

# Puget Sound

## Submerged Vegetation Monitoring Project

### 2006 - 2007 Monitoring Report



December 2008

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Sandy Wyllie-Echeverria, Thomas Mumford

*The Submerged Vegetation Monitoring Project is implemented by the  
Nearshore Habitat Program. It is a component of the  
Puget Sound Assessment and Monitoring Program within the Puget Sound Partnership.*



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The following document fulfills a tasks identified in the 2007-2009 Puget Sound Conservation and Recovery Plan and provides information on the status and trends of one of the indicators of health in the Puget Sound Partnership's Action Agenda.

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Blain Reeves assisted with site selection and field preparation. Jennifer McKim, Trisha Towanda, and Lisa Ferrier assisted with the field sampling effort and post-processed all the underwater video.

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## EXECUTIVE SUMMARY

Eelgrass, *Zostera marina* L., monitoring is used by the Washington Department of Natural Resources, the Puget Sound Partnership and other resource managers to assess the health of nearshore habitat in Puget Sound. Since 2000, the Submerged Vegetation Monitoring Project (SVMP) monitored the abundance and distribution of *Z. marina* in greater Puget Sound using underwater videography. *Zostera marina* is considered an indicator of ecosystem health and provides valuable nearshore habitat to ecologically and economically important species. In addition to sampling multiple sites throughout Puget Sound, the SVMP assessed the status of *Z. marina* with greater sampling intensity in the *Saratoga-Whidbey Basin Region* (2006) and in the *Central Puget Sound Region* (2007).

### KEY FINDINGS

1. The SVMP has detected a pattern of sound-wide decline – sites with *Z. marina* losses outnumber those with gains. This pattern of annual loss has occurred consistently since 2000. Because the area of *Z. marina* beds lost has been relatively small, the total annual *Z. marina* area estimates throughout greater Puget Sound have not been statistically different from previous estimates. The current *Z. marina* area estimate in Puget Sound is  $21,400 \pm 3,700$  hectares ( $52,900 \pm 9,100$  acres).
2. A multiple parameter assessment identified 14 sites with evidence of decline in *Z. marina*. There are 17 additional sites that previously showed evidence of decline and have rotated out of the sample pool.
3. *Hood Canal Region* was identified as the region of greatest concern for losses, based on a multiple parameter assessment. Strong indications of *Z. marina* decline were also observed in the *San Juan-Straits* and *Central Puget Sound Regions* whereas *Z. marina* appears to be stable in the *Saratoga-Whidbey Basin* and the *North Puget Sound Regions*.
4. A focus study in the *Saratoga-Whidbey Basin Region* identified that more than half of the *Z. marina* occurs in flats. The region accounts for 16% of the *Z. marina* area in greater Puget Sound.
5. *Z. marina* in the *Central Puget Sound Region* focus area was distributed predominantly in the fringe strata with a small fraction of the *Z. marina* in the flats strata. The region accounts for 10% of the *Z. marina* area in greater Puget Sound.

### PRIORITIES

The primary priorities identified include:

1. Continue to monitor status and trends in *Z. marina* throughout Puget Sound and in focus areas to meet goals identified by DNR and the Puget Sound Partnership.
2. Provide timely results of *Z. marina* status and trends in annual SVMP reports, Puget Sound Reports, and in the State of the Sound publications.
3. Continue to provide technical support and data to collaborators and management on the status and trends of *Z. marina* and on sites and regions of concern.
4. Continue to work with the Eelgrass Stressor-Response Project, academics, citizen groups, and other researchers who are investigating the causes of *Z. marina* decline in Puget Sound.

# 1 Introduction

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## 1.1 The Submerged Vegetation Monitoring Project

The overall goal of the Submerged Vegetation Monitoring Program (SVMP) is to monitor the status and trends of *Z. marina* in greater Puget Sound. *Zostera marina* is an important nearshore resource that is an indicator of estuarine health, it is distributed throughout the study area, and it provides a suite of ecological functions. In Puget Sound, *Z. marina* provides spawning grounds for Pacific herring (*Clupea harengus pallasii*), out-migrating corridors for juvenile salmon (*Oncorhynchus* spp.) (Phillips 1984, Simenstad 1994), and important feeding and foraging habitats for waterbirds such as the black brant (*Branta bernicla*) (Wilson & Atkinson 1995) and great blue heron (*Ardea herodias*) (Butler 1995).

*Zostera marina* has been extensively studied throughout its range. This research has generated an abundance of peer-reviewed literature and brought significant ecological and political attention to the species (for example, Phillips 1984, Orth & Moore 1988, Krause-Jensen et al. 2003, Kemp et al. 1983, 2004, Moore & Short 2006). Previous work has demonstrated its usefulness as an indicator of habitat condition and impacts from anthropogenic stressors (Dennison et al. 1993, Short & Burdick 1996, Lee et al. 2004, Kenworthy et al. 2006). In addition, *Z. marina* provides valued hunting grounds and ceremonial foods for Native Americans and First Nation People in the Pacific Northwest (Suttles 1951, Felger & Moser 1973, Kuhnlein & Turner 1991, Wyllie-Echeverria & Ackerman 2003).

The SVMP is one component of the Puget Sound Assessment and Monitoring Program (PSAMP), a program coordinated by the Puget Sound Action Team historically and, more recently, by the Puget Sound Partnership (2002a). PSAMP is a multi-agency effort mandated by the state legislature (RCW 90.71.060) to monitor diverse physical and biotic aspects of the Puget Sound ecosystem.

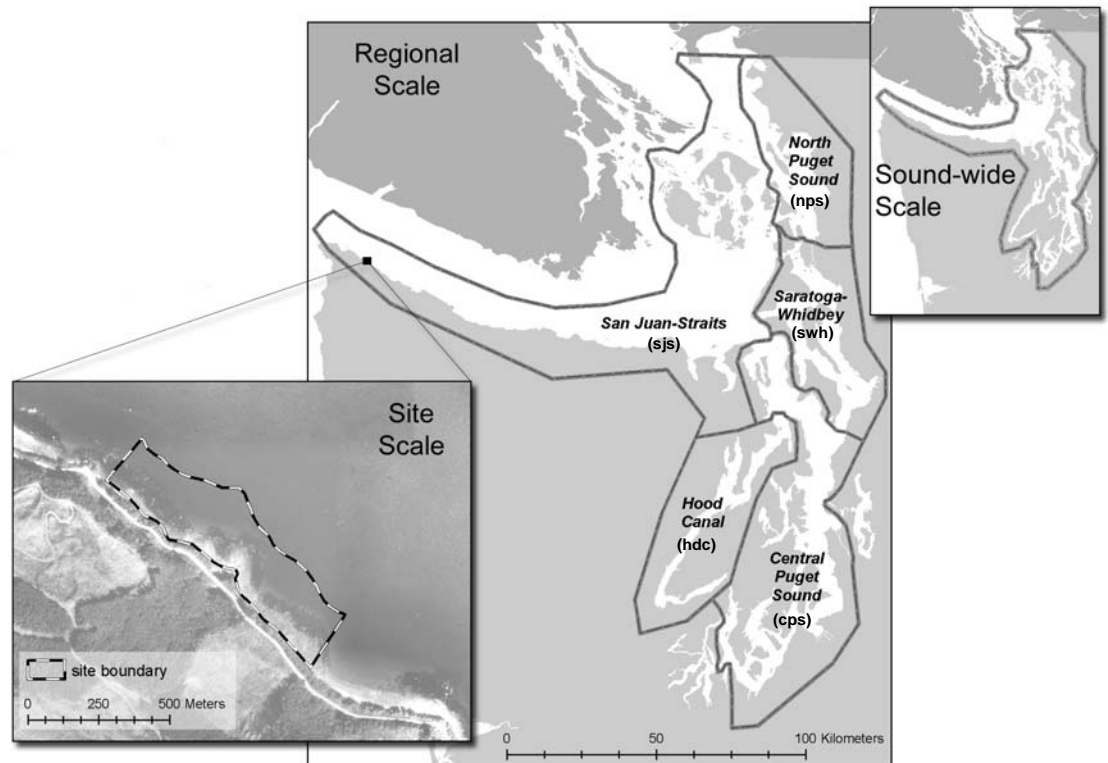
Currently, the SVMP *Z. marina* status and trend data provide the basis for a key ecosystem indicator that is used for integrated assessments of Puget Sound (Puget Sound Action Team 2007, 2005, 2002b).

The SVMP is implemented by the Washington State Department of Natural Resources (DNR) and represents a key component of the agency's contribution to PSAMP. The Department of Natural Resources initiated *Z. marina* monitoring as a natural complement to its role as manager of state-owned aquatic lands and attached or embedded resources such as *Z. marina*, including all subtidal areas and a substantial amount of the state's intertidal lands. The legislature has stipulated management guidelines for these lands that balance various uses of state aquatic resources with "ensuring environmental protection" (RCW 79.105.030). Given the key ecological functions of *Z. marina* and its value as a resource under DNR's management, the tracking of seagrass resources by the SVMP serves DNR's direct mandate as well as that of the broader PSAMP.



Other Washington State agencies also recognize the value of *Z. marina* as an aquatic resource. The Washington Department of Fish and Wildlife designated areas of *Z. marina* as habitats of special concern (WAC 220-110-250) under its statutory authority over hydraulic projects (RCW 77.55.021). Similarly, the Washington Department of Ecology designated *Z. marina* areas as critical habitat (WAC 173-26-221) under its statutory authority in implementing the state Shoreline Management Act (RCW 90.58).

In order to satisfy a broad range of data needs, the SVMP produces results at a range of spatial scales (site, region, and sound-wide scales; Figure 1-1) based on sampling at randomly selected sites. The SVMP was also designed to produce results at annual and long-term (5- and 10-year) temporal scales. The SVMP's primary programmatic performance measure is the ability to detect a 20% decline in *Z. marina* abundance with suitable statistical power over 10 years at the sound-wide scale (4,115 km of shoreline).



**Figure 1-1.** The SVMP produces estimates of *Z. marina* abundance and distribution at sound-wide, regional, and site scales throughout greater Puget Sound, WA. Letters in parentheses indicate the regional prefix for site codes (see Table 2-2).

## 2 Methods

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### 2.1 The SVMP Study Area and Sampling Design

The SVMP study area includes all of greater Puget Sound: the Strait of Juan de Fuca, southern Georgia Strait, the San Juan Islands, Saratoga Passage–Whidbey Basin, Hood Canal and Puget Sound proper. The extreme reaches of southern Puget Sound are excluded from the study because of the sparse distribution of *Z. marina* in this area (Figure 1-1; Berry et al. 2003).

The SVMP sampling design and statistical analyses have been thoroughly described in earlier reports (Berry et al. 2003, Skalski 2003, Dowty 2005, Dowty et al. 2005, Gaeckle et al. 2007). The sound-wide and focus area sampling designs, including specific changes for the 2006 and 2007 sampling efforts, are outlined below.

### 2.2 Sound-Wide Sampling Design

#### 2.2.1 Stratification and Sampling Frames

All potential *Z. marina* habitat within the study area was delineated into either flats or fringe geomorphic categories (Berry et al. 2003). The fringe sampling frame was further divided into narrow fringe and wide fringe (Table 2-1; Berry et al. 2003). The flats sampling frame was divided into persistent and rotational flats (Table 2-1; Dowty et al. 2005). Six sites from the total number of sites (2469) were non-randomly selected and designated as core sites for long-term sampling (Table 2-1; Berry et al. 2003). The core stratum contains sites in the fringe and flats geomorphic categories. The six core sites include four flats sites (*core001-Padilla Bay*, *core002-Picnic Cove*, *core003-Jamestown* and *core004-Lynch Cove*, a wide fringe site (*core005-Dumas Bay*), and a narrow fringe site (*core006-Burley Spit*).

**Table 2-1. Summary of SVMP sampling frames, strata and numbers of sites in 2006 and 2007. Detailed explanations of SVMP sampling frame corrections and updates can be found in earlier reports (Dowty 2006a, Gaeckle et al. 2007).**

Geomorphic Category	Sampling Frame	No. Sites in Frame	Stratum	No. Sites in Stratum
fringe	fringe frame	2396	core	2
			narrow fringe	2035
			wide fringe	359
flats	flats frame	73	core	4
			persistent flats	3
			rotational flats	66

All other fringe sites that are not in the core stratum have a prefix to identify the associated region (Table 2-2), and the remaining flats sites contain a prefix (flats) to identify their geomorphic type.

**Table 2-2. Prefixes used in the site codes to identify the SVMP region for the fringe sites (see Figure 1-1).**

Prefix	Region
cps	Central Puget Sound
hdc	Hood Canal
nps	North Puget Sound
sjs	San Juan Islands-Strait of Juan de Fuca*
swh	Saratoga Passage-Whidbey Basin*

\* Note: the San Juan Islands-Strait of Juan de Fuca Region is referred to as the *San Juan-Straits Region* and the Saratoga Passage-Whidbey Basin Region is referred to as the *Saratoga-Whidbey Basin Region* throughout the report.

### 2.2.2 Rotational Design and Site Selection

Yearly site selection follows a rotational design in the narrow fringe, wide fringe and rotational flats strata as performed in previous years (Berry et al. 2003, Dowty 2005, Dowty et al. 2005, Gaeckle et al. 2007). The core stratum and the persistent flats stratum are not subject to rotation and are completely surveyed each year (Table 2-3; Dowty et al. 2005). The rotational design and site selection is described in more detail in Appendix P.

### 2.2.3 Sound-wide Sites

A total of 79 sites were selected in 2006 and in 2007 as part of the sound-wide sample design. The sites were distributed in the core, persistent flats, and rotational flats and fringe strata throughout the five regions of greater Puget Sound (2006, Figure 2-1; 2007, Figure 2-2). There were 66 matching sites from 2005 to 2006 and 65 matching sites from 2006 to 2007 that were used to calculate the sound-wide change estimate (Table 2-3).

The annual sound-wide sampling does not have a sufficient number of sites to calculate annual regional *Z. marina* area status estimates. Regional trends are evaluated annually using a multiple parameter assessment.

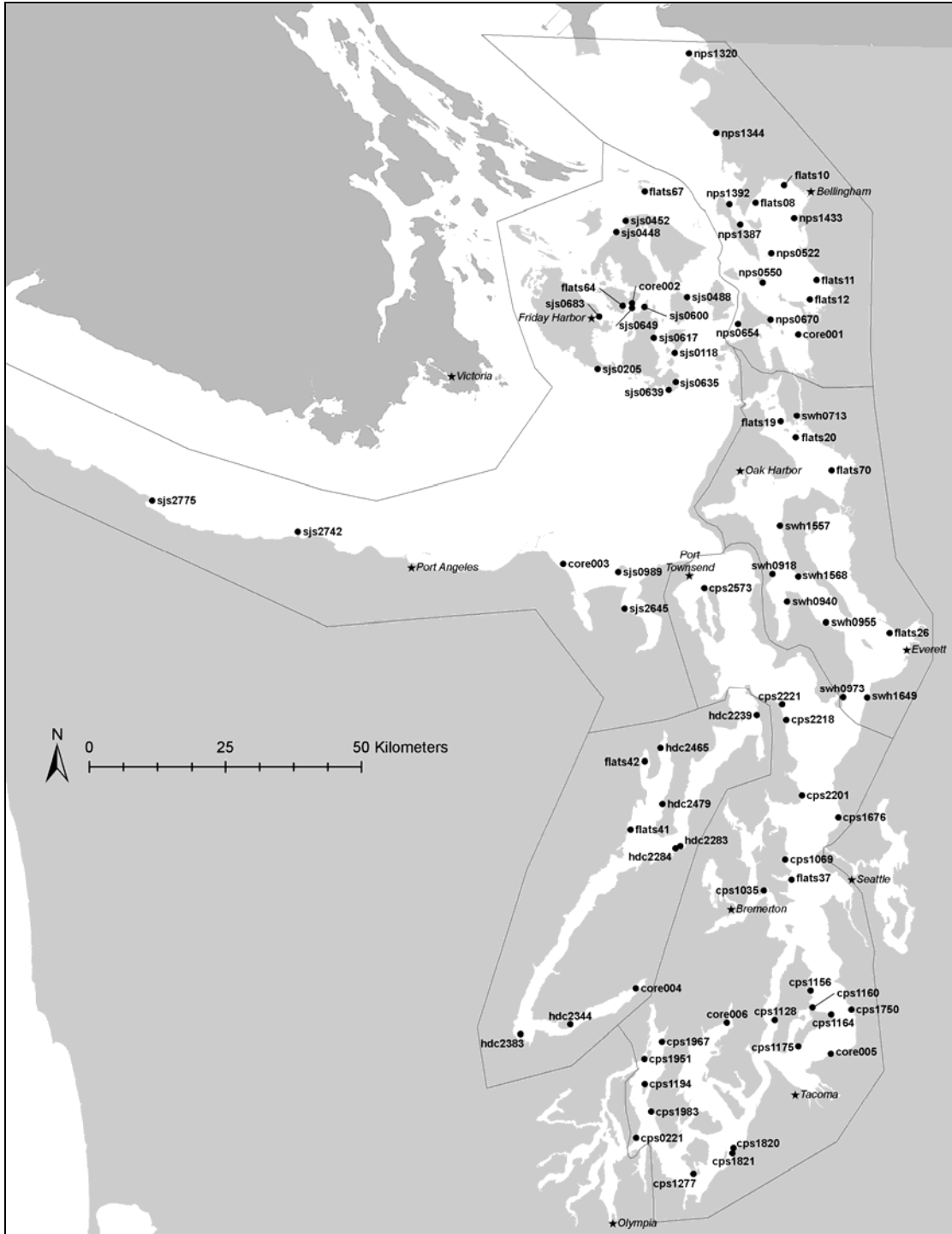


Figure 2-1. Sites sampled in 2006 for the SVMP sound-wide study.

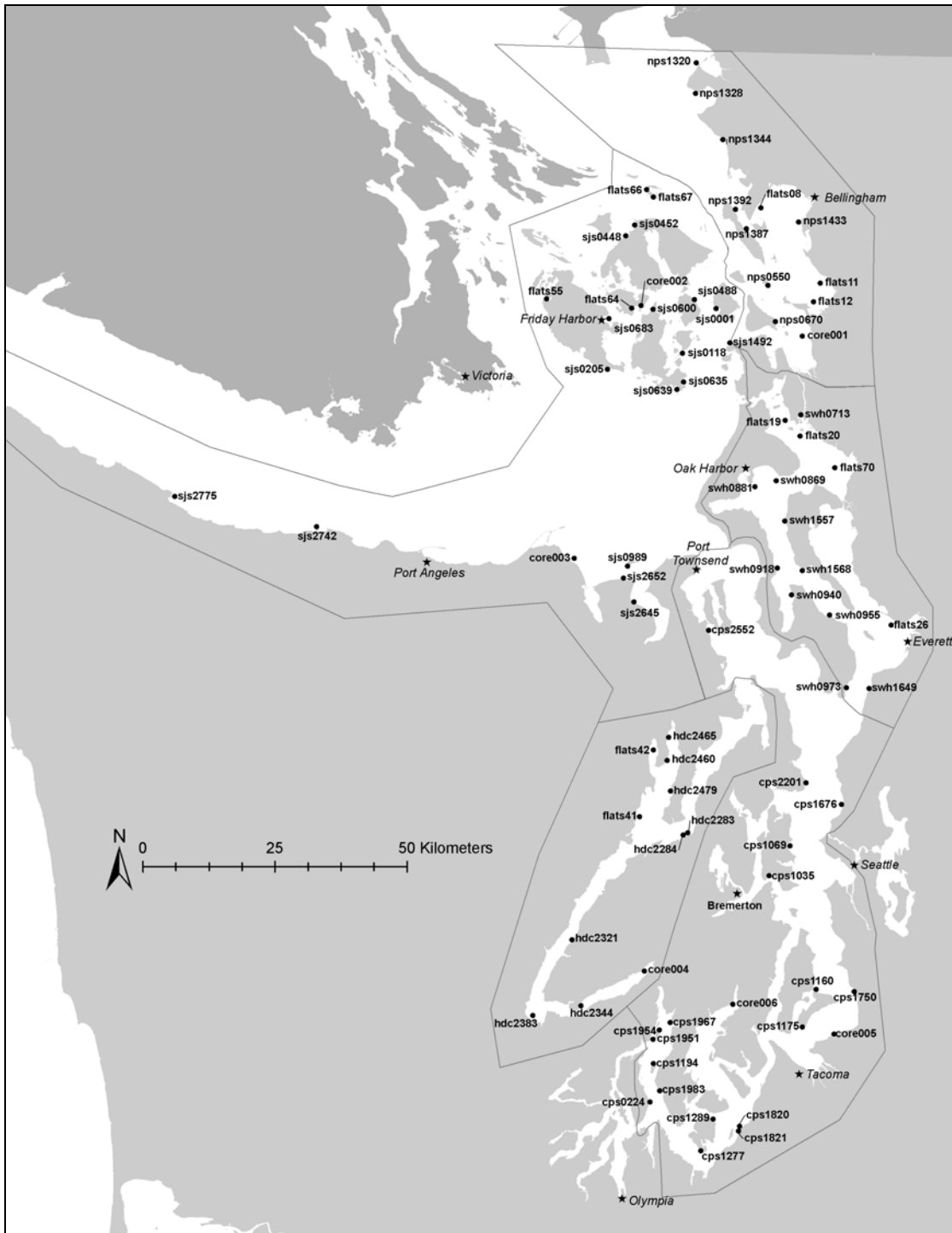


Figure 2-2. Sites sampled in 2007 for the SVMP sound-wide study.

**Table 2-3. Distribution of 2006 and 2007 sample sites by region. The sound-wide annual change estimate is calculated by comparing matching sites – sites that were sampled in both the year under consideration and the previous year.**

2006	CPS	HDC	NPS	SJS	SWH	Total
<b>SOUND-WIDE</b>						
core	2	1	1	2	0	6
flats – persistent	0	0	2	0	1	3
flats – rotational	1	2	2	2	3	10
narrow fringe	19	3	5	13	6	46
wide fringe	2	4	4	2	2	14
						79
<b>2005 – 2006 Matching Sites</b>						
flats	1	3	5	3	5	17
fringe	20	6	7	10	6	49
						66
<b>2007</b>						
<b>SOUND-WIDE</b>						
core	2	1	1	2	0	6
flats – persistent	0	0	2	0	1	3
flats – rotational	0	2	1	4	3	10
narrow fringe	17	5	4	14	6	46
wide fringe	1	3	4	2	4	14
						79
<b>2006 – 2007 Matching Sites</b>						
flats	0	3	4	4	4	15
fringe	16	6	7	13	8	50
						65

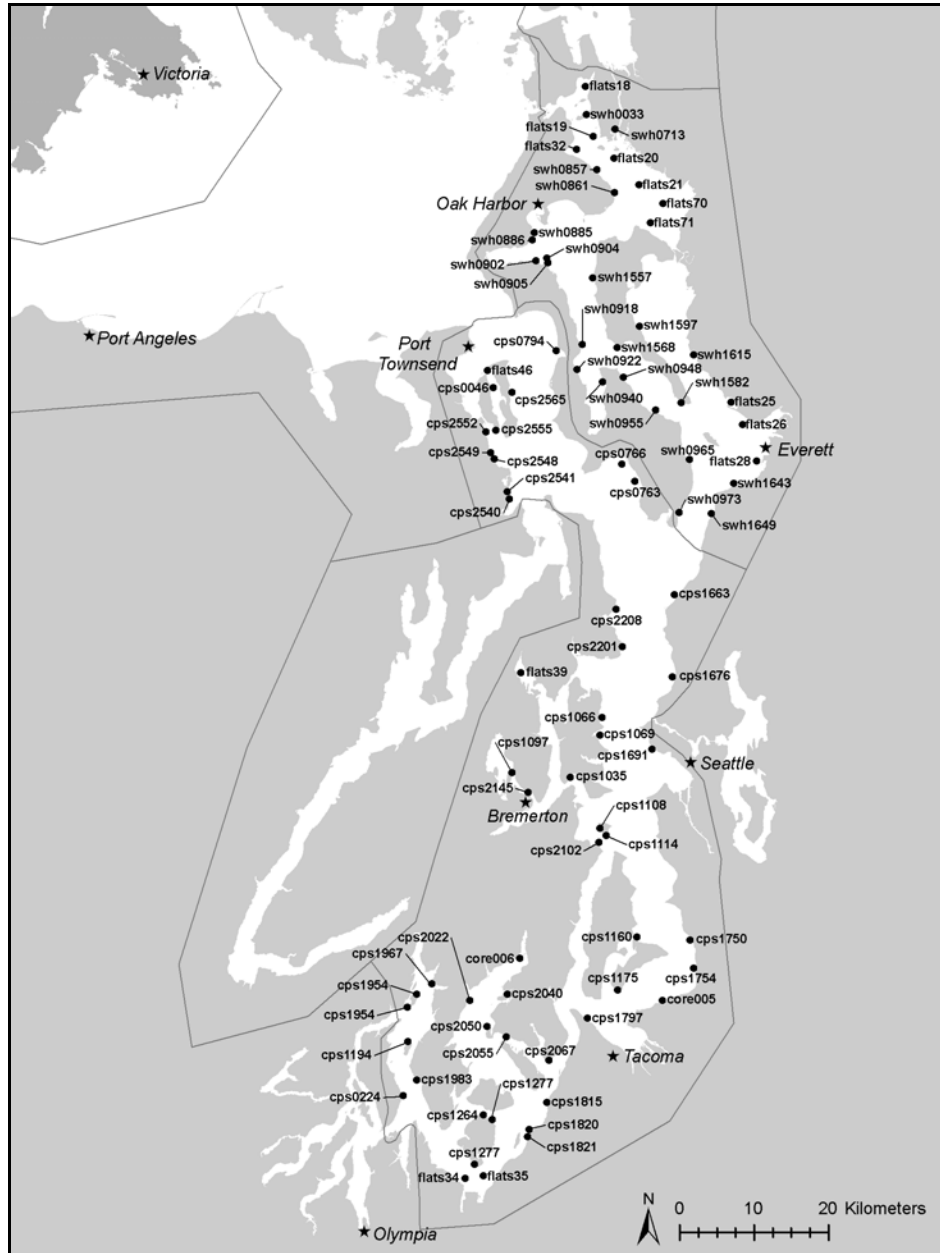
### 2.3 Focus Area Sampling Design and Site Selection: 2006 Saratoga–Whidbey Basin and 2007 Central Puget Sound Region

Each year, one of the five defined regions in greater Puget Sound (Figure 1-1) is sampled on a rotating basis at higher intensity to estimate regional status and to assess trends every five years. The SVMP focus areas for 2006 and 2007 were the *Saratoga-Whidbey Basin* and *Central Puget Sound Regions*, respectively. The sampling effort goal for both focus areas was based on the sampling effort in previous years (Gaeckle et al. 2007). A more detailed description of the site selection for the 2006 and 2007 focus areas is outlined in Appendix Q.

#### 2.3.1 Stratification and Site Selection

The total effort available for focus area sampling is 36 fringe equivalents (the nominal effort to sample one fringe site). This effort is allocated among sampling strata based on available information on variance within the strata, as well as a region-specific conversion factor that relates the effort to sample a flats site to the effort to sample a fringe site (Figure 2-3, Table 2-4, Appendix Q). For the *Saratoga-Whidbey Basin Region* focus area this

conversion factor was set at 2.5 (i.e. a flat site requires 2.5 times the effort of a fringe site), and for the *Central Puget Sound Region* focus area this factor was set at 2.



**Figure 2-3.** Sites sampled for the focus area *Z. marina* estimate in the 2006 *Saratoga-Whidbey Basin Region* (n = 33) and in the 2007 *Central Puget Sound Region* (n = 52).

**Table 2-4. The total number of sites sampled in the *Saratoga-Whidbey Basin* and *Central Puget Sound Regions* that were used to calculate the *Z. marina* area in each region. The total numbers of sites were calculated as the combination of the final allocation of the sampling effort by stratum for the focus area sampling (Focus *n*) in each region as well as sites sampled as part of the sound-wide study (Other *n*).**

	2006 Saratoga –Whidbey Basin			2007 Central Puget Sound			
	Stratum	Focus <i>n</i>	Other <i>n</i>	Total <i>n</i>	Focus <i>n</i>	Other <i>n</i>	Total <i>n</i>
flats strata	flats	8	2	10	4	0	4
fringe strata	narrow	10	6	16	22	17	39
	wide	6	1	7	6	3	9
total		24	9	33	32	20	52

## 2.4 Site Sampling

At each site, underwater videography was used to sample the presence of *Z. marina* along random transects in a modified line-intercept technique (Norris et al. 1997). The random transects are restricted to a sample area that represents the general location of *Z. marina* presence within a site that was delineated from reconnaissance and other available data from previous years and other sources (e.g. Puget Sound Environmental Atlas 1987, ShoreZone Inventory 2001). The random transects, oriented perpendicular to shore, extend beyond the shallow and deep edges of the sample area. The target number of 11 random transects varies in practice and depends on the precision of previous estimates sampled at the site.

The video sampling resolution is nominally one square meter and *Z. marina* is categorized as present or absent based on the observation of rooted shoots within the video field of view. The fractional cover of *Z. marina* along transects is used to calculate site *Z. marina* area. The depth at which *Z. marina* grows along each transect is used to estimate mean maximum and minimum depth of *Z. marina* relative to Mean Lower Low Water (MLLW) at each site and within each region.

A 17' aluminum work skiff is used to sample sites where obstructions prevent the primary 36' research vessel from safely accessing the full extent of the sample area. The data collection method at these sites varies from normal protocols; *Z. marina* presence and absence is determined from interpretation of the BioSonics echosounder echogram in concert with drop-camera observations (Sabol et al. 2002).

Further details of site sampling methods are provided in earlier SVMP reports (Berry et al. 2003, Dowty et al. 2005, Gaeckle et al. 2007).



## 2.5 Video Data Processing and Analysis

Technicians review the video from the random transects at each site to classify the *Z. marina* presence and absence. The fundamental video processing procedures are described in earlier publications (Berry et al. 2003, Dowty et al. 2005, Gaeckle et al. 2007, Reeves et al. 2006).

### 2.5.1 Data Analysis

#### Zostera marina Area Estimation

*Zostera marina* area estimation at the site-level follows procedures described in Appendix L of the first SVMP report (Berry et al. 2003, Skalski 2003). The probabilistic sampling design allows for statistical extrapolation methods to calculate the status of *Z. marina* area within each stratum, and on a site and sound-wide basis. Status estimates for regions are not produced annually because the insufficient number of sites sampled in each region to produce a reliable estimate. Instead, status estimates in each region are produced every five years as part of the rotating focus area study. In focus areas, the *Z. marina* area estimate is calculated from the sites selected for the focus area sampling plus any sites selected for the sound-wide sampling that are located in the focus area (Dowty et al. 2005).

#### Zostera marina Change Analysis

The sampling design allows for change analyses at multiple temporal and spatial scales (Berry et al. 2003, Dowty 2005, Skalski 2003). The SVMP is designed to detect five and 10-year trends in *Z. marina* area at the site- and sound-wide scales. Furthermore, documentation of the shallow and deep edge of the seagrass bed provides a basis to detect change in *Z. marina* depth distribution at the site-level. At all scales, long-term trend calculations rely on regression analysis of status estimates. Year-to-year change analysis methods vary depending on the scale of the site- and sound-wide data.

At the site-level, year-to-year change was assessed and tested for significance based on the calculation of relative change in three parameters (area, mean minimum depth and mean maximum depth) for consecutive years. Confidence intervals, measures of estimate precision, were calculated using analytical statistics.

At the sound-wide level, year-to-year change was assessed through the comparison of paired sites sampled in consecutive years. Confidence intervals are derived through Monte Carlo simulations.

#### Multiple Parameter Assessment of Region-Level Change

Multiple parameters were assessed to determine the condition of *Z. marina* in each region relative to the other regions. The multiple parameter analysis assessed the number of significant changes (positive or negative,  $\alpha=0.05$ ) relative to the cumulative number of significant tests in each region from 2000 to 2007. The five parameters used to determine the status of *Z. marina* at the regional level include:

- Region-level *Z. marina* change: the estimate of relative change in regional *Z. marina* area. The region-level extrapolation is calculated from randomly selected

sites sampled over two consecutive years. The region-level parameter must be interpreted with caution because the Monte Carlo analysis has shown that calculated significance does not reliably represent actual significance due to small sample sizes (Dowty 2005).

- Site-level *Z. marina* change: the number of sites with a significant change in *Z. marina* area from one year to the next.
- Deep edge depth change: the number of sites with a significant change in the deep edge depth of *Z. marina* from one year to the next.
- Shallow edge depth change: the number of sites with a significant change in the shallow edge depth of *Z. marina* from one year to the next.
- Five-year trends: the number of sites with significant five-year trends in area.

The primary goal of the multiple parameter assessment was to identify the status of *Z. marina* in each region based on the proportion of significant positive or negative indicators of *Z. marina* change. Another goal of the multiple parameter assessment was to identify regions with the greatest frequency of change (variability), identified as the regions with the greatest proportion of positive or negative change. In addition to the annual multiple parameter regional assessment, status and trends in each region are explored in detail through 5-year rotating focus area studies.

#### Multiple Parameter Assessment of Site-Level Change

Sites that were previously evaluated and classified into two categories (strong evidence of decline and very strong evidence of decline; Gaeckle et al. 2007) were further evaluated based on *Z. marina* decline from 2002 to 2007, changes in *Z. marina* area and depth from 2005 to 2007, and five-year trends. Sites with three or more *Z. marina* parameters in decline were classified as strong evidence of decline and additional weight was given to statistically significant results. A significant five-year declining trend was classified as strong evidence of decline.

## 3 Results

### 3.1 Field Effort Summary

In 2006, the SVMP sampled 101 sites from June through September and in 2007 the project sampled 111 sites from June through October (Table 3-1). The level of effort in 2006 and 2007 remained consistent with the previous years. In both years, a total of 79 sites were sampled as part of the sound-wide effort while the sites added for the focus area effort ranged from 24 in the *Saratoga-Whidbey Basin Region* to 32 in the *Central Puget Sound Region* (Table 3-1). In 2006, *flats35-Nisqually Delta E.*, was retained in the sampling pool to increase the number of flats in the *Central Puget Sound Region* estimate but the results were not included in the sound-wide estimate, and it was added to the sample plan in 2007 as part of the focus area effort.

**Table 3-1. Summary of the SVMP sampling effort for 2000-2007. The value in parentheses ( ) indicates the number of sites sampled in the focus area for that year.**

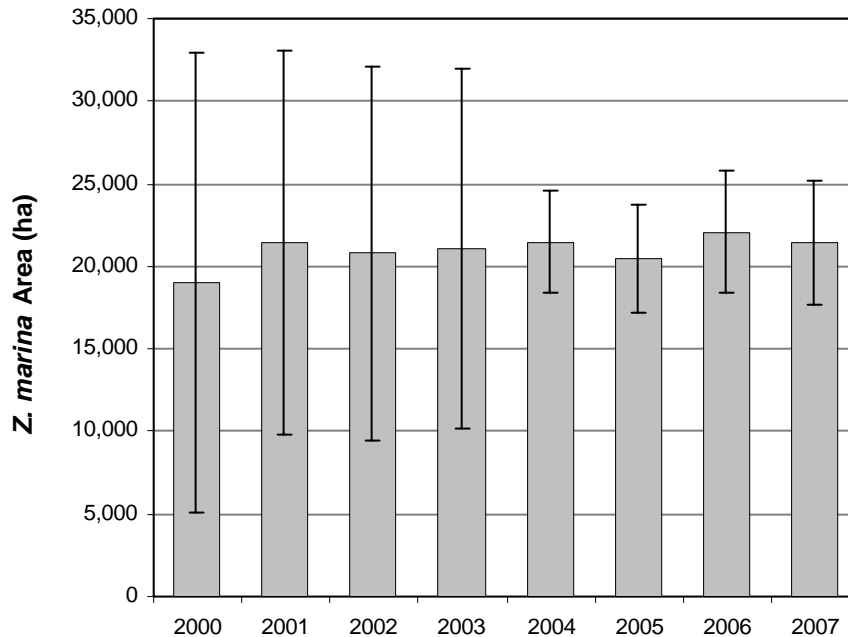
Year	Field season months	Number of sites visited	Number sampled	Sites not sampled due to obstructions	Average transects per site	Sites without <i>Z. marina</i>	Number of sampling days
2000	July – October	66	61 (0)	5	12	13	46
2001	July – October	77	74 (0)	3	13	15	54
2002	June - September	76	73 (0)	3	12	14	54
2003	July and August	76	76 (0)	0	15	12	50
2004	June – September	110	110 (28)	0	14	12	72
2005	June – September	109	108(30)	1	14	6	67
2006	June – September	101	101(24)	0	14	9	67
2007	June – October	111	111(32)	0	14	21	71

Two sites were sampled in 2006 from a 17' aluminum work skiff with the Biosonics echosounder (instead of a towed video camera) due to extensive shoaling (*flats08-Portage Bay*) and large rocks (*nps0522-Eliza Island NE*). Natural or anthropogenic obstructions did not inhibit sampling at any sites in 2006 and 2007 (Appendix T). The average number of random videography transects per sites was 14 (Table 3-1) and ranged from 5 – 26 (*sjs0649-Canoe Island* and *flats19-Pull and Be Damned*, respectively) in 2006 and 9 (*flats11-Samish Bay N*; *flats70- South Fork Skagit River*) to 21 (*sjs0683-Brown Island N*; *flats19-Pull and Be Damned*) in 2007. Previously, the average number of random transects varied from 12 to 15 from 2000 to 2005 (Table 3-1).

### 3.2 Status of *Zostera marina*

#### 3.2.1 Sound-wide *Zostera marina* Area

The greater Puget Sound *Z. marina* estimate was 22,100 ± 3,700 ha in 2006 and 21,400 ± 3,700 ha in 2007 (95% confidence interval; Figure 3-1, Appendix K).



**Figure 3-1. Estimates of total *Z. marina* area in the study area, 2000-2007. Error bars are 95% confidence intervals.**

#### 3.2.2 *Zostera marina* Area – 2006 Saratoga-Whidbey Basin and 2007 Central Puget Sound Focus Areas

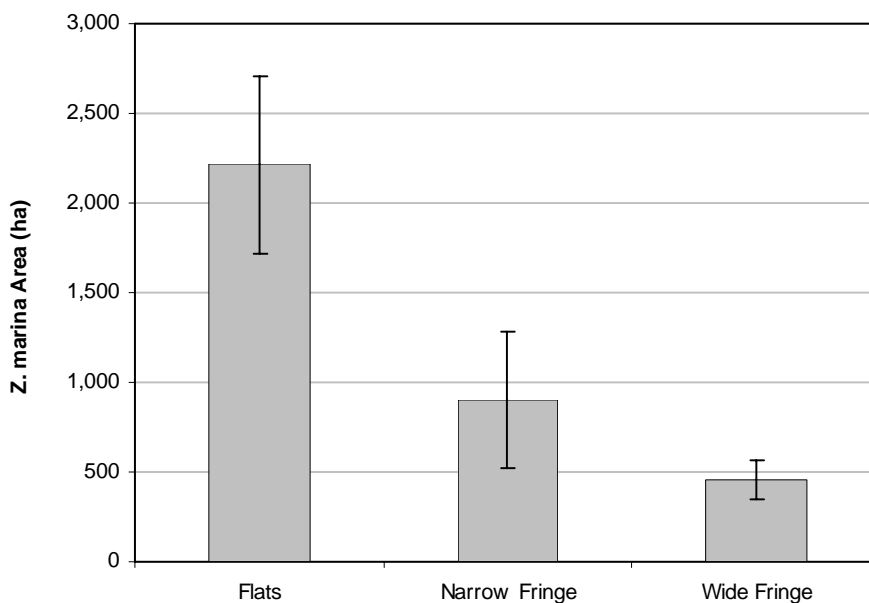
The *Saratoga-Whidbey Basin* focus area *Z. marina* estimate of 3,600 ± 600 ha (95% CI) represented 16 % of the total sound-wide estimate (22,100 ha) in 2006. The focus area estimate was based on a total of 33 sites (9 from the yearly sound-wide rotation, Appendix A; 24 from the focus area site selection, Appendix B) sampled in the *Saratoga-Whidbey Basin Region*. Sixty-one percent of the *Z. marina* area in the *Saratoga-Whidbey Basin Region* falls within the flats strata, while 26% is narrow fringe and 13% wide fringe (Table 3-2, Figure 3-2, Appendix B).

A total of 52 sites (20 sound-wide, 32 focus area) were sampled in the *Central Puget Sound Region* as part of the 2007 focus area effort (Appendices A and B). The *Z. marina* estimate for the *Central Puget Sound Region* focus area was 2,400 ± 800 ha (95% CI; Table 3-2). The distribution of *Z. marina* in the *Central Puget Sound Region* was different than observed in the *Saratoga-Whidbey Basin Region* with nearly all the *Z. marina* area

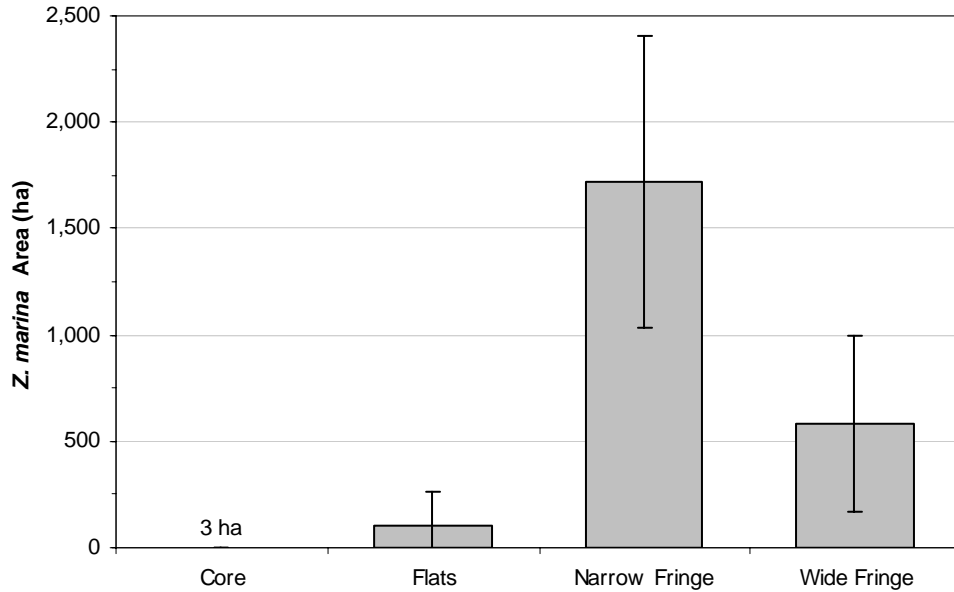
found in the fringe strata (71% narrow fringe, 24% wide fringe) and a small fraction of the *Z. marina* in the flats strata (Table 3-2, Figure 3-3, Appendix D).

**Table 3-2. Estimates of *Z. marina* area and uncertainty by stratum for the Saratoga-Whidbey Basin and Central Puget Sound focus areas. The number of sites used in each estimate (*n*) and the total number of sites in the stratum (*N*) are also shown.**

Focus Area	Strata	<i>n/N</i>	<i>Z. marina</i> Area (ha)	Variance	s.e.	c.v.	95% CI	Proportion of <i>Z. marina</i> area
Saratoga - Whidbey Basin	Flats	8/15	2,214	64,179	253	0.11	497	62%
	Narrow Fringe	16/211	904	38,269	196	0.22	383	25%
	Wide Fringe	7/44	459	3,139	56	0.12	110	13%
	Total		3,577	105,587	324	0.09	637	
Central Puget Sound	Core	2/2	3	0.2	0.5	0.16	1	0.1%
	Flats	4/11	108	6,425	80	0.74	157	5%
	Narrow Fringe	38/758	1,718	123,462	351	0.20	689	71%
	Wide Fringe	8/92	581	44,438	211	0.36	413	24%
	Total	52/863	2,410	174,325	418	0.17	818	



**Figure 3-2. Estimates of *Z. marina* area by stratum for the 2006 Saratoga-Whidbey Basin Region focus area. Error bars are 95% confidence intervals.**

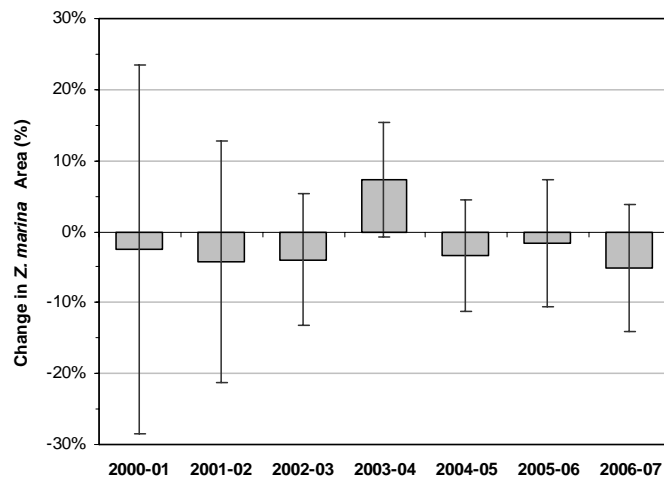


**Figure 3-3. Estimates of *Z. marina* area by stratum for the 2007 Central Puget Sound Region focus area. Error bars are 95% confidence intervals.**

### 3.3 Sound-wide and Site-Level Change in *Zostera marina* Area

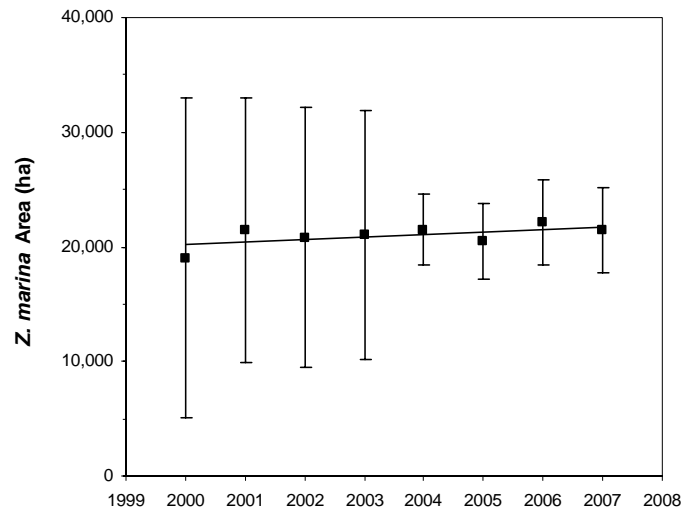
#### 3.3.1 Sound-Wide Change in *Zostera marina* Area

The *Z. marina* area change estimate based on 66 matching sites between 2005-2006 was  $-1.6\%$  ( $\pm 2.8\%$ ) and between 2006-2007 was  $-5.1\%$  ( $\pm 2.5\%$ ). The sound-wide change estimate for both time intervals was not statistically significant (Figure 3-4).



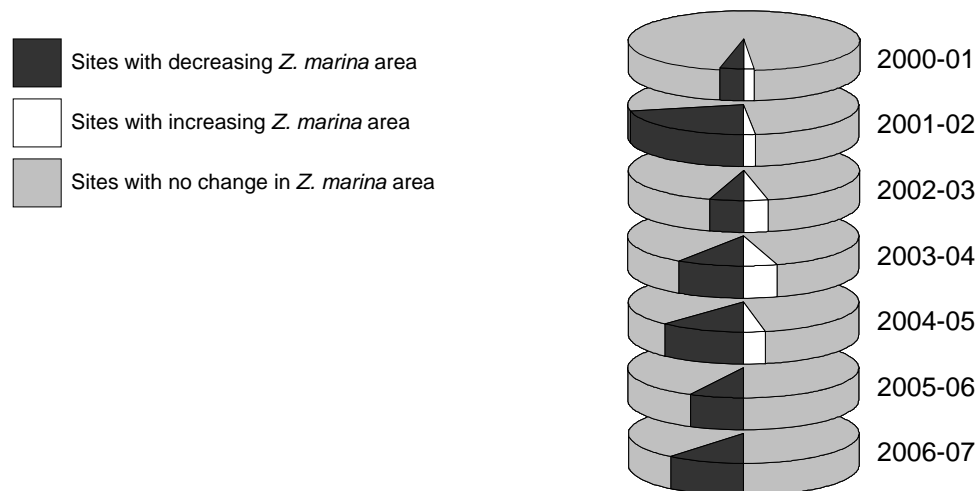
**Figure 3-4. Overall sound-wide annual change in *Z. marina* area from 2000 - 2007. Error bars are Monte Carlo 95% confidence intervals. Error bars that overlap the 0% line indicate that the change for the time period is not significant.**

The sound-wide trend in *Z. marina* area from 2000 to 2007 was not significant ( $\alpha=0.05$ ; Figure 3-5).



**Figure 3-5. Sound-wide trend analysis in *Z. marina* area from 2000 to 2007. There was no significant trend in sound-wide *Z. marina* area since 2000 ( $\alpha=0.05$ ). Error bars are Monte Carlo 95% confidence intervals.**

However, there is a pattern of sound-wide decline. Throughout Puget Sound, a greater proportion of sites showed significant *Z. marina* loss compared to sites with significant *Z. marina* gains ( $\alpha=0.05$ ; Figure 3-6). This pattern has occurred every year since 2000, and since 2005, there have been no sites that increased in *Z. marina* area.



**Figure 3-6. Proportion of sites with statistically significant increases and decreases in *Z. marina* area ( $\alpha=0.05$ ). Sites with no significant change in *Z. marina* area are also shown.**

### 3.3.2 Site-Level Change in *Zostera marina* Area

#### Year-to-Year Change in *Zostera marina* Area

There were 67 sites (includes flats35-Nisqually Delta E.) sampled in 2005 and 2006 that were tested for year-to-year change in *Z. marina* area at the site-level (Table 2-3, Figure 3-7, Appendix E). From 2005-2006, five sites showed an observed decrease in *Z. marina* area, whereas no sites showed an increase in *Z. marina* area during the same interval ( $\alpha=0.05$ ; Figure 3-7, Figure 3-8). Three of the five sites with evidence of *Z. marina* decline were core sites. Declining sites were located in three out of five regions, with the greatest number of declines in the southern reaches of the *Central Puget Sound Region*.

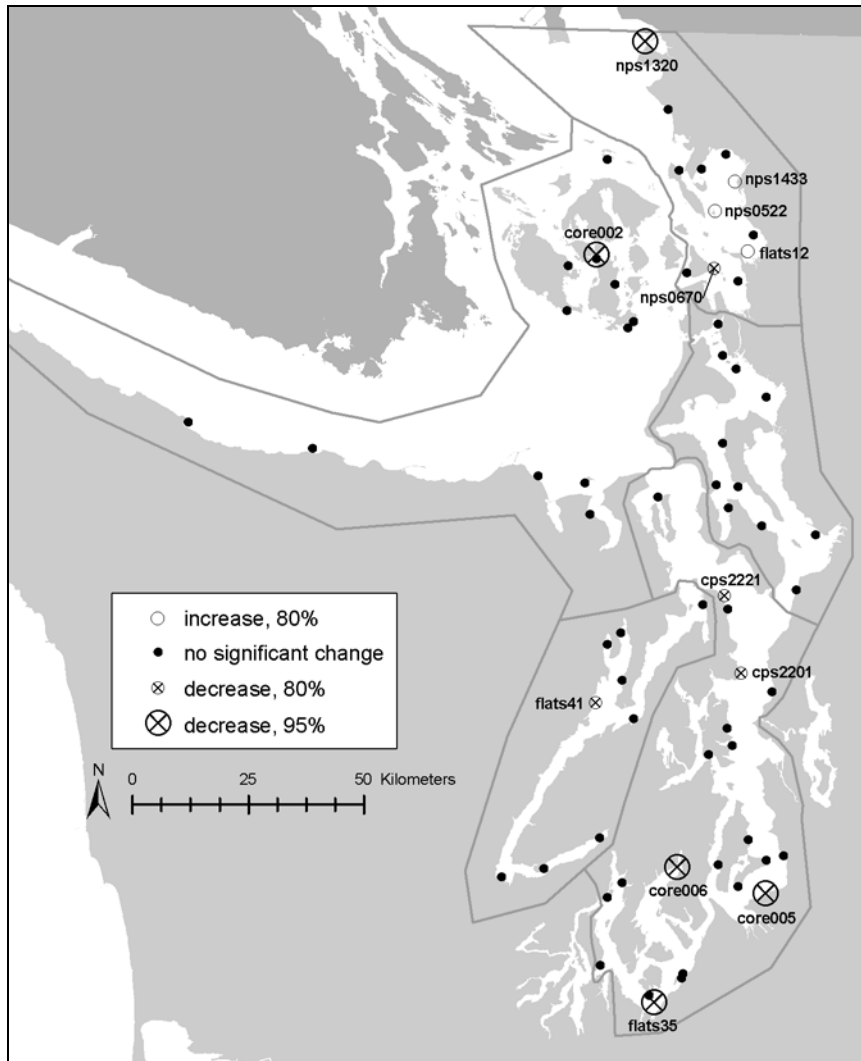
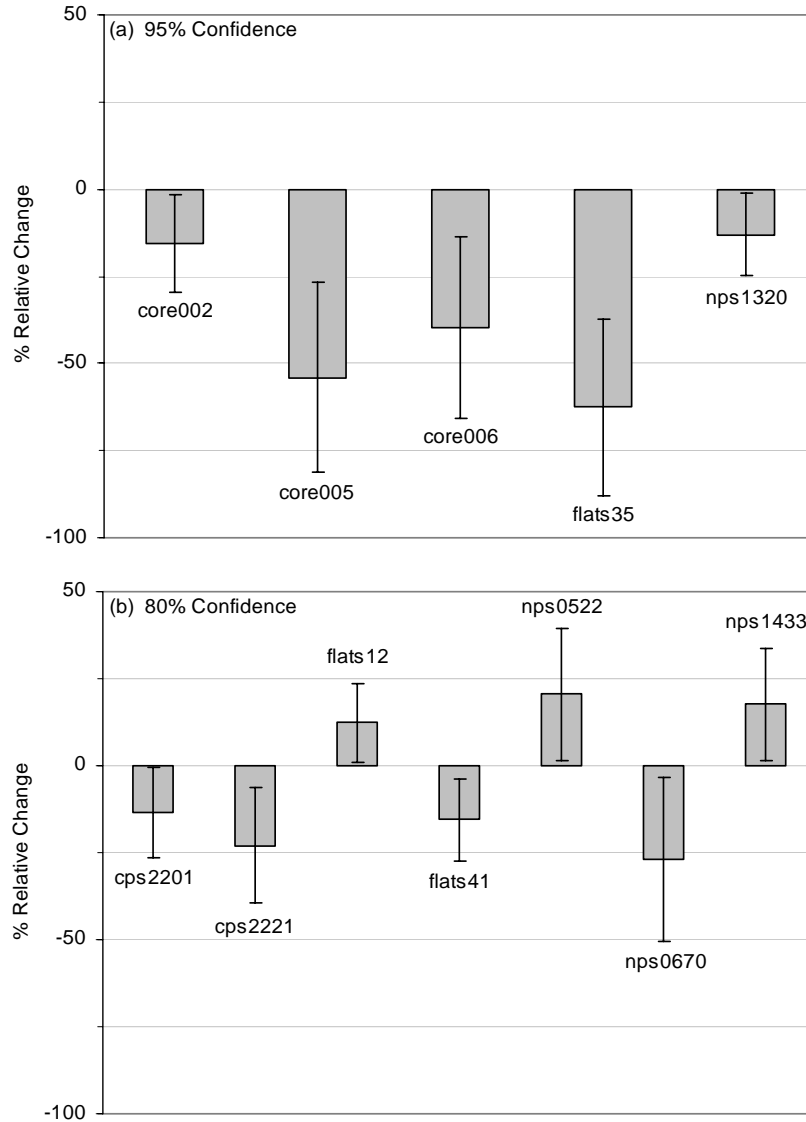


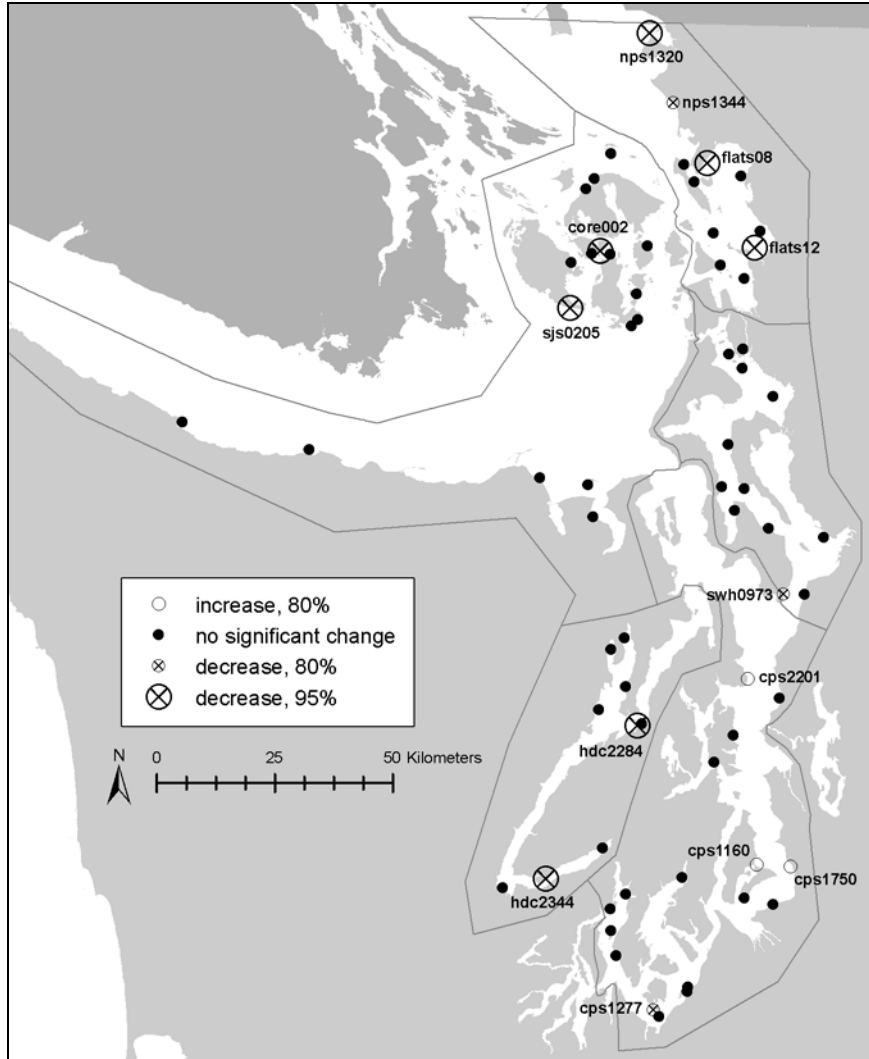
Figure 3-7. Sites with significant relative change in *Z. marina* area from 2005 to 2006 ( $\alpha=0.2$  and  $\alpha=0.05$ ). A total of 67 matching sites were sampled in 2005 and in 2006. Sites that were tested but exhibited no significant change are also shown.





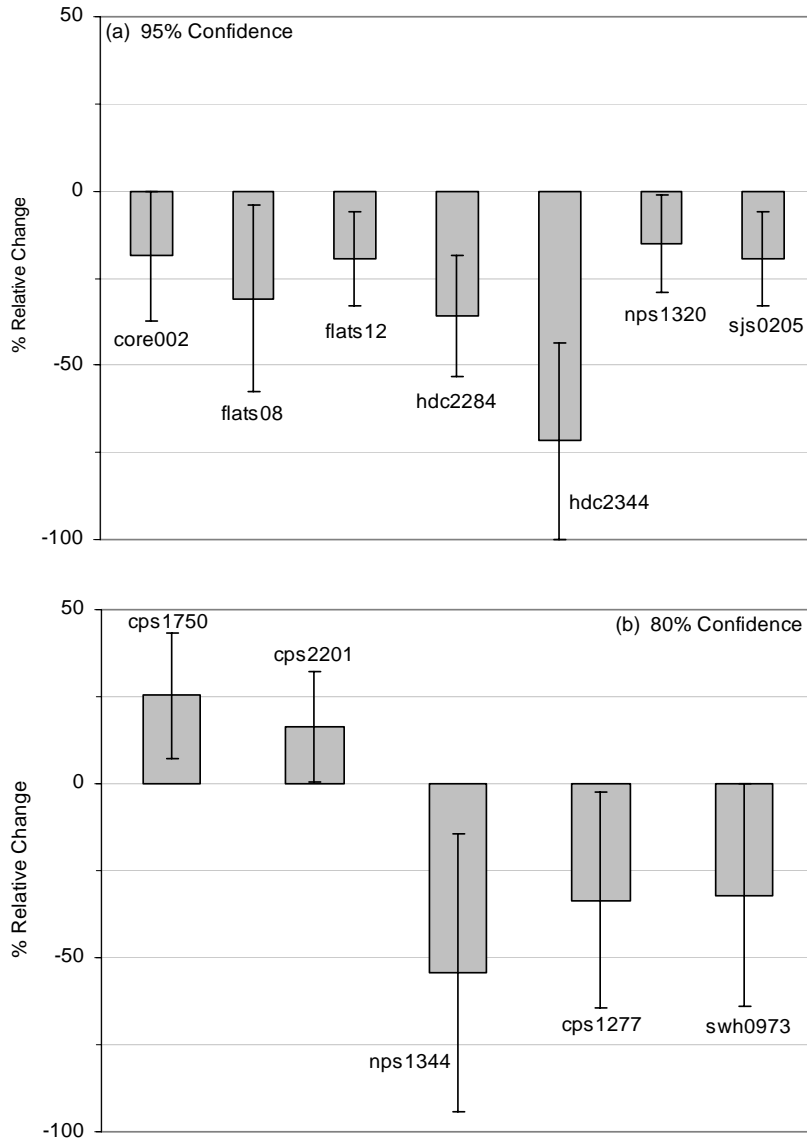
**Figure 3-8. Estimated relative change in *Z. marina* area from 2005 to 2006 for sites with significant change ( $\alpha=0.2$  and  $\alpha=0.05$ ). Error bars are associated 95% confidence intervals.**

There were 66 sites that were sampled in 2006 and 2007 that were tested for change in *Z. marina* area. Out of the 66 sites sampled there were seven sites that had a significant decrease in *Z. marina* area while the remainder showed no significant change in *Z. marina* area ( $\alpha=0.05$ ; Figure 3-9, Figure 3-10). The sites that had a significant change from 2006 to 2007 were located in the *North Puget Sound Region*, *San Juan-Straits Region*, and *Hood Canal Region* (Figure 3-9).



**Figure 3-9. Sites with significant relative change in *Z. marina* area between 2006 and 2007 ( $\alpha=0.2$  and  $\alpha=0.05$ ). A total of 66 matching sites were sampled in 2006 and in 2007. Sites that were tested but exhibited no significant change are also shown.**

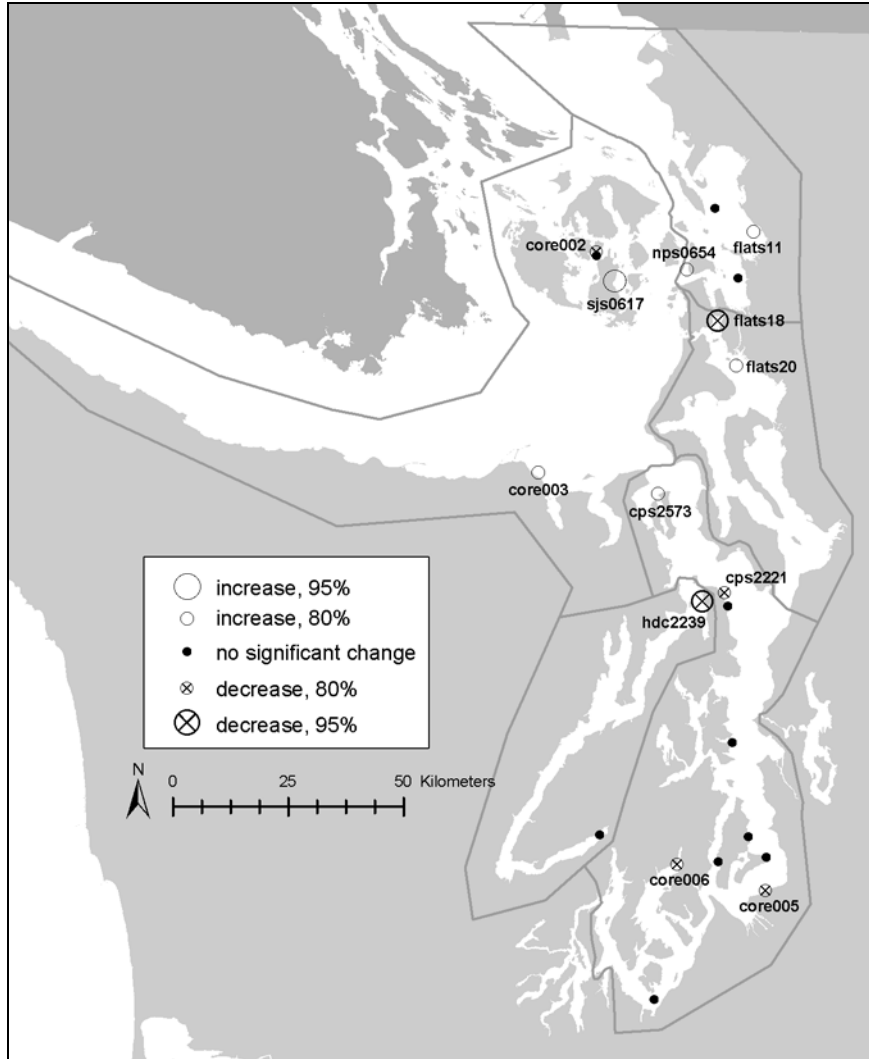
An additional five sites had significant changes (2 increased, 3 decreased) from 2006 to 2007 in *Z. marina* area when tested at the 80% confidence interval (Figure 3-10).



**Figure 3-10. Magnitude of estimated change in *Z. marina* area for sites with significant change from 2006 to 2007 ( $\alpha=0.2$  and  $\alpha=0.05$ ). Error bars shown are 95% confidence intervals.**

#### Five-Year Trends in Site-Level *Zostera marina* Area

Through 2006, 22 sites have been sampled for five or more consecutive years. Only one site (*sjs0617-Lopez Sound Road*) had a significant increase in *Z. marina* area between 2002 - 2006 ( $\alpha=0.05$ ; Figure 3-11, Table 3-3). Two sites (*flats18-Similk Bay* and *hdc2239-Hood Canal NE*) had a significant decrease in *Z. marina* area ( $\alpha=0.05$ ; Figure 3-11, Table 3-3).



**Figure 3-11. Sites with significant trends in *Z. marina* area estimates through 2006 ( $\alpha=0.2$  and  $\alpha=0.05$ ). Sites that exhibited no significant trend for five or more years are also shown.**

In addition, there were five sites that showed a significant increase in *Z. marina* and four sites that showed a significant decrease in *Z. marina* area for five or more years when tested at  $\alpha=0.2$  (Table 3-3). Ten sites sampled for five or more consecutive years through 2006 showed no significant change in *Z. marina* area when tested at  $\alpha=0.2$  and  $\alpha=0.05$  (Table 3-3, Appendix G, Appendix H).

**Table 3-3. *Zostera marina* area trends observed for five years or more through 2006 at two levels of significance. The estimated trends are based on the regression slope and the percentage change values are relative to the *Z. marina* area calculated the first year the site was sampled.**

Direction of Trend	Site code	Site name	Years sampled	p - value	$\alpha$	Estimated trend (ha yr <sup>-1</sup> )	Equivalent annual relative change (% yr <sup>-1</sup> )
increasing area	sjs0617	Lopez Sound Road	5	0.020	0.05	+0.2	+15.6
	core003	Jamestown	7	0.066	0.2	+17.4	+4.6
	flats11	Samish Bay N.	6	0.096	0.2	+20.4	+1.8
	flats20	Skagit Bay N.	7	0.112	0.2	+8.9	+4.6
	cps2573	Ft. Flagler	5	0.157	0.2	+0.3	+8.9
	nps0654	Yellow Reef	5	0.176	0.2	+0.3	+3.4
decreasing area	flats18	Similk Bay	7	0.006	0.05	-2.0	-4.7
	hdc2239	Hood Canal NE	5	0.048	0.05	-1.0	-9.4
	core002	Picnic Cove	7	0.155	0.2	-0.1	-3.7
	core005	Dumas Bay	7	0.056	0.2	-0.3	-11.9
	core006	Burley Spit	7	0.137	0.2	-0.5	-9.9
	cps2221	Point No Point	5	0.114	0.2	-0.5	-5.3
no trend	core001	Padilla Bay	5				
	core004	Lynch Cove	7				
	flats35	Nisqually Delta E.	7				
	flats37	Wing Point	5				
	cps1128	Paradise Cove	5				
	cps1156	Klahanic Beach	5		no trend	no trend	no trend
	cps1164	N. of Pt. Robinson	5				
	cps2218	Pilot Pt.	5				
	nps0522	Eliza Island NE	5				
sjs0649	Canoe Island	5					

In 2007, 23 sites which had been sampled for five years or more were tested for trends in *Z. marina* area. One site, *flats20-Skagit Bay N.*, had a significant increasing trend in *Z. marina* measured over eight years from 2000 to 2007 (Figure 3-12, Table 3-4, Appendix I, Appendix J). Five sites had significant declining trends at the 95% level of confidence and 17 sites showed no trend in *Z. marina* area (Figure 3-12, Table 3-4, Appendix I, Appendix J).

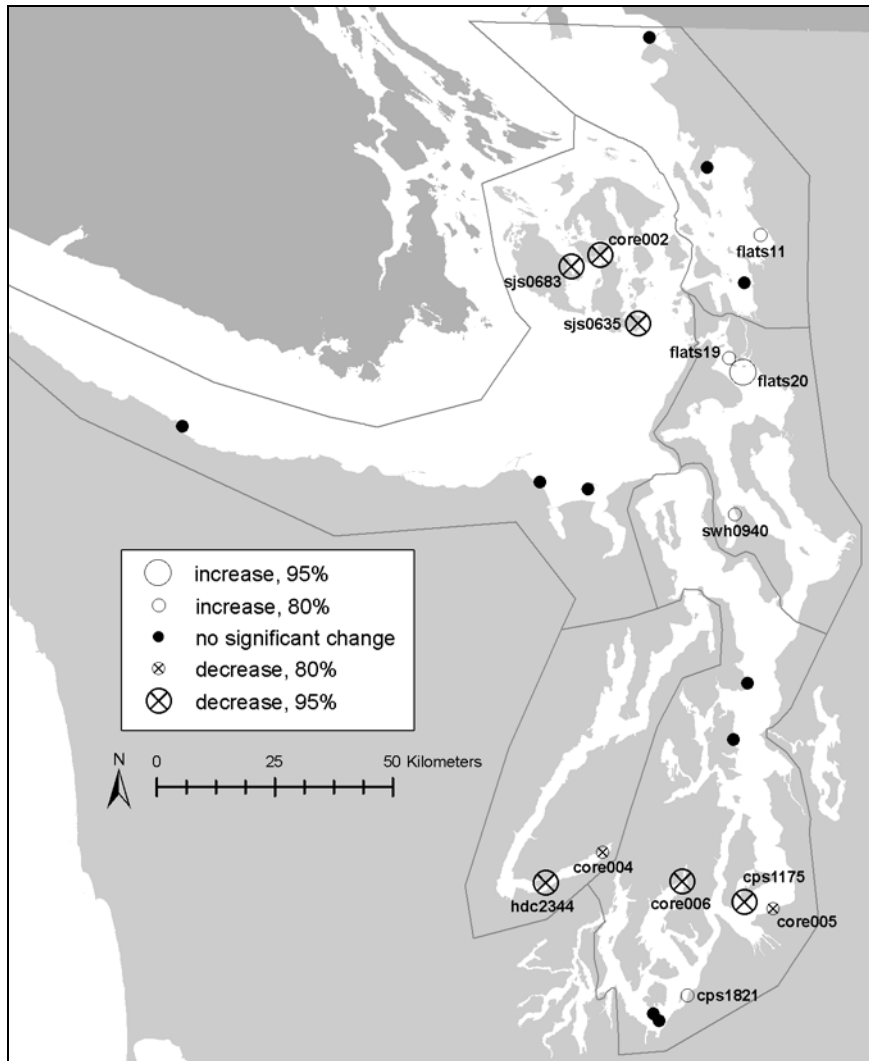


Figure 3-12. Sites sampled in 2007 with significant trends in *Z. marina* area for five years or more ( $\alpha=0.2$  and  $\alpha=0.05$ ). Sites that were tested but exhibited no significant trend are also shown.

**Table 3-4. *Zostera marina* area trends observed for five years or more at sites sampled through 2007. The estimated trends are based on the regression slope and the percentage change.**

Direction of Trend	Site code	Site name	Years sampled	p - value	$\alpha$	Estimated trend (ha yr <sup>-1</sup> )	Equivalent annual relative change (% yr <sup>-1</sup> )
increasing area	flats20	Skagit Bay N.	8	0.024	0.05	8.6	4.4
	flats11	Samish Bay N.	7	0.033	0.2	16.5	1.4
	flats19	Pull and Be Damned	5	0.079	0.2	5.0	3.2
	cps1821	Cormorant Passage	5	0.042	0.2	0.1	11.9
	swh0940	Holmes Harbor E.	5	0.137	0.2	0.2	2.4
decreasing area	core002	Picnic Cove	8	0.018	0.05	-0.2	-4.1
	core006	Burley Spit	8	0.017	0.05	-0.6	-11.7%
	cps1175	Piner Point	5	0.016	0.05	-0.2	-3.7
	hdc2344	Great Peninsula	5	0.011	0.05	-0.5	-21.9
	sjs0635	Watmough Bay	5	0.008	0.05	-0.5	-15.4
	sjs0683	Brown Island N.	5	0.039	0.05	-0.04	-4.1
	core004	Lynch Cove	8	0.143	0.2	-4.9	-4.4
core005	Dumas Bay	8	0.027	0.2	-0.2	-9.2	
no trend	core001	Padilla Bay	7				
	core003	Jamestown	8				
	flats08	Portage Bay	5				
	flats35	Nisqually Delta E.	8				
	cps1069	Murden Cove	5		no trend	no trend	no trend
	cps1277	Thompson Cove	5				
	cps2201	S. of President Point	5				
	nps1320	Semiahmoo Spit	5				
	sjs0989	Protection Island SW	5				
sjs2775	Pysht River	5					

### 3.4 *Zostera marina* Depth Distribution

#### 3.4.1 2006 and 2007 *Zostera marina* Depth Distribution

The minimum and maximum depths (MLLW) of *Z. marina* were recorded on all transects at all sites sampled in 2006 and 2007 throughout the greater Puget Sound study area (Table 3-5, Appendix L, Appendix N) and in the *Saratoga-Whidbey Basin* focus area (Appendix M) and the *Central Puget Sound Region* focus area (Appendix O). The deepest *Z. marina* depth was observed in 2006 in the *San-Juan Straits Region* (-12.4 m, *sjs0205-E. of Eagle Point*). For both years the deepest mean maximum *Z. marina* depth occurred in the *San Juan-Straits Region* followed by *North Puget Sound* and *Central Puget Sound Regions*.

**Table 3-5. Range of maximum and minimum *Z. marina* depth (MLLW) for all strata by region in 2000-2007. The 2007 depth extremes that expanded the range relative to 2006 values are in bold with the 2006 value in parentheses.**

Region	Minimum Depth (m)		Maximum Depth (m)	
	Absolute	Range in Site Means	Absolute	Range in Site Means
Central Puget Sound	+1.6	+1.1 to -3.5 (-3.0)	-11.9	-0.5 to -6.9
Hood Canal	+1.8	+1.1 to -2.6 (-1.7)	<b>-7.6</b> (-7.3)	-1.4 to -4.8
North Puget Sound	+1.4	+0.6 to -3.3	-8.4	-0.7 to -6.6
San Juan/Straits	+1.5	0.4 to -5.4	-12.4	-0.4 to -11.0
Saratoga/Whidbey	+1.3	0.5 to -1.7	-8.0	-0.3 to -4.5

#### 3.4.2 Site-Level Change in *Zostera marina* Depth from 2005 to 2006

##### Mean maximum depth

Seven sites, out of the 67 paired sites, showed significant changes in mean maximum *Z. marina* bed depth from 2005 to 2006 (Figure 3-13, Table 3-6). *Flats67-Fossil Bay* was the only site that had a significant change in maximum depth when tested at  $\alpha=0.05$ . The mean deep edge depth of the *Z. marina* at *flats67-Fossil Bay* was -3.4 m in 2006 compared to -5.4 m in 2005. The six other sites showed a significant change in mean maximum *Z. marina* bed depth when tested at  $\alpha=0.2$ . At four of these sites the deep edge depth of *Z. marina* was deeper in 2006 compared to 2005. The deep edge depth of *Z. marina* at the other two sites was shallower in 2006 compared to 2005. Overall, there were no observed spatial patterns in the changes of the maximum deep edge depth of *Z. marina* across greater Puget Sound.



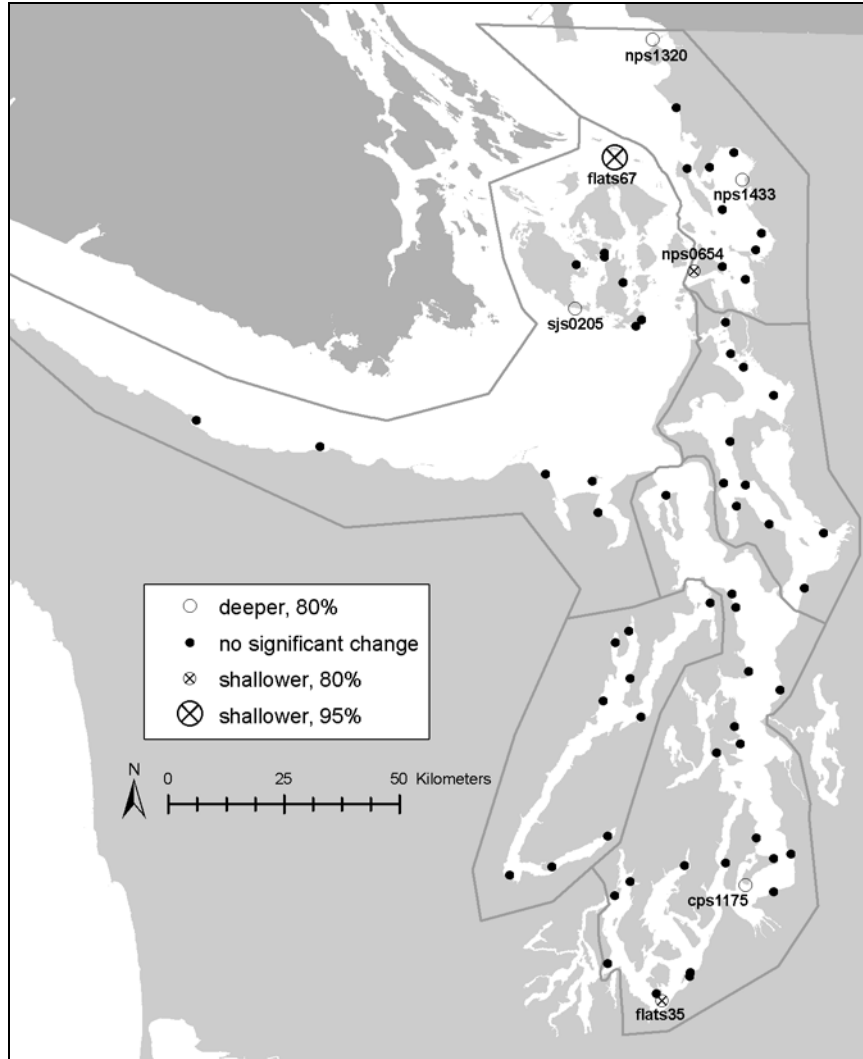


Figure 3-13. Sites with significant change in mean maximum *Z. marina* depth from 2005 to 2006 ( $\alpha=0.2$  and  $\alpha=0.05$ ). Sites that exhibited no significant change in maximum depth are also shown.

Table 3-6. Significant changes in mean maximum *Z. marina* depth from 2005 to 2006 tested at two different levels of significance ( $\alpha=0.2$  and  $\alpha=0.05$ ).

Deep edge direction of change	Site	$\alpha$	Mean maximum depth (m)				
			2005	2006	Difference	Lower CI	Upper CI
deeper (expanding)	cps1175	0.2	-1.9	-2.7	-0.8	-1.3	-0.3
	nps1320	0.2	-3.6	-3.9	-0.3	-0.6	0.0
	nps1433	0.2	-3.0	-3.4	-0.4	-0.7	-0.1
	sjs0205	0.2	-10.3	-11.0	-0.7	-1.2	-0.2
shallower (receding)	flats67	0.05	-5.4	-3.4	2.0	1.4	2.6
	flats35	0.2	-1.0	-0.7	0.3	0.0	0.6
	nps0654	0.2	-5.4	-4.3	0.9	0.1	1.9

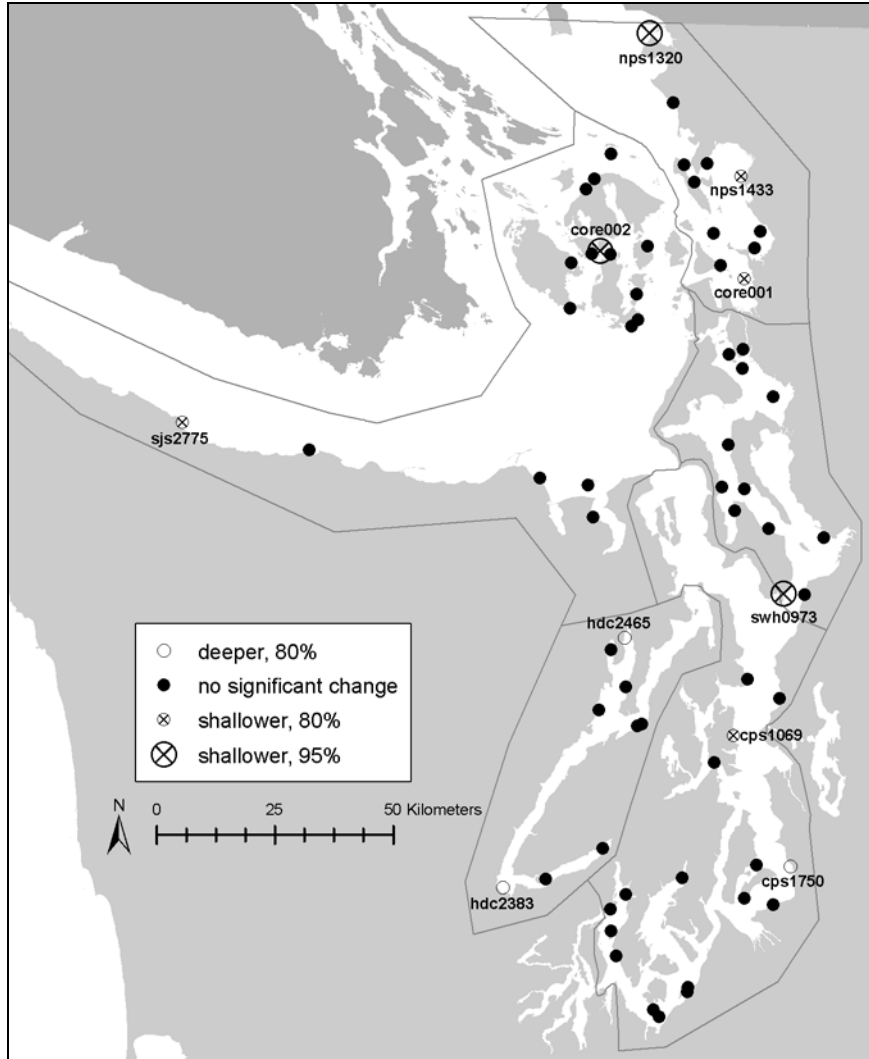


Figure 3-14. Sites with significant change in mean maximum *Z. marina* bed depth between 2006 and 2007 ( $\alpha=0.2$  and  $\alpha=0.05$ ). Sites that were tested but exhibited no significant change are also shown.

**Table 3-7. Significant changes in mean maximum *Z. marina* depth between 2006 and 2007.**

Deep edge direction of change	Site	$\alpha$	Mean maximum depth (m)				
			2006	2007	Difference	Lower CI	Upper CI
deeper (expanding)	cps1750	0.2	-3.3	-3.8	-0.5	-1.0	0.0
	hdc2383	0.2	-1.4	-2.0	-0.6	-1.3	0.0
	hdc2465	0.2	-3.3	-3.6	-0.3	-0.7	0.1
shallower (receding)	core002	0.05	-5.3	-5.0	0.3	0.0	0.8
	nps1320	0.05	-3.9	-3.3	0.6	0.2	0.6
	shw0973	0.05	-3.8	-3.3	0.5	0.0	1.0
	core001	0.2	-4.1	-3.3	0.8	-0.1	1.7
	cps1069	0.2	-4.2	-3.7	0.5	0.0	1.0
	nps1433	0.2	-3.4	-3.2	0.2	-0.1	0.5
	sis2775	0.2	-6.4	-6.0	0.4	-0.2	1.0

### Mean minimum depth

Eight sites, out of the 67 paired sites, showed a significant change ( $\alpha=0.2$  and  $\alpha=0.05$ ) in the mean minimum *Z. marina* depth from 2005 to 2006 (Figure 3-15, Table 3-8). The mean minimum depth was shallower at two sites in 2006 compared to 2005 ( $\alpha=0.05$ ). Two additional sites observed a similar direction of change at  $\alpha=0.2$ . The mean minimum depth was deeper at four sites ( $\alpha=0.2$ ).

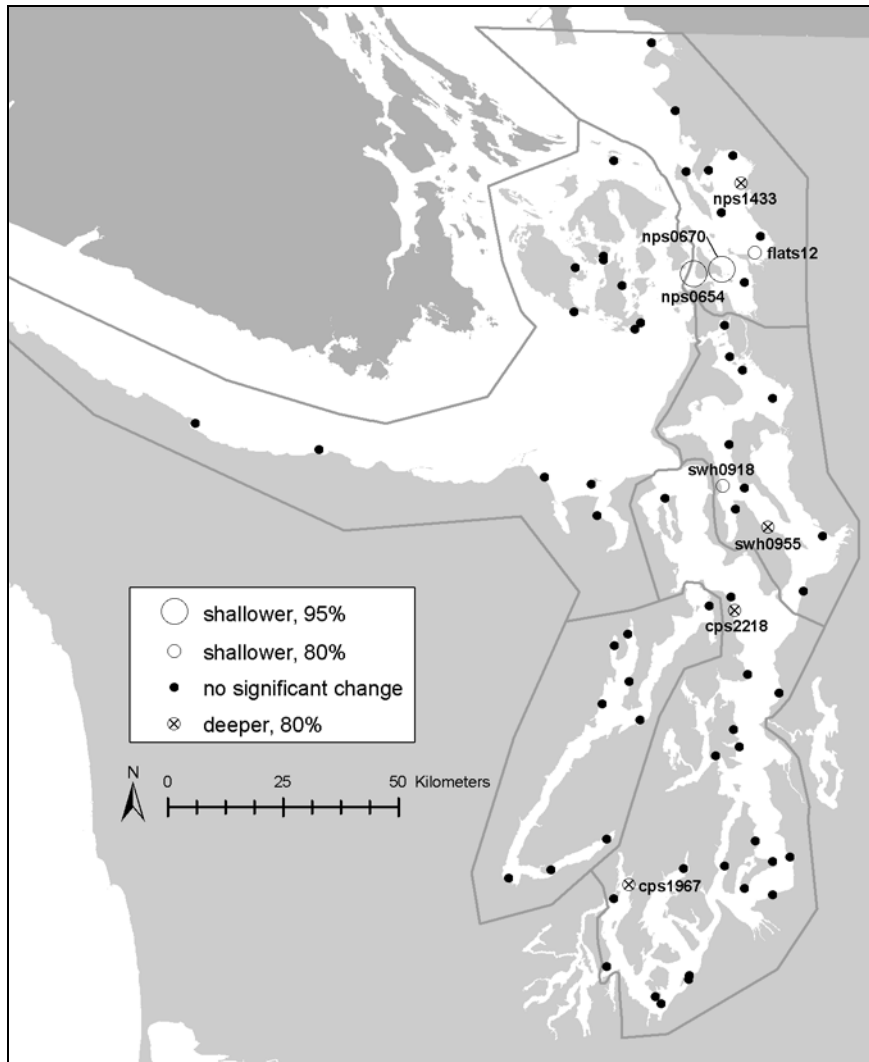
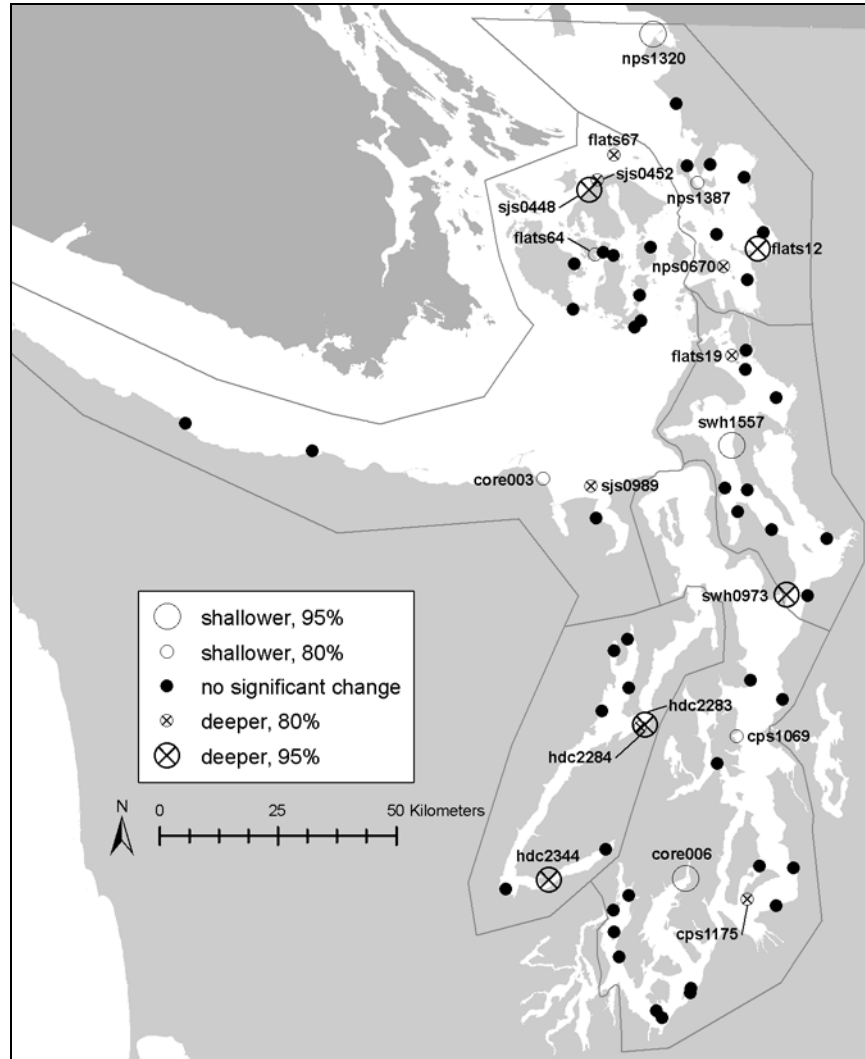


Figure 3-15. Sites with significant change in mean minimum *Z. marina* depth from 2005 to 2006 ( $\alpha=0.2$  and  $\alpha=0.05$ ). Sites that were tested but exhibited no significant change are also shown.

Table 3-8. Significant changes in mean minimum *Z. marina* depth from 2005 to 2006 when tested at two different levels of significance ( $\alpha=0.2$  and  $\alpha=0.05$ ).

Shallow edge direction of change	Site	$\alpha$	Mean minimum depth (m)				
			2005	2006	Difference	Lower CI	Upper CI
shallower (expanding)	nps0654	0.05	-1.9	-0.9	1.0	0.4	1.6
	nps0670	0.05	-2.0	-0.7	1.3	1.0	1.6
	flats12	0.2	0.4	0.6	0.2	0.0	0.3
	swh0918	0.2	-0.5	-0.2	0.3	0.1	0.5
deeper (receding)	cps1967	0.2	-0.8	-1.2	-0.4	-0.7	-0.1
	cps2218	0.2	0.9	0.3	-0.6	-1.0	-0.2
	nps1433	0.2	-0.4	-0.9	-0.5	-1.0	0.0
	swh0955	0.2	0.0	-0.4	-0.4	-0.7	-0.1

Between 2006 and 2007 eight sites, out of the 66 paired sites, showed a significant change ( $\alpha=0.05$ ) in the mean minimum *Z. marina* depth from 2006 to 2007 (Figure 3-16, Table 3-9). The mean minimum depth was deeper at five sites and shallower at three in 2007 compared to 2006 ( $\alpha=0.05$ ).



**Figure 3-16.** Sites with significant change in mean minimum *Z. marina* depth between 2006 and 2007 ( $\alpha=0.2$  and  $\alpha=0.05$ ). Sites that were tested but exhibited no significant change are also shown.

**Table 3-9. Significant changes in mean minimum *Z. marina* depth between 2006 and 2007 when tested at two different levels of significance ( $\alpha=0.2$  and  $\alpha=0.05$ ).**

Shallow edge direction of change	Site	$\alpha$	Mean minimum depth (m)				
			2006	2007	Difference	Lower CI	Upper CI
shallower (expanding)	core006	0.05	-1.1	-0.9	0.2	0.1	0.3
	nps1320	0.05	-0.3	-0.1	0.2	0.0	0.4
	swh1557	0.05	-1.1	-0.7	0.4	0.0	0.8
	core003	0.2	-0.3	0.0	0.3	-0.2	0.8
	flats64	0.2	-1.3	-1.2	0.1	0.0	0.3
	cps1069	0.2	-0.4	-0.2	0.2	-0.1	0.5
	nps1387	0.2	-0.9	-0.1	0.8	0.0	1.5
deeper (receding)	flats12	0.05	0.6	0.3	-0.3	-0.4	0.0
	hdc2283	0.05	-0.1	-0.4	-0.3	-0.7	-0.1
	hdc2344	0.05	-1.7	-2.6	-0.9	-1.6	-0.3
	sjs0448	0.05	-0.1	-0.8	-0.7	-1.2	0.6
	swh0973	0.05	0.4	-0.5	-0.9	-1.2	-0.6
	flats19	0.2	0.0	-0.4	-0.4	-0.9	0.0
	flats67	0.2	-2.6	-3.1	-0.5	-1.2	0.2
	cps1175	0.2	-0.2	-0.4	-0.2	-0.6	0.1
	hdc2284	0.2	-0.2	-0.4	-0.2	-0.4	0.1
	nps0670	0.2	-0.7	-0.9	-0.2	-0.3	0.0
	sjs0452	0.2	-1.1	-1.4	-0.3	-0.9	0.2
	sjs0989	0.2	-0.2	-0.4	-0.2	-0.5	0.1

### 3.5 Multiple Parameter Assessment

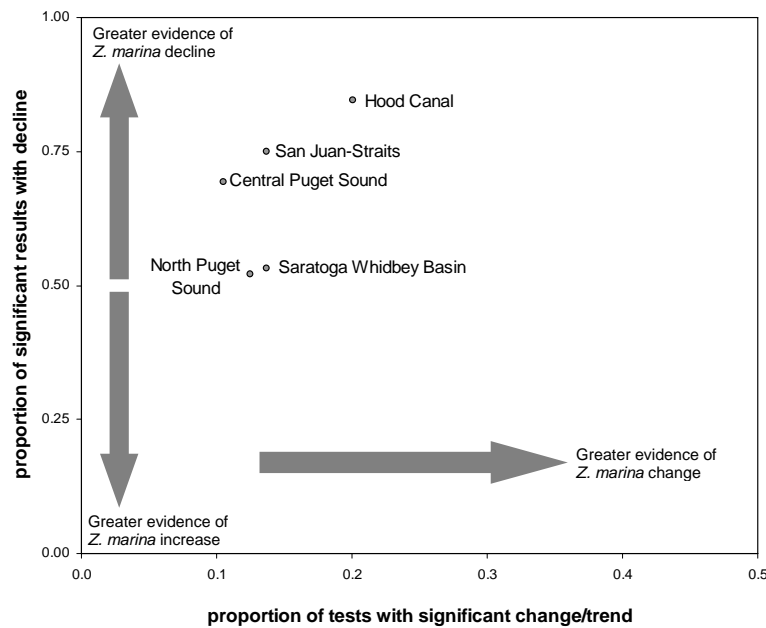
#### 3.5.1 Assessment of Region-Level *Zostera marina* Change

The multiple parameter assessment evaluated regional trends by quantifying the proportion of significant changes among all *Z. marina* parameter tests within each region from 2000 to 2007 (Table 3-10). The proportion of significant *Z. marina* parameter assessments provides an indicator of change within a region and the proportion of negative or positive changes indicates the status of the resource in the region (Table 3-10, Figure 3-17). Every region exhibited both positive and negative changes in four of the five measured parameters from 2000-2007 (Table 3-10).

The *Hood Canal Region* had the largest proportion of significant and negative changes in *Z. marina* parameters compared to the other four regions in the study area (Table 3-10, Figure 3-17). The *San Juan-Straits* and *Central Puget Sound Regions* had greater numbers of significant negative changes to *Z. marina* than positive changes. In contrast, the *Saratoga-Whidbey* and *North Puget Sound Regions* did not show a high proportion of declines relative to increases. The *North Puget Sound Region* was the region with the greatest proportion of significant positive changes (48%) and the lowest frequency of change (Table 3-10, Figure 3-17).

**Table 3-10. Results of multiple parameter assessment of regional *Z. marina* condition based on data collected from 2000 – 2007. The number of measurable changes within a region was quantified and compared to the number of significant positive or negative changes ( $\alpha=0.05$ ). The *Hood Canal Region* has been identified as the region of highest concern for *Z. marina* losses due to the high proportion of significant negative results.**

	CPS				HDC				NPS				SJS				SWH			
	No. Change Tests	Significant change	Positive change	Negative change	No. Change Tests	Significant change	Positive change	Negative change	No. Change Tests	Significant change	Positive change	Negative change	No. Change Tests	Significant change	Positive change	Negative change	No. Change Tests	Significant change	Positive change	Negative change
Region-level area	3	0	0	0	5	0	0	0	4	0	0	0	5	0	0	0	5	0	0	0
Site-level area	133	9	0	9	62	13	1	12	60	8	3	5	115	15	1	14	77	8	4	4
Deep edge depth	107	12	4	8	59	8	0	8	55	7	4	3	94	12	2	10	71	8	5	3
Shallow edge depth	107	16	7	9	58	13	5	8	54	8	4	4	93	12	6	6	71	14	6	8
5-year area trends	20	2	1	1	10	5	0	5	11	0	0	0	14	5	2	3	9	2	0	2
Proportion of significant results	0.11				0.20				0.13				0.14				0.14			
Proportion of significant positive results	0.31				0.15				0.48				0.25				0.47			
Proportion of significant negative results	0.69				0.85				0.52				0.75				0.53			



**Figure 3-17. Proportion of significant declining results in the multiple parameter *Z. marina* assessment relative to the proportion of significant *Z. marina* parameter changes in each region from 2000 – 2007.**

3.5.2 Assessment of Site-Level *Zostera marina* Change

Sites sampled in 2006 and in 2007 were identified through the multiple parameter assessment to have strong or very strong evidence of declining *Z. marina* (Appendix U).

The Central *Puget Sound Region* had the most sites (6) identified in the very strong and strong evidence of decline categories followed by the *Hood Canal* (3), *San Juan-Straits* (3), *North Puget Sound* (1) and *Saratoga Whidbey Basin Regions* (1) (Table 3-11).

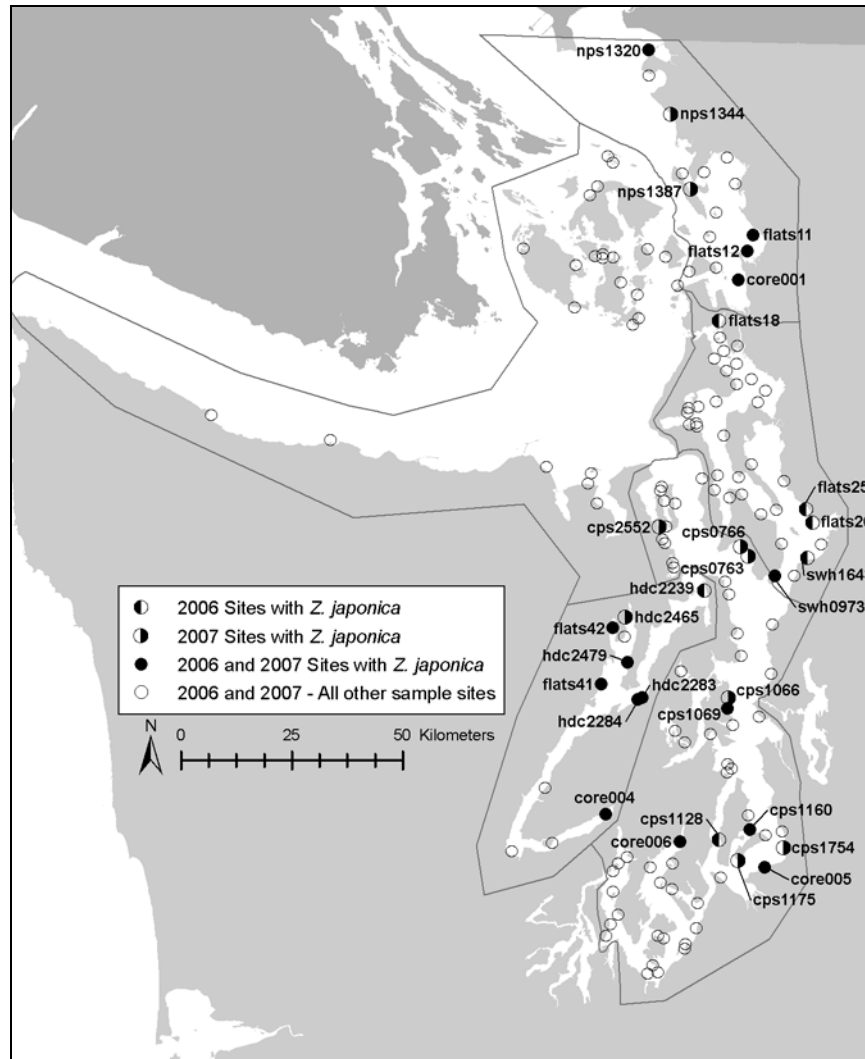
**Table 3-11. Sites identified in 2006 and 2007 by the multiple parameter assessment as having a strong or very strong evidence of *Z. marina* decline. The last column indicates whether the site will be sampled in 2008 or when the site rotated out of the SVMP sampling after the year listed in parentheses (.). Sites with previous evidence of decline are also listed.**

category	site code	site name	region	remains in sample 2008 pool?
very strong evidence of decline	core002	Picnic Cove	sjs	yes
	core006	Burley Spit	cps	yes
	cps1175	Piner Point	cps	no (2007)
	hdc2239	Hood Canal NE	hdc	no (2006)
	hdc2344	Great Peninsula	hdc	no (2007)
strong evidence of decline	core005	Dumas Bay	cps	yes
	cps1069	Murden Cove	cps	no (2007)
	cps2221	Point No Point	cps	no (2006)
	flats26	Snohomish Delta North	swh	yes
	flats41	Dosewallips	hdc	yes
	flats35	Nisqually Delta E.	cps	no (2006)
	nps1320	Semiahmoo Spit	nps	no (2007)
	sjs0635	Watmough Bay	sjs	no (2007)
sjs0683	Brown Island North	sjs	no (2007)	
sites with previous evidence of decline	flats18	Similk Bay	swh	no (2005)
	flats53	Westcott Bay	sjs	no (2001)
	cps1686	Fort Lawton	cps	no (2004)
	flats37	Wing Point	cps	no (2006)
	flats43	Dabob Bay	hdc	no (2005)
	flats62	Swifts Bay	sjs	no (2004)
	hdc2338	Across from Union	hdc	no (2005)
	hdc2345	Sisters Point	hdc	no (2001)
	hdc2359	Lynch Cove Fringe	hdc	no (2005)
	hdc2465	SE of Dabob Bay	hdc	no (2006)
	hdc2529	S. of Tala Point	hdc	no (2005)
	nps0059	Sinclair Island	nps	no (2005)
	nps0654	Yellow Reef	nps	no (2006)
	nps1363	Village Point	nps	no (2004)
	sjs0081	Broken Point	sjs	no (2005)
swh1556	NW Camano Island	swh	no (2004)	
swh1625	S. of Tulalip Bay	swh	no (2005)	



### 3.6 Observations of *Zostera japonica* and *Phyllospadix* spp.

In 2006, *Z. japonica* was observed at 21 sites throughout Puget Sound (Figure 3-18). *Zostera japonica* was observed in the northern and southern part of the *Hood Canal* and the *Saratoga-Whidbey Basin Regions*, and throughout the *Central Puget Sound Region*. *Zostera japonica* was not observed in the *San Juan-Straits Region* in 2006 and 2007.



**Figure 3-18.** Sites where *Z. japonica* was observed during the 2006 and 2007 SVMP sampling.

The presence of *Z. japonica* and surfgrass, *Phyllospadix* spp. has been documented at the SVMP sites since 2004. *Zostera japonica* has been observed at 39 sites and *Phyllospadix* spp. has been observed at four sites (Figure 3-19). The sites where *Z. japonica* was observed in 2006 varied from the previous year due to the changes in the location of the focus area effort. In 2006, the *Saratoga – Whidbey Basin* focus area had fewer sites with *Z. japonica* compared to the 2005 *Hood Canal Region* focus area effort. In addition, *Z.*

*Z. japonica* was observed at *flats18-Similk Bay* in 2005 but not in 2006. It is unlikely that *Z. japonica* no longer grows at *flats18-Similk Bay*; instead, *Z. japonica* was probably not observed due to the random location of the transects, video quality or the minimum depth at which the video transects started.

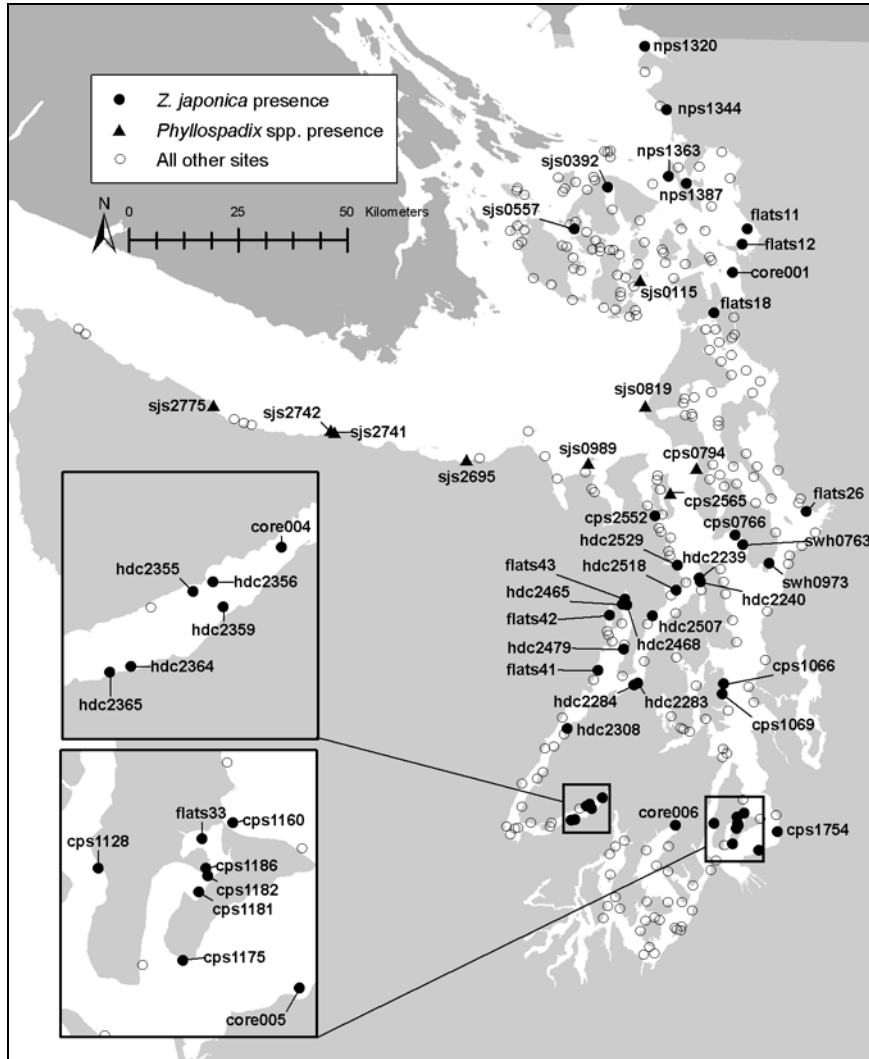


Figure 3-19. The SVMP sites where *Z. japonica* or *Phyllospadix* spp. have been observed since 2004.

The SVMP will continue to record observations of *Z. japonica* and *Phyllospadix* spp. throughout Puget Sound to track broad patterns in species distribution. In addition, it is important to assess the ecological functions and values that *Z. japonica* provides and the competitive interactions it has with *Z. marina*.

## 4 Discussion

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### 4.1 Importance of *Zostera marina*

*Zostera marina* beds provide many ecological functions that are important to the nearshore ecosystem in Puget Sound. *Zostera marina* creates complex habitat that supports a diverse food web including fish, invertebrates, and waterfowl. *Zostera marina* also produces oxygen, dampens wave energy, absorbs nutrients and promotes conditions that facilitate organic matter mineralization and sedimentation. *Zostera marina* has been recognized as an ecological indicator throughout its range (Dennison et al 1993, Krause-Jensen et al. 2005, Lee et al. 2004, Short et al. 1993), responding to natural and anthropogenic activities that modify its habitat and the water quality in Puget Sound. Therefore, the presence and distribution of *Z. marina* in Puget Sound is a valuable indicator of environmental condition and ecosystem health for the region. The SVMP tracks the abundance and distribution of *Z. marina* and identifies areas where it is declining in Puget Sound.

### 4.2 Status and trends in Puget Sound

The SVMP provides a number of ways to assess status and trends in *Z. marina* abundance and depth distribution at different spatial scales. These results vary across temporal and spatial scales. While the observed declines are not sufficient to cause a significant decrease in the total sound-wide *Z. marina* area estimate, the combination of localized losses and the collective evidence of the multiple parameter analyses suggest that declines in *Z. marina* are persistent throughout three regions (*Hood Canal, San Juan-Straits* and *Central Puget Sound Regions*) and greater Puget Sound.

One indicator of change in *Z. marina* is the number of individual sites with declines in *Z. marina* compared to the number with gains over a one year period. Each year since program inception, there has been a greater number of sites with declines in *Z. marina* area relative to gains (Figure 3-6). And, in the last two years, there have been sites with *Z. marina* decline, but no corresponding sites with gains. The persistence of this imbalance suggests that these declines do not reflect natural site-level variability, but rather are indicative of a sound-wide pattern of decline.

Another indicator of sound-wide decline is the greater prevalence of long-term declining trends in *Z. marina* area than increasing trends at sites throughout Puget Sound. In 2006 and in 2007, there were more sites, sampled for 5 years or more, that had significant long-term declining trends in *Z. marina* (9% and 26% respectively) compared to sites with increasing trends (5% and 4% respectively). This indicator provides assessment of change in *Z. marina* area over a minimum of 5 years and provides insight as to whether the change is a result of yearly variability or an indication of persistent losses in *Z. marina*. Sites with significant annual declines or long-term declining trends in *Z. marina* area are strong

candidates for additional, more intensive analyses that investigate causes of decline. The SVMP refers such sites to DNR's Eelgrass Stressor-Response Project for further research into causal factors of *Z. marina* decline.

Although site level results indicate a pattern of decline throughout Puget Sound, the annual sound-wide status estimates and trend from 2000 to 2007 do not indicate a decline in overall *Z. marina* area that exceeds the precision of the results. This indicator provides a robust assessment of sound-wide *Z. marina* abundance, but the results are disproportionately affected by the stability of large sites (e.g. *core001-Padilla Bay*, *core003-Jamestown*, *core004-Lynch Cove*, *flats11-Samish Bay N.*, *flats12-Samish Bay S.*, *flats19-Pull and Be Damned*, *flats20-Skagit Bay N.*, *flats26-Snohomish Delta N.*, and *flats70-South Fork Skagit River*) in the study area that represent approximately 30% of the total *Z. marina* area.

### 4.3 Focus Area Regional Assessment

The findings of the more intensive focus area studies are important baseline data for status and trend detection at the region level. The estimate of *Z. marina* area for each region, sampled at five year intervals, improves the ability to detect change at different spatial scales. The *Saratoga-Whidbey Basin* and *Central Puget Sound Regions* will be sampled next in 2011 and 2012, respectively (Figure 4-1).

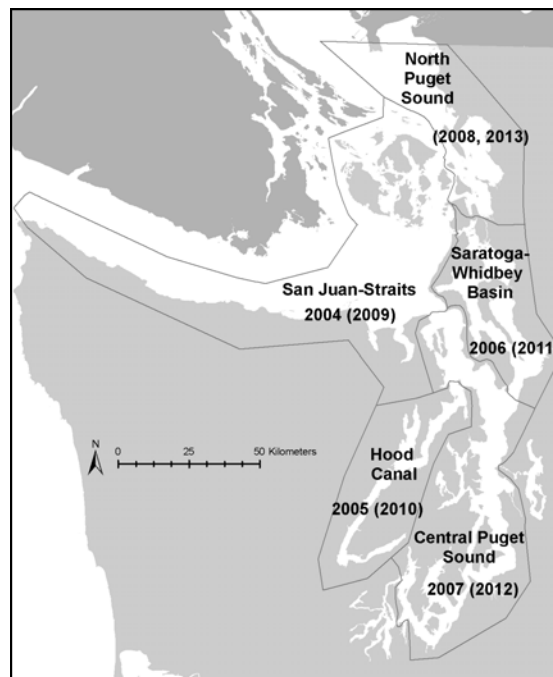


Figure 4-1. Map of study area regions and the year each region was sampled or will be sampled (year in parentheses).

The focus area results from *Saratoga-Whidbey Basin* and the *Central Puget Sound Region* provide important information on the unique characteristics of *Z. marina* habitat in different areas of Puget Sound. Although the total *Z. marina* area in each region is similar, the distribution among habitat types is markedly different. *Zostera marina* in the *Saratoga-Whidbey Basin* predominantly grows in the flats habitat type and provides a more expansive habitat resource than the narrow and wide fringe sites that are abundant in the *Central Puget Sound Region*.

The large, expansive flats in the *Saratoga-Whidbey Basin* are indicative of areas associated with several large river systems - the Skagit, Stillaguamish, and Snohomish Rivers. The maximum depth of *Z. marina* tends to be shallower near river deltas due to the abundance of sediments that affect water clarity and, ultimately, light availability (Boström et al. 2003; Nielsen et al. 2003; Krause-Jensen et al. 2005). In the *Saratoga-Whidbey Basin* the maximum depth of *Z. marina* is shallower compared the *Central Puget Sound Region* and this difference is likely due to the greater prevalence of the flats strata in the *Saratoga-Whidbey Basin* (Table 3-2, Figure 3-2).

With the completion of the focus area studies in *Saratoga-Whidbey Basin* and *Central Puget Sound Regions* in 2006 and 2007, the SVMP has completed initial sampling in four out of five regions in Puget Sound (Figure 4-1). After sampling in *North Puget Sound* in 2008, intensive sampling will return to the *San Juan – Straits*, the first region sampled in 2004. The intensive focus area studies will augment the sound-wide monitoring program through greater status and trend detection capabilities at the region level over 5 year periods.

#### 4.4 Areas of Concern

##### Individual Sites

The detection of *Z. marina* change at the site-level on a year-to-year and five-year time scale provides valuable information for managers prior to potentially irreversible seagrass loss (Kirkman 1996). A number of sites in Puget Sound are considered to be areas of concern due to significant *Z. marina* declines. *Zostera marina* loss at *flats53-Westcott Bay* and at sites in the *Hood Canal Region* (e.g. *core004-Lynch Cove*, *hdc2338-Across from Union*, *hdc2344-Great Peninsula*, *hdc2345-Sisters Point*, and *hdc2359-Lynch Cove Fringe*) has led to the initiation of more intensive research by the Eelgrass Stressor – Response Project. In addition, scientists from the University of Washington have been investigating changes in *Z. marina* at *core002-Picnic Cove* for a number of years. Some additional sites of concern because of significant declines in year-to-year and 5-year trends of *Z. marina* area include: *core005-Dumas Bay*, *core006-Burley Spit*, and *cps1175-Piner Point*. However, other sites (e.g. *flats18-Similk Bay* and *flats53-Westcott Bay*) with observed *Z. marina* decline will inevitably be removed from the sample pool due to the sampling with partial replacement design of the SVMP methods (Berry et al. 2003). Continued monitoring by DNR, academics and other groups at sites throughout the greater Puget Sound study area will provide valuable data on causal or correlative factors for *Z. marina* loss at different spatial and temporal scales.

### Hood Canal

The multi-parameter assessment identified the *Hood Canal Region* as the area of greatest concern for *Z. marina* losses. These findings are particularly relevant given the current scientific and political focus on environmental degradation in Hood Canal. At the site-level, the multiple parameter results identified seven sites that indicated *Z. marina* decline in the *Hood Canal Region*. Additional research has to be conducted to identify factors that cause *Z. marina* decline in the *Hood Canal Region*.

The SVMP will continue to monitor *Z. marina* in the *Hood Canal Region* through the yearly rotational sound-wide sampling. The yearly sound-wide sampling will provide site specific year-to-year *Z. marina* changes in the *Hood Canal Region* and an opportunity to compare the condition of *Z. marina* in the region relative to the other four regions. The next focus area effort in 2010 will provide a five-year *Z. marina* change assessment for the *Hood Canal Region* (Figure 4-1).

### San Juan Archipelago

The *San Juan Straits* also showed substantial evidence of decline, but the proportion of significant losses was slightly lower than in the *Hood Canal Region*. *Zostera marina* decline in the *San-Juan Straits Region* has been observed at specific sites and in the site- and region-level multiple parameter assessments (Table 3-10, Table 3-11, and Figure 3-17). The significant results from these tests support the need to further investigate causal factors for *Z. marina* decline in this region. The next intensive focus area sampling will take place in the *San Juan – Straits*, specifically in the San Juan Archipelago, in 2009 (Figure 4-1). These data will provide a detailed picture of changes in *Z. marina* abundance and distribution between 2004 and 2009.

## **4.5 Current Priorities**

The SVMP monitors *Z. marina* as part of the PSAMP to determine the health of Puget Sound for the Puget Sound Partnership. The SVMP accomplishes a number of tasks to meet its mandate to monitor the status and trends of *Z. marina* in Puget Sound efficiently and successfully.

The primary priorities identified by the SVMP for future sampling include:

1. Continue to monitor the status and trends of *Z. marina* throughout Puget Sound and in the annual focus areas to fulfill the goals identified by DNR, PSAMP, and the Puget Sound Partnership (PSP).
2. Provide timely results of *Z. marina* status and trends in annual SVMP reports, Puget Sound Reports, and in the State of the Sound publications.
3. Continue to provide technical support and data to collaborators and management on the status and trends of *Z. marina* and on sites and regions of concern.
4. Continue to work with the Eelgrass Stressor-Response Project, academics, concern citizen groups and other researchers who are investigating the causes of *Z. marina* decline.

With additional funding the SVMP should:

1. Continue to monitor sites with a strong evidence of *Z. marina* decline that rotate out of the annual sample pool.
2. Improve web-based data dissemination of detailed site level results.
3. Determine an historical estimate of *Z. marina* distribution and monitor additional sites to estimate *Z. marina* according to the PSP Action Areas.
4. Assess the distribution and abundance of other important vegetation in the nearshore habitats of Puget Sound.

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## 6 APPENDICES

### Appendix A *Z. marina* area estimates at 2006 sample sites

Site	Location	Approximate Latitude (decimal degrees)	Approximate Longitude (decimal degrees)	Date Sampled	Number of Transects	<i>Z. marina</i> Fraction Along Transects	<i>Z. marina</i> Area at Site (hectares)	Variance	Coefficient of Variation	Estimated <i>Z. marina</i> Area Confidence Interval (hectares)		
										80% Lower Limit	80% Upper Limit	
<b>Core</b>												
Core001	Padilla Bay	48.52086	-122.50592	23-Jul	11	0.7313	3,272.26	29,230.715	0.05	3,053.42	3,491.10	
Core002	Picnic Cove	48.56229	-122.92167	28-Jun	14	0.6055	2.80	0.058	0.09	2.49	3.11	
Core003	Jamestown	48.13078	-123.07213	17-Sep	11	0.5687	481.85	1618.092	0.08	430.36	533.34	
Core004	Lynch Cove	47.43036	-122.86130	17-Aug	13	0.5740	132.36	392.972	0.15	106.98	157.73	
Core005	Dumas Bay	47.33286	-122.37606	25-Aug	11	0.1533	0.64	0.022	0.23	0.45	0.83	
Core006	Burley Spit	47.37774	-122.63707	1-Sep	15	0.1598	2.17	0.119	0.16	1.73	2.61	
<b>Persistent Flats</b>												
Flats11	Samish Bay N.	48.55837	-122.52759	20-Jul	9	0.8422	1,256.97	2,332.171	0.04	1,195.16	1,318.79	
Flats12	Samish Bay S.	48.57917	-122.48041	21-Jul	10	0.7606	867.98	1,575.633	0.05	817.17	918.79	
Flats20	Skagit Bay N.	48.38564	-122.57115	21-Jun	20	0.3244	224.57	453.538	0.09	197.31	251.83	
<b>Rotational Flats</b>												
Flats08	Portage Bay S.	48.73727	-122.62043	28-Sep	17	0.6182	56.84	39.815	0.11	48.76	64.91	
Flats10	Nooksack Delta E.	48.76776	-122.55054	18-Jul	6	0.0052	0.47	0.058	0.51	0.17	0.78	
Flats19	Pull and Be Damned	48.37637	-122.54388	23-Jun	26	0.3673	172.15	404.445	0.12	146.41	197.89	
Flats26	Snohomish Delta N	48.03343	-122.26322	10-Aug	11	0.2399	119.96	1,345.750	0.31	73.01	166.92	
Flats35*	Nisqually Delta E	47.11264	-122.69174	30-Aug	15	0.1060	7.87	3.248	0.23	5.65	10.17	
Flats37	Wing Point	47.61775	-122.48772	23-Aug	11	0.2399	13.39	22.220	0.35	7.36	19.43	
Flats41	Dosewallips	47.69311	-122.88664	16-Aug	12	0.3168	91.96	70.149	0.09	81.24	102.68	
Flats42	Quilcene Bay	47.80769	-122.85687	21-Aug	11	0.6929	91.62	30.649	0.06	84.54	98.71	
Flats64	Squaw Bay	48.56012	-122.94623	27-Jun	15	0.5967	1.37	0.037	0.14	1.12	1.61	
Flats67	Fossil Bay	48.75037	-122.90005	11-Jun	18	0.3136	4.66	1.793	0.29	2.94	6.37	
Flats70	South Fork Skagit River	48.29729	-122.41593	7-Jul	11	0.3341	333.63	1,273.747	0.11	287.95	379.32	

**Narrow Fringe**

cps0221	SE Harstene Island	47.18247	-122.84974	29-Aug	N/A	N/A	0	N/A	N/A	N/A	N/A
cps1035	NE of Point White	47.35918	-122.45125	24-Aug	16	0.0198	0.03	0.001	0.67	0.00	0.06
cps1128	Paradise Cove (Vashon Island)	47.38423	-122.52060	4-Sep	18	0.4002	2.57	0.166	0.16	2.05	3.10
cps1156	Klahanic Beach (Vashon Island)	47.43463	-122.43504	5-Sep	13	0.5683	5.82	0.191	0.08	5.26	6.38
cps1164	N. of Pt. Robinson (Maury Island)	47.39574	-122.38260	24-Aug	14	0.6466	5.93	0.067	0.04	5.60	6.26
cps1175	Piner Point (Maury Island)	47.34251	-122.46132	28-Aug	14	0.5186	3.98	0.006	0.06	3.66	4.30
cps1194	N. Herron Island	47.27291	-122.83397	31-Aug	N/A	N/A	0	N/A	N/A	N/A	N/A
cps1277	Thompson Cove (Anderson Island)	47.12628	-122.70791	28-Aug	15	0.3120	1.60	0.138	0.23	1.13	2.08
cps1676	Broadview	47.43400	-122.22610	6-Sep	13	0.4804	5.86	0.541	0.13	4.92	6.80
cps1750	Des Moines Beach	47.40448	-122.33522	25-Aug	12	0.4561	4.19	0.139	0.09	3.72	4.67
cps1820	Gordon Point	47.16997	-122.61359	29-Aug	10	0.0989	0.05	0.001	0.61	0.01	0.09
cps1821	Cormorant Passage	47.16177	-122.61504	29-Aug	15	0.2870	1.03	0.0360	0.18	0.78	1.27
cps1951	S. of Stretch Island	47.31581	-122.83490	31-Aug	N/A	N/A	0	N/A	N/A	N/A	N/A
cps1967	Vaughn Bay (Case Inlet)	47.34373	-122.79453	31-Aug	11	0.4593	2.29	0.0370	0.08	2.05	2.54
cps1983	N. Joemma Beach	47.22638	-122.81610	30-Jul	N/A	N/A	0	N/A	N/A	N/A	N/A
cps2201	South of President Point	47.75883	-122.46804	22-Aug	11	0.4452	7.23	0.365	0.08	6.46	8.00
cps2218	Pilot Pt.	47.88290	-122.51054	14-Aug	12	0.2026	4.47	0.522	0.16	3.54	5.39
cps2573	Ft. Flagler	48.09745	-122.72160	7-Sep	16	0.3862	4.50	0.864	0.21	3.31	5.69
hdc2344	Great Peninsula	47.36785	-123.01834	18-Aug	20	0.2066	0.69	0.024	0.23	0.49	0.89
hdc2465	SE of Dabob Bay	47.83015	-122.81914	16-Aug	14	0.6281	6.44	0.215	0.07	5.85	7.03
hdc2479	Toanados Peninsula, West Side	47.73832	-122.81109	21-Aug	11	0.5519	7.12	0.235	0.07	6.50	7.74
nps0522	Eliza Island NE	48.65539	-122.57840	28-Sep	11	0.5199	3.94	0.143	0.10	3.46	4.42
nps0550	Vendovi East, Light	48.60542	-122.59851	18-Jul	N/A	N/A	0	N/A	N/A	N/A	N/A
nps0670	Boat Harbor (Guemes Island)	48.54435	-122.57668	15-Jun	11	0.3333	0.10	0.000	0.19	0.07	0.12
nps1344	E. of Ferndale	48.51148	-122.43443	13-Jul	20	0.0354	0.23	0.011	0.46	0.09	0.36
nps1392	Lummi Point (Lummi Island)	48.73358	-122.68769	19-Jul	17	0.6610	14.80	0.582	0.05	13.83	15.78
sj0118	SE Decatur Island	48.48537	-122.81331	30-Jun	15	0.4448	24.12	2.791	0.07	21.98	26.26
sj0205	E. of Eagle Point	48.27320	-123.02075	25-Jul	12	0.4027	12.63	0.280	0.04	11.96	13.31
sj0285**	Echo Bay North	48.76499	-122.89987	24-May	16	0.3551	4.13	0.577	0.18	3.16	5.10
sj0286**	Echo Bay South	48.76192	-122.91019	24-May	9	0.6041	6.27	0.538	0.12	5.33	7.21
sj0448	S. of West Beach	48.68274	-122.96809	11-Jul	11	0.5846	5.26	0.252	0.10	4.62	5.90
sj0452	S. of Pt. Doughty	48.70193	-122.94517	10-Jun	11	0.7015	13.60	0.979	0.07	12.33	14.86
sj0488	East Blakley Peak	48.57781	-122.78637	24-Jul	N/A	N/A	0	N/A	N/A	N/A	N/A
sj0600	Odlin State County Park	48.55923	-122.89171	28-Jun	15	0.5309	2.95	0.138	0.13	2.47	3.42
sj0617	Lopez Sound Road	48.50873	-122.86600	26-Jun	15	0.3016	2.45	0.122	0.14	2.00	2.90

sjs0635	Watumough Bay (Lopez Island)	48.43688	-122.80167	26-Jun	15	0.3021	1.54	0.045	0.14	1.27	1.81
sjs0639	Blind Island	48.42355	-122.82234	29-Jun	N/A	N/A	0	N/A	N/A	N/A	N/A
sjs0649	Canoe Island E. (Shaw Island)	48.55695	-122.92123	27-Jun	5	0.4749	0.03	0.000	0.13	0.03	0.04
sjs0683	Brown Island N.	48.54114	-123.00301	28-Jun	24	0.4181	0.80	0.019	0.17	0.63	0.98
sjs0989	Protection Island SW	48.12010	-122.93553	8-Sep	12	0.7315	7.92	0.583	0.10	6.94	8.89
sjs2645	Gardiner, Discovery Bay	48.05943	-122.91812	8-Sep	13	0.3725	0.41	0.039	0.49	0.15	0.66
swh0713	Entrance Shelter Bay	48.38609	-122.50577	3-Jul	11	0.2844	0.74	0.020	0.19	0.56	0.92
swh0940	Holmes Harbor E. (Whidbey Island)	48.07925	-122.51623	2-Aug	11	0.7483	7.93	0.134	0.05	7.46	8.40
swh0973	North Possession	47.92266	-122.37309	10-Aug	11	0.6558	14.37	1.399	0.08	12.85	15.88
swh1557	Rockaway Beach (Camano Island)	48.20462	-122.53993	31-Jul	15	0.5902	3.81	0.287	0.14	3.13	4.50
swh1568	Lowell Point (Camano Island)	48.12075	-122.49197	2-Aug	18	0.3315	0.15	0.001	0.15	0.12	0.18
swh1649	Nelson's Corner	47.55312	-122.18864	10-Aug	15	0.6578	4.88	0.134	0.07	4.42	5.35

#### Wide Fringe

cps1069	Murden Cove (Bainbridge Island)	47.65080	-122.50460	23-Aug	11	0.3669	8.85	0.955	0.11	7.60	10.10
cps1160	Tramp Harbor	47.40676	-122.43075	5-Sep	14	0.1759	1.44	0.156	0.27	0.93	1.95
cps2221	Point no Point	47.90831	-122.52171	14-Aug	11	0.2606	7.18	1.121	0.15	5.83	8.54
hdc2239	Hood Canal NE	47.88957	-122.58418	15-Aug	12	0.3337	6.91	0.273	0.08	6.25	7.58
hdc2283	E. of Warrentville	47.66838	-122.76384	15-Aug	12	0.7332	12.02	0.956	0.08	10.77	13.28
hdc2284	Warrentville	47.66278	-122.77334	15-Aug	14	0.4612	7.08	0.348	0.59	6.32	7.83
hdc2383	Anna's Bay	47.34856	-123.13948	18-Aug	17	0.1839	2.90	0.451	0.23	2.04	3.76
nps0654	Yellow Reef (Guemes Island)	48.53537	-122.65604	16-Jun	11	0.7830	9.39	0.228	0.05	8.78	10.00
nps1320	Semiahmoo Spit	48.98181	-122.79820	12-Jul	11	0.4823	14.20	0.722	0.06	13.11	15.29
nps1387	Sunrise Cove	48.70126	-122.65836	14-Jul	11	0.6060	3.93	0.141	0.10	3.45	4.41
nps1433	Post Point, Fairhaven	48.71454	-122.52422	13-Jul	17	0.6742	3.17	0.039	0.06	2.92	3.42
sjs2742	Between Agate & Crescent Bays	48.16697	-123.73143	14-Jun	N/A	N/A	0	N/A	N/A	N/A	N/A
sjs2775	Pysht River	48.20922	-124.09449	14-Jun	15	0.3375	5.17	2.174	0.29	3.28	7.06
swh0918	Pratts Bluff (Whidbey Island)	48.12396	-122.55524	28-Jul	11	0.7343	15.08	0.985	0.07	13.81	16.35
swh0955	West of Langley	48.04484	-122.41940	4-Aug	11	0.7636	7.38	0.050	0.03	7.09	7.67

\*Note: *Flats35-Nisqually Delta E.* was added to the 2006 sound-wide sampling effort to satisfy a flats stratum sample size requirement in the *Central Puget Sound Region*. The *Z. marina* area estimates and depth values for *Flats35-Nisqually Delta E.* were not incorporated in the sound-wide area estimates, area change calculations or depth estimates. The *Z. marina* area estimates and depth values for *Flats35-Nisqually Delta E.* were analyzed for year-to-year change at the site-level and presence of *Z. japonica* or *Phyllospadix* spp. (Sections 3.3.2, 3.4.2, 3.5.2 and 3.6).

\*\*Note: *sjs0285-Echo Bay North* and *sjs0286-Echo Bay South* were sampled on May 24, 2006, as part of a collaborative project between WA DNR, Washington State Parks and Recreation Commission Northwest Region Office (WSPRC) and UW (Reeves 2006). The *Z. marina* area estimates from *sjs0285-Echo Bay North* and *sjs0286-Echo Bay South* were not included in any 2006 sound-wide or site-level calculations.



**Appendix B      *Z. marina* area estimates at 2006 focus area sites**

Site	Location	Approximate Latitude (decimal degrees)	Approximate Longitude (decimal degrees)	Date Sampled	Number of Transects	<i>Z. marina</i>		Coefficient of Variation	Estimated <i>Z. marina</i> Area Confidence Interval (hectares)		
						Fraction Along Transects	Area at Site (hectares)		80% Lower Limit	80% Upper Limit	
<b>Flats</b>											
Flats18	Similk Bay	48.43667	-122.56061	19-Jun	25	0.3819	30.89	12.837	0.12	26.31	35.48
Flats19	Pull and Be Damned	48.37637	-122.54388	23-Jun	26	0.3673	172.15	404.444	0.12	146.41	197.89
Flats21	Skagit Bay mid	48.31923	-122.45983	4-Jul	11	0.5066	405.96	240.132	0.04	386.13	425.80
Flats25	Tulalip Bay	48.05603	-122.28907	9-Aug	12	0.3586	36.20	55.750	0.21	26.64	45.75
Flats28	Snohomish Delta S.	47.98805	-122.23443	10-Aug	20	0.6425	124.48	32.272	0.05	117.21	131.75
Flats32	Duqualla Bay	48.36001	-122.57494	20-Jun	15	0.4125	85.43	223.901	0.18	66.28	104.59
Flats70	South Fork Skagit River	48.29729	-122.41593	7-Jul	11	0.3716	333.63	1273.747	0.11	287.95	379.32
Flats71	Skagit Bay South	48.27356	-122.43799	1-Aug	13	0.2516	151.03	485.835	0.15	122.81	179.24
<b>Narrow Fringe</b>											
swh0033	NE Hope Island	48.40249	-122.55918	20-Jun	16	0.4823	1.32	0.028	0.13	1.11	1.53
swh0861	Strawberry Point Road	48.30863	-122.50428	4-Jul	15	0.5702	3.43	0.039	0.20	3.18	3.69
swh0886	S. Blowers Bluff	48.24904	-122.65166	26-Jul	N/A	N/A	0	N/A	N/A	N/A	N/A
swh0902	Long Point	48.22400	-122.64394	27-Jul	11	0.4778	6.20	1.146	0.17	4.83	7.57
swh0922	South of Greenbank	48.09331	-122.56368	2-Aug	16	0.7492	3.04	0.008	0.03	2.93	3.16
swh0948	North of Bells Beach	48.08548	-122.47988	2-Aug	14	0.7009	9.26	0.238	0.05	8.64	9.89
swh0965	Randall Point	47.98733	-122.35675	2-Aug	14	0.4236	3.24	0.054	0.07	2.95	3.54
swh1582	Camano Head	48.05612	-122.37416	3-Aug	14	0.3439	2.14	0.131	0.17	1.68	2.60
swh1597	Mt. View Beach	48.14730	-122.45292	3-Aug	15	0.2569	4.35	0.580	0.18	3.37	5.32
swh1615	S. of Kayak Pt.	48.11441	-122.35350	3-Aug	16	0.3038	2.17	0.147	0.18	1.68	2.66
<b>Wide Fringe</b>											
swh0857	N. Green Rd.	48.33595	-122.53702	4-Jul	15	0.4136	4.56	0.2773	0.12	3.89	5.24
swh0885	Blowers Bluff	48.25790	-122.64752	26-Jul	15	0.4059	12.23	0.6869	0.07	11.17	13.29
swh0904	Snakelum Point	48.22701	-122.62404	27-Jul	11	0.5362	8.65	3.0042	0.20	6.43	10.87
swh0905	East of Snakelum Point	48.22142	-122.62174	27-Jul	11	0.5427	9.48	0.2575	0.05	8.83	10.13

Site	Location	Approximate Latitude (decimal degrees)	Approximate Longitude (decimal degrees)	Date Sampled	Number of Transects	<i>Z. marina</i>	<i>Z. marina</i>	Coefficient of Variation	Estimated <i>Z. marina</i> Area Confidence Interval (hectares)		
						Fraction Along Transects	Area at Site (hectares)		Variance	80% Lower Limit	80% Upper Limit
swh0955	West of Langley	48.04635	-122.41994	4-Aug	11	0.7636	7.38	0.0504	0.03	7.09	7.67
swh1643	Edgewater	47.95983	-122.27597	11-Aug	11	0.5501	10.40	1.3135	0.11	8.93	11.87

**Appendix C**

**Z. marina estimates at 2007 sample sites**

Site	Location	Approximate Latitude (decimal degrees)	Approximate Longitude (decimal degrees)	Date Sampled	Number of Transects	Z. marina Fraction Along Transects	Z. marina Area at Site (hectares)	Variance	Coefficient of Variation	Estimated Z. marina Area Confidence Interval (hectares)		
										80% Lower Limit	80% Upper Limit	
<b>Core</b>												
core001	Padilla Bay	48.52069	-122.50720	10-Jul	10	0.6608	2956.97	67409.313	0.09	2448.98	3467.11	
core002	Picnic Cove	48.56492	-122.92278	5-Jun	15	0.4924	2.28	0.031	0.08	1.93	2.62	
core003	Jamestown	48.13060	-123.07341	19-Sep	11	0.5164	437.82	2282.791	0.11	344.30	531.66	
core004	Lynch Cove	47.43018	-122.86256	23-Jul	15	0.4939	113.90	127.395	0.10	91.81	136.07	
core005	Dumas Bay	47.33103	-122.38256	9-Aug	11	0.2578	1.07	0.079	0.26	0.52	1.63	
core006	Burley Spit	47.37756	-122.63831	16-Aug	15	0.1462	1.98	0.170	0.21	1.18	2.79	
<b>Persistent Flats</b>												
flats11	Samish Bay N.	48.61154	-122.46484	11-Jul	9	0.8119	1211.81	3056.121	0.05	1103.86	1320.64	
flats12	Samish Bay S.	48.57917	-122.48041	11-Jul	11	0.6115	698.62	2631.664	0.07	598.29	799.46	
flats20	Skagit Bay N.	48.35028	-122.50653	9-Jul	19	0.3525	244.01	585.259	0.10	196.66	291.53	
<b>Rotational Flats</b>												
flats08	Portage Bay S.	48.73710	-122.62172	28-Jun	14	0.4274	39.29	41.588	0.16	26.66	51.95	
flats19	Pull and Be Damned	48.37619	-122.54516	3-Oct	21	0.3808	178.46	333.175	0.10	142.74	214.31	
flats26	Snohomish Delta N	48.03158	-122.26273	4-Jul	11	0.2057	102.90	879.054	0.29	44.80	161.07	
flats41	Dosewallips	47.69311	-122.88664	18-Jul	12	0.6468	85.83	186.174	0.16	59.11	112.62	
flats42	Quilcene Bay	47.80769	-122.85687	25-Jul	15	0.5743	88.18	45.828	0.08	74.94	101.48	
flats55	Mitchell Bay	48.57096	-123.16532	14-Jun	15	0.3397	3.43	0.385	0.18	2.22	4.65	
flats64	Squaw Bay	48.56012	-122.94623	6-Jun	20	0.3561	1.55	0.040	0.13	1.16	1.95	
flats66	Shallow Bay, Sucia	48.76299	-122.91738	12-Jun	15	0.2638	3.72	0.292	0.15	2.66	4.78	
flats67	Fossil Bay	48.75037	-122.90005	12-Jun	20	0.4858	6.77	1.430	0.18	4.43	9.12	
flats70	South Fork Skagit River	48.29729	-122.41593	4-Oct	9	0.3708	332.88	1126.179	0.10	267.20	398.80	
<b>Narrow Fringe</b>												
cps0224	Wilson Point (Harstene Island)	47.12191	-122.50558	14-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
cps1035	NE of Point White	47.59866	-122.55655	7-Aug	13	0.0314	0.05	0.001	0.61	-0.01	0.12	

Site	Location	Approximate Latitude (decimal degrees)	Approximate Longitude (decimal degrees)	Date Sampled	Number of Transects	<i>Z. marina</i>	<i>Z. marina</i>	Variance	Coefficient of Variation	Estimated <i>Z. marina</i> Area Confidence Interval (hectares)	
						Fraction Along Transects	Area at Site (hectares)			80% Lower Limit	80% Upper Limit
cps1175	Piner Point (Maury Island)	47.34233	-122.46255	10-Aug	14	0.4577	3.51	0.113	0.10	2.86	4.17
cps1194	N. Herron Island	47.27250	-122.83442	14-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
cps1277	Thompson Cove (Anderson Island)	47.12610	-122.70915	13-Aug	16	0.2072	1.06	0.089	0.28	0.48	1.65
cps1289	Villa Beach N	47.10941	-122.41142	13-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
cps1676	Broadview	47.72351	-122.37832	1-Aug	14	0.4498	5.49	0.233	0.09	4.55	6.44
cps1750	Des Moines Beach	47.40448	-122.33522	8-Aug	13	0.5717	5.26	0.125	0.07	4.56	5.95
cps1820	Gordon Point	47.16997	-122.61359	21-Aug	11	0.1689	0.08	0.002	0.53	0.00	0.17
cps1821	Cormorant Passage	47.16159	-122.61627	21-Aug	15	0.3894	1.39	0.025	0.11	1.08	1.70
cps1951	S. of Stretch Island	47.31580	-122.83490	14-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
cps1954	Stretch Point State Park	47.19858	122.49565	14-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
cps1967	Vaughn Bay (Case Inlet)	47.34373	-122.79453	14-Aug	13	0.4811	2.40	0.029	0.07	2.07	2.74
cps1983	N. Joemma Beach	47.22593	-122.81611	15-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
cps2201	South of President Point	47.75865	-122.46928	31-Jul	11	0.5185	8.42	0.310	0.07	7.33	9.52
cps2552	Oak Bay Boat Ramp	48.01471	-122.72551	24-Aug	13	0.5097	8.14	0.531	0.09	6.71	9.57
hdc2321	Across from Eagle Creek	47.28965	-123.02561	19-Jul	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
hdc2344	Great Peninsula	47.36767	-123.01960	19-Jul	20	0.0585	0.20	0.008	0.45	0.02	0.37
hdc2460	Lindsay's Beach	47.79062	-122.82123	24-Jul	12	0.5444	5.08	0.134	0.07	4.37	5.80
hdc2465	SE of Dabob Bay	47.83015	-122.81914	24-Jul	14	0.5937	6.09	0.298	0.09	5.02	7.16
hdc2479	Toanados Peninsula, West Side	47.73832	-122.81109	24-Jul	12	0.5751	7.42	0.136	0.05	6.70	8.15
nps0550	Vendovi East, Light	48.60600	-122.59999	22-Jun	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
nps0670	Boat Harbor (Guemes Island)	48.54435	-122.57668	19-Jun	11	0.3568	0.10	0.001	0.22	0.06	0.15
nps1344	E. of Ferndale	48.85168	-122.72520	25-Jun	20	0.0162	0.10	0.003	0.50	0.00	0.20
nps1392	Lummi Point (Lummi Island)	48.73358	-122.68769	21-Jun	17	0.6885	15.42	0.591	0.05	13.92	16.93
sjis0001	Strawberry Bay North	48.56347	-122.73034	7-Jun	15	0.6332	9.45	0.630	0.08	7.90	11.01
sjis0118	SE Decatur Island	48.48537	-122.81331	4-Jun	15	0.4810	26.09	2.150	0.06	23.22	28.97
sjis0205	E. of Eagle Point	48.45469	-123.00388	18-Jun	12	0.3235	10.15	0.575	0.07	8.67	11.64
sjis0448	S. of West Beach	48.68274	-122.96809	13-Jun	15	0.5987	5.39	0.095	0.06	4.78	5.99
sjis0452	S. of Pt. Doughty	48.70193	-122.94517	13-Jun	14	0.7519	14.57	0.432	0.05	13.29	15.87
sjis0488	E. of Blakely Peak	48.57797	-122.78777	7-Jun	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
sjis0600	Odlin County Park	48.55923	-122.89171	6-Jun	20	0.5279	2.93	0.098	0.11	2.32	3.54
sjis0635	Watmough Bay (Lopez Island)	48.43695	-122.80837	8-Jun	16	0.2777	1.41	0.047	0.15	0.99	1.84
sjis0639	Blind Island	48.42355	-122.82234	4-Jun	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09

Site	Location	Approximate Latitude (decimal degrees)	Approximate Longitude (decimal degrees)	Date Sampled	Number of Transects	<i>Z. marina</i>	<i>Z. marina</i>	Variance	Coefficient of Variation	Estimated <i>Z. marina</i> Area Confidence Interval (hectares)	
						Fraction Along Transects	Area at Site (hectares)			80% Lower Limit	80% Upper Limit
sjs0683	Brown Island N.	48.54096	-123.00430	15-Jun	21	0.4059	0.78	0.020	0.18	0.50	1.06
sjs0989	Protection Island SW	48.11992	-122.93682	18-Sep	13	0.6580	7.12	0.260	0.07	6.12	8.12
sjs1492	Shannon Point W.	48.50556	-122.69195	11-Jun	16	0.5792	13.23	1.058	0.08	11.22	15.26
sjs2645	Gardiner, Discovery Bay	48.05943	-122.91812	18-Sep	15	0.4876	0.53	0.006	0.15	0.38	0.69
sjs2652	Thompson Spit, Discovery Bay	48.09950	-122.94606	28-Aug	14	0.4815	5.51	0.287	0.10	4.46	6.56
swh0713	Entrance Shelter Bay	48.38609	-122.50577	6-Jul	19	0.1338	0.35	0.015	0.36	0.10	0.59
swh0940	Holmes Harbor E. (Whidbey Island)	48.07907	-122.51749	3-Jul	15	0.7314	7.75	0.119	0.04	7.08	8.43
swh0973	North Possession	47.92266	-122.37309	30-Jul	11	0.4453	9.76	1.135	0.11	7.67	11.85
swh1557	Rockaway Beach	48.20462	-122.53993	29-Jun	15	0.5934	3.83	0.220	0.12	2.91	4.75
swh1568	Lowell Point	48.12075	-122.49197	4-Jul	20	0.2785	0.13	0.001	0.23	0.07	0.18
swh1649	Nelson's Corner	47.92261	-122.31476	30-Jul	12	0.6735	5.00	0.129	0.07	4.30	5.71

### Wide Fringe

cps1069	Murden Cove (Bainbridge Island)	47.65062	-122.50584	2-Aug	11	0.3877	9.35	0.767	0.09	7.63	11.07
cps1160	Tramp Harbor	47.40676	-122.43075	8-Aug	20	0.2869	2.35	0.076	0.12	1.81	2.89
hdc2283	E. of Warrentville	47.66838	-122.76384	17-Jul	13	0.4898	8.03	1.700	0.16	5.48	10.59
hdc2284	Warrentville	47.66415	-122.77544	18-Jul	14	0.2958	4.54	0.254	0.11	3.55	5.53
hdc2383	Anna's Bay	47.34856	-123.13948	20-Jul	20	0.2160	3.41	0.500	0.21	2.03	4.80
nps1320	Semiahmoo Spit	48.98164	-122.79950	25-Jun	11	0.4091	12.05	0.534	0.06	10.62	13.48
nps1328	W of Birch Bay	48.92917	-122.79906	26-Jun	10	0.0616	0.63	0.114	0.54	-0.03	1.29
nps1387	Sunrise Cove	48.70126	-122.65836	27-Jun	13	0.6512	4.22	0.049	0.05	3.79	4.66
nps1433	Post Point, Fairhaven	48.71454	-122.52422	20-Jun	17	0.6727	3.16	0.021	0.05	2.88	3.45
sjs2742	Between Agate & Crescent Bays	48.16697	-123.73143	30-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
sjs2775	Pysht River	48.20903	-124.09581	29-Aug	19	0.3254	4.99	0.104	0.06	4.35	5.62
swh0869	Polnell Point Light W.	48.27284	-122.56433	2-Jul	8	0.1261	0.06	0.001	0.59	-0.01	0.13
swh0881	Maylor Point, Whidbey Island	48.16081	-122.37609	2-Jul	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09
swh0918	Pratts Bluff (Whidbey Island)	48.12393	-122.55524	3-Jul	12	0.6661	13.68	0.537	0.05	12.25	15.12
swh0955	West of Langley	48.04635	-122.41994	2-Oct	11	0.7983	7.72	0.061	0.03	7.24	8.20

## Appendix D *Z. marina* estimates at 2007 focus area sites

Site	Location	Approximate Latitude (decimal degrees)	Approximate Longitude (decimal degrees)	Date Sampled	Number of Transects	<i>Z. marina</i> Fraction Along Transects	<i>Z. marina</i> Area at Site (hectares)	Variance	Coefficient of Variation	Estimated <i>Z. marina</i> Area Confidence Interval (hectares)		
										80% Lower Limit	80% Upper Limit	
<b>Flats</b>												
flats34	Nisqually Delta W	47.1091	-122.7246	20-Aug	15	0.1154	33.27	0.002	0.35	10.29	56.27	
flats35	Nisqually Delta E.	47.1125	-122.6930	15-Aug	15	0.0840	6.23	0.000	0.18	4.03	8.44	
flats39	Liberty Bay	47.4272	-122.3825	6-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
flats46	Kilisut Harbor	48.0890	-122.7257	4-Sep	14	0.2705	29.97	0.002	0.15	21.25	38.72	
<b>Narrow Fringe</b>												
cps0046	East Indian Island	48.0684	-122.7145	4-Sep	12	0.5968	7.41	0.001	0.06	6.49	8.33	
cps1097	E. of Rocky Point	47.3588	-122.3939	7-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
cps1108	W. Blake Island	47.5378	-122.5013	22-Aug	13	0.4839	2.68	0.001	0.06	2.38	2.98	
cps1114	SW Blake Island	47.5291	-122.4901	22-Aug	11	0.1117	0.08	0.001	0.34	0.03	0.13	
cps1264	Eagle Island South	47.1134	-122.4175	13-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
cps1691	S of Fourmile Rock Light	47.6354	-122.4113	23-Aug	12	0.6015	6.17	0.117	0.06	5.70	6.63	
cps1754	Saltwater State Park	47.3705	-122.3275	9-Aug	13	0.3866	3.84	0.003	0.15	2.73	4.96	
cps1797	Tacoma Yacht Club	47.3069	-122.5150	10-Aug	15	0.1390	0.16	0.002	0.34	0.05	0.27	
cps1815	Pioneer	47.1241	122.3489	17-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
cps2022	S of Thompson Spit	47.3250	-122.7260	16-Aug	16	0.1160	1.39	0.000	0.18	0.91	1.87	
cps2040	Lay Inlet	47.3338	-122.6591	16-Aug	15	0.1214	0.61	0.002	0.36	0.17	1.05	
cps2050	Forest Beach	47.2938	-122.6938	17-Aug	16	0.0875	0.78	0.001	0.28	0.36	1.21	
cps2055	Across from Neams Points	47.1706	-122.3978	17-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
cps2067	Point Fosdick	47.1528	-122.3527	17-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
cps2102	North Southward	47.5207	-122.5024	22-Aug	14	0.5395	2.39	0.001	0.05	2.15	2.63	
cps2145	Olympic College	47.3470	-122.3826	7-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
cps2208	NE of Kingston	47.8038	-122.4826	1-Aug	11	0.3963	10.07	0.001	0.07	8.66	11.48	
cps2540	N of Port Ludlow	47.9341	-122.6798	17-Jul	13	0.5579	3.83	0.001	0.06	3.35	4.32	
cps2541	S of Snake Rock Light	47.5768	-122.6218	26-Jul	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09	
cps2548	S of Oak Bay 2	47.9822	-122.7086	16-Jul	12	0.3942	2.23	0.000	0.05	2.02	2.44	
cps2549	S of Oak Bay 1	47.9899	-122.7163	16-Jul	13	0.2252	1.46	0.003	0.25	0.75	2.17	
cps2555	E of Oak Bay Boat Ramp	48.0172	-122.7072	24-Aug	12	0.4093	5.90	0.002	0.12	4.49	7.32	

Site	Location	Approximate Latitude (decimal degrees)	Approximate Longitude (decimal degrees)	Date Sampled	Number of Transects	<i>Z. marina</i>	<i>Z. marina</i>	Variance	Coefficient of Variation	Estimated <i>Z. marina</i> Area Confidence Interval (hectares)	
						Fraction Along Transects	Area at Site (hectares)			80% Lower Limit	80% Upper Limit
<b>Wide Fringe</b>											
cps0763	N. Dave Mackie Park	47.9594	-122.4548	31-Jul	11	0.3662	20.70	0.003	0.15	14.61	26.80
cps0766	S. Useless Bay	47.9796	-122.4787	27-Jul	15	0.0968	3.03	0.000	0.14	2.22	3.84
cps0794	Lake Hancock Target Range	48.1155	-122.6020	1-Jun	13	0.1000	1.42	0.002	0.39	0.34	2.51
cps1066	Rolling Bay	47.6720	-122.5031	2-Aug	11	0.3238	7.83	0.001	0.09	6.47	9.20
cps1663	Edmonds Cable Area	47.8233	-122.3777	1-Aug	17	0.2774	5.05	0.003	0.19	3.13	6.98
cps2565	N of East Beach County Park	48.0402	-122.4114	27-Aug	0	0.0000	0.00	-9999.000	-9999.00	0.09	-0.09

## Appendix E Relative change in *Z. marina* area for sites sampled in 2005 and 2006

Site	2005	2006		Relative					Confidence in	
	<i>Z. marina</i> area (m <sup>2</sup> )	2005 variance	<i>Z. marina</i> area (m <sup>2</sup> )	2006 variance	Change (%)	Variance of Change	SE of Change	80% CI (half width)	95% CI (half width)	Detected Change
core001	34,591,411	4,371,865,751,298	32,722,570	2,923,071,446,923	-5.4	57.12	7.56	9.7	14.8	ns
core002	33,178	3,839,209	27,979	2,828,436	-15.7	50.50	7.11	9.1	13.9	95% dec
core003	4,933,871	232,741,890,907	4,818,512	161,809,242,522	-2.3	157.66	12.56	16.1	24.6	ns
core004	1,307,853	15,553,912,903	1,323,550	39,297,207,281	1.2	322.87	17.97	23.0	35.2	ns
core005	13,897	7,093,193	6,386	2,228,384	-54.0	192.94	13.89	17.8	27.2	95% dec
core006	35,967	29,564,863	21,662	11,853,937	-39.8	174.53	13.21	16.9	25.9	95% dec
cps0221	No Zm		No Zm							ns
cps1069	94,036	66,887,158	88,460	95,469,145	-5.9	174.90	13.22	17.0	25.9	ns
cps1128	26,754	9,512,101	25,740	16,574,310	-3.8	354.57	18.83	24.1	36.9	ns
cps1156	65,156	43,002,548	58,197	19,127,882	-10.7	125.87	11.22	14.4	22.0	ns
cps1164	59,189	7,558,444	59,275	6,696,146	0.1	40.75	6.38	8.2	12.5	ns
cps1175	39,346	2,285,582	39,803	61,599,999	1.2	413.01	20.32	26.1	39.8	ns
cps1277	19,758	16,107,345	16,036	13,800,046	-18.8	625.30	25.01	32.1	49.0	ns
cps1676	48,777	20,180,909	58,636	54,047,129	20.2	349.74	18.70	24.0	36.7	ns
cps1750	39,909	9,879,524	41,934	13,871,852	5.1	155.58	12.47	16.0	24.4	ns
cps1820	447	17,892	480	85,323	7.4	5,302.78	72.82	93.4	142.7	ns
cps1821	9,162	3,086,955	10,268	3,585,538	12.1	889.04	29.82	38.2	58.4	ns
cps1951	No Zm		No Zm							ns
cps1967	25,069	4,239,526	22,929	3,693	-8.5	56.49	7.52	9.6	14.7	ns
cps2201	83,722	46,630,349	72,306	36,519,510	-13.6	101.72	10.09	12.9	19.8	80% dec
cps2218	34,202	21,734,204	44,653	52,160,876	30.6	762.6	27.62	35.4	54.1	ns
cps2221	93,095	52,840,694	71,834	112,079,694	-22.8	165.6	12.87	16.5	25.2	80% dec
cps2573	53,174	133,383,421	45,020	86,346,266	-15.3	643.54	25.37	32.5	49.7	ns
flats08	473,424	2,978,554,250	568,378	3,981,535,258	20.1	369.19	19.21	24.6	37.7	ns
flats10	No Zm		4,747	5,772						ns
flats11	11,864,803	320,971,546,899	12,569,706	233,217,081,885	5.9	42.16	6.49	8.3	12.7	ns
flats12	7,724,758	245,241,501,616	8,679,770	157,563,336,282	12.4	78.29	8.85	11.3	17.3	80% inc
flats18	359,197	800,802,582	308,938	1,283,710,698	-14.0	145.41	12.06	15.5	23.6	ns
flats19	1,625,885	40,531,698,708	1,721,519	40,444,364,718	5.9	324.89	18.02	23.1	35.3	ns
flats20	2,304,826	66,882,326,823	2,245,729	45,353,837,904	-2.6	204.91	14.31	18.4	28.1	ns



Site	2005	2005 variance	2006	2006 variance	Relative	Variance of Change	SE of Change	80% CI (half width)	95% CI (half width)	Confidence in
	Z. marina area (m <sup>2</sup> )		Z. marina area (m <sup>2</sup> )		Change (%)					Detected Change
flats26	1,506,812	134,245,780,724	1,199,612	134,574,860,870	-20.4	967.47	31.10	39.9	61.0	ns
flats35*	209,744	2,935,440,405	78,655	324,813,997	-62.5	167.67	12.95	16.6	25.4	95% dec
flats37	149,608	758,365,720	133,927	2,222,026,907	-10.5	1,264.27	35.56	45.6	69.7	ns
flats41	1,088,506	4,022,621,634	919,634	7,014,937,218	-15.5	83.44	9.13	11.7	17.9	80% dec
flats42	985,716	2,556,284,149	916,213	3,064,915,661	-7.1	54.27	7.37	9.4	14.4	ns
flats67	51,611	164,710,209	46,565	179,303,583	-9.8	1,176.49	34.30	44.0	67.2	ns
flats70	2,823,638	160,093,852,587	3,336,330	127,374,727,379	18.2	440.09	20.98	26.9	41.1	ns
hdc2239	61,959	32,137,986	69,145	27,274,295	11.6	175.31	13.24	17.0	26.0	ns
hdc2284	78,628	60,756,486	70,770	34,796,847	-10.0	135.90	11.66	14.9	22.8	ns
hdc2344	4,846	2,064,703	6,896	2,409,130	42.3	2,806.28	52.97	67.9	103.8	ns
hdc2383	28,357	24,861,254	29,043	45,086,725	2.4	885.01	29.75	38.1	58.3	ns
hdc2465	57,586	14,785,845	64,404	21,514,949	11.8	120.65	10.98	14.1	21.5	ns
hdc2479	74,210	22,665,331	71,199	23,507,526	-4.1	80.57	8.98	11.5	17.6	ns
nps0522	32,700	6,425,549	39,387	14,268,677	20.4	220.62	14.85	19.0	29.1	80% inc
nps0654	99,437	14,193,102	93,911	22,753,212	-5.6	35.81	5.98	7.7	11.7	ns
nps0670	1,299	45,249	950	32,755	-26.9	337.54	18.37	23.6	36.0	80% dec
nps1320	163,144	30,250,429	142,005	72,175,531	-13.0	35.73	5.98	7.7	11.7	95% dec
nps1344	2,851	397,026	2,253	1,071,021	-21.0	1,622.70	40.28	51.6	79.0	ns
nps1392	150,328	80,764,047	148,036	58,239,555	-1.5	60.43	7.77	10.0	15.2	ns
nps1433	26,966	5,439,288	31,709	3,923,220	17.6	157.38	12.55	16.1	24.6	80% inc
sjs0205	126,540	58,410,715	126,334	27,966,576	-0.2	53.83	7.34	9.4	14.4	ns
sjs0617	20,721	6,740,440	24,492	12,217,064	18.2	503.87	22.45	28.8	44.0	ns
sjs0635	17,205	5,390,936	15,376	4,513,752	-10.6	297.94	17.26	22.1	33.8	ns
sjs0639	No Zm		No Zm							ns
sjs0649	292	3,055	340	49,521	16.4	6,293.74	79.33	101.7	155.5	ns
sjs0683	9,204	1,700,419	8,037	1,847,416	-12.7	371.1	19.26	24.7	37.8	ns
sjs0989	70,751	20,887,031	79,153	58,335,841	11.9	168.8	12.99	16.7	25.5	ns
sjs2645	4,253	766,521	4,065	3,892,448	-4.4	2,539.1	50.39	64.6	98.8	ns
sjs2742	No Zm		No Zm							ns
sjs2775	59,265	17,295,156	51,702	217,354,724	-12.8	656.3	25.62	32.8	50.2	ns
swh0918	160,651	30,996,661	150,822	98,475,140	-6.1	48.7	6.98	9.0	13.7	ns
swh0940	81,433	10,296,670	79,293	13,350,451	-2.6	34.9	5.90	7.6	11.6	ns
swh0955	60,143	3,873,333	73,811	470,807,264	22.7	1,317.7	36.30	46.5	71.1	ns
swh1557	36,176	22,110,463	38,111	28,709,921	5.3	406.9	20.17	25.9	39.5	ns
swh1568	1,720	81,426	1,509	50,424	-12.3	382.3	19.55	25.1	38.3	ns

Site	2005 <i>Z. marina</i> area (m <sup>2</sup> )	2005 variance	2006 <i>Z. marina</i> area (m <sup>2</sup> )	2006 variance	Relative Change (%)	Variance of Change	SE of Change	80% CI (half width)	95% CI (half width)	Confidence in Detected Change
swh1649	52,593	6,457,452	48,834	13,389,677	-7.1	68.5	8.28	10.6	16.2	ns

ns = change is not significant

No Zm = no *Z. marina* at site

\*Note: *Flats35-Nisqually Delta E.* was added to the 2006 sound-wide sampling to satisfy a flats stratum sample size requirement in the *Central Puget Sound Region*. The *Z. marina* area estimates and depth values for *Flats35-Nisqually Delta E.* were not incorporated in the sound-wide area estimates, area change calculations or depth estimates. The *Z. marina* area estimates and depth values for *Flats35-Nisqually Delta E.* were analyzed for year-to-year change at the site-level and presence of *Z. japonica* or *Phyllospadix* spp. (Sections 3.3.2, 3.4.2, 3.5.2 and 3.6).

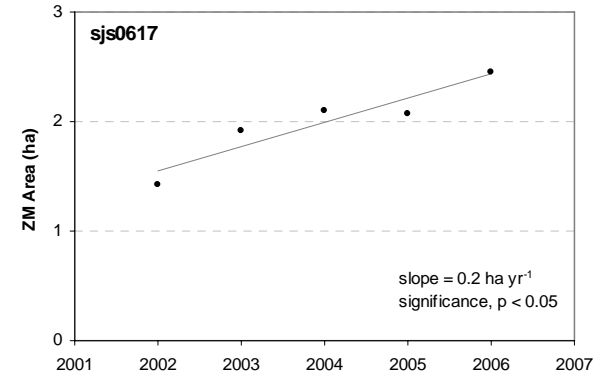
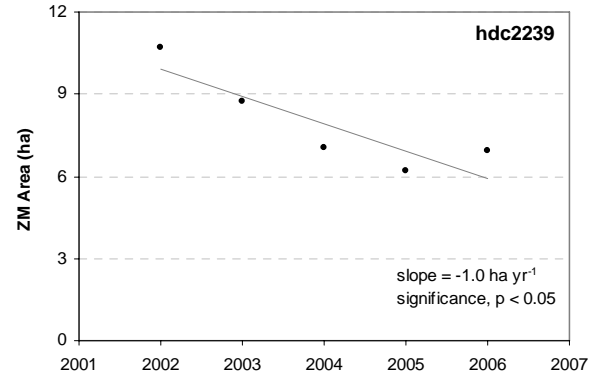
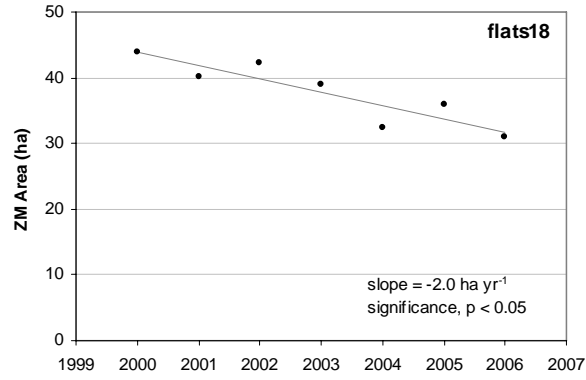
**Appendix F Relative change in *Z. marina* area for sites sampled in 2006 and 2007**

Site	2006		2007		Relative Change (%)	Variance of Change	SE of Change	80% CI (half width)	95% CI (half width)	Confidence in Detected Change
	<i>Z. marina</i> area (m <sup>2</sup> )	2006 variance	<i>Z. marina</i> area (m <sup>2</sup> )	2007 variance						
core001	32,722,570	2,923,071,446,923	29569733.03	6,740,930,937,806	-9.6	85.25	9.23	11.8	18.1	ns
core002	27,979	5,828,436	22752.95171	3,147,425	-18.7	89.44	9.46	12.1	18.5	95% dec
core003	4,818,512	161,809,242,522	4378161.084	228,279,089,665	-9.1	155.86	12.48	16.0	24.5	ns
core004	1,323,550	39,297,207,281	1139007.385	12,739,476,963	-13.9	238.85	15.45	19.8	30.3	ns
core005	6,386	2,228,384	10736.30529	7,930,999	68.1	3,489.26	59.07	75.7	115.8	ns
core006	21,662	11,853,937	19823.11952	16,953,027	-8.5	572.83	23.93	30.7	46.9	ns
cps1035	330	49,197	523.7768494	102,230	58.7	20,768.38	144.11	184.8	282.5	ns
cps1069	88,460	95,469,145	93462.18	76,728,870	5.7	234.24	15.31	19.6	30.0	ns
cps1160	14,405	15,604,416	23492.21856	7,636,854	63.1	2,368.09	48.66	62.4	95.4	80% inc
cps1175	39,803	61,599,999	35128.67374	11,255,290	-11.7	373.90	19.34	24.8	37.9	ns
cps1194	No Zm		No Zm							ns
cps1277	16,036	13,800,046	10648.24789	8,925,262	-33.6	583.70	24.16	31.0	47.4	80% dec
cps1676	58,636	54,047,129	54902.82609	23,303,690	-6.4	205.60	14.34	18.4	28.1	ns
cps1750	41,934	13,871,852	52568.5128	12,547,838	25.4	195.33	13.98	17.9	27.4	80% inc
cps1820	480	85,323	819.8232755	189,739	70.8	19,038.14	137.98	176.9	270.4	ns
cps1821	10,268	3,585,538	13931.465	2,480,410	35.7	861.31	29.35	37.6	57.5	ns
cps1951	No Zm		No Zm							ns
cps1967	22,929	3,693	24016.90008	2,886,941	4.7	54.99	7.42	9.5	14.5	ns
cps1983	No Zm		No Zm							ns
cps2201	72,306	36,519,510	84205.02244	31,023,065	16.5	154.07	12.41	15.9	24.3	80% inc
flats08	568,378	3,981,535,258	392935.3418	4,158,814,156	-30.9	187.64	13.70	17.6	26.8	95% dec
flats11	12,569,706	233,217,081,885	12118089.31	305,612,076,828	-3.6	33.06	5.75	7.4	11.3	ns
flats12	8,679,770	157,563,336,282	6986186.973	263,166,352,860	-19.5	48.48	6.96	8.9	13.6	95% dec
flats19	1,721,519	40,444,364,718	1784597.229	33,317,468,482	3.7	259.07	16.10	20.6	31.5	ns
flats20	2,245,729	45,353,837,904	2440052.359	58,525,898,771	8.7	222.21	14.91	19.1	29.2	ns
flats26	1,199,612	134,574,860,870	1028954.797	87,905,352,141	-14.2	1,298.86	36.04	46.2	70.6	ns
flats35	78,655	324,813,997	62331.85725	126,387,258	-20.8	534.01	23.11	29.6	45.3	ns
flats41	919,634	7,014,937,218	858341.1516	18,617,435,697	-6.7	292.39	17.10	21.9	33.5	ns
flats42	916,213	3,064,915,661	881790.3535	4,582,756,017	-3.8	88.41	9.40	12.1	18.4	ns
flats64	13,688	3,693,278	15545.89861	42,652,677	13.6	2,530.76	50.31	64.5	98.6	ns
flats67	46,565	179,303,583	67700.95118	142,997,423	45.4	2,407.49	49.07	62.9	96.2	ns
flats70	3,336,330	127,374,727,379	3328807.804	112,617,900,549	-0.2	215.09	14.67	18.8	28.7	ns

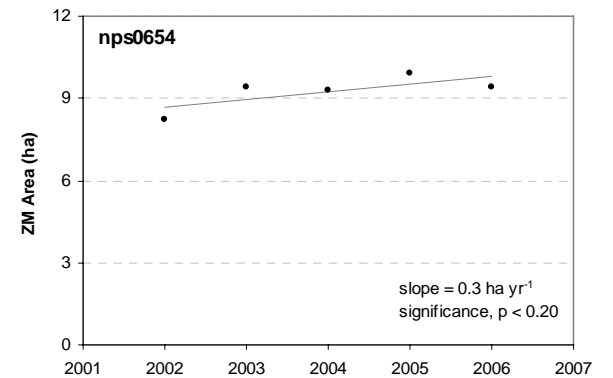
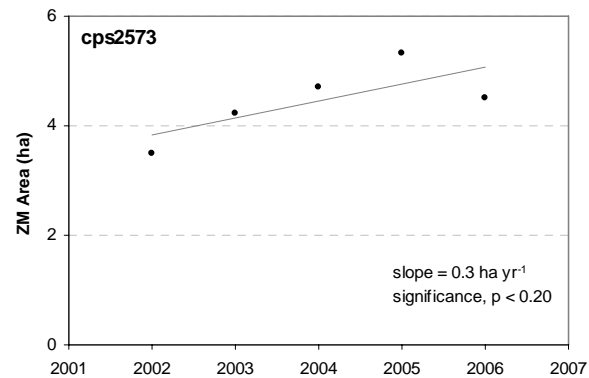
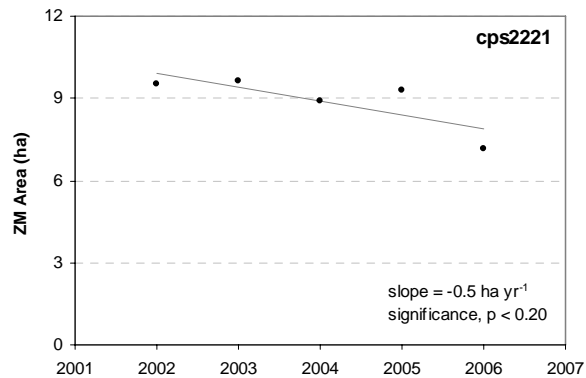
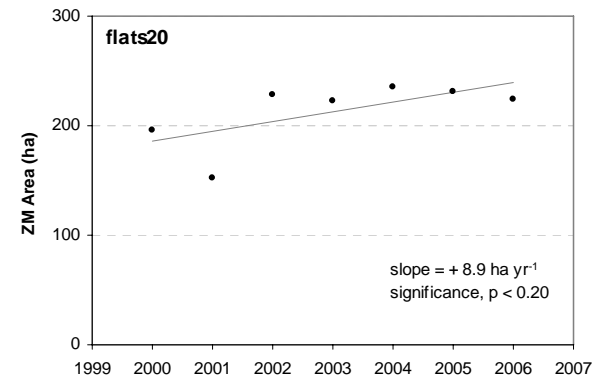
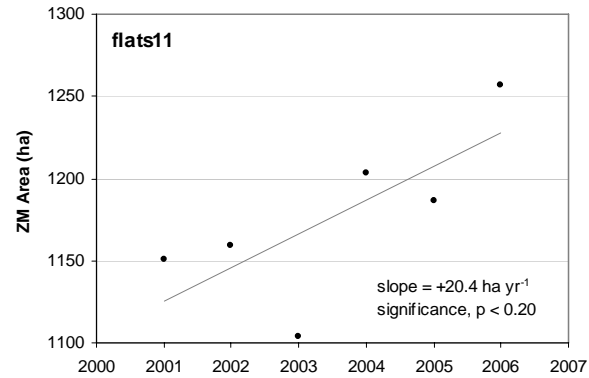
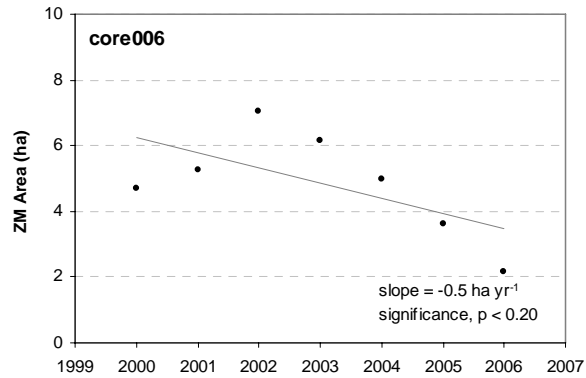
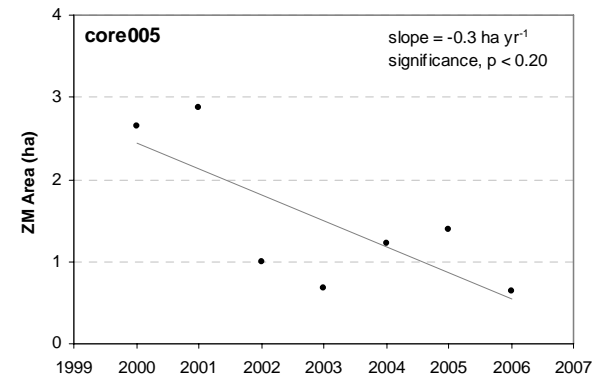
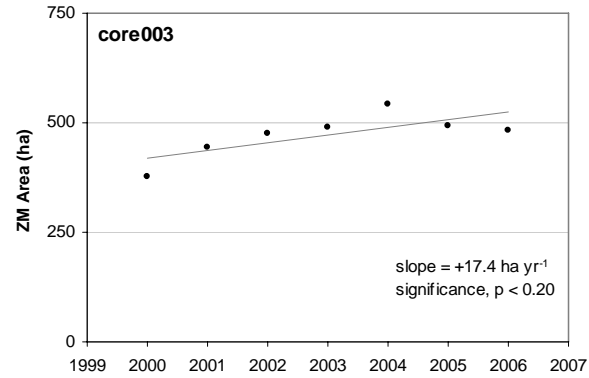
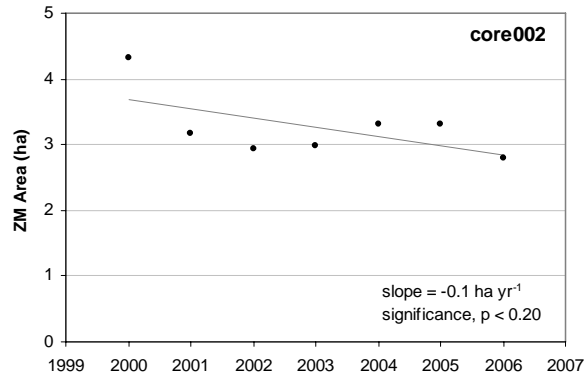
hdc2283	120,236	95,648,226	80316.68967	1,829,454,772	-33.2	1,294.99	35.99	46.1	70.5	ns
hdc2284	70,770	34,796,847	45386.72153	25,416,853	-35.9	79.32	8.91	11.4	17.5	95% dec
hdc2344	6,896	2,409,130	1953.579933	784,745	-71.7	205.68	14.34	18.4	28.1	95% dec
hdc2383	29,043	45,086,725	34119.61468	49,961,490	17.5	1,330.03	36.47	46.8	71.5	ns
hdc2465	64,404	21,514,949	60871.4377	29,833,435	-5.5	118.26	10.87	13.9	21.3	ns
hdc2479	71,199	23,507,526	74188.62511	13,627,804	4.2	77.23	8.79	11.3	17.2	ns
nps0550	No Zm	No Zm	No Zm	No Zm						ns
nps0670	950	32,755	1017.187351	50,939	7.1	980.51	31.31	40.1	61.4	ns
nps1320	142,005	72,175,531	120471.4134	53,427,640	-15.2	52.25	7.23	9.3	14.2	95% dec
nps1344	2,253	1,071,021	1028.768644	268,826	-54.3	969.54	31.14	39.9	61.0	80% dec
nps1387	39,273	14,064,744	42203.82547	52,519,721	7.5	445.82	21.11	27.1	41.4	ns
nps1392	148,036	58,239,555	154206.8527	59,112,841	4.2	55.81	7.47	9.6	14.6	ns
nps1433	31,709	3,923,220	31641.2141	2,053,897	-0.2	59.28	7.70	9.9	15.1	ns
sjs0118	241,225	279,142,198	260873.8024	2,314,076,000	8.1	453.78	21.30	27.3	41.8	ns
sjs0205	126,334	27,966,576	101498.9754	57,507,102	-19.7	47.34	6.88	8.8	13.5	95% dec
sjs0448	52,586	25,203,001	53853.80209	101,824,729	2.4	463.81	21.54	27.6	42.2	ns
sjs0452	135,970	97,925,821	145734.9365	465,252,801	7.2	312.50	17.68	22.7	34.6	ns
sjs0488	No Zm	No Zm	No Zm	No Zm						ns
sjs0600	29,459	13,768,564	29291.93101	105,328,783	-0.6	1,370.56	37.02	47.5	72.6	ns
sjs0635	15,376	4,513,752	14133.55372	4,702,036	-8.1	360.20	18.98	24.3	37.2	ns
sjs0639	No Zm	No Zm	No Zm	No Zm						ns
sjs0683	8,037	1,847,416	7802.043793	2,017,451	-2.9	581.86	24.12	30.9	47.3	ns
sjs0989	79,153	58,335,841	71193.95234	26,016,995	-10.1	116.85	10.81	13.9	21.2	ns
sjs2645	4,065	3,892,448	5321.311318	625,937	30.9	4,415.42	66.45	85.2	130.2	ns
sjs2742	No Zm	No Zm	No Zm	No Zm						ns
sjs2775	51,702	217,354,724	49855.10338	10,437,896	-3.6	795.11	28.20	36.1	55.3	ns
swh0713	7,366	1,951,373	3465.26208	16,533,614	-53.0	3,126.82	55.92	71.7	109.6	ns
swh0918	150,822	98,475,140	136812.5917	53,662,152	-9.3	59.21	7.69	9.9	15.1	ns
swh0940	79,293	13,350,451	77502.5063	11,927,446	-2.3	39.26	6.27	8.0	12.3	ns
swh0955	73,811	470,807,264	77168.6972	6,097,245	4.5	955.78	30.92	39.6	60.6	ns
swh0973	143,679	139,916,844	97560.31678	1,221,834,181	-32.1	623.12	24.96	32.0	48.9	80% dec
swh1557	38,111	28,709,921	38319.07037	21,982,662	0.5	351.18	18.74	24.0	36.7	ns
swh1568	1,509	50,424	1268.173383	83,128	-16.0	521.5	22.84	29.3	44.8	ns
swh1649	48,834	13,389,677	50002.60792	12,872,403	2.4	112.8	10.62	13.6	20.8	ns

ns = change is not significant  
No Zm = no *Z. marina* at site

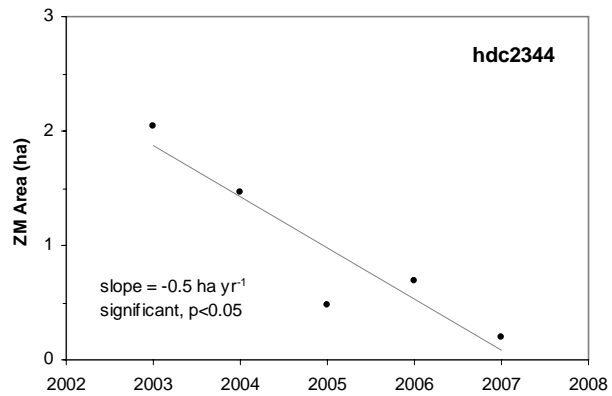
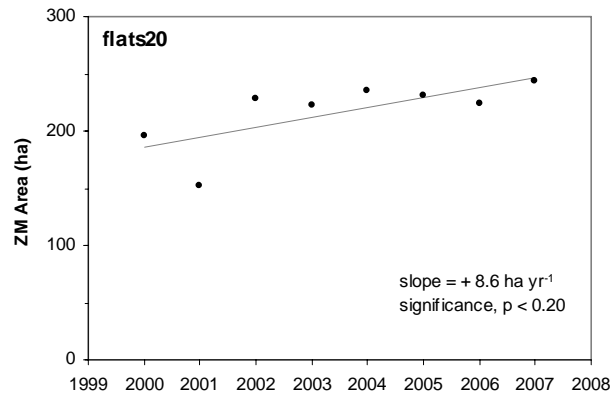
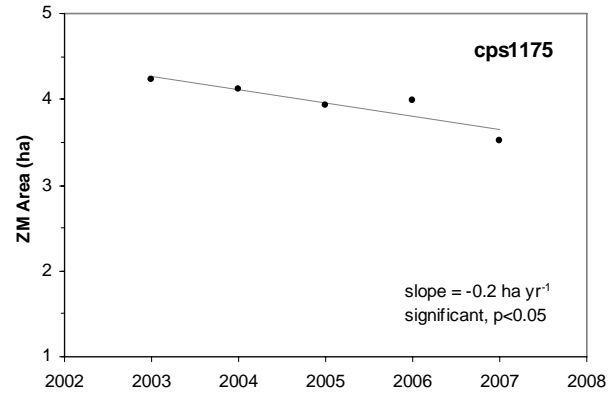
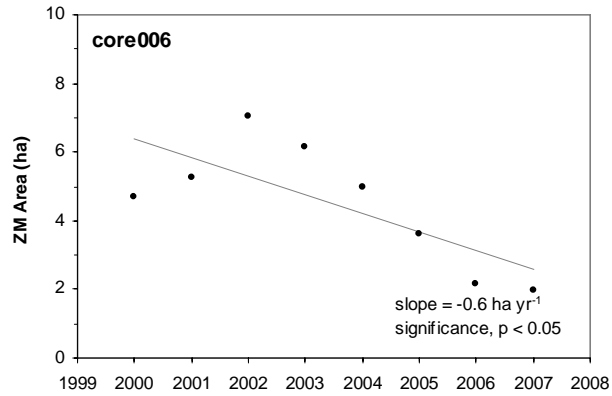
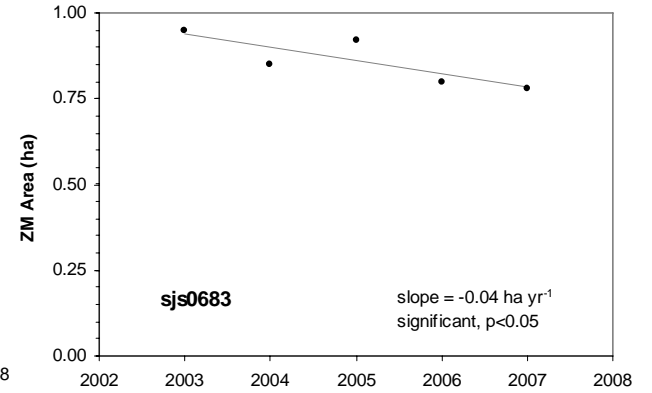
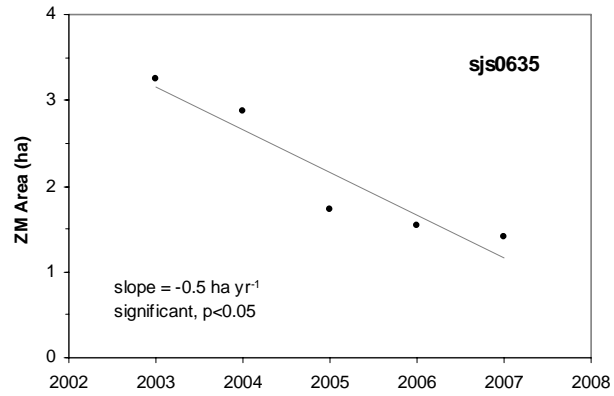
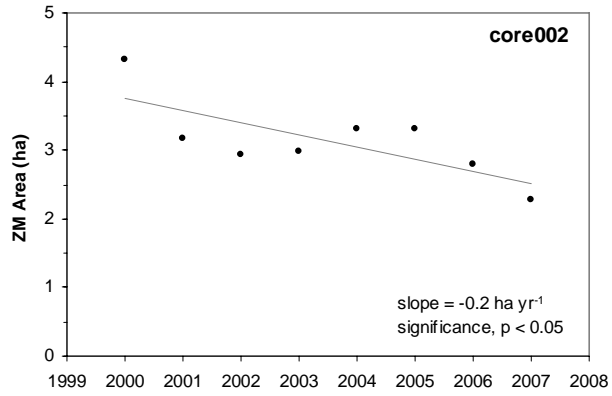
**Appendix G      2006 Site-Level Trend Analysis ( $p < 0.05$ )**



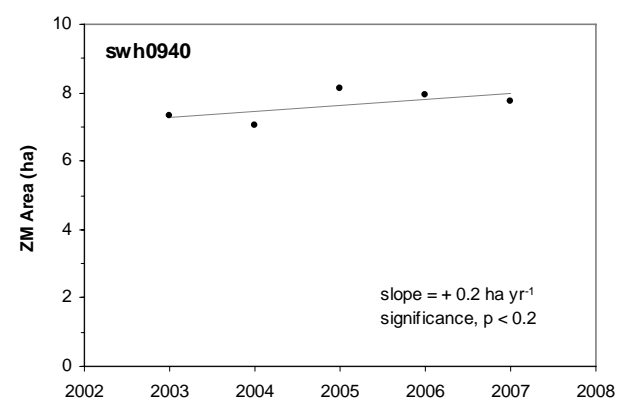
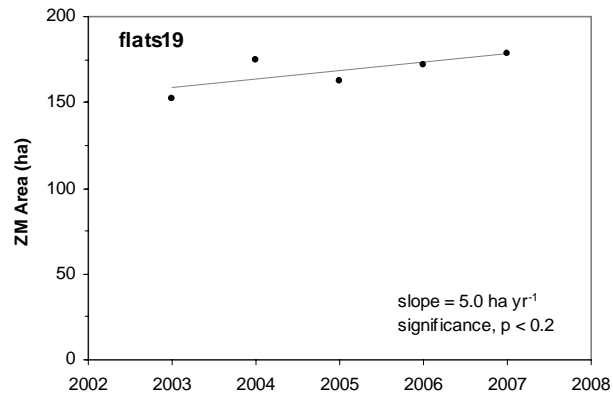
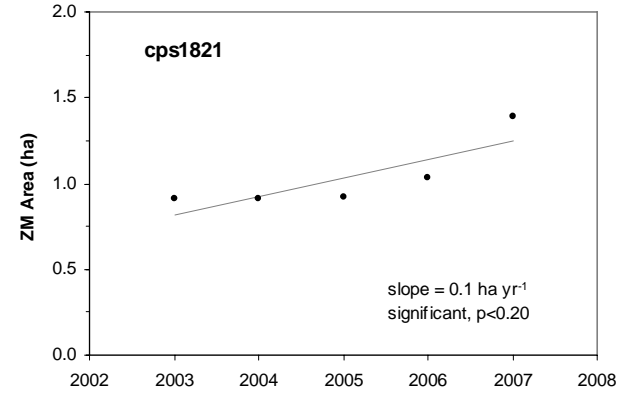
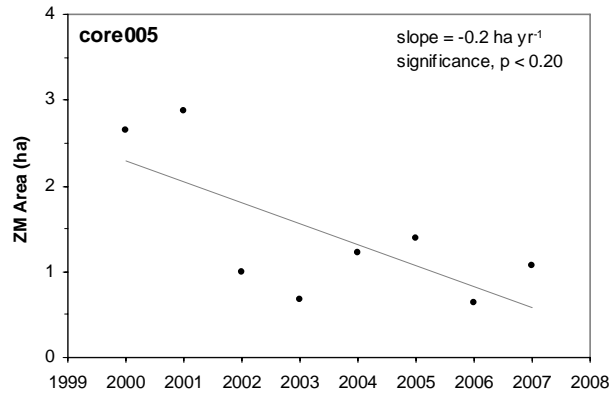
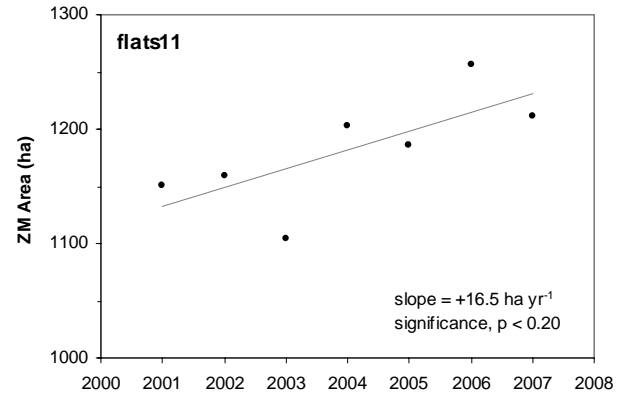
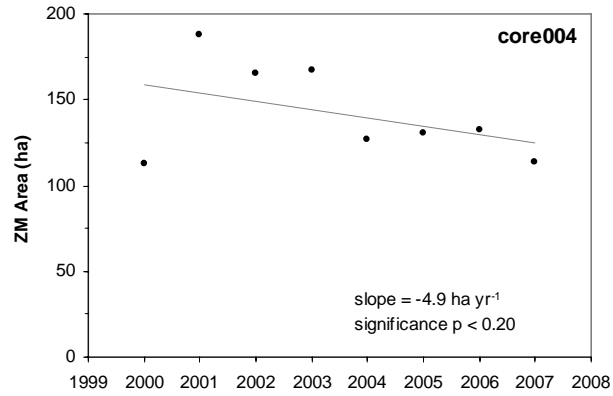
## Appendix H 2006 Site-Level Trend Analysis ( $p < 0.20$ )



## Appendix I 2007 Site-Level Trend Analysis ( $p < 0.05$ )



## Appendix J 2007 Site-Level Trend Analysis ( $p < 0.20$ )





**Appendix K Total *Z. marina* area estimates from 2000-2007**

	2000	2001	2002	2003	2004	2005	2006	2007
Estimate (ha)	19,000	21,400	20,800	21,000	21,500	20,400	22,100	21,400
Standard Error (ha)	7,100	5,900	5,800	5,600	1,600	1,700	1,900	1,900
CV	0.17	0.27	0.27	0.26	0.07	0.08	0.09	0.09
Conf. Interval (95%)	±13,970	±11,570	±11,330	±10,880	±3,090	±3,300	±3,700	±3,700

Note: Values listed for 2000 to 2004 reflect the inclusion of Pt. Roberts, Salmon Bank and Wyckoff Shoal and differ slightly from values published in previous reports (Berry et al. 2003, Dowty et al. 2005).

**Appendix L *Z. marina* depth estimates at the 2006 SVMP sample sites**

Site	Location	Minimum <i>Z. marina</i> Depth					Maximum <i>Z. marina</i> Depth						
		n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% Lower Limit (m)	95% Upper Limit (m)	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% Lower Limit (m)	95% Upper Limit (m)
<b>Core</b>													
Core001	Padilla Bay	11	0.6	0.4	0.0	0.4	0.5	10	-7.2	-4.1	0.4	-4.9	-3.2
Core002	Picnic Cove	14	-0.4	-2.2	0.4	-3.1	-1.3	14	-5.9	-5.3	0.1	-5.6	-5.1
Core003	Jamestown	11	0.2	-0.3	0.2	-0.8	0.2	11	-7.5	-5.9	0.5	-7.0	-4.8
Core004	Lynch Cove	12	0.5	-0.2	0.2	-0.5	0.2	13	-4.3	-2.4	0.3	-3.1	-1.8
Core005	Dumas Bay	7	-0.5	-1.0	0.1	-1.2	-0.7	7	-1.8	-1.6	0.1	-1.8	-1.5
Core006	Burley Spit	15	-0.9	-1.1	0.0	-1.2	-1.0	15	-3.1	-2.1	0.1	-2.3	-1.8

Site	Location	Minimum <i>Z. marina</i> Depth					Maximum <i>Z. marina</i> Depth						
		n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95%	95%	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95%	95%
						Lower Limit (m)	Upper Limit (m)					Lower Limit (m)	Upper Limit (m)
<b>Persistent Flats</b>													
Flats11	Samish Bay N.	9	0.8	0.2	0.2	-0.2	0.6	9	-3.0	-3.6	0.3	-4.3	-2.9
Flats12	Samish Bay S.	9	0.8	0.6	0.1	0.4	0.7	10	-3.3	-3.1	0.0	-3.2	-3.1
Flats20	Skagit Bay N.	19	-0.1	-0.4	0.1	-0.5	-0.3	19	-2.9	-1.5	0.2	-1.9	-1.1

<b>Rotational Flats</b>													
Flats08	Portage Bay S.	14	-0.2	-0.6	0.1	-0.8	-0.5	14	-3.2	-2.5	0.1	-2.8	-2.2
Flats10	Nooksack Delta E.	3	-0.2	-0.4	0.2	-1.3	0.5	3	-0.9	-0.7	0.1	-1.2	-0.2
Flats19	Pull and Be Damned	24	0.8	0.0	0.1	-0.2	0.3	23	-2.5	-1.5	0.1	-1.7	-1.2
Flats26	Snohomish Delta N	11	0.5	0.0	0.1	-0.3	0.2	11	-2.9	-2.1	0.2	-2.6	-1.7
Flats35*	Nisqually Delta E.	12	0.4	-0.2	0.1	-0.4	0.0	12	-1.1	-0.7	0.1	-0.9	-0.6
Flats37	Wing Point	10	-0.7	-1.7	0.5	-2.8	-0.6	10	-6.1	-4.4	0.3	-5.1	-3.8
Flats41	Dosewallips	11	0.3	-0.3	0.2	-0.7	0.1	9	-4.5	-3.7	0.2	-4.1	-3.3
Flats42	Quilcene Bay	11	0.4	-0.1	0.1	-0.3	0.2	11	-4.2	-2.9	0.2	-3.4	-2.3
flats64	Squaw Bay	15	-1.0	-1.3	0.1	-1.5	-1.2	15	-3.5	-2.4	0.2	-2.9	-1.9
Flats67	Fossil Bay	12	-0.7	-2.6	0.3	-3.2	-1.9	13	-5.4	-3.4	0.4	-4.3	-2.5
Flats70	South Fork Skagit River	11	0.1	-0.2	0.0	-0.3	-0.1	11	-3.4	-2.7	0.1	-3.0	-2.4

<b>Narrow Fringe</b>													
cps0221	SE Harstene Island	No Zm											
cps1035	NE of Point White	2	-1.2	-3.0	1.7	N/A	N/A	2	-4.7	-3.0	1.7	N/A	N/A
cps1128	Paradise Cove (Vashon Island)	18	0.7	-1.0	0.2	-1.5	-0.5	18	-5.5	-4.1	0.3	-4.7	-3.4
cps1156	Klahanic Beach (Vashon Island)	13	1.1	-0.1	0.2	-0.5	0.3	13	-4.3	-2.9	0.3	-3.5	-2.3
cps1164	N. of Pt. Robinson (Maury Island)	14	-0.3	-0.8	0.1	-1.1	-0.6	14	-3.3	-2.6	0.1	-2.8	-2.3
cps1175	Piner Point (Maury Island)	14	0.2	-0.2	0.1	-0.3	0.0	14	-3.6	-2.7	0.2	-3.1	-2.4

Site	Location	Minimum <i>Z. marina</i> Depth						Maximum <i>Z. marina</i> Depth					
		n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95%	95%	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95%	95%
						Lower Limit (m)	Upper Limit (m)					Lower Limit (m)	Upper Limit (m)
cps1194	N. Herron Island	No Zm											
cps1277	Thompson Cove (Anderson Island)	11	0.0	-0.9	0.2	-1.4	-0.5	11	-4.0	-2.6	0.4	-3.4	-1.8
cps1676	Broadview	13	0.6	-0.8	0.1	-1.0	-0.5	13	-5.7	-4.7	0.2	-5.1	-4.2
cps1750	Des Moines Beach	12	-0.1	-0.5	0.1	-0.8	-0.3	12	-4.3	-3.3	0.2	-3.7	-2.9
cps1820	Gordon Point	3	-1.5	-1.6	0.1	-2.1	-1.1	2	-2.7	-2.5	0.1	-3.9	-1.1
cps1821	Cormorant Passage	13	0.0	-0.9	0.1	-1.2	-0.5	13	-6.2	-3.4	0.4	-4.2	-2.7
cps1951	S. of Stretch Island	No Zm											
cps1967	Vaughn Bay (Case Inlet)	11	-0.9	-1.2	0.1	-1.4	-1.1	11	-3.6	-2.9	0.2	-3.3	-2.6
cps1983	N. Joemma Beach	No Zm											
cps2201	South of President Point	11	0.4	-0.2	0.1	-0.5	0.1	11	-10.2	-6.9	0.5	-8.0	-5.8
cps2218	Pilot Pt.	11	0.9	0.3	0.2	-0.1	0.7	12	-5.5	-3.4	0.5	-4.5	-2.3
cps2573	Ft. Flagler	15	-0.3	-1.0	0.2	-1.3	-0.7	15	-9.7	-5.0	0.8	-6.7	-3.3
hdc2344	Great Peninsula	17	-1.2	-1.7	0.1	-0.2	0.1	17	-4.0	-3.1	0.1	-3.4	-2.8
hdc2465	SE of Dabob Bay	14	-0.1	-0.7	0.1	-0.9	-0.5	14	-4.5	-3.3	0.2	-3.7	-2.9
hdc2479	Toanados Peninsula, West Side	11	-0.5	-0.8	0.0	-0.9	-0.7	11	-5.9	-4.3	0.2	-4.7	-3.8
nps0522	Eliza Island NE	11	-1.2	-2.0	0.2	-2.4	-1.6	11	-3.0	-4.1	0.1	-4.4	-3.7
nps0550	Vendovi East, Light	No Zm											
nps0670	Boat Harbor (Guemes Island)	10	-0.5	-0.7	0.0	-0.9	-0.6	10	-2.8	-2.2	0.2	-2.6	-1.8
nps1344	E. of Ferndale	9	-0.6	-1.2	0.1	-1.5	-0.8	9	-2.8	-1.6	0.3	-2.3	-1.0
nps1392	Lummi Point (Lummi Island)	17	0.0	-0.9	0.2	-1.2	-0.5	17	-4.3	-3.8	0.1	-4.0	-3.7
sjis0118	SE Decatur Island	13	-2.0	-3.7	0.3	-4.3	-3.0	15	-8.7	-8.0	0.1	-8.2	-7.8
sjis0205	E. of Eagle Point	12	-3.6	-4.9	0.2	-5.5	-4.4	12	-12.4	-11.0	0.2	-11.5	-10.6
sjis0285**	Echo Bay North	13	-1.3	-2.7	0.3	-3.3	-2.2	13	-6.6	-5.1	0.2	-5.6	-4.7
sjis0286**	Echo Bay South	9	-0.6	-1.6	0.3	-2.3	-0.9	9	-6.5	-5.1	0.3	-5.7	-4.6
sjis0448	S. of West Beach	7	0.2	0.1	0.0	0.0	0.1	8	-7.5	-6.6	0.3	-7.2	-6.0

Site	Location	Minimum <i>Z. marina</i> Depth						Maximum <i>Z. marina</i> Depth					
		n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95%	95%	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95%	95%
						Lower Limit (m)	Upper Limit (m)					Lower Limit (m)	Upper Limit (m)
sj0452	S. of Pt. Doughty	11	-0.3	-1.0	0.2	-1.5	-0.6	11	-8.0	-6.2	0.3	-6.9	-5.5
sj0488	East Blakley Park	No Zm											
sj0600	Odlin County Park	15	0.1	-0.6	0.2	-1.0	-0.2	15	-6.8	-4.7	0.4	-5.5	-3.9
sj0617	Lopez Sound Road	15	0.0	-0.3	0.1	-0.4	-0.2	15	-6.6	-3.2	0.6	-4.5	-2.0
sj0635	Watmough Bay (Lopez Island)	11	-4.5	-4.8	0.1	-5.1	-4.5	11	-9.3	-6.7	0.3	-7.3	-6.0
sj0639	Blind Island	No Zm											
sj0649	Canoe Island (Shaw Island)	5	-3.1	-3.6	0.2	-4.2	-3.0	5	-6.0	-5.4	0.3	-6.2	-4.7
sj0683	Brown Island N.	18	-0.9	-3.1	0.3	-3.8	-2.4	18	-7.6	-5.7	0.3	-6.3	-5.2
sj0989	Protection Island SW	12	0.2	-0.2	0.1	-0.4	0.0	12	-9.1	-6.7	0.7	-8.3	-5.1
sj2645	Gardiner, Discovery Bay	10	-0.8	-1.5	0.2	-2.1	-1.0	10	-5.6	-4.2	0.2	-4.7	-3.7
swh0713	Entrance Shelter Bay	10	0.2	-0.9	0.2	-1.3	-0.4	10	-2.5	-1.9	0.2	-2.2	-1.5
swh0940	Holmes Harbor E. (Whidbey Island)	11	0.1	0.0	0.0	-0.1	0.1	11	-4.3	-3.6	0.1	-3.8	-3.3
swh0973	North Possession	11	0.6	0.4	0.1	0.2	0.5	11	-4.3	-3.8	0.1	-4.1	-3.5
swh1557	Rockaway Beach	12	0.1	-1.1	0.1	-0.7	-0.2	12	-4.0	-2.9	0.2	-3.2	-2.5
swh1568	Lowell Point	17	-0.4	-1.6	0.1	-1.9	-1.3	17	-3.5	-2.9	0.1	-3.1	-2.6
swh1649	Nelson's Corner	15	0.8	-0.1	0.1	-0.3	0.2	15	-3.9	-2.9	0.2	-3.3	-2.6

<b>Wide Fringe</b>													
cps1069	Murden Cove (Bainbridge Island)	11	0.1	-0.4	0.1	-0.6	-0.2	11	-5.7	-4.2	0.2	-4.6	-3.8
cps1160	Tramp Harbor	11	0.4	-0.2	0.1	-0.5	0.1	11	-1.6	-0.9	0.2	-1.3	-0.5
cps2221	Point no Point	11	0.6	-0.2	0.4	-1.1	0.8	11	-6.2	-4.5	0.5	-5.7	-3.4
hdc2239	Hood Canal NE	12	0.5	0.2	0.0	0.2	0.4	12	-6.6	-4.2	0.3	-4.8	-3.6
hdc2283	E. of Warrentville	12	0.4	0.0	0.1	-0.2	0.1	12	-3.5	-2.8	0.1	-3.0	-2.6
hdc2284	Warrentville	14	0.2	-0.2	0.1	-0.3	0.0	14	-3.6	-3.1	0.1	-3.3	-2.9
hdc2383	Anna's Bay	12	-0.2	-0.5	0.1	-0.7	-0.4	12	-2.7	-1.4	0.2	-1.9	-0.9

Site	Location	Minimum <i>Z. marina</i> Depth						Maximum <i>Z. marina</i> Depth					
		n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95%	95%	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95%	95%
						Lower Limit (m)	Upper Limit (m)					Lower Limit (m)	Upper Limit (m)
nps0654	Yellow Reef (Guemes Island)	11	-0.6	-0.9	0.1	-1.2	-0.6	11	-6.2	-4.3	0.4	-5.3	-3.4
nps1320	Semiahmoo Spit	11	0.2	-0.3	0.1	-0.5	-0.1	11	-4.2	-3.9	0.1	-4.0	-3.7
nps1387	Sunrise Cove	10	0.6	-0.9	0.3	-1.6	-0.1	10	-3.8	-3.0	0.4	-3.8	-2.1
nps1433	Post Pt. (Fairhaven)	17	-0.1	-0.9	0.2	-1.4	-0.4	17	-3.9	-3.4	0.1	-3.5	-3.2
sjs2742	Between Agate & Crescent Bays	No Zm											
sjs2775	Pysht River	14	-0.7	-2.3	0.2	-2.9	-1.8	14	-7.3	-6.4	0.1	-6.7	-6.1
swh0918	Pratts Bluff	10	-0.1	-0.2	0.0	-0.3	-0.2	10	-4.0	-3.4	0.1	-3.7	-3.2
swh0955	West of Langlely	11	0.0	-0.4	0.1	-0.5	-0.2	11	-5.0	-4.2	0.1	-4.5	-3.9

No Zm = no *Z. marina* found at site

\*Note: *Flats35-Nisqually Delta E.* was added to the 2006 sound-wide sampling effort to satisfy a flats stratum sample size requirement in the *Central Puget Sound Region*. The *Flats35-Nisqually Delta E. Z. marina* area estimates and depth values were not incorporated in the sound-wide area estimates, area change calculations or depth estimates. The *Flats35-Nisqually Delta E. Z. marina* area estimates and depth values were analyzed for year-to-year change at the site-level and presence of *Z. japonica* or *Phyllospadix* spp. (Sections 3.3.2, 3.4.2, 3.5.2 and 3.6).

\*\*Note: *sjs0285-Echo Bay North* and *sjs0286-Echo Bay South* were sampled on May 24, 2006, as part of a collaborative project between WA DNR, Washington State Parks and Recreation Commission Northwest Region Office (WSPRC) and UW (Reeves 2006). The *Z. marina* area estimates from *sjs0285-Echo Bay North* and *sjs0286-Echo Bay South* were not included in any 2006 sound-wide or site-level calculations.

**Appendix M      *Z. marina* depth estimates at the 2006 focus area sample sites**

		Minimum <i>Z. marina</i> Depth						Maximum <i>Z. marina</i> Depth					
Site	Location	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% Lower Limit (m)	95% Upper Limit (m)	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% Lower Limit (m)	95% Upper Limit (m)
<b>Flats</b>													
Flats18	Similk Bay	24	0.5	-0.5	0.2	-0.9	-0.2	24	-3.5	-2.2	0.2	-2.5	-1.9
Flats19	Pull and Be Damned	24	0.8	0.0	0.1	-0.2	0.3	23	-2.5	-1.5	0.1	-1.7	-1.2
Flats21	Skagit Bay mid	11	-0.1	-0.3	0.0	-0.4	-0.2	11	-3.6	-2.8	0.1	-3.0	-2.6
Flats25	Tulalip Bay	10	-0.4	-0.7	0.1	-0.9	-0.5	12	-3.7	-2.2	0.3	-2.8	-1.6
Flats28	Snohomish Delta S.	20	0.1	-0.5	0.1	-0.7	-0.3	20	-5.1	-2.5	0.2	-3.0	-2.1
Flats32	Dugualla Bay	15	0.2	-0.3	0.1	-0.5	-0.2	15	-3.3	-2.3	0.2	-2.6	-1.9
Flats70	South Fork Skagit River	11	0.1	-0.2	0.0	-0.3	-0.1	11	-3.4	-2.7	0.1	-3.0	-2.4
Flats71	Skagit Bay South	13	-0.1	-0.5	0.1	-0.6	-0.3	13	-2.8	-2.1	0.2	-2.5	-1.8
<b>Narrow Fringe</b>													
swh0033	NE Hope Island	14	-0.8	-1.1	0.1	-1.2	-0.9	14	-3.8	-3.2	0.2	-3.5	-2.9
swh0861	Strawberry Point Road	15	-0.5	-0.8	0.1	-0.9	-0.7	15	-3.2	-2.9	0.1	-3.0	-2.8
swh0886	S. Blowers Bluff	No Zm											
swh0902	Long Point	10	0.7	0.3	0.1	0.1	0.6	10	-4.2	-2.3	0.4	-3.3	-1.3
swh0922	South of Greenbank	16	0.1	-0.3	0.1	-0.4	-0.2	16	-5.8	-3.5	0.2	-4.0	-3.0
swh0948	North of Bells Beach	14	0.3	-0.1	0.1	-0.2	0.1	14	-3.9	-2.5	0.2	-3.0	-2.0
swh0965	Randall Point	12	0.6	0.0	0.1	-0.2	0.3	12	-3.9	-2.9	0.2	-3.4	-2.5
swh1582	Camano Head	14	-0.1	-0.6	0.1	-0.8	-0.4	14	-4.4	-3.2	0.2	-3.7	-2.7
swh1597	Mt. View Beach	13	0.2	-0.2	0.1	-0.5	0.0	13	-1.8	-1.2	0.1	-1.4	-1.0
swh1615	S. of Kayak Pt.	15	-0.7	-1.2	0.1	-1.4	-1.0	15	-3.6	-2.7	0.1	-3.0	-2.3

Site	Location	Minimum <i>Z. marina</i> Depth					Maximum <i>Z. marina</i> Depth						
		n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% Lower Limit (m)	95% Upper Limit (m)	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% Lower Limit (m)	95% Upper Limit (m)
<b>Wide Fringe</b>													
swh0857	N. Green Road	15	0.5	0.2	0.1	0.1	0.4	15	-2.7	-1.8	0.1	-2.0	-1.5
swh0885	Blowers Bluff	15	-1.3	-1.0	0.0	-1.1	-0.9	15	-3.3	-2.9	0.1	-3.2	-2.7
swh0904	Snakelum Point	10	0.1	-0.5	0.1	-0.8	-0.1	10	-3.4	-2.7	0.3	-3.4	-2.0
swh0905	East of Snakelum Point	11	0.4	-0.2	0.1	-0.5	0.0	11	-5.5	-3.6	0.3	-4.2	-2.9
swh0955	West of Langley	11	0.0	-0.4	0.1	-0.5	-0.2	11	-5.0	-4.2	0.1	-4.5	-3.9
swh1643	Edgewater	11	0.1	-0.4	0.1	-0.7	-0.1	11	-3.9	-3.3	0.1	-3.5	-3.0

nsg = no seagrass found at site

**Appendix N      *Z. marina* depth estimates at the 2007 SVMP sample sites**

		Minimum <i>Z. marina</i> Depth					Maximum <i>Z. marina</i> Depth				
Site	Location	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% CI Interval (m)	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% CI Interval (m)
<b>Core</b>											
core001	Padilla Bay	10	0.6	0.3	0.1	0.3	10	-4.1	-3.3	0.2	0.4
core002	Picnic Cove	15	-0.5	-2.3	0.4	0.9	15	-6.0	-4.9	0.1	0.3
core003	Jamestown	10	0.4	0.0	0.1	0.1	10	-7.2	-5.7	0.4	0.7
core004	Lynch Cove	15	0.2	-0.4	0.1	0.2	15	-4.1	-2.7	0.2	0.5
core005	Dumas Bay	10	-0.6	-1.0	0.1	0.2	10	-1.7	-1.5	0.0	0.1
core006	Burley Spit	14	-0.7	-0.9	0.0	0.1	14	-2.9	-2.2	0.1	0.2
<b>Persistent Flats</b>											
flats11	Samish Bay N.	8	0.6	0.0	0.1	0.2	9	-4.9	-3.5	0.2	0.4
flats12	Samish Bay S.	11	0.6	0.3	0.1	0.1	11	-3.3	-3.1	0.0	0.1
flats20	Skagit Bay N.	17	0.0	-0.3	0.0	0.1	17	-2.6	-1.5	0.1	0.3
<b>Rotational Flats</b>											
flats08	Portage Bay S.	13	-0.2	-0.7	0.1	0.1	14	-2.9	-2.3	0.2	0.3
flats19	Pull and Be Damned	18	0.6	-0.4	0.2	0.4	18	-2.6	-1.5	0.2	0.4
flats26	Snohomish Delta N	11	0.3	0.0	0.1	0.2	11	-2.8	-2.2	0.1	0.2
flats41	Dosewallips	11	0.2	-0.5	0.2	0.4	11	-7.0	-3.9	0.5	0.9
flats42	Quilcene Bay	15	0.4	-0.1	0.1	0.1	15	-3.7	-2.5	0.2	0.4
flats55	Mitchell Bay	12	-1.0	-3.3	0.5	1.0	12	-5.9	-4.9	0.3	0.6
flats64	Squaw Bay	19	-0.9	-1.2	0.0	0.1	19	-3.3	-2.4	0.2	0.3
flats66	Shallow Bay, Sucia	13	-0.1	-2.3	0.4	0.8	13	-5.7	-3.4	0.4	0.8
flats67	Fossil Bay	16	-2.6	-3.1	0.1	0.2	1	-5.2	-5.2	-9999.0	-9999.0
flats70	South Fork Skagit River	9	-0.1	-0.3	0.0	0.1	9	-3.5	-2.8	0.1	0.3



Site	Location	Minimum <i>Z. marina</i> Depth					Maximum <i>Z. marina</i> Depth				
		n	Absolute	Mean	Standard	95% CI	n	Absolute	Mean	Standard	95% CI
			Depth	Depth	Error	Interval		Depth	Depth	Error	Interval
		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	
<b>Narrow Fringe</b>											
cps0224	Wilson Point (Harstene Island)	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps1035	NE of Point White	3	-1.3	-3.5	1.1	2.2	3	-4.8	-3.6	1.0	2.0
cps1175	Piner Point (Maury Island)	14	-0.1	-0.4	0.1	0.3	14	-3.9	-2.7	0.2	0.4
cps1194	N. Herron Island	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps1277	Thompson Cove	11	-0.1	-1.1	0.2	0.4	11	-3.6	-2.4	0.3	0.5
cps1289	Villa Beach N	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps1676	Broadview	14	0.6	-0.6	0.2	0.4	14	-5.9	-4.3	0.2	0.5
cps1750	Des Moines Beach	13	-0.1	-0.6	0.1	0.3	13	-4.8	-3.8	0.2	0.3
cps1820	Gordon Point	4	-0.9	-1.2	0.1	0.2	4	-2.8	-1.9	0.5	0.9
cps1821	Cormorant Passage	13	-0.8	-1.1	0.1	0.1	13	-6.0	-3.8	0.3	0.7
cps1951	S. of Stretch Island	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps1954	Stretch Point State Park	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps1967	Vaughn Bay (Case Inlet)	13	-0.9	-1.1	0.1	0.1	13	-3.2	-2.7	0.1	0.3
cps1983	N. Joemma Beach	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps2201	South of President Point	11	0.6	-0.1	0.2	0.3	11	-7.3	-5.5	0.4	0.8
cps2552	Oak Bay Boat Ramp	10	0.2	-0.1	0.1	0.2	10	-5.4	-3.0	0.5	0.9
hdc2321	Across from Eagle Creek	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
hdc2344	Great Peninsula	10	-1.2	-2.6	0.3	0.5	10	-4.0	-3.2	0.2	0.4
hdc2460	Lindsay's Beach	12	-0.7	-1.2	0.1	0.3	12	-7.6	-4.8	0.3	0.6
hdc2465	SE of Dabob Bay	14	-0.4	-0.8	0.1	0.1	14	-4.2	-3.6	0.1	0.2
hdc2479	Toanados Peninsula, West Side	12	-0.6	-0.8	0.0	0.1	12	-4.9	-4.1	0.1	0.3
nps0550	Vendovi East, Light	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
nps0670	Boat Harbor (Guemes Island)	10	-0.4	-0.9	0.1	0.1	10	-2.9	-2.0	0.2	0.4

Site	Location	Minimum <i>Z. marina</i> Depth					Maximum <i>Z. marina</i> Depth				
		n	Absolute	Mean	Standard	95% CI	n	Absolute	Mean	Standard	95% CI
			Depth	Depth	Error	Interval		Depth	Depth	Error	Interval
		(m)	(m)		(m)		(m)	(m)		(m)	
nps1344	E. of Ferndale	4	-0.7	-1.6	0.4	0.8	4	-3.6	-2.5	0.5	1.0
nps1392	Lummi Point (Lummi Island)	17	0.0	-0.5	0.1	0.2	17	-4.5	-3.7	0.1	0.2
sjs0001	Strawberry Bay North	12	-0.5	-2.0	0.4	0.8	12	-6.5	-5.6	0.2	0.4
sjs0118	SE Decatur Island	15	-1.7	-3.4	0.3	0.6	15	-8.6	-7.9	0.1	0.2
sjs0205	E. of Eagle Point	12	-3.3	-4.9	0.2	0.4	12	-12.0	-10.7	0.2	0.4
sjs0448	S. of West Beach	13	-0.3	-0.8	0.1	0.3	14	-8.6	-6.3	0.3	0.7
sjs0452	S. of Pt. Doughty	14	-0.7	-1.4	0.2	0.3	14	-8.5	-6.7	0.3	0.6
sjs0488	E. of Blakely Peak	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
sjs0600	Odlin County Park	18	0.1	-0.9	0.3	0.6	20	-8.6	-5.2	0.4	0.7
sjs0635	Watmough Bay (Lopez Island)	11	-4.2	-4.9	0.2	0.3	11	-7.6	-6.5	0.2	0.3
sjs0639	Blind Island	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
sjs0683	Brown Island N.	15	-2.0	-3.5	0.3	0.6	16	-7.1	-5.7	0.3	0.5
sjs0989	Protection Island SW	13	0.1	-0.4	0.1	0.2	13	-10.0	-5.9	0.8	1.7
sjs1492	Shannon Point W.	16	-0.6	-1.8	0.3	0.6	16	-6.5	-4.6	0.4	0.7
sjs2645	Gardiner, Discovery Bay	13	-0.6	-1.2	0.2	0.4	13	-5.0	-4.1	0.2	0.3
sjs2652	Thompson Spit, Discovery Bay	13	-0.2	-0.9	0.1	0.3	13	-7.7	-5.3	0.4	0.9
swh0713	Entrance Shelter Bay	13	0.3	-1.0	0.2	0.4	13	-2.8	-2.1	0.2	0.4
swh0940	Holmes Harbor E.	15	0.2	-0.1	0.1	0.1	15	-4.3	-3.6	0.1	0.2
swh0973	North Possession	11	0.2	-0.5	0.1	0.3	11	-4.3	-3.3	0.2	0.4
swh1557	Rockaway Beach	13	-0.1	-0.7	0.1	0.3	13	-4.3	-2.7	0.2	0.5
swh1568	Lowell Point	15	-0.3	-1.6	0.2	0.3	15	-3.7	-2.9	0.2	0.3
swh1649	Nelson's Corner	12	0.7	-0.2	0.2	0.3	12	-3.5	-3.0	0.1	0.3
<b>Wide Fringe</b>											
cps1069	Murden Cove (Bainbridge Island)	11	0.3	-0.2	0.1	0.2	11	-4.4	-3.7	0.2	0.3

Site	Location	Minimum <i>Z. marina</i> Depth					Maximum <i>Z. marina</i> Depth				
		n	Absolute	Mean	Standard	95% CI	n	Absolute	Mean	Standard	95% CI
			Depth	Depth	Error	Interval		Depth	Depth	Error	Interval
(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)		
cps1160	Tramp Harbor	17	0.4	-0.3	0.1	0.2	17	-1.7	-1.2	0.1	0.2
hdc2283	E. of Warrenville	13	0.1	-0.4	0.1	0.2	13	-3.4	-2.8	0.1	0.2
hdc2284	Warrenville	14	0.3	-0.4	0.1	0.2	14	-3.4	-3.1	0.1	0.1
hdc2383	Anna's Bay	14	0.2	-0.5	0.1	0.2	14	-4.3	-2.0	0.2	0.5
nps1320	Semiahmoo Spit	10	0.1	-0.1	0.1	0.1	10	-3.9	-3.5	0.1	0.2
nps1328	W of Birch Bay	5	-0.7	-1.3	0.2	0.4	5	-3.4	-2.5	0.3	0.6
nps1387	Sunrise Cove	13	0.4	-0.1	0.1	0.2	13	-3.9	-2.7	0.3	0.6
nps1433	Post Point, Fairhaven	0	-9999.0	-9999.0	-9999.0	-9999.0	17	-3.7	-3.2	0.1	0.2
sjs2742	Between Agate & Crescent Bays	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
sjs2775	Pysht River	15	-0.8	-2.5	0.2	0.5	15	-7.2	-6.0	0.3	0.5
swh0869	Polnell Point Light W.	2	-0.6	-0.7	0.1	0.2	2	-1.2	-1.2	0.0	0.1
swh0881	Maylor Point, Whidbey Island	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
swh0918	Pratts Bluff (Whidbey Island)	12	-0.1	-0.2	0.0	0.1	12	-4.0	-3.5	0.1	0.2
swh0955	West of Langley	11	0.0	-0.3	0.1	0.1	11	-4.9	-4.0	0.2	0.3

## Appendix O *Z. marina* depth estimates at the 2007 focus area sample sites

Site	Location	Minimum <i>Z. marina</i> Depth				Maximum <i>Z. marina</i> Depth					
		n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% CI Interval (m)	n	Absolute Depth (m)	Mean Depth (m)	Standard Error	95% CI Interval (m)
<b>Rotational Flats</b>											
flats34	Nisqually Delta W	8	0.3	-0.6	0.2	0.5	8	-3.3	-1.5	0.4	0.9
flats35	Nisqually Delta E.	13	0.1	-0.3	0.1	0.1	13	-1.0	-0.7	0.0	0.1
flats39	Liberty Bay	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
flats46	Kilisut Harbor	9	-0.1	-0.6	0.1	0.3	9	-8.2	-4.7	0.7	1.3
<b>Narrow Fringe</b>											
cps0046	East Indian Island	10	-0.3	-0.6	0.0	0.1	12	-5.0	-3.6	0.2	0.4
cps1097	E. of Rocky Point	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps1108	W. Blake Island	13	-0.1	-0.6	0.1	0.2	13	-7.1	-6.0	0.2	0.4
cps1114	SW Blake Island	6	-0.5	-1.1	0.2	0.3	6	-4.6	-3.0	0.5	1.0
cps1264	Eagle Island South	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps1691	S of Fourmile Rock Light	12	-0.7	-0.8	0.0	0.1	12	-4.3	-3.6	0.2	0.4
cps1754	Saltwater State Park	13	-0.1	-0.9	0.2	0.4	13	-3.7	-2.9	0.3	0.5
cps1797	Tacoma Yacht Club	10	-1.3	-2.6	0.4	0.9	10	-5.9	-3.7	0.4	0.9
cps1815	Pioneer	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps2022	S of Thompson Spit	14	-0.1	-0.6	0.1	0.1	14	-1.7	-1.4	0.1	0.2
cps2040	Lay Inlet	7	-1.0	-1.4	0.2	0.3	7	-3.5	-2.5	0.3	0.5
cps2050	Forest Beach	12	-1.0	-1.3	0.1	0.1	12	-3.0	-1.8	0.1	0.3
cps2055	Across from Nearns Points	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps2067	Point Fosdick	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps2102	North Southward	14	-0.6	-1.2	0.1	0.2	14	-4.6	-3.7	0.1	0.3
cps2145	Olympic College	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps2208	NE of Kingston	11	0.4	0.0	0.1	0.2	11	-5.6	-5.0	0.1	0.2

Site	Location	Minimum <i>Z. marina</i> Depth					Maximum <i>Z. marina</i> Depth				
		n	Absolute	Mean	Standard	95% CI	n	Absolute	Mean	Standard	95% CI
			Depth	Depth	Error	Interval		Depth	Depth	Error	Interval
		(m)	(m)		(m)		(m)	(m)		(m)	
cps2540	N of Port Ludlow	13	0.7	0.2	0.1	0.2	13	-2.8	-1.8	0.1	0.2
cps2541	S of Snake Rock Light	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0
cps2548	S of Oak Bay 2	12	-0.9	-1.4	0.1	0.2	12	-4.0	-3.4	0.1	0.3
cps2549	S of Oak Bay 1	9	-0.5	-1.4	0.2	0.5	9	-4.0	-3.1	0.3	0.6
cps2555	E of Oak Bay Boat Ramp	12	-0.2	-0.6	0.1	0.1	12	-5.3	-3.5	0.3	0.6
<b>Wide Fringe</b>											
cps0763	N. Dave Mackie Park	11	0.2	-0.2	0.1	0.2	11	-5.4	-4.2	0.2	0.4
cps0766	S. Useless Bay	13	0.1	-0.5	0.1	0.1	14	-5.7	-2.6	0.5	1.0
cps0794	Lake Hancock Target Range	4	-2.3	-2.6	0.1	0.3	4	-5.7	-5.2	0.3	0.6
cps1066	Rolling Bay	11	0.6	0.1	0.2	0.3	11	-4.7	-3.8	0.2	0.5
cps1663	Edmonds Cable Area	11	-1.0	-2.7	0.5	0.9	11	-6.5	-4.5	0.5	0.9
cps2565	N of East Beach County Park	0	-9999.0	-9999.0	-9999.0	-9999.0	0	-9999.0	-9999.0	-9999.0	-9999.0

## **Appendix P            2006 and 2007 SVMP rotational sample design and site selection**

Sites in the narrow fringe, wide fringe and rotational flats strata are selected based on a yearly rotational sample design. For these strata, 80% of the randomly selected sites from the previous year are retained and 20% are replaced with new randomly selected sites (Berry et al. 2003). The rate of site rotation to determine the status estimate and change estimate has been thoroughly reviewed (Dowty 2005a).

In general, for each field season the sample of sites within each stratum subject to rotation is determined in two steps. First, 20% of sites from the previous year that have been sampled for at least five years are selected for removal. Second, an equal number of sites are randomly selected from eligible sites in the stratum for addition to the pool of sites. Eligible sites are those that (a) are not currently in the sample and (b) have not been in the sample pool within the previous five years.

## **Appendix Q            2006 Saratoga-Whidbey Basin Region and 2007 Central Puget Sound Region focus area site selection**

The initial task in the *Saratoga-Whidbey Basin Region* and *Central Puget Sound Region* site selections process was to match the total focus area effort of 36 fringe-equivalents. A fringe-equivalent is the nominal effort to sample one fringe site, and is used as an accounting aid for managing sampling effort from year to year. Therefore, if the time it takes to sample two fringe sites is equivalent to one flats site then the sampling effort to sampling the flats site is two fringe-equivalents. In the 2004 *San Juan-Straits Region* focus area eight flats sites were sampled and in 2005, additional fringe sites were added at a 2:1 effort ratio to account for the limited number of flats sites (5) available in the *Hood Canal Region* (Gaeckle et al. 2007).

The *Saratoga-Whidbey Basin Region* had eight available flats sites to sample and since many flats in the region are very large, a multiplier of 2.5 was used to achieve an allocation of 36 fringe-equivalents across the strata. Based on the 2.5:1 effort ratio (fringe:flats), 16 additional fringe sites (10 narrow fringe and 6 wide fringe) were selected to make the *Saratoga-Whidbey Basin Region* focus area sampling effort consistent with the 2004 and 2005 focus area effort (Table I-1).

The four available flats sites in the *Central Puget Sound Region* were smaller than those in the *Saratoga-Whidbey Basin Region*, therefore, a multiplier of 2.0 was used to achieve an allocation of 36 fringe-equivalents across the strata. Based on the 2.0:1 effort ratio (fringe:flats), 28 additional fringe sites (22 narrow fringe and 6 wide fringe) were selected to make the *Central Puget Sound Region* focus area sampling effort consistent with the 2004, 2005, and 2006 focus area effort (Table I-1).

### Fringe Stratification

*Zostera marina* area estimates for the narrow and wide fringe sites from 2000 to 2004 were compared prior to site selection in the *Hood Canal Region* focus area to determine whether the fringe strata should be stratified or pooled. A significant difference in the mean *Z. marina* area between the narrow and wide fringe strata justified maintaining the stratification of the fringe sites (Gaeckle et al. 2007).

### Site selection

The allocation of effort between the strata was determined and the respective numbers of sites were randomly selected from the pool of eligible sites in each stratum. Since sites for the sound-wide sampling were randomly selected, data from sites that fell within the focus area could be used in the focus area *Z. marina* analysis and estimates.

**Table I-1. Allocation of sampling effort among the flats and fringe frames in 2004, 2005, 2006 and 2007. Sites were selected on the basis that 1) overall focus area effort in 2007 will be the same as in 2004, 2005 and 2006, and 2) the effort to sample a typical flats site is 2.5:1 in 2006 and 2:1 in 2007. Number in parentheses in flats stratum is the fringe equivalents. A fringe equivalent is the nominal effort to sample one fringe site.**

	San Juan Focus Area	Hood Canal Focus Area	Saratoga – Whidbey Focus Area	Central Puget Sound Focus Area
	2004	2005	2006	2007
flats	8(16)	5 (10)	8 (20)	4 (8)
fringe	20	26	16	28
total effort (fringe equivalents)	36	36	36	36

Appendix R

Sites used in the Saratoga – Whidbey Basin Region Focus Area analysis

Table L-1. Complete list of the 33 sites used to calculate the 2006 Saratoga – Whidbey Basin Region focus area status estimate. The list includes sites sampled explicitly as part of the focus area study and sites sampled as part of the Puget Sound study.

geomorphic category	study	Site	sound-wide stratum
fringe	focus area study	swh0033	narrow fringe
		swh0857	wide fringe
		swh0861	narrow fringe
		swh0885	wide fringe
		swh0886	narrow fringe
		swh0902	narrow fringe
		swh0904	wide fringe
		swh0905	wide fringe
		swh0922	narrow fringe
		swh0948	narrow fringe
		swh0965	narrow fringe
		swh1582	narrow fringe
		swh1597	narrow fringe
	swh1615	narrow fringe	
	swh1643	wide fringe	
	sound-wide study	swh0713	narrow fringe
		swh0918	wide fringe
		swh0940	narrow fringe
		swh0955	wide fringe
swh0973		narrow fringe	
swh1557		narrow fringe	
swh1568		narrow fringe	
swh1649	narrow fringe		
flats	focus area study	flats18	rotational flats
		flats21	rotational flats
		flats25	rotational flats
		flats28	rotational flats
		flats32	rotational flats
		flats71	rotational flats
	sound-wide study	flats19	rotational-flats
		flats20	rotational-flats
		flats26	rotational-flats
		flats70	rotational flats



**Appendix S                      Sites used in the Central Puget Sound Region Focus Area analysis**

**Table M-1. Complete list of the 33 sites used to calculate the 2007 *Central Puget Sound Region* focus area status estimate. The list includes sites sampled explicitly as part of the focus area study and sites sampled as part of the Puget Sound study.**

<b>geomorphic category</b>	<b>study</b>	<b>Site</b>	<b>sound-wide stratum</b>
		cps0046	narrow fringe
		cps0763	wide fringe
		cps0766	wide fringe
		cps0794	wide fringe
		cps1066	wide fringe
		cps1097	narrow fringe
		cps1108	narrow fringe
		cps1114	narrow fringe
		cps1264	narrow fringe
		cps1663	wide fringe
		cps1691	narrow fringe
		cps1754	narrow fringe
		cps1797	narrow fringe
<b>fringe</b>	<b>focus area study</b>	cps1815	narrow fringe
		cps2022	narrow fringe
		cps2040	narrow fringe
		cps2050	narrow fringe
		cps2055	narrow fringe
		cps2067	narrow fringe
		cps2102	narrow fringe
		cps2145	narrow fringe
		cps2208	narrow fringe
		cps2540	narrow fringe
		cps2541	narrow fringe
		cps2548	narrow fringe
		cps2549	narrow fringe
		cps2555	narrow fringe
		cps2565	wide fringe

		core005	wide fringe
		core006	narrow fringe
		cps0224	narrow fringe
		cps1035	narrow fringe
		cps1069	wide fringe
		cps1160	wide fringe
		cps1175	narrow fringe
		cps1194	narrow fringe
		cps1277	narrow fringe
<b>fringe</b>	<b>sound-wide study</b>	cps1289	narrow fringe
		cps1676	narrow fringe
		cps1750	narrow fringe
		cps1820	narrow fringe
		cps1821	narrow fringe
		cps1951	narrow fringe
		cps1954	narrow fringe
		cps1967	narrow fringe
		cps1983	narrow fringe
		cps2201	narrow fringe
		cps2552	narrow fringe
		flats34	rotational flats
<b>flats</b>	<b>focus area study</b>	flats35	rotational flats
		flats39	rotational flats
		flats46	rotational flats

## Appendix T      Obstructed sites

### *Obstructed sites*

A detailed description of the Procedures for Obstructed Sites is outlined in Appendix K of a previous report (Gaeckle et al. 2007). There were no sites considered obstructed in 2006 (Table K-1).

**Table K-1. Record of all sites that have been considered obstructed, 2000-2006, and whether the site was actually visited or whether it was replaced at the time of the random draw.**

	2000	2001	2002	2003	2004	2005	2006	2007
nps1342	visited obstructed	visited obstructed	visited obstructed					
sjs0819	visited obstructed	visited sampled	visited sampled	visited sampled	visited sampled	visited sampled		
swh0718	visited obstructed	visited sampled	visited sampled	visited sampled				
sjs2764		visited obstructed						
sjs2815		visited obstructed	visited obstructed					
sjs2692			visited obstructed					
swh0714						visited obstructed		
hdc2276						drawn/repl. obstructed		
hdc2274						drawn/repl. obstructed		

## Appendix U Multiple parameter assessment of site-level change

All site level results that were used for the multiple parameter assessment of change are shown in Table U-1. The results of the assessment are summarized in Section 3.5.2.

**Table U-1. Summary of seven measures of *Z. marina* site-level change for all sites sampled in 2006 and 2007. Many sites do not have values for all seven measures. Results of the five-plus-year trend tests are also included. Statistical significance of individual measures of change is indicated for  $p < 0.2$  (\*) and  $p < 0.05$  (\*\*). Sites considered to have sufficient evidence for heightened concern in 2006 and 2007 are listed in bold.**

site	2002-04	2004-05	2004-05	2004-05	2005-06	2005-06	2005-06	5 plus-year	2006-07	2006-07	2006-07	5 plus-year	indications of decline 2007 (added to 2006 values)		
	<i>Z. marina</i> decline evidence	<i>Z. marina</i> area change	mean maximum depth change	mean minimum depth change	indications of decline 2005	<i>Z. marina</i> area change	mean max depth change	mean min depth change	<i>Z. marina</i> area trend	indications of decline 2006	<i>Z. marina</i> area change	mean max depth change	mean min depth change	<i>Z. marina</i> area trend	
core001	no	no change	expanded*	receded	1	no change			no trend decreasing *	1	no change	receded*		no trend decreasing **	2
<b>core002</b>	no	increase	expanded	expanded	0	decrease**				1	decrease**	receded**			4
core003	no	decrease	no change	receded	2	no change			expanding*	2	no change		expanded*	no trend decreasing *	2
core004	no	increase	no change	no change	0	no change			no trend decreasing *	0	no change			decreasing *	1
<b>core005</b>	no	increase	no change	no change	0	decrease**				1	no change			decreasing *	2
<b>core006</b>	strong	decrease*	receded*	receded*	4	decrease**			decreasing *	5	no change		expanded*	decreasing *	6
cps1035						no change					no change				0
cps1069	no	decrease	receded**	expanded	2	no change				2	no change	receded*	expanded*	no trend	3
cps1128	no	decrease	expanded expanded*	receded*	2	no change			no trend	2					
cps1156	no	increase		receded	1	no change			no trend	1					
cps1160											decrease*				1
cps1164	no	decrease*	no change	receded*	2	no change			no trend	2					
cps1175	no	decrease	receded**	expanded*	2	no change	expanded*			2	no change		receded*	decreasing **	4
cps1277	no	increase	expanded	expanded	0	no change				0	decrease*			no trend	1
<b>cps1676</b>										0	no change				0
cps1750	no	decrease*	receded**	receded	3	no change				3	increase*	expanded*		no trend	3
cps1820						no change				0	no change				0

site	2002-04	2004-05	2004-05	2004-05	2005-06	2005-06	2005-06	5 plus-year	2006-07	2006-07	2006-07	5 plus-year	indications of decline 2007 (added to 2006 values)		
site	Z. marina decline evidence	Z. marina area change	mean maximum depth change	mean minimum depth change	indications of decline 2005	Z. marina area change	mean max depth change	mean min depth change	Z. marina area trend	indications of decline 2006	Z. marina area change	mean max depth change	mean min depth change	Z. marina area trend	indications of decline 2007 (added to 2006 values)
cps1821	no	increase	receded**	expanded	1	no change				1	no change			increasing*	1
cps1967		decrease**	receded	expanded	2	no change		receded*		3	no change				3
cps2201	no	increase	receded*	receded	2	decrease*				3	increase*			no trend	3
cps2218	no	decrease	receded	expanded*	2	no change		receded*	no trend decreasing	3					
<b>cps2221</b>	no	increase	expanded*	receded	1	decrease*				2					
cps2573	no	increase	expanded*	receded	1	no change			increasing*	1					
flats08	no	decrease	receded*	receded	3	no change				3	decrease**			no trend	4
flats11	no	decrease	receded	no change	2	no change			increasing*	2	no change			increasing*	2
flats12	no	increase	expanded	receded	1	increase*		expanded*		1	decrease**		receded**		3
<b>flats18</b>	very strong	increase	no change	no change	1	no change			decreasing**	1					
flats19	no	decrease	expanded	no change	1	no change				1			receded*	increasing* increasing*	2
flats20	no	decrease	expanded*	no change	1	no change			expanding*	1	no change			*	1
flats26										0	no change				0
flats35	no	decrease	expanded	receded	2	decrease**	receded*		no trend	4	no change			no trend	4
flats37	strong	increase	expanded	receded	2	no change			no trend	2					
flats41		increase	expanded	receded	1	decrease*				2	no change				2
flats42										0	no change				0
flats43	strong	increase	expanded	expanded	1				decreasing**	1					
flats64					0					0	no change				0
flats67		increase	no change expanded*	receded*	1	no change	receded**			2	no change		receded*		3
flats70		decrease	*	expanded	1	no change				1	no change				1
<b>hdc2239</b>	very strong	decrease	expanded	expanded	2	no change			decreasing**	2					
hdc2283											no change		receded**		1
hdc2284									decreasing**		decrease**		receded*		2
hdc2338	no	decrease**	receded*	receded*	3					3					
hdc2344	no	decrease**	receded*	receded	3	no change				3	decrease**		receded**	decreasing**	6
hdc2359	strong	decrease**	expanded	receded	3				decreasing**	3					
hdc2383		decrease*	expanded	no change	1	no change				1	no change	expanded*			1

hdc2465		decrease**	receded	receded	3	no change				3	no change	expanded*			3
hdc2479		decrease	receded	no change	2	no change				2	no change				2
	2002-04	2004-05	2004-05	2004-05		2005-06	2005-06	2005-06	5 plus-year		2006-07	2006-07	2006-07	5 plus-year	
site	Z. marina decline evidence	Z. marina area change	mean maximum depth change	mean minimum depth change	indications of decline 2005	Z. marina area change	mean max depth change	mean min depth change	Z. marina area trend	indications of decline 2006	Z. marina area change	mean max depth change	mean min depth change	Z. marina area trend	indications of decline 2007 (added to 2006 values)
hdc2529	no	decrease	receded	expanded	2				decreasing*	2					
nps0059	no	decrease	receded*	expanded	2				decreasing**	2					
nps0522	no	increase	expanded*	receded	1	decrease*			no trend	2					
nps0654	strong	increase	expanded	no change	1	no change	receded*	expanded*	increasing*	2					
nps0670		increase	receded	receded*	2	decrease*		expanded*		3	no change		receded* expanded*		4
nps1320	no	increase	receded	no change	1	decrease**	expanded*			2	decrease**	receded**		no trend	4
nps1344											decrease*				1
nps1387											no change				0
nps1392		increase	receded	no change	1	no change				1	no change				0
nps1433		decrease	receded*	expanded	2	increase*	expanded*	receded*		3	no change	receded*			4
sjs0081	very strong	increase	expanded	receded*	2				decreasing**	2					
sjs0118											no change				0
sjs0205											decrease**				1
sjs0448											no change		receded**		1
sjs0452											no change				0
sjs0600											no change				0
sjs0617	no	decrease	receded expanded*	no change	2				increase**	2					
sjs0635	no	decrease**	expanded*	receded	2	no change				2	no change			decreasing**	3
sjs0649	no	increase	expanded	no change	0	no change			no trend	0					
sjs0683	no	increase	expanded	receded**	1	no change				1	no change			decreasing**	2
sjs0819	no	decrease**	receded**	receded*	3				decreasing**	3	no change				0
sjs0989	no	decrease*	receded**	expanded*	2	no change				2	no change		receded*	no trend	3
sjs2645		decrease	expanded	no change	1	no change				1	no change				1
sjs2741	no	decrease*	receded	receded	3				no trend	3					
sjs2775	no	increase	receded	receded*	2	no change				2	no change	receded*		no trend	3
swh0918		increase**	no change	receded	1	no change		expanded*		1	no change				1

swh0940	no	increase*	receded	no change	1	no change				1	no change			increasing*	1
swh0943	no	increase	receded**	expanded	1				no trend	1					
swh0955											no change				0
	2002-04	2004-05	2004-05	2004-05		2005-06	2005-06	2005-06	5 plus-year		2006-07	2006-07	2006-07	5 plus-year	
site	<i>Z. marina</i> decline evidence	<i>Z. marina</i> area change	mean maximum depth change	mean minimum depth change	indications of decline 2005	<i>Z. marina</i> area change	mean max depth change	mean min depth change	<i>Z. marina</i> area trend	indications of decline 2006	<i>Z. marina</i> area change	mean max depth change	mean min depth change	<i>Z. marina</i> area trend	indications of decline 2007
swh0973											decrease*	receded**	receded**	expanded*	3
swh1557		increase	receded**	receded	2	no change				2	no change				2
swh1568											no change				0
swh1593	no	increase**	no change	receded	1				no trend	1					
swh1625	very strong	increase	receded	receded	3				decreasing*	3					
swh1649											no change				0