nutrients and water motion.
- Sample extant *Z. marina* within Westcott and Garrison Bays for the presence of "wasting" disease (e.g. lethal infection by the slime mold *Labyrinthula zosterae*) and plant tissue and sediment for the presence of toxins such as Mercury (Hg), Copper (Cu), Cadmium (Cd), Zinc (Zn), Chromium (Cr) and Lead (Pb) which are known to reduce *Z. marina* fitness (Lyngby and Brix 1984; Wyllie-Echeverria et al. 2001).
- Evaluate the possible effect of bioturbation, especially re-working the sediment by invertebrates (e.g. Dumbauld and Wyllie-Echeverria 2003) and grazing pressure by invertebrates (e.g. Zimmerman et al. 1996;) and birds (e.g. Tubbs and Tubbs 1983) as a mechanism for loss.
- Examine the potential effects of watershed alterations which may have increased nutrient input from compromised septic systems, sedimentation from tree and shrub removal upstream and the leaching of toxins and fertilizers associated with residential gardening and lawn care.
- Establish control sites (n =5) at locations in Puget Sound with a similar geomorphological features to Westcott and Garrison Bays but without the sharp decline of *Z. marina* cover. Such embayments could then serve as reference sites both in a program designed to track potential recovery and to track the status of *Z. marina* health on a regional scale. Include environmental parameters of temperature, salinity, submarine light, and water motion in the vegetation survey effort.
- Design and initiate a transplant experiment, taking into account appropriate genetic status (e. g. Williams 2001) and ensuring disease free status within the transplant program to determine if Westcott and Garrison Bays will support *Z. marina*.
- Develop a conceptual model to guide experimental designs and interpret data and information collected.

Because no obvious causative factor(s) was identified, workshop participants agreed that process studies designed to determine possible causes should be immediately developed in collaboration with colleagues attending the meeting and others in the region. Each participant was also urged to seek out and then communicate possible funding sources to others in the group, including the ability of state and federal agencies to support this research as mandated. To guide this effort, a brain-storming exercise revealed that approximately $100,000 per site was needed to sponsor the research agenda identified in the list above. Given that there is high value placed on the ecological services provided by *Z. marina* throughout the Puget Sound/Georgia Basin, it was decided a second meeting was warranted to bring others into the proposal writing process, discuss the status of fund raising efforts and bring to the public forum the scenario that initiated this workshop.

The loss of 35 ac of *Z. marina*, and possibly more, raises a red flag with respect to the health of the regional ecosystem. As such it requires immediate and decisive diagnosis and action by concerned citizens and agencies mandated with the protection of this crucial resource. Because the distribution of seagrass populations can respond rapidly to both natural and human induced disturbance (Short and Wyllie-Echeverria 1996; Fonseca et al in press), and regulatory authority can only influence human behavior, it is critical that a potential source of damaging human activity be identified and, to the extent possible, arrested to prevent further loss. It is hoped that this preliminary investigation and reported findings underscore the need to identify the sources of disturbance at Westcott and Garrison Bays, and other parts of Puget Sound/ Georgia Basin where a similar scenario might exist, so that appropriate administrative action can proceed.

Acknowledgements

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APPENDIX A

2000-2002 SVMP Westcott Bay Summary

2000

Monitoring was done July 13, 2000.

2001

Monitoring was done August 26, 2001.

2002

No monitoring was done in ’02 – Dropped out of rotation

Trends

Table 1 shows a significant decrease in eelgrass coverage at Westcott Bay from 2000 to 2001 (@ 80%CI). The percent relative change was –23.8 ± 21.1 @ 80% CI (high within transect variance at site).

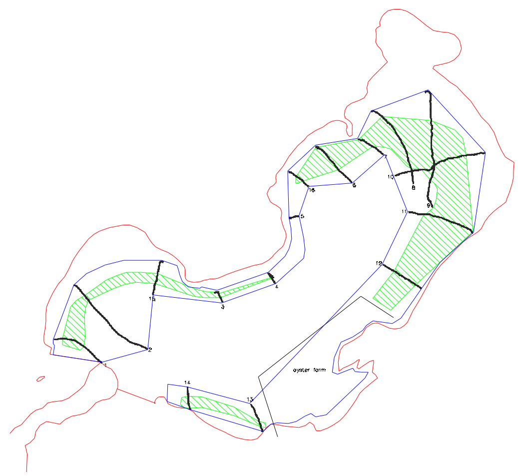
Table 1. Significant BAC change at Westcott Bay from 2000 to 2001

	2000 to 2001			2001 to 2002		
Reference area	Signficant difference (m^2) at 80% CI	Relative % change at 80% CI	Relative % change at 95% CI	Signficant difference (m^2) at 80% CI	Relative % change at 80% CI	Relative % change at 95% CI
Westcott Bay	yes	-23.8 ± 21.1	-23.8 ± 32.3	N/A	N/A	N/A

Site Maps and Transect Summaries

Figures 1 and 2 shows the transect sampling maps with statistics for 2000 and 2001 respectively.

Figure 1. 2000 SVMP Flats 53 (Westcott Bay)



Key:

Red Poly = GIS Polygon or Sample Site

Blue Poly = '00 Sample Polygon (everything outside assumed to have no grass present)

Black lines = transect locations

Green hatch = grass locations

General Summary: Tracks 1-16 were randomly selected from within sample polygon. Oyster Farm area was assumed to have grass present (included in sample poly)

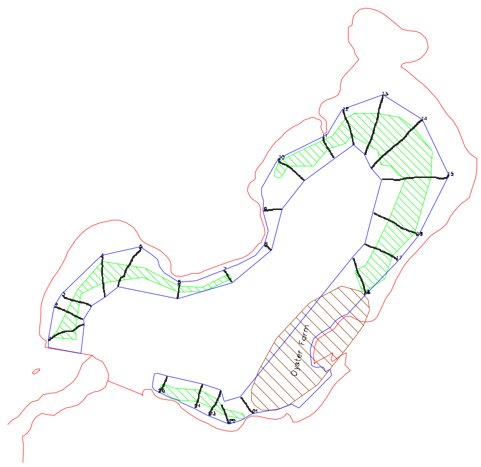
BAC Summary: Tracks 1-16 were used for analysis.

Depth Summary:
Used tracks 1-16 for minimum and maximum depth estimates

Site		Number of Transects	Eelgrass fraction	Estimated Basal Area (m^2)	Estimated Variance	Estimated Standard Error	cv	80% Lower Limit	80% Upper Limit	Patchiness Index
Flats53	**Westcott Bay**	**16**	**0.2555**	**185,270**	**813,367,970**	**28,520**	**0.15**	**148,765**	**221,775**	**5.11**

Site	n	Mean Minimum Depth	Estimated Standard Error	80% Lower Limit	80% Upper Limit	n	Mean Maximum Depth	Estimated Standard Error	80% Lower Limit	80% Upper Limit
Flats53	**15**	**-0.4**	**0.4**	**-1.4**	**0.5**	**15**	**-13.4**	**2.4**	**-18.6**	**-8.2**

Figure 2. 2001 SVMP Flats 53 (Westcott Bay)



Key:

Red Poly = GIS Polygon or Sample Site

Blue Poly = '00 Sample Polygon (everything outside assumed to have no grass present)

Black lines = transect locations

Green hatch = grass locations

General Summary: Tracks 1-25 were randomly selected from within sample polygon. Oyster Farm area was assumed to have grass present (included in sample poly)

BAC Summary: Tracks 1-25 (except 2, 19, 20 and 22 had technical problems or were not randomly chosen) were used for analysis.

Depth Summary:

Site		Number of Transects	Eelgrass fraction	Estimated Basal Area (m^2)	Estimated Variance	Estimated Standard Error	cv	80% Lower Limit	80% Upper Limit	Patchiness Index
Flats53	**Westcott Bay**	**21**	**0.2389**	**141,178**	**457,925,731**	**21,399**	**0.15**	**113,787**	**168,569**	**4.17**

Site	n	Mean Minimum Depth	Estimated Standard Error	80% Lower Limit	80% Upper Limit	n	Mean Maximum Depth	Estimated Standard Error	80% Lower Limit	80% Upper Limit
Flats53	**16**	**0.0**	**0.4**	**-0.7**	**0.8**	**16**	**-5.7**	**0.3**	**-6.4**	**-5.1**

APPENDIX B

Mini- Workshop Participants

26 July 2003

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