PNNL-24445

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Final Summary Report

Eelgrass Restoration in Puget Sound Project Summary

July 2015

LA Aston
J Vavrinec
AB Borde

U.S. DEPARTMENT OF ENERGY
Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

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1.0 Background

The restoration of eelgrass (*Zostera marina* L.) is a high priority in Puget Sound. The Pacific Northwest National Laboratory (PNNL) and the Washington Department of Natural Resources (DNR) developed a set of tools to identify and test potential restoration sites from 2012 – 2014 as part of an EPA grant. These tools, in order to maximize the chances of success, are part of a multi-step process for eelgrass restoration with each step building on the previous and then feeding back to the beginning to improve the approach. The first step uses an eelgrass biomass model and selection protocol to identify potential restoration sites around Puget Sound. Researchers can then visit these sites to evaluate the location for the presence of eelgrass, appropriate environmental conditions (e.g., substrate and depth), and potential stressors. If the site evaluation is promising, small test transplant plots can be set up at the site and monitored for eelgrass survival. Test transplants with good eelgrass survival can be selected for larger restoration efforts. Lastly, monitoring the eelgrass restoration sites can not only demonstrate successful projects but also provide valuable feedback to improve all steps of the approach. These steps are therefore a very measured approach to eelgrass restoration that seeks to place eelgrass in locations with the highest chances for success while optimizing limited resources available in plants, personnel, and funding.

The Aquatic Restoration Program funded PNNL from 2014-2015 to continue the restoration efforts around Puget Sound with large-scale transplants and more test transplants. Specifically, the goals were to:

1. Transplant eelgrass at three large-scale planting sites in areas that showed success and resilience in earlier test transplants (from 2012-2014)
2. Conduct a donor harvest study to determine harvesting effects on donor beds/meadows
3. To identify and set up 14 additional test transplants at various locations in Puget Sound.

The following sections summarize field trip reports that have been previously submitted throughout the project and are broken into three sections: Large-scale Planting, Donor Harvest Study, and Test Transplants. All maps for this report are provided in Appendix A and are numbered 1 – 17.

2.0 Large-Scale Planting

The large-scale restoration efforts were focused in south Puget Sound based on the results of earlier surveys and test transplanting. One site was located in Zangle Cove off the Dana Passage while the other two sites were situated off Joemma State Park in Case Inlet (Maps 1 – 4). All restoration was done on subtidal state-owned aquatic lands from May 4-8, 2015 at Zangle Cove, from June 17-20, 2015, at Joemma State Park North (did not complete the entire plot), and June 7-12, 2015 at Joemma State Park South and finishing the North plot.

Transplanting at the restoration sites involved 3 steps: 1) eelgrass harvest from donor areas; 2) processing the eelgrass into planting units; and 3) planting by divers. Eelgrass was harvested from two established eelgrass meadows located off Anderson Island (for Zangle Cove, South Joemma and North Joemma) and in upper Case Inlet off Rocky Point (for South Joemma and North Joemma only) (Map 2). PNNL research divers harvested the eelgrass shoots by hand in small patches and did not take more than 5 – 10% of the shoots in a given area. This ensures minimal impact to the donor meadow since the small size of the disturbance is more likely to fill in quickly through natural recolonization. The divers were also careful to get rhizome material with each shoot. The shoots were placed into mesh catch bags and brought to the boat where they were immediately transferred to coolers full of cold seawater. The coolers of eelgrass were then transferred to the shore for processing.

Processing of the plants was conducted on shore near the donor and planting areas. During processing, the plants were held in flowing seawater tanks to ensure the plants were kept cool. A sorting station was established with shaded tables containing trays periodically filled with fresh seawater to maintain cool temperatures. The eelgrass was removed from the tanks, cleaned of sediment and excess material, and sorted for shoots with viable rhizome material (complete with root hairs). These roots are critical for successful transplantation. Shoots were separated, or kept in small bundles on the same rhizome, and placed into groups of four before being attached to turf staples by the rhizomes so the roots overlapped and shoots face the outward side of the bundle (Figure 1). The eelgrass was attached using a paper tie that will decompose in a short period of time and allow the eelgrass to grow naturally. The anchors help hold the eelgrass shoots in place until the rhizomes can attach to the substrate. The staples were then placed on PVC plates and stored in coolers with cool seawater until planted by the divers.

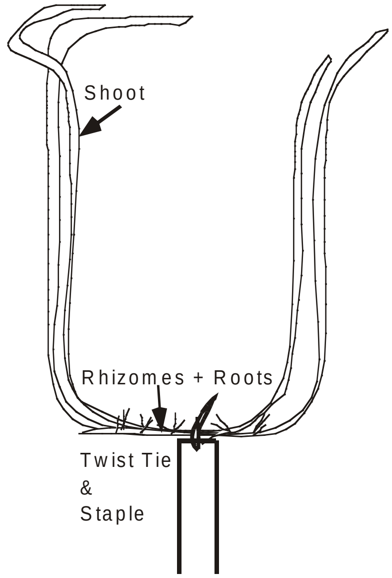


Figure 1. Diagram of eelgrass shoots tied onto a turf staple.

The final step in the restoration process was planting the eelgrass. The plated eelgrass bundles were brought by boat to the restoration site in coolers and transferred to the divers after they entered the water. The divers planted the staples into the substrate by lifting a small section of sediment with a trowel, inserting the staple into the sediment below, and then replacing the lifted sediment onto the shoots such that the top of the staple and eelgrass rhizomes were covered. Staples were planted in groups of five per 0.25 m^2 as a minimum viable population unit.

The restoration sites were designed to efficiently use the plants over a larger area and planted in long lines roughly parallel to shore. Eelgrass was planted in a checkerboard pattern along the line to provide nuclei for expansion and cover a greater area while limiting the number of eelgrass shoots removed from the donor bed (see Figure 2 for a schematic of single line of plantings within the large-scale plots). Eelgrass shoots were placed on each side of the reference line at a density of 20 shoots (i.e., 5 staples) per m^2. The planting alternated on either side of the line so a new cluster of eelgrass was positioned ever 0.5 m. The ends of each line were demarked with a helical screw anchors for future monitoring.

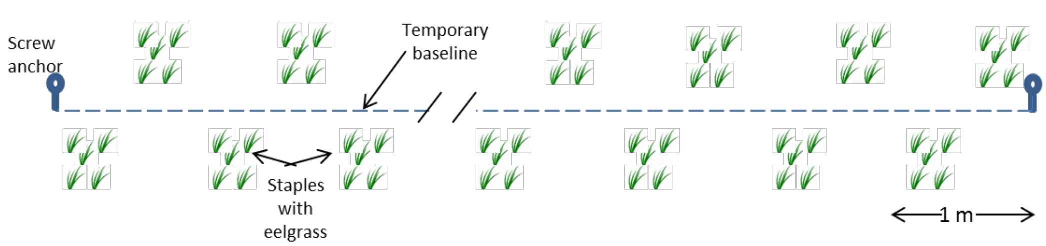


Figure 2. Schematic of baseline plantings. Each tuft represents a staple with 4 shoots attached. Quadrat density is 20 shoots per square meter.

Each restoration site was delineated with four (Zangle Cove) or five (both Joemma sites) planting lines (Figures 3 – 5). Each line was separated horizontally by 10 m when there was adequate bathymetry for seagrass. A helical anchor was used to mark the ends of each line and were marked with electrical zip ties based on the position within the area (i.e., the 0 m line had no zip ties, the 10 m line had one zip tie, the 20 m line had two zip ties, etc.). Coordinates for the corners of each restoration area are given in Table 1.

Table 1. Coordinates for the large-scale restoration sites.

Site Name	Corner	Lat	Long	Map Number	Date Planted
Zangle large scale	NW	47° 08.744' N	122° 53.591' W	3	May 4-8, 2015
	NE	47° 08.738' N	122° 53.548' W	3	
	SE	47° 08.724' N	122° 53.553' W	3	
	SW	47° 08.733' N	122° 53.594' W	3	
Joemma SP - large scale	W	47° 13.341' N	122° 48.630' W	4	June 17-20, 2015
	N	47° 13.351' N	122° 48.602' W	4	
	E	47° 13.329' N	122° 48.580' W	4	
	S	47° 13’.320’N	122° 48.605' W	4	
Joemma NP - large scale	NW	47° 13.403' N	122° 48.64' W	4	June 7-12, 2015
	NE	47° 13.403' N	122° 48.609' W	4	
	SE	47° 13.370' N	122° 48.609' W	4	
	SW	47° 13.370' N	122° 48.64' W	4	

The donor plants from Anderson Island were considerably different than those from Case Inlet (Figure 6). The Anderson Island plants were often up to 1 meter long, with a high occurrence of reproductive shoots. In contrast, the Case Inlet plants were much smaller, rarely larger than 30 cm in length, with no reproductive shoots observed. Due to these observations, we decided to place the plants in different parts of the planting areas in order to differentially track their success over time. Plants from both donor areas were planted at the Joemma site, and the configuration of plantings are shown in the planting diagrams for the Joemma sites. (Figure 4 and Figure 5).

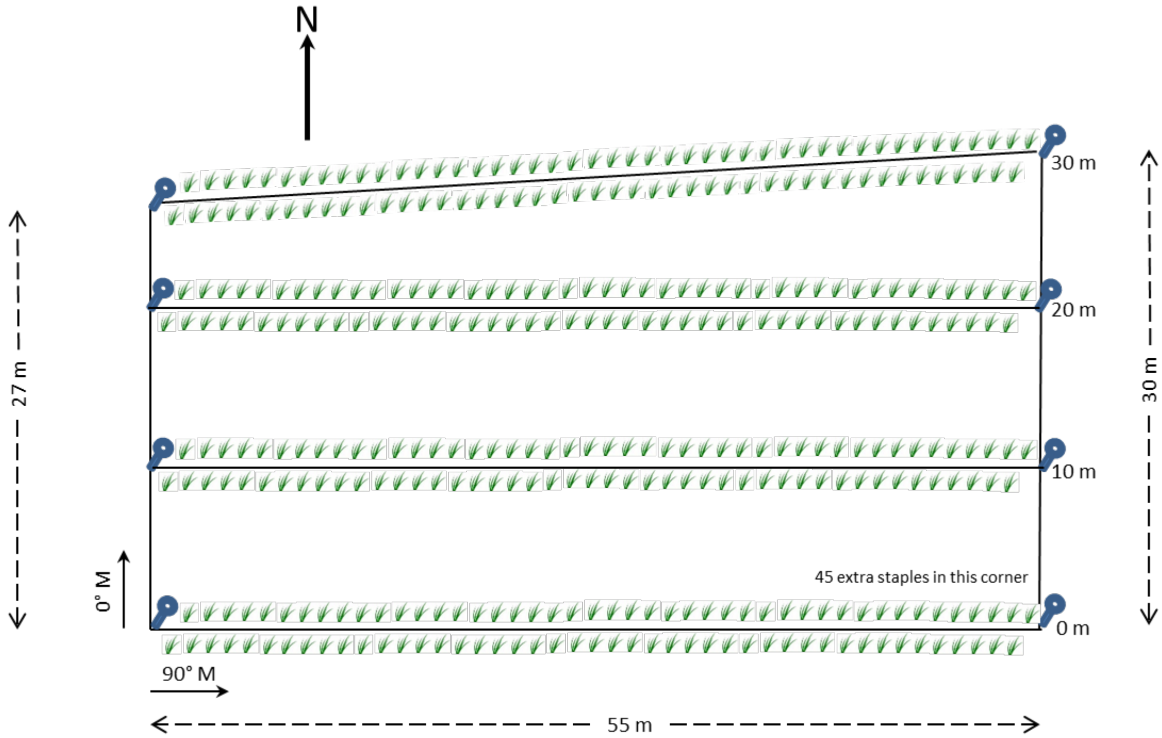


Figure 3. Schematic of the Zangle Cove large scale restoration planting.

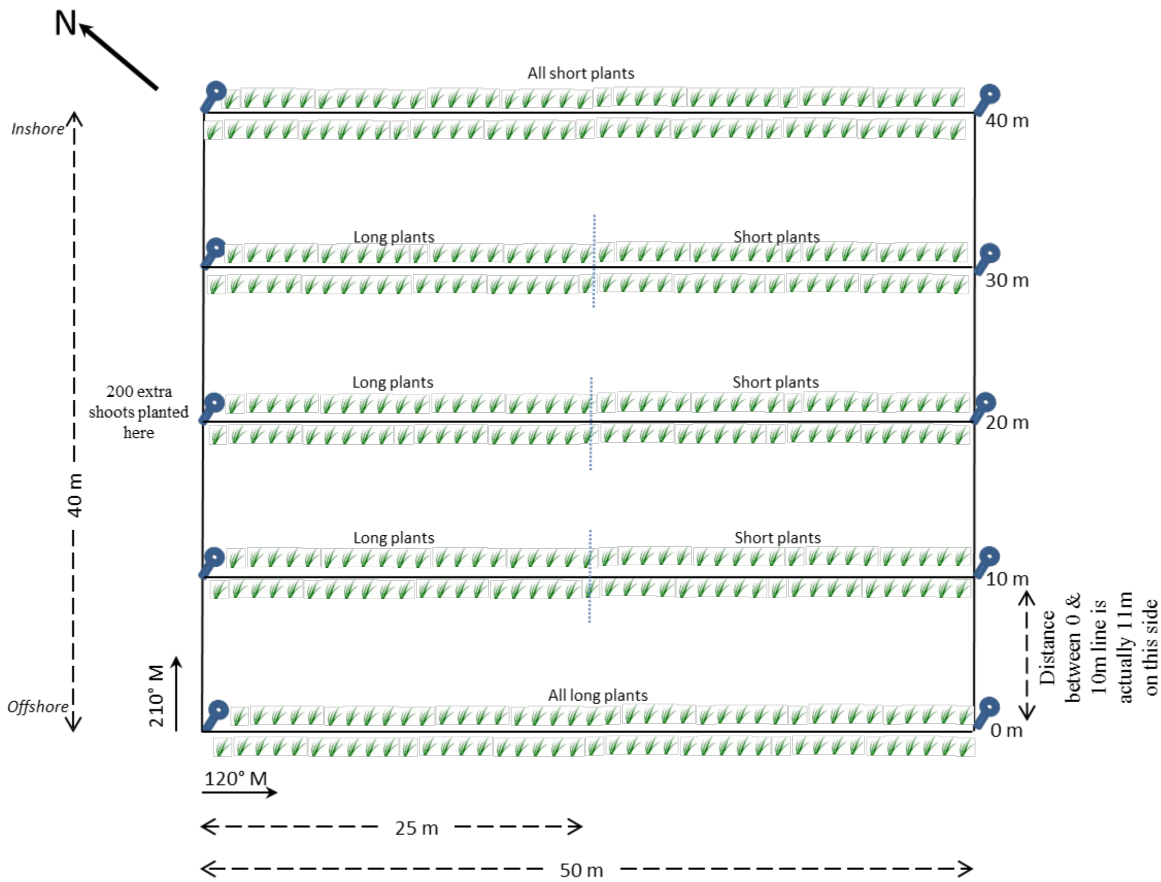


Figure 4. Schematic of the South Joemma large scale restoration planting.

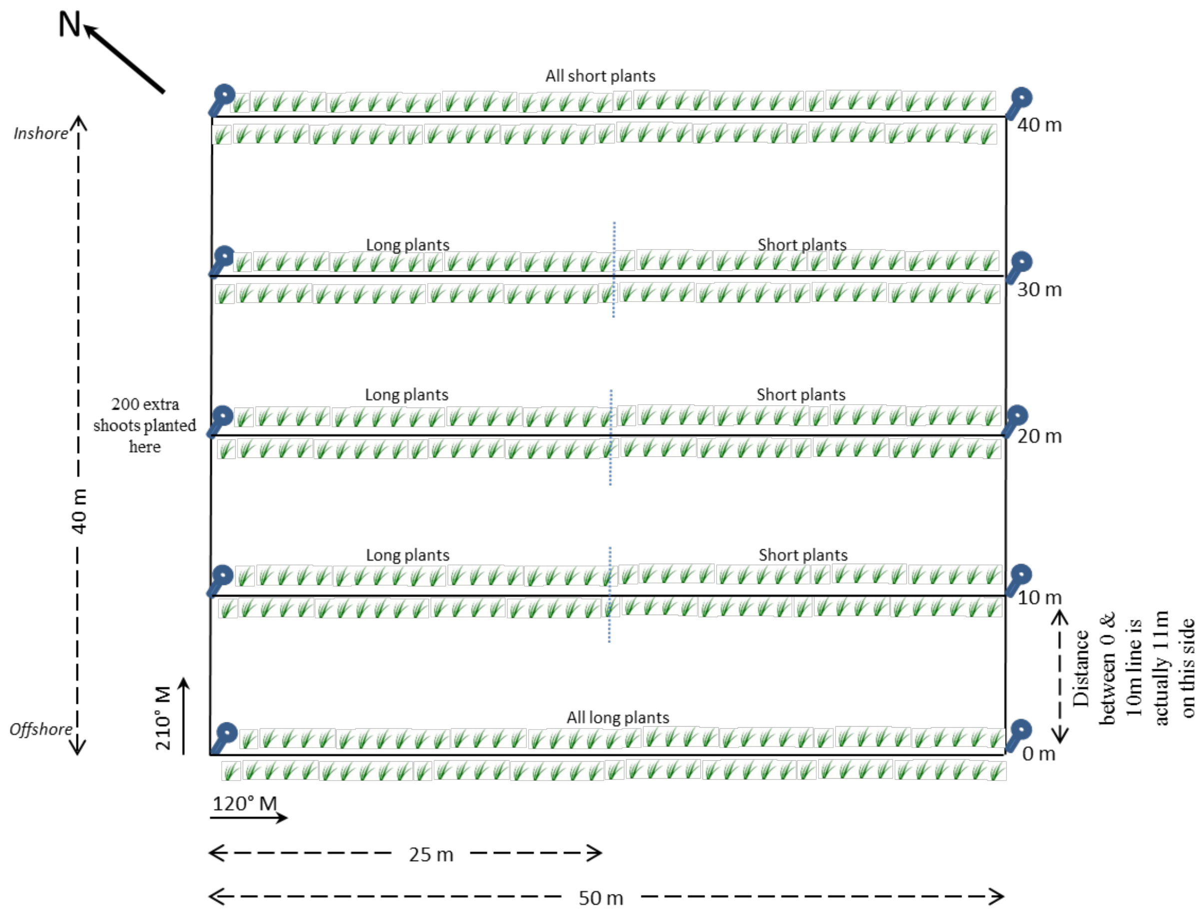


Figure 5. Schematic of the North Joemma large scale restoration planting.

Figure 6. Eelgrass bundles from Anderson Island and Case Inlet. The morphological difference is apparent in that the Anderson Island plants were much larger than the Case Inlet plants. Note that the tops of the Anderson Island plants had already been trimmed for planting and were even bigger prior to the trimming.

The number of shoots planted in the large-scale restoration plots are provided in Table 2. An additional 2,900 shoots were gathered into "mega" bundles (20 shoots per staple) and planted outside the North Joemma plot at the 10, 20, and 30 m transect lines (Figure 6). With the addition of the "mega" bundles, the total number of shoots planted increases to 34,080. Area was limited at all sites due to available suitable habitat. However, we were able to increase the planting density at all locations by keeping the total number of shoots relatively high.

Table 2. Planting Metrics for Large-Scale Planting Sites

Site	Area (m^2)	Planting Density (shoots/m2)	Total Number of Shoots
South Joemma	2,000	5.1	10,200
North Joemma	2,400	5.0	12,000
North Joemma	extra		2,900
Zangle Cove	1,568	5.7	8,980
TOTAL	**5,968**	**5.2**	**34,080**

All large-scale efforts for this project were supported by a large volunteer contingency. The Zangle Cove effort yielded the largest community response. On any given day there were 5 to 10 volunteers working on shore support activities at Boston Harbor Marina. The community was very positive about having eelgrass restoration in Zangle Cove. The Puget Sound Conservation Corps provided the most consistent volunteer support for all three efforts deploying 2 staff each day. Several DNR staff also provided shore support during all three large-scale efforts. Having consistent, skilled help with shore support activities was crucial for getting work done on time and within the allocated budget. A full list of volunteers who helped on the large-scale planting efforts can be provided upon request.

3.0 Donor Harvest Study

Although seagrass mitigation and restoration projects are well documented in the literature, there are limited data that demonstrate optimal donor site harvest rates and recovery of seagrass donor sites from harvest activities. This study was designed to help determine the effects of donor stock harvesting on eelgrass populations by testing different donor site harvest rates and monitoring subsequent recovery.

The objective of this study was to evaluate the effects of different eelgrass harvest levels at two donor sites located near large-scale transplant sites at Zangle Cove and Joemma State Park in South Puget Sound and Port Gamble Bay (associated with another project) in Central Puget Sound (Map 5). The donor sites were located within larger eelgrass beds that have shown population stability over recent years based on DNR's SVMP data or other available data. These larger beds tend to have lower variability per depth range than smaller or patchier beds and will allow for better power to detect differences between treatments. Eelgrass collected for the study was used at the large-scale restoration planting sites. The Port Gamble donor study was set up and harvested April 11-12 and the Anderson Island was set up May 2 and harvested June 6.

The two donor site study areas were delineated with markers on the bottom. The markers were small helical anchors that divers installed into the substrate with very little ecological impact. GPS coordinates were taken above all markers to facilitate repeat monitoring. The following sections will describe actual field procedures and provide coordinates (Table 3) and experimental design information (Tables 4 and 5) for the donor harvest study sites at Port Gamble and Anderson Island. Figure 7 provides a schematic for the donor study transect layout at each site (note that it is only a partial layout of 3 blocks).

Table 3. Coordinates of the helical anchors marking the donor study sites (see Map 5)

Donor Study Site Name	Lat	Long
Port Gamble	47° 51.743' N	122° 34.562' W
	47° 51.738' N	122° 34.570' W
	47° 51.731' N	122° 34.578' W
	47° 51.729' N	122° 34.584' W
	47° 51.722' N	122° 34.590' W
	47° 51.717' N	122° 34.599' W
Anderson Island	47° 7.597' N	122° 42.482' W
	47° 7.602' N	122° 42.430' W

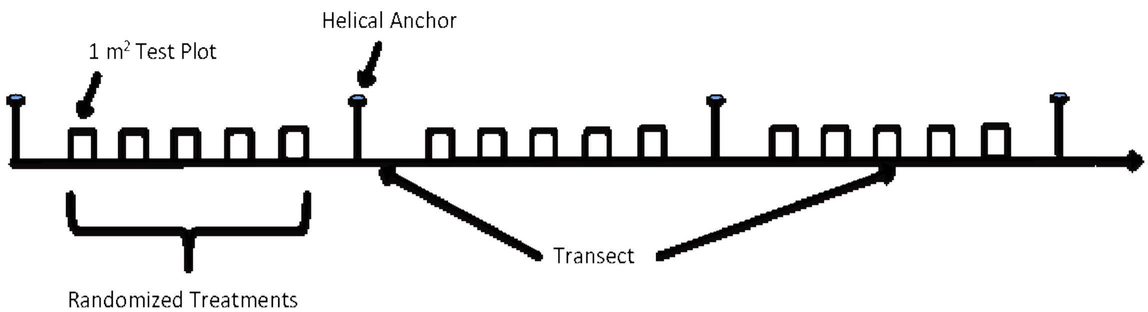


Figure 3. Transect layout for eelgrass donor harvest study. The transects had 5 blocks separated by a helical anchor with 5 randomized treatments (0%, 10%, 20%, 30%, and 50% harvest rates) this diagram only shows 3 blocks.

3.1 Port Gamble Field Procedure

At the Port Gamble study location, buoys were placed to mark the start middle and end of the test transect. The transect was set up within one isobath to minimize variability in eelgrass density. Six helical anchors were already placed from an earlier dive when the donor site was identified and the study area was delineated (Table 3). The transect was 65 m long with helical anchors placed every 13 m. Divers placed a meter tape along transect by starting at the offshore screw anchor at 0 m and moving inshore to 65 m (Table 4). The meter tape wrapped around helical anchors to keep the line straight and taut during harvesting procedures.

Along the transect, 25, 1 m^2 test plots were established, yielding 5 replicates of each harvesting treatment (0%, 10%, 20%, 30% and 50% plants removed). Test plots were placed 1 m apart along the baseline transect and 2 m from each helical anchor establishing five test plots between each helical anchor. All test plots remained on the eastern inshore side of the baseline transect. Harvest treatments were previously randomized within each block of test plots along the length of the transect. Figure 7 is an accurate representation of the test transect layout, just note that while the figure shows 3 blocks, the actual study was composed of 5 blocks.

In each test plot, divers used a 1 m^2 quadrat, to mark the designated area in which to count. Once all of shoots within the quadrat were counted, divers would read, through underwater communication systems, the total count and their location along the transect to a data recorder on the dive support vessel. . Data recorders used pre-established guide sheets with information on which test plots were randomly assigned each harvest treatments. Given the diver's location, the recorder would find the appropriate treatment and, given the diver's count, the recorder would use another guide sheet to determine what percentage of the total number of shoots needed to be removed. Recorders would then tell divers exactly how many shoots needed to be harvested. Harvesting was done haphazardly throughout the test plot to avoid the creation of large, bare patches. Once divers completed the harvest, they copied back up to surface to confirm the harvested number of shoots and a waited instruction for the next harvest location along the test transect. The process confirmed that all test plots were counted and harvested.

Once all blocks were counted and harvested accordingly, the R/V Strait Science worked with divers to navigate directly above each helical anchor to collect GPS coordinates for future monitoring needs. Harvested shoots were then stored in coolers with salt water and shortly transplanted into the larger restoration planting sites using similar methods described in 2.0. Table 4 summarizes the actual experimental design at the Port Gamble donor harvest study site.

Table 4. Donor Harvest Study: Port Gamble (harvested April 11-12)

Block	Test Plot	Distance on baseline (m)	Treatment	Initial density (# shoots)	# shoots removed
1	1	2-3	30%	43	13
1	2	4-5	50%	37	19
1	3	6-7	20%	49	10
1	4	8-9	10%	51	5
1	5	10-11	0%	56	0
2	1	15-16	20%	56	11
2	2	17-18	30%	39	12
2	3	19-20	0%	52	0
2	4	21-22	50%	38	19
2	5	23-24	10%	41	4
3	1	28-29	0%	73	0
3	2	30-31	30%	78	23
3	3	32-33	10%	51	5
3	4	34-35	20%	77	15
3	5	36-37	50%	81	41
4	1	41-42	10%	73	7
4	2	43-44	30%	59	18
4	3	45-46	0%	67	0
4	4	47-48	20%	69	14
4	5	49-50	50%	87	44
5	1	54-55	0%	71	0
5	2	56-57	30%	61	18
5	3	58-59	50%	54	27
5	4	60-61	10%	56	6
5	5	62-63	20%	69	14

3.2 Anderson Island Field Procedure

The field procedures conducted at Anderson Island were the same as those conducted in Port Gamble, aside from the following site-specific differences:

- Divers placed the meter tape along the transect from West (0m) to East (65m). All study plots were located on the south (i.e., offshore) side of the transect line. The system in which divers and data recorders communicated in determining the proper location to count shoots and the number of shoots to harvest was the same as that for Port Gamble.

- Only the first quadrat (2-3m) of block 1 was counted and sampled on May 2, 2015, because strong currents made it extremely difficult for divers to accurately count eelgrass shoots. Divers decided to complete the study during a better tide. The meter tape was left in place on the seafloor; buoys were picked up and placed back onboard the boat.

- All sampled eelgrass was later bundled and replanted at the restoration site, just as was done at Port Gamble.

Table 3 gives the exact coordinates for the helical anchors marking the Anderson Island donor study site and Figure 7 provides a schematic for the donor study transect layout (note that it is only a partial layout of 3 blocks). Table 5 summarizes the experimental design at the Anderson Island donor harvest study site.

Table 5. Donor Harvest Study: Anderson Island (harvested June 6).

Block	Test Plot	Distance on baseline (m)	Treatment	Initial density (# shoots)	# shoots removed
1	1	2-3	10%	130	13
1	2	4-5	20%	119	24
1	3	6-7	30%	105	32
1	4	8-9	50%	117	59
1	5	10-11	0%	107	0
2	1	15-16	20%	120	24
2	2	17-18	50%	89	45
2	3	19-20	0%	103	0
2	4	21-22	30%	126	38
2	5	23-24	10%	93	9
3	1	28-29	30%	91	27
3	2	30-31	20%	96	19
3	3	32-33	0%	72	0
3	4	34-35	10%	74	7
3	5	36-37	50%	56	28
4	1	41-42	20%	79	16
4	2	43-44	0%	80	0
4	3	45-46	30%	98	29
4	4	47-48	10%	84	8
4	5	49-50	50%	57	29
5	1	54-55	50%	65	33
5	2	56-57	20%	62	12
5	3	58-59	30%	72	22
5	4	60-61	10%	63	6
5	5	62-63	0%	50	0

3.3 Summary of Donor Harvest Study

Due to the time constraints for this project, the donor sites have not been evaluated since harvest activities (Port Gamble Bay, April 11-12, 2015, and Anderson Island, June 6, 2015). Both sites should be monitored to quantify the effects of different harvest rates and track eelgrass recovery rates. The recovery of donor sites is predicted to be anywhere from six months to five years depending on bed resilience and environmental conditions. Results from the harvest treatment study will provide valuable data to adaptively manage future harvest rate practices and provide guidance to best management practices related to future seagrass mitigation and restoration projects in Puget Sound and the region.

As stated in the Donor Site Harvest Study Design and Procedure document, monitoring at the donor study sites should involve sampling all the harvest treatment levels (0%, 10%, 20%, 30% and 50%). Therefore, the shoot density at each harvest location before and after harvesting will be measured. Sampling should occur annually to determine the number of shoots in all the quadrats used in the experiment. Recovery of each treatment plot will be determined based on the number of shoots initially in the plot and an estimate of inter-annual variability, as determined from the control plots (0% harvest rate). To document longer-term donor site recovery, subsequent qualitative and quantitative sampling would be required.

4.0 Test Transplants

The PNNL Eelgrass Biomass Model was used to produce maps of potential locations for eelgrass test transplants throughout Puget Sound. Using the map as a guide, PNNL researchers visited those locations to further evaluate potential suitable habitat for test transplants. Map 6 shows all of the locations where site suitability surveys were conducted. A Splashcam Sidewinder 360 underwater drop camera (Oceans Systems, Everett WA) and Raymarine C90W depth sounder (Raymarine Inc., NH) were deployed from a boat over each site. While at each location, the researchers evaluated the site for a number of elements including:

1. Presence or absence of eelgrass
2. Depth
3. Appropriate substrate
4. Potential for eelgrass expansion
5. Any obvious stressors that may impact eelgrass growth or survival

Using a drop camera instead of the scientific divers for this work allowed the team to visit more locations in a day. Our previous work has shown the camera (when compared to results obtained with SCUBA divers) yields accurate information to assess the conditions of the site for eelgrass. Once collected, the results of the surveys were entered into a GIS map along with the model results and bathymetry as a tool for determining where to place the test transplant plots. Maps 7 – 14 are close-up views for the survey locations in the following five areas:

1. Port Susan
2. Seattle waterfront areas
3. Hood Canal (2 maps)
4. SW South Sound (3 maps)
5. SE South Sound

A total of 15 locations were chosen for test transplants. One site was established in Hood Canal (Quilcene Bay) and two sites in Dyes Inlet (Ostrich Bay and Chico Bay) (Map 15). Ten sites were established in SW South Puget Sound; Anderson Island, Eld Inlet (2), Heron Island, Joemma, Pickering Passage, Rigwall/Hunter Pt (2), Stretch Island, and Zangle Cove (Map 16). Three sites were established in SE South Sound; Anderson Island, Delano Beach, and McNeil Island (Map 17).

A 5 m by 5 m square was marked at each site with helical screw anchors and PCV stakes. Eelgrass was then planted at a density of five staples (i.e., 20 shoots) per m^2 for a total of 500 eelgrass shoots planted per site. Coordinates for one corner of each site were recorded, the temporary transect tape was recovered, and the site was left until the spring for evaluation. In total, 7,500 eelgrass shoots were planted at 15, 25 m^2 transplant sites for this project. The total area planted was 0.0375 ha (0.1 acre).

All the areas where eelgrass was planted were marked to serve as a guide for planting and identify the sites for future monitoring. The PNNL research divers placed two types of markers at these sites. The first were helical screw anchors. These were screwed into the substrate by hand and work very well in the substrates where eelgrass grows. In addition to the helical anchors and stakes, which were left at the site for future monitoring, lines were also placed at the site to help guide the setup of the site and provide reference lines while planting. Fiberglass transect tapes were used to make the lines and were left in place for the duration of the eelgrass planting. The lines were anchored on a stake or helical anchor. After the planting was completed, all the lines were removed. With the boat positioned over the site, all GPS coordinates were recorded (Table 6). In order for the boat operator to get a good visual reference on the surface the diver/s would pull a buoy tight (i.e., vertical) next to the marker. Depths were determined by the dive computer (Scubapro Galileo Luna, Wisconsin) and then tide corrected using NOAA-based tide predication software (Tides and Currents Pro, Nobeltec, Oregon) to mean lower low water (MLLW).

Table 6. Coordinates of test transplant plots.[a]

Site Name	Corner	Lat	Long	Date Planted	Map #
Quilcene Bay	SE	47° 47.866’ N	122° 50.980’ W	24-Nov-14	15
Ostrich Bay	NW	47° 35.525' N	122° 40.744' W	18-Feb-15	15
Chico Bay	NW	47° 36.389' N	122° 41.951' W	18-Feb-15	15
Delano Beach	SW	47° 15’.299 N	122° 44.227' W	26-Feb-15	17
McNeil Island	SE	47° 13’.484 N	122° 40.386' W	26-Feb-15	17
Anderson Island	SW	47° 10.247' N	122° 43.733' W	27-Feb-15	17
Graham Point (Pickering Passage)	NE	47° 15.116' N	122° 55.669' W	12-Mar-15	16
Stretch Island	SE	47° 19.205' N	122° 49.893' W	12-Mar-15	16
Herron Island	NE	47° 16.769' N	122°48.557' W	12-Mar-15	16
Eld Inlet - shallow	E	47° 05.844' N	122° 57.315' W	12-Mar-15	16
Eld Inlet - deep	E	47° 05.851' N	122° 57.321' W	12-Mar-15	16
Zangle Cove	SW	47° 08.742' N	122° 53.535' W	6-May-15	16
Edgewater – 1 (Rigwall)	NW	47° 09.112' N	122° 55.787' W	18-May-15	16
Edgewater – 2 (Hunter Pt.)	NW	47° 09.300' N	122° 55.571' W	18-May-15	16
Joemma State Park	NE	47° 12.656' N	122° 48.398' W	9-Jun-15	16

a. The coordinates are actually taken over the corner of the plot indicated in the table.

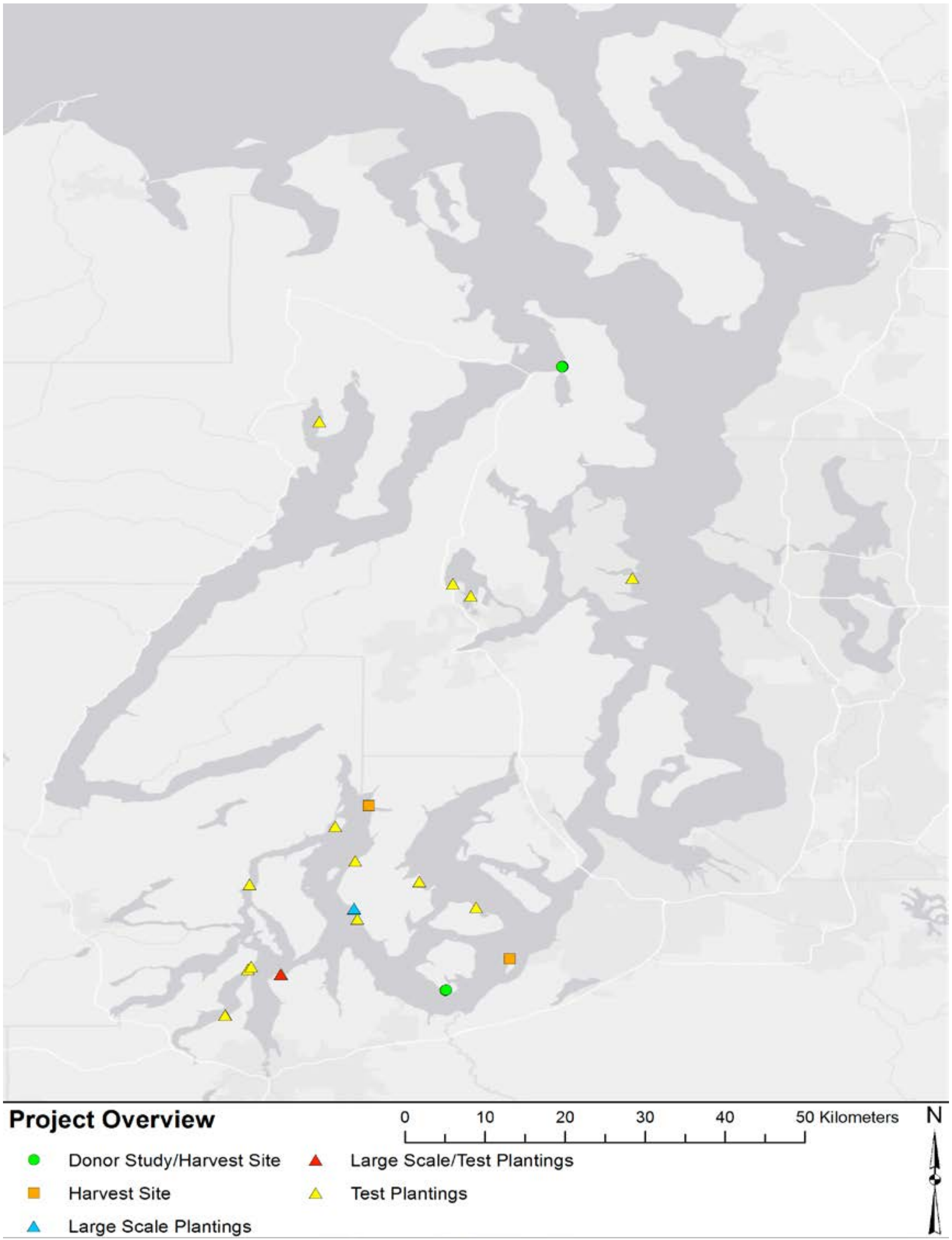
SUMMARY

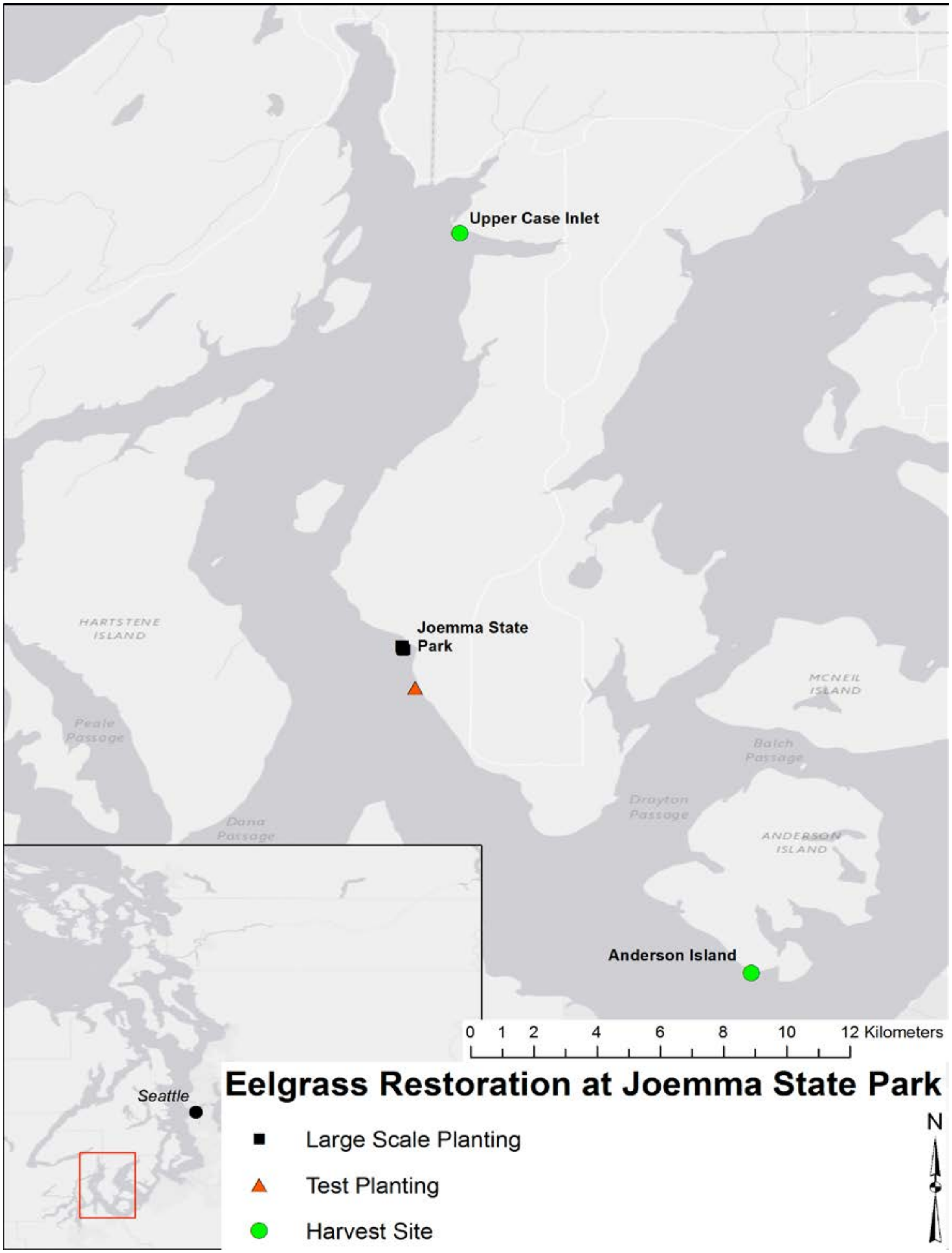
We successfully transplanted eelgrass at 15 test transplant sites and 3 large scale restoration sites between 2014 and 2015. The area transplanted was 375 m^2 for the test transplant plots and 5,968 m^2 for the large scale transplant areas. The cumulative area transplanted with eelgrass was 6,343 m^2 (0.6343 ha, 1.6 acres). Although a limited amount of transplanted eelgrass area, these transplanted eelgrass populations will spread through vegetative expansion and production of seeds that could recruit to areas well beyond the transplanted footprint.

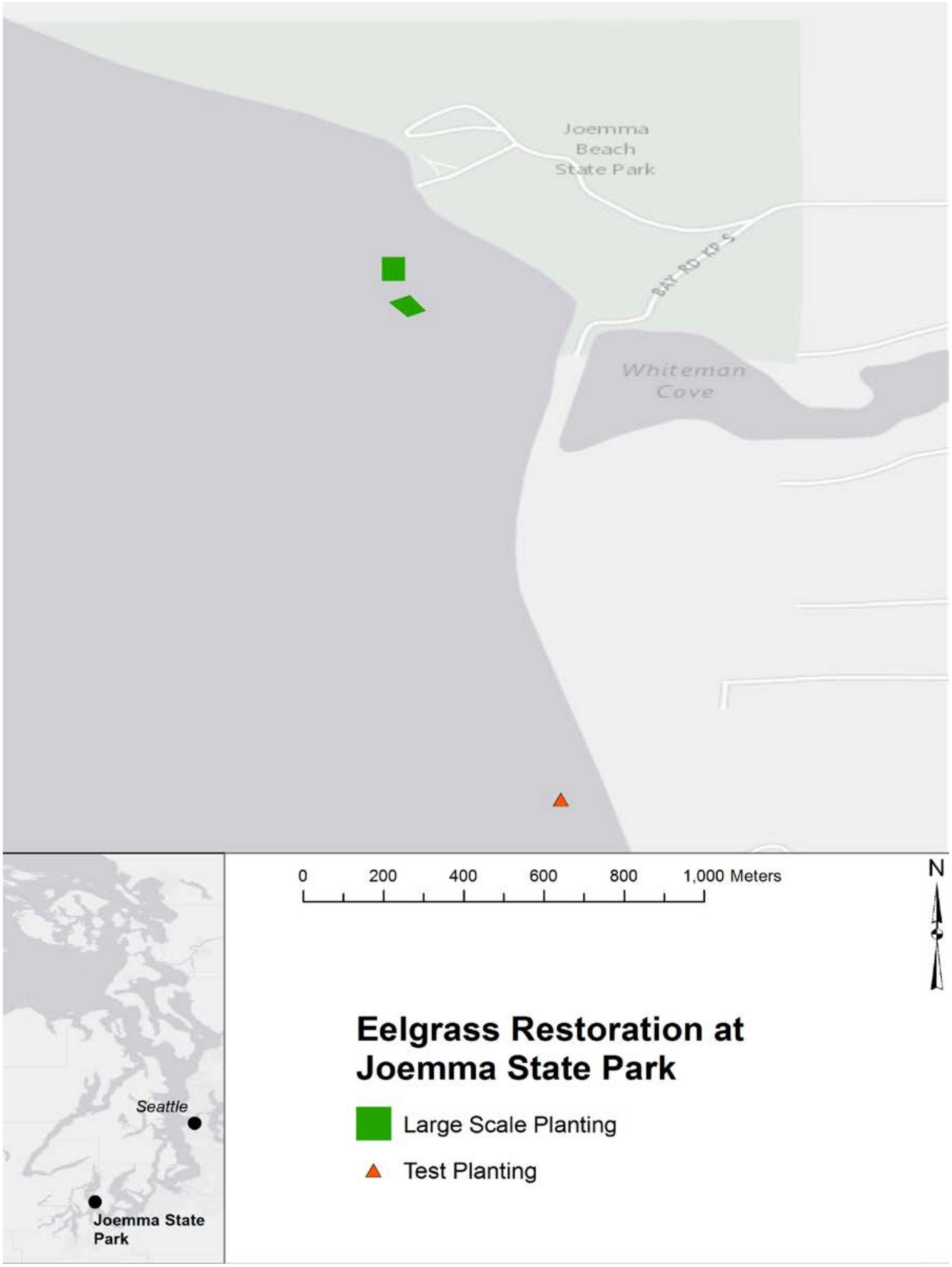
We also successfully established and harvested eelgrass from donor study sites near Port Gamble Bay and Anderson Island. These sites were established to understand the effects of different harvest rates on eelgrass donor populations. These data will provide guidance to the eelgrass recovery effort in Puget Sound and the sustainability of harvesting whole shoots for restoration purposes.

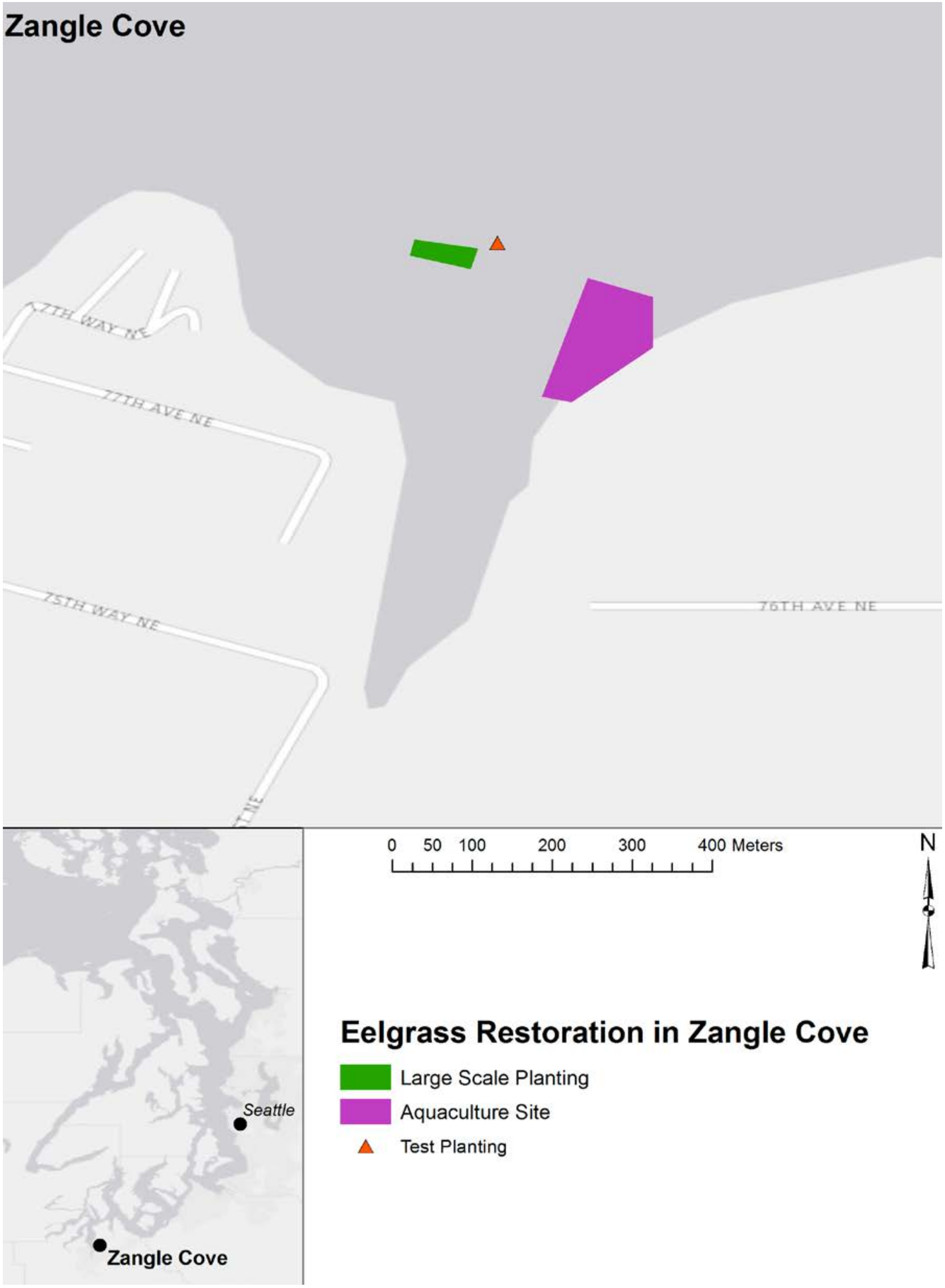
It is recommended that the test transplant sites and donor sites are monitored to evaluate the survival of the transplanted eelgrass shoots and the recovery of shoots from harvest activities at donor sites. Monitoring should occur at a minimum of 3 month intervals, but not longer than one year since transplanting or harvesting to determine transplant success and donor site recovery.

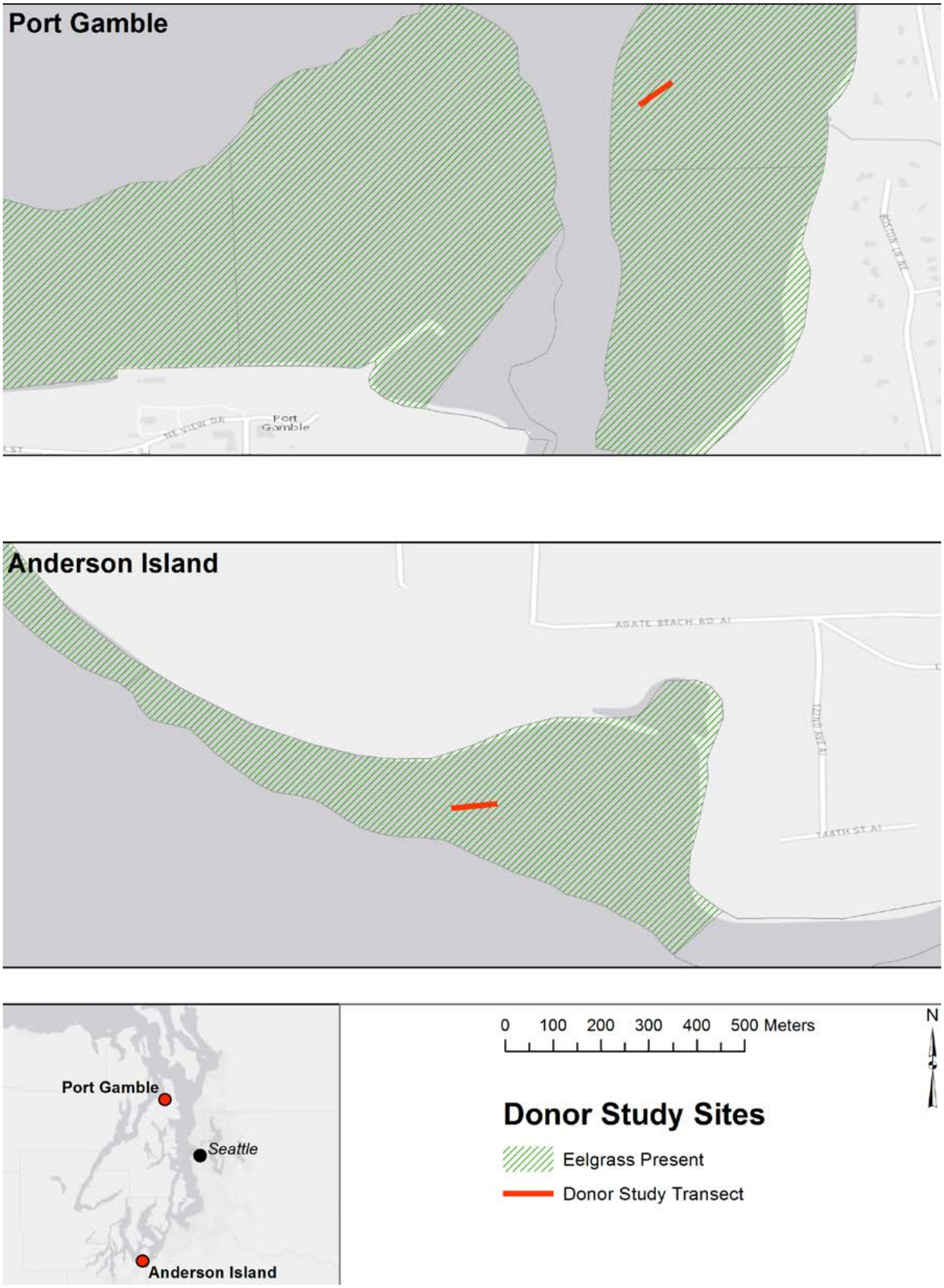
Appendix A


Project Overview
0
10
20
30
40
50 Kilometers
N
Donor Study/Harvest Site
Harvest Site
Large Scale Plantings
Large Scale/Test Plantings
Test Plantings
Map 1

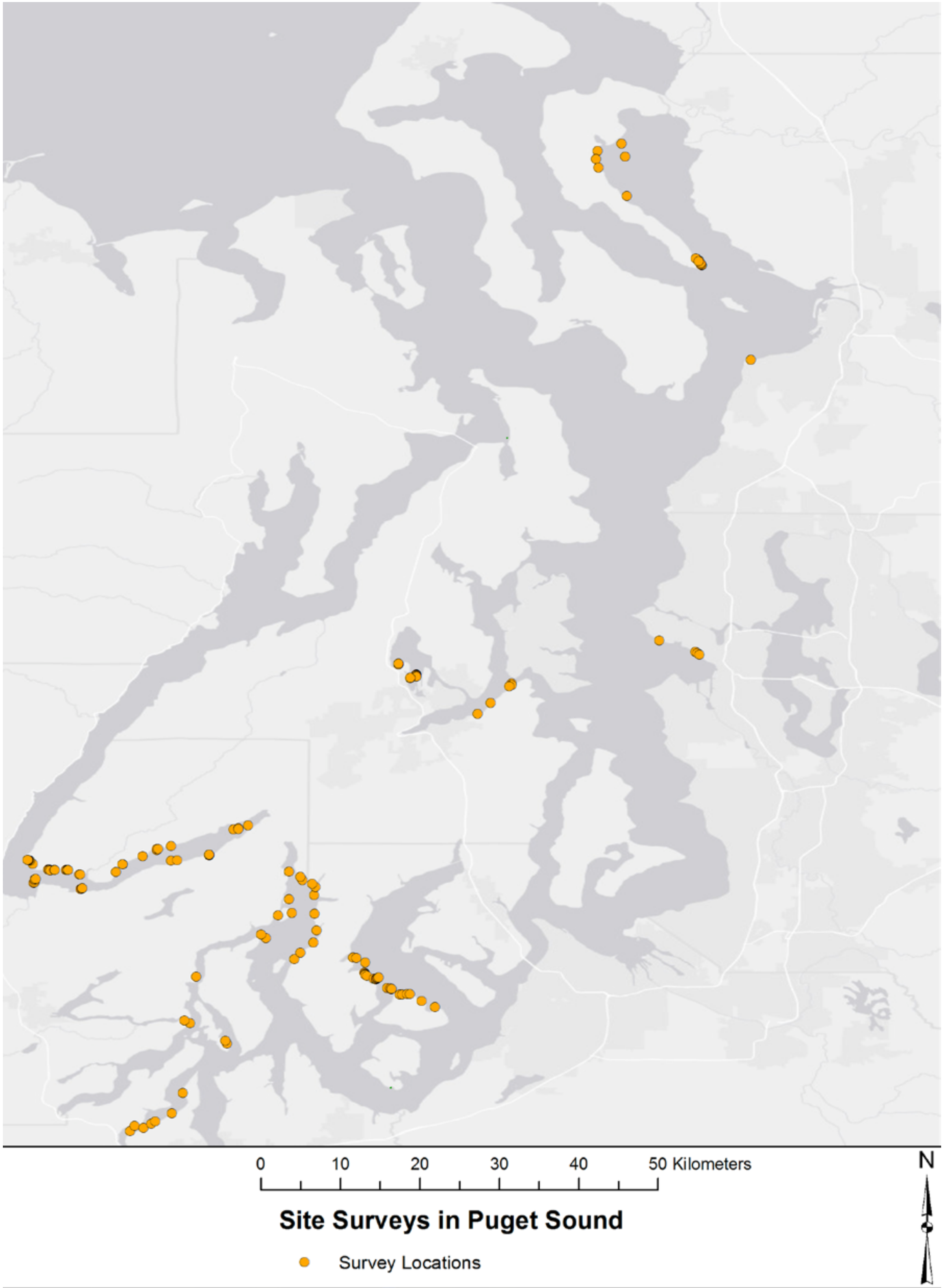

Upper Case Inlet
HARTSTENE ISLAND
Joemma State Park
MCNEIL ISLAND
Peale Passage
Balch Passage
Drayton Passage
Dana Passage
ANDERSON ISLAND
Anderson Island
Seattle
0 1 2 4 6 8 10 12 Kilometers
Eelgrass Restoration at Joemma State Park
Large Scale Planting
Test Planting
Harvest Site
N
Map 2


Joemma
Beach
State Park
BAY RD KP S
Whiteman
Cove
Seattle
Joemma State
Park
0
200
400
600
800
1,000 Meters
N
Eelgrass Restoration at
Joemma State Park
Large Scale Planting
Test Planting
Map 3

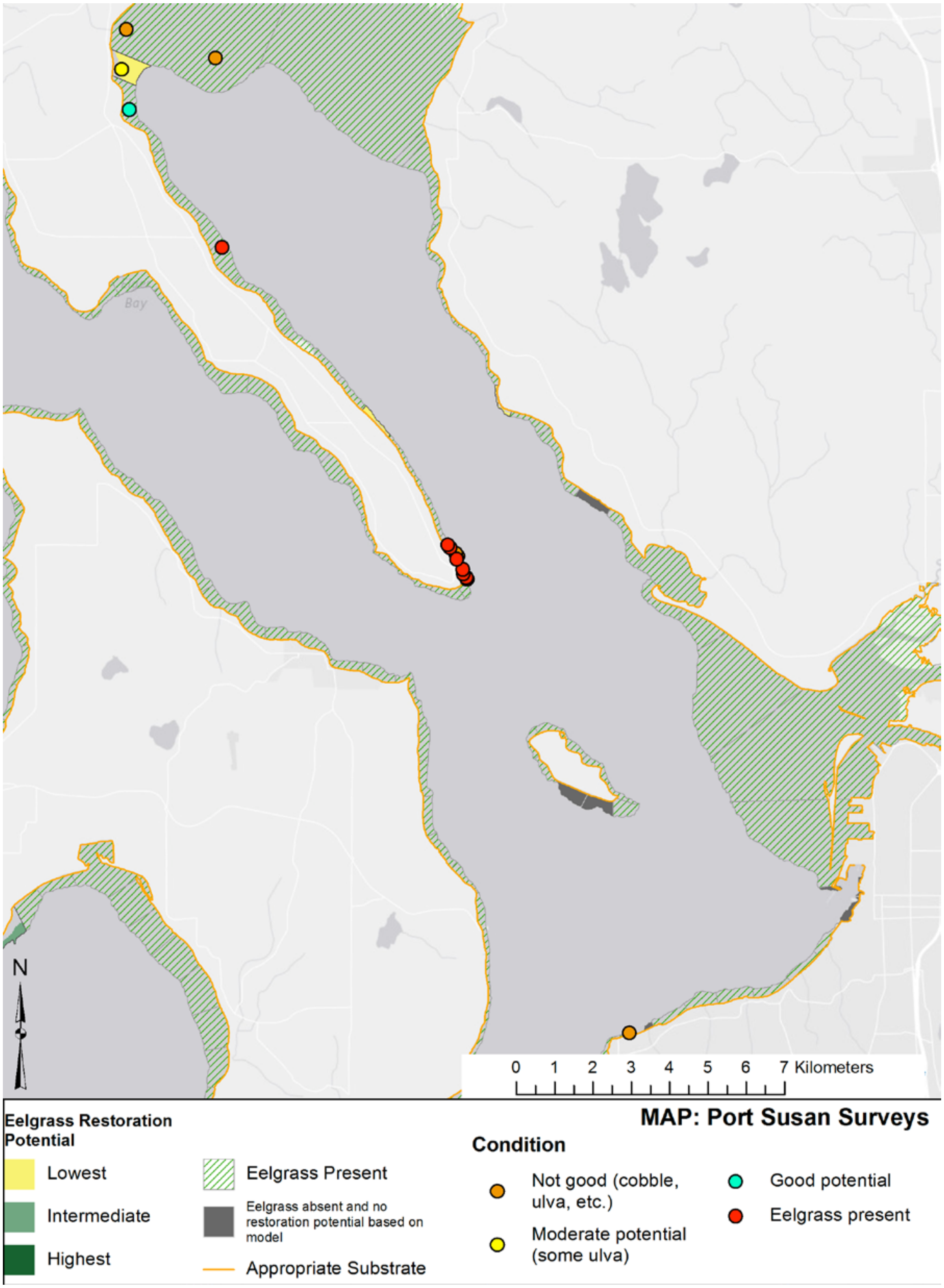

Zangle Cove
77TH WAY NE
77TH AVE NE
75TH WAY NE
76TH AVE NE
0 50 100 200 300 400 Meters
N
Eelgrass Restoration in Zangle Cove
Large Scale Planting
Aquaculture Site
Test Planting
Seattle
Zangle Cove
Map 4

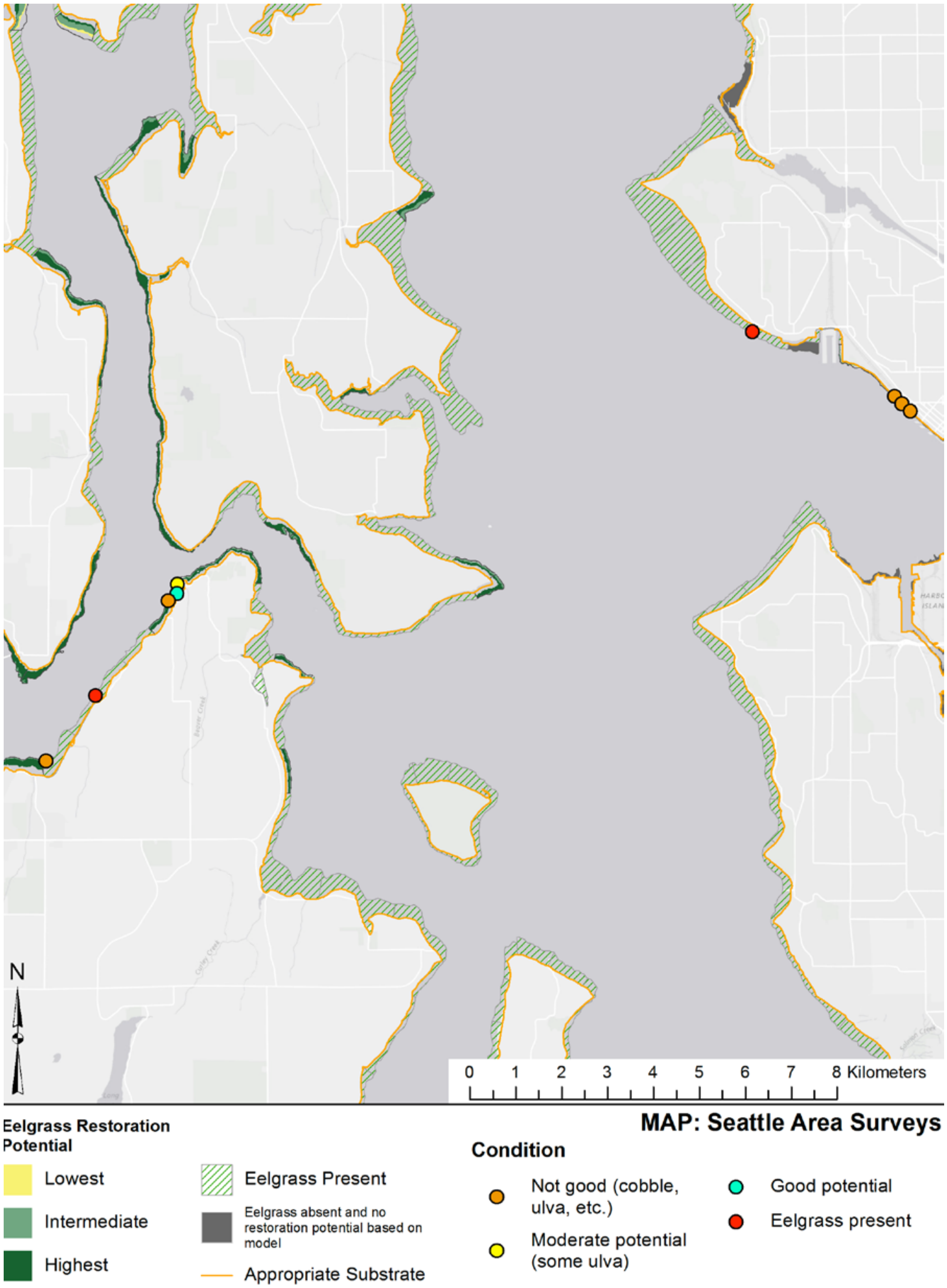

Port Gamble
Anderson Island
0 100 200 300 400 500 Meters
N
Donor Study Sites
Eelgrass Present
Donor Study Transect
Port Gamble
Seattle
Anderson Island

Map 5

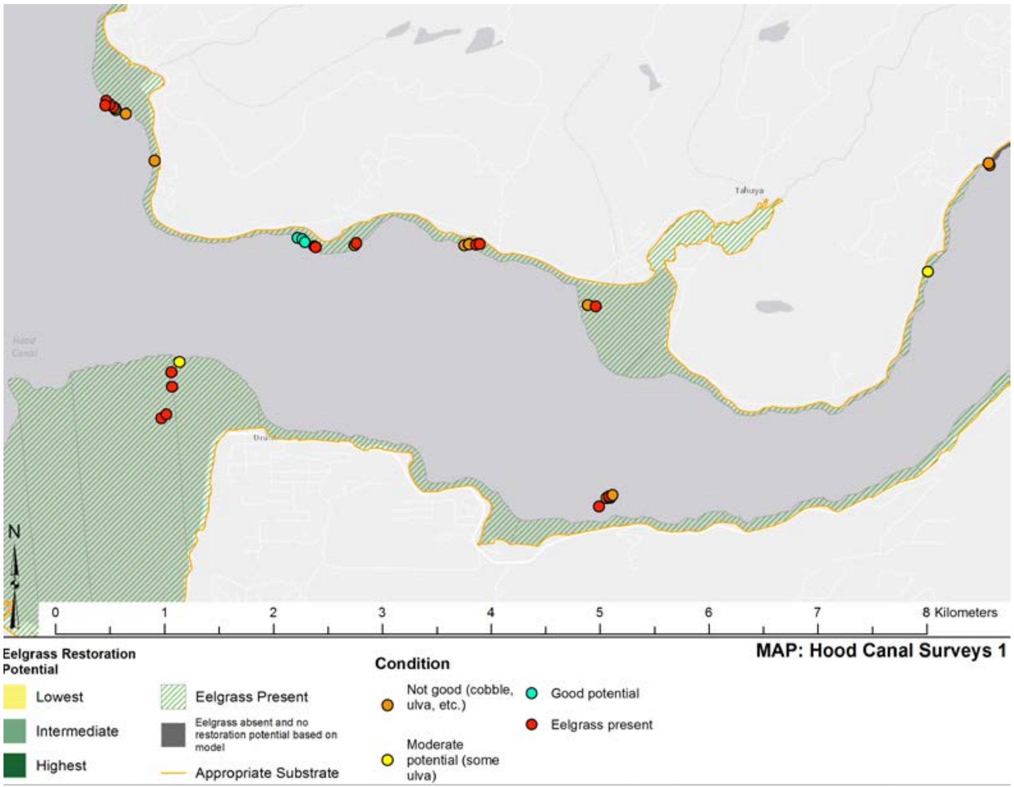

0
10
20
30
40
50 Kilometers
N
Site Surveys in Puget Sound
Survey Locations

Map 6

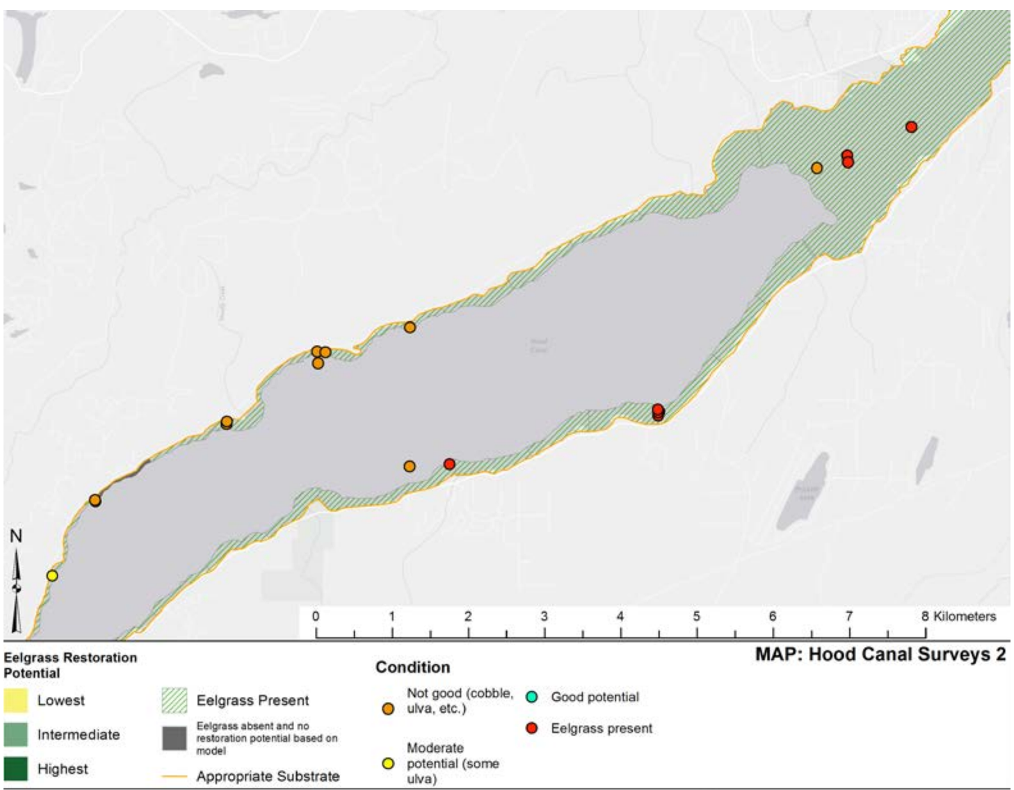

Bay
N
0 1 2 3 4 5 6 7 Kilometers
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
MAP: Port Susan Surveys
Condition
Not good (cobble, ulva, etc.)
Moderate potential (some ulva)
Good potential
Eelgrass present
Map 7


N
0 1 2 3 4 5 6 7 8 Kilometers
MAP: Seattle Area Surveys
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Condition
Not good (cobble, ulva, etc.)
Moderate potential (some ulva)
Good potential
Eelgrass present

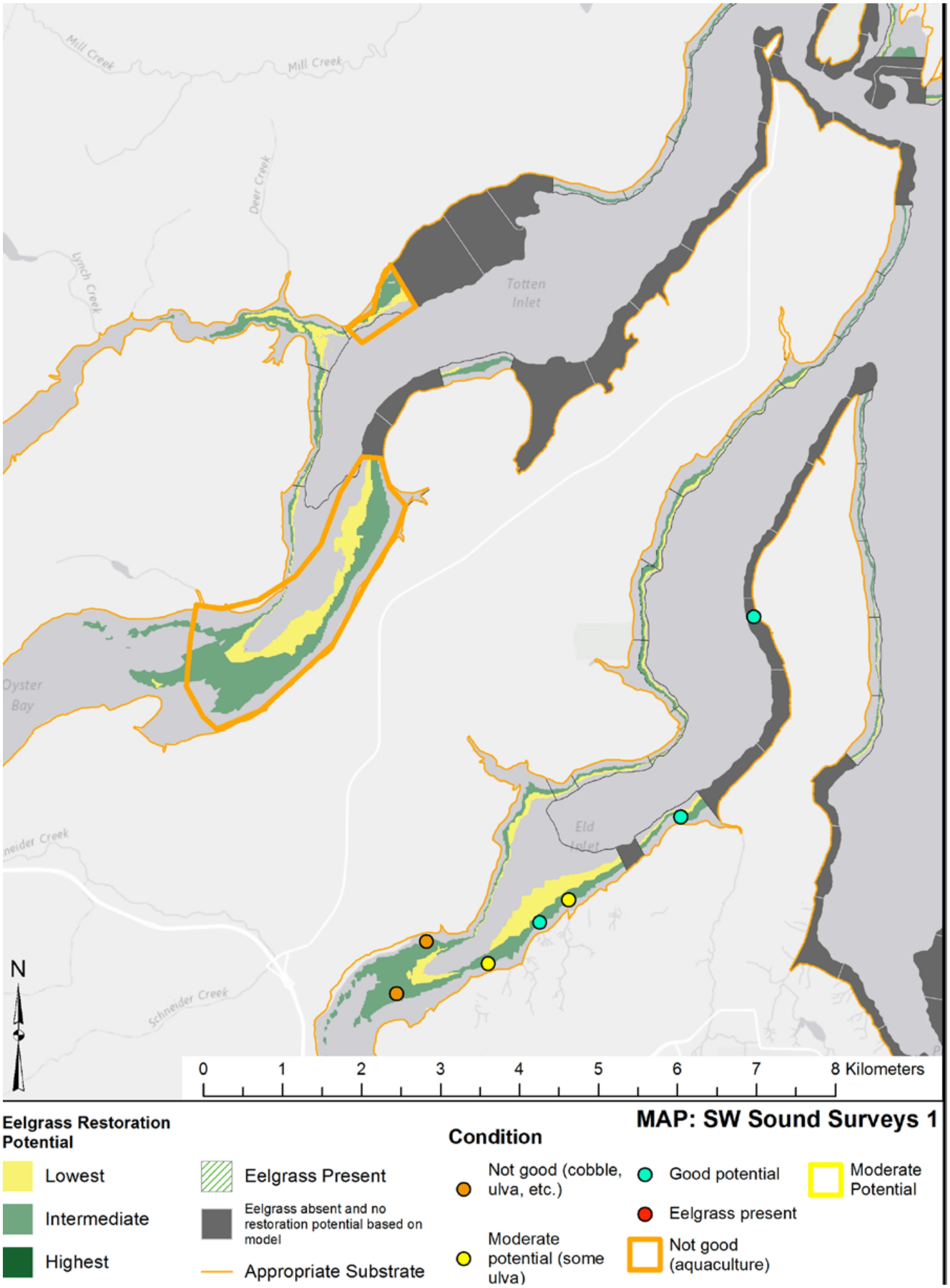
Map 8


Tahuya
N
0
1
2
3
4
5
6
7
8 Kilometers
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Condition
Not good (cobble, ulva, etc.)
Moderate potential (some ulva)
Good potential
Eelgrass present
MAP: Hood Canal Surveys 1

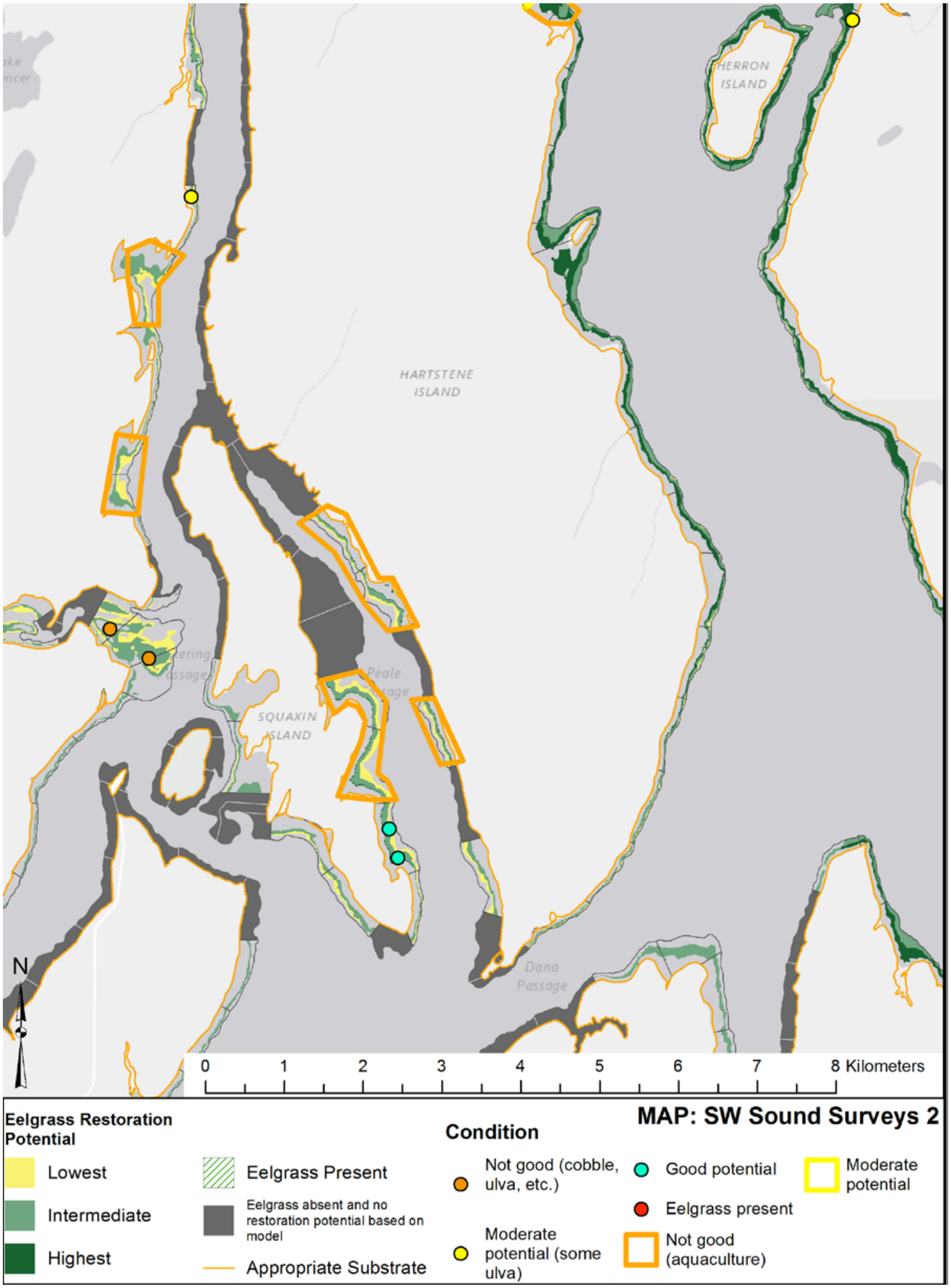
Map 9


N
0
1
2
3
4
5
6
7
8 Kilometers
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Condition
Not good (cobble, ulva, etc.)
Moderate potential (some ulva)
Good potential
Eelgrass present
MAP: Hood Canal Surveys 2

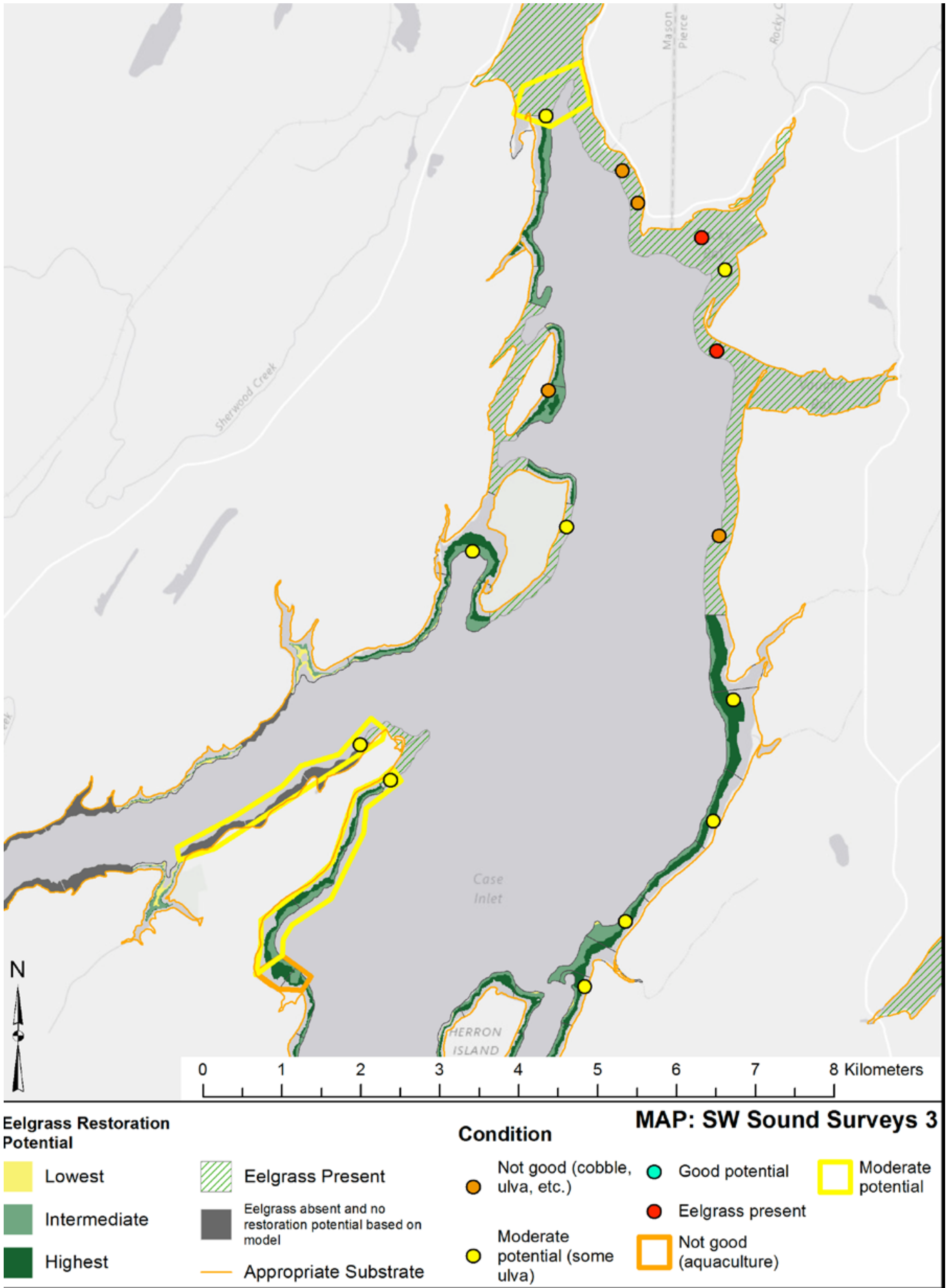
Map 10

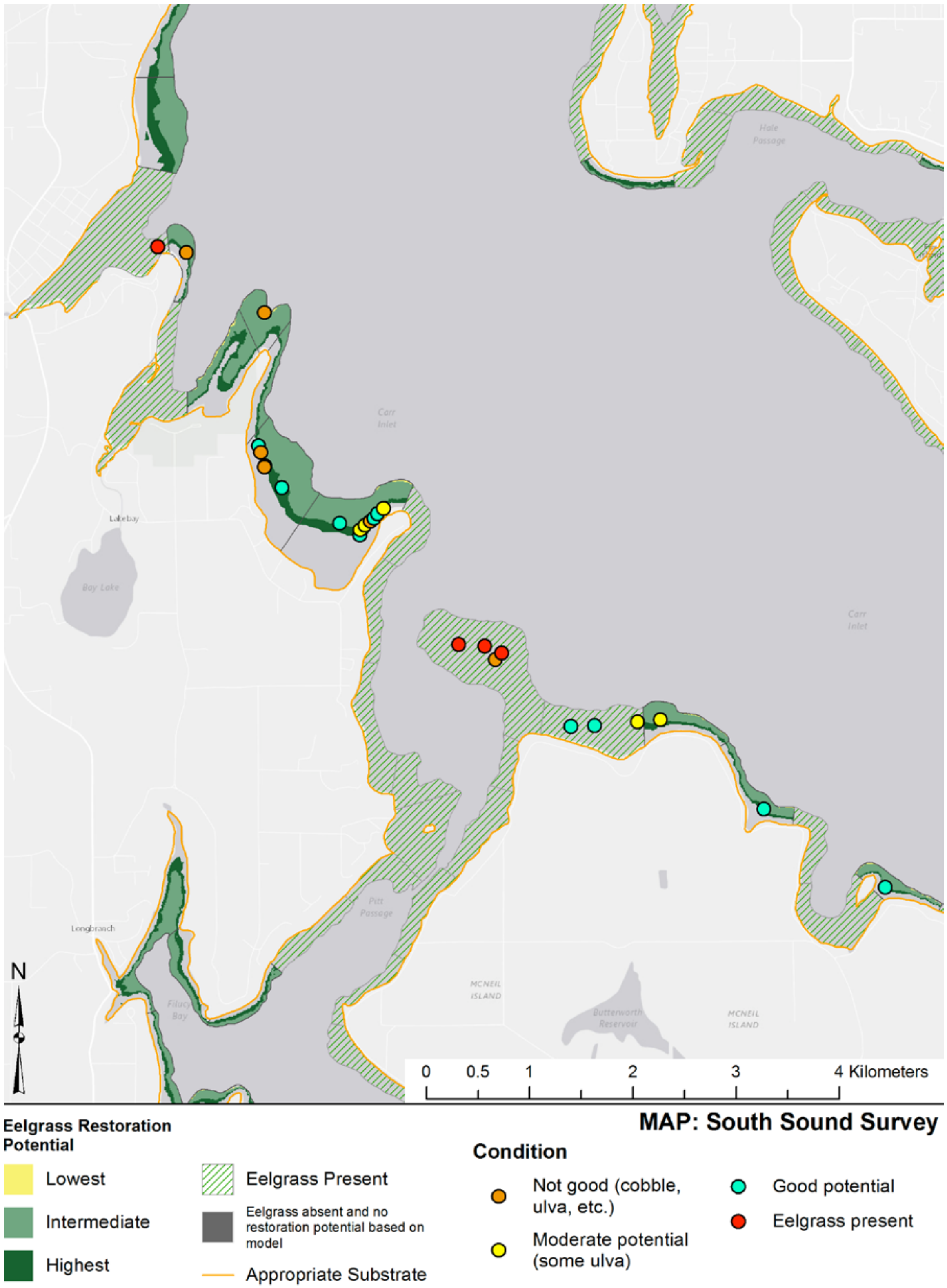

Mill Creek
Mill Creek
Deer Creek
Lynch Creek
Totten Inlet
Oyster Bay
Eld Inlet
Schneider Creek
Schneider Creek
N
0
1
2
3
4
5
6
7
8 Kilometers
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Condition
Not good (cobble, ulva, etc.)
Moderate potential (some ulva)
Good potential
Eelgrass present
Not good (aquaculture)
Moderate Potential
MAP: SW Sound Surveys 1

Map 11


HERRON ISLAND
HARTSTENE ISLAND
SQUAXIN ISLAND
Dana Passage
N
0 1 2 3 4 5 6 7 8 Kilometers
MAP: SW Sound Surveys 2
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Condition
Not good (cobble, ulva, etc.)
Moderate potential (some ulva)
Good potential
Eelgrass present
Not good (aquaculture)
Moderate potential

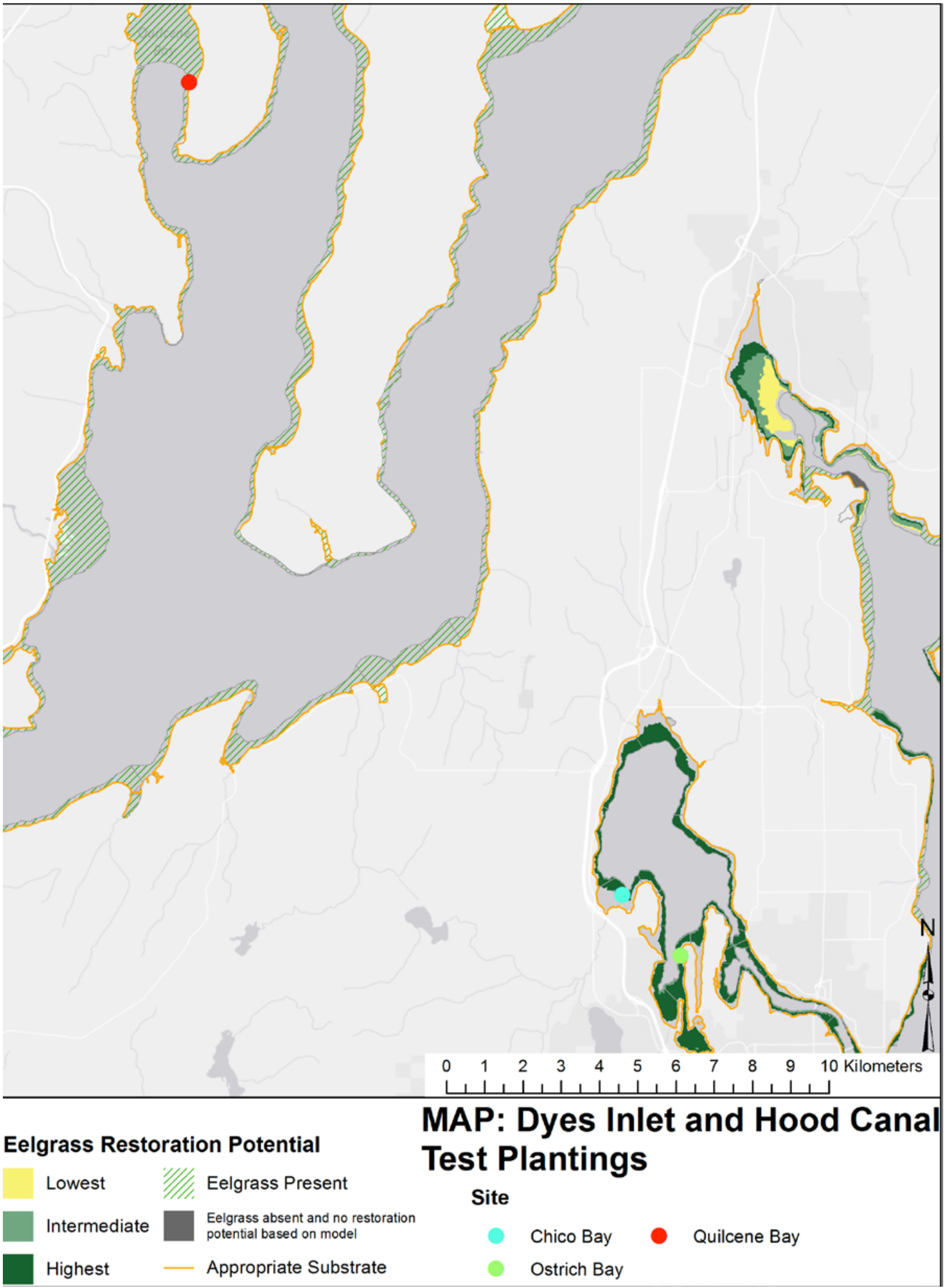
Map 12

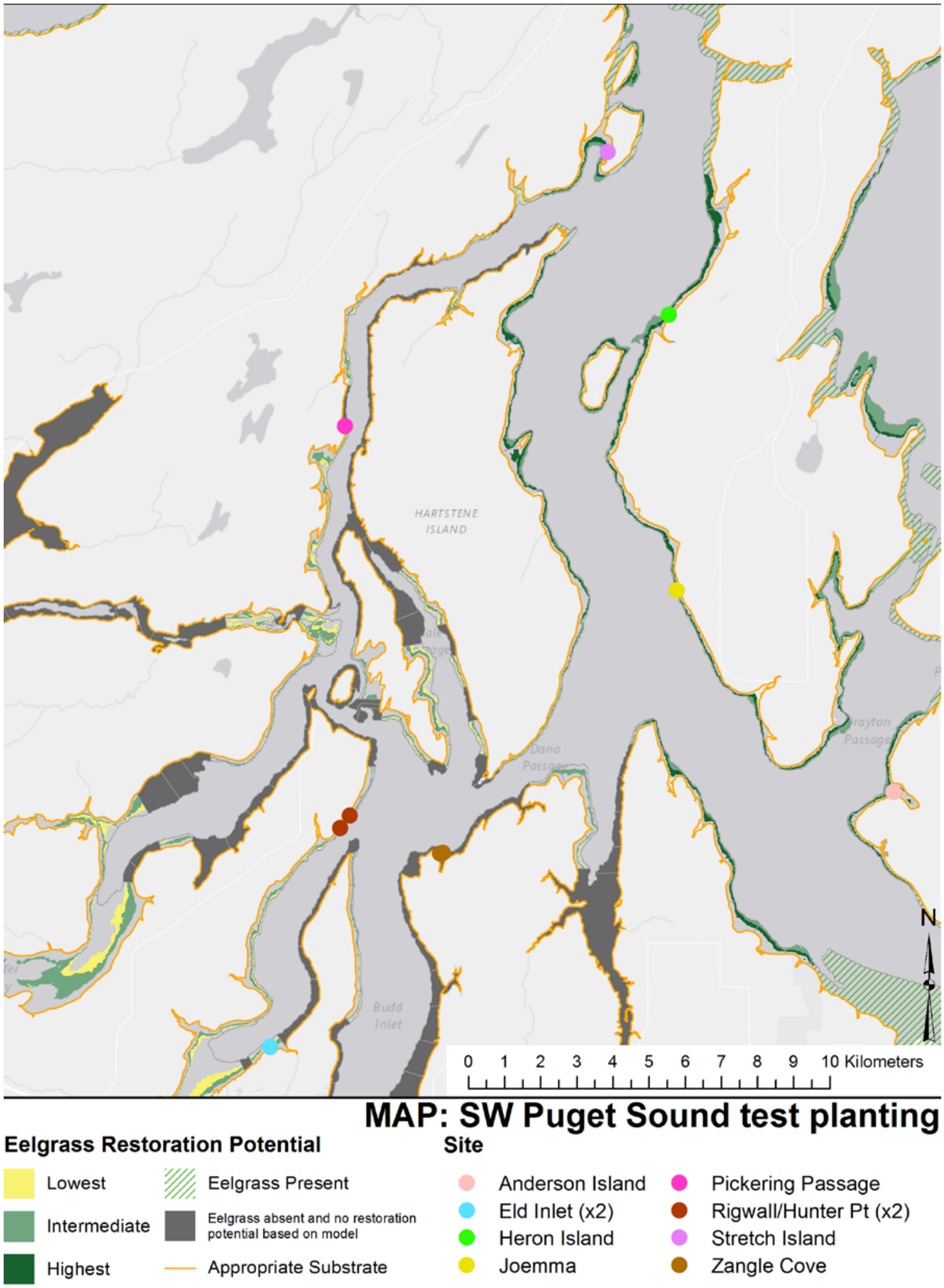

Sherwood Creek
Mason Pierce
Case Inlet
HERRON ISLAND
N
0
1
2
3
4
5
6
7
8 Kilometers
MAP: SW Sound Surveys 3
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Condition
Not good (cobble, ulva, etc.)
Moderate potential (some ulva)
Good potential
Eelgrass present
Not good (aquaculture)
Moderate potential
Map 13

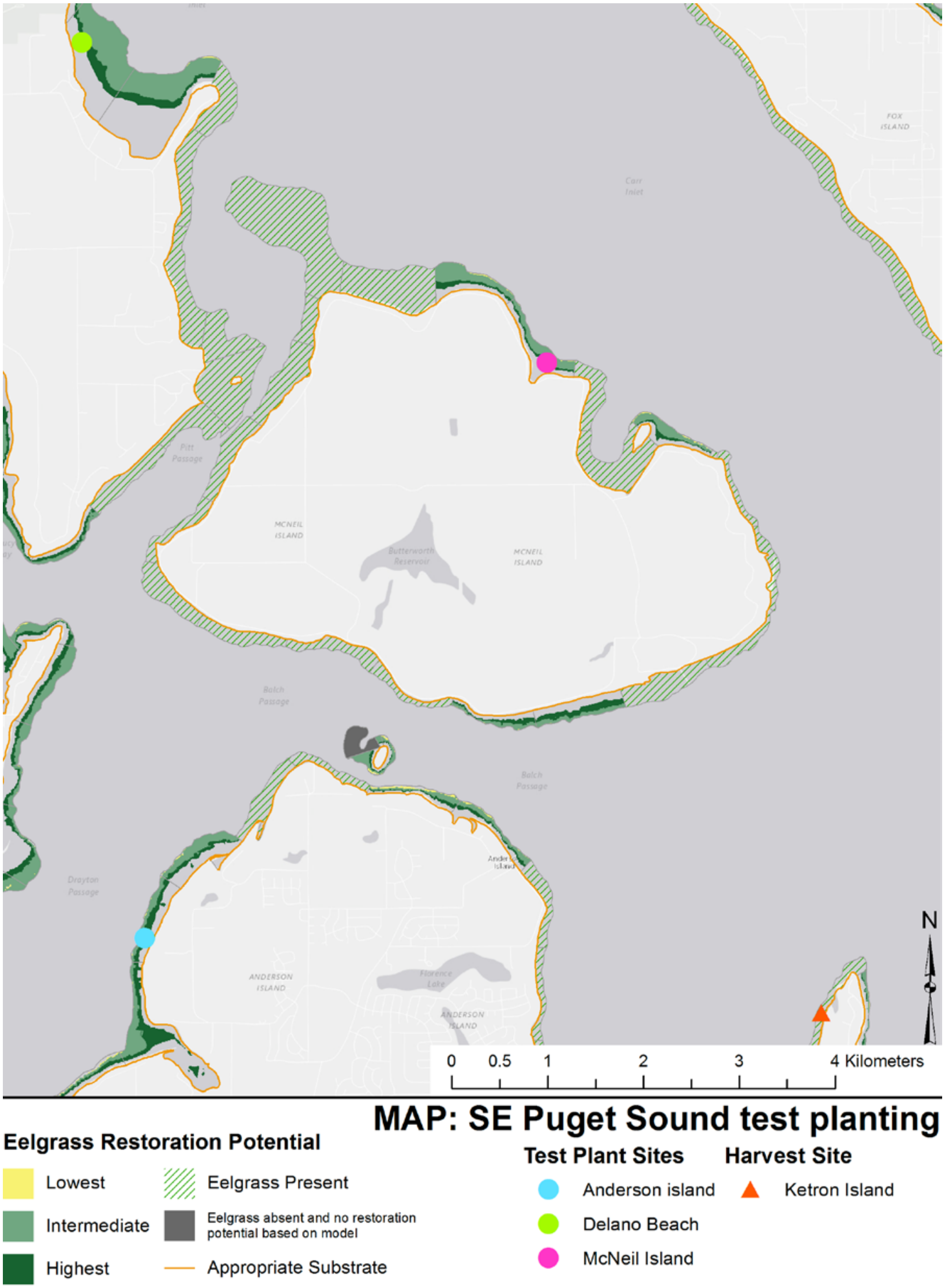


N
Carr Inlet
Hale Passage
Lakebay
Bay Lake
Carr Inlet
Longbranch
Pitt Passage
Filucy Bay
MCNEIL ISLAND
Butterworth Reservoir
MCNEIL ISLAND
0 0.5 1 2 3 4 Kilometers
MAP: South Sound Survey
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Condition
Not good (cobble, ulva, etc.)
Moderate potential (some ulva)
Good potential
Eelgrass present

Map 14


0 1 2 3 4 5 6 7 8 9 10 Kilometers
N
MAP: Dyes Inlet and Hood Canal Test Plantings
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Site
Chico Bay
Quilcene Bay
Ostrich Bay
Map 15


MAP: SW Puget Sound test planting
HARTSTENE ISLAND
Dana Passage
Budd Inlet
0 1 2 3 4 5 6 7 8 9 10 Kilometers
N
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Site
Anderson Island
Eld Inlet (x2)
Heron Island
Joemma
Pickering Passage
Rigwall/Hunter Pt (x2)
Stretch Island
Zangle Cove
Map 16


MAP: SE Puget Sound test planting
Carr Inlet
Fox Island
Pitt Passage
McNeil Island
Butterworth Reservoir
Balch Passage
Drayton Passage
Anderson Island
Florence Lake
0 0.5 1 2 3 4 Kilometers
N
Eelgrass Restoration Potential
Lowest
Intermediate
Highest
Eelgrass Present
Eelgrass absent and no restoration potential based on model
Appropriate Substrate
Test Plant Sites
Anderson island
Delano Beach
McNeil Island
Harvest Site
Ketron Island

Map 17

Pacific Northwest
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