May 1st, 3:30 PM - 5:00 PM

20% More Eelgrass in Puget Sound by 2020: Restoration Site Selection

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Objective

- Puget Sound Partnership Goal – *Restore 20% more eelgrass by 2020*
- Present extent = 20,300ha (F. Short, WDNR, Oct. 2013)
- Historical losses have occurred but are not well quantified
- Recent (since 2000) losses are indicated
- Objective of study –
  - *Locate specific areas where eelgrass could be restored to meet the (~4,000 ha) recovery goal.*
    - *Restore, Enhance, Conserve, Protect*

Approach to Find Sites

Ecosystem-wide assessment, then site specific tests

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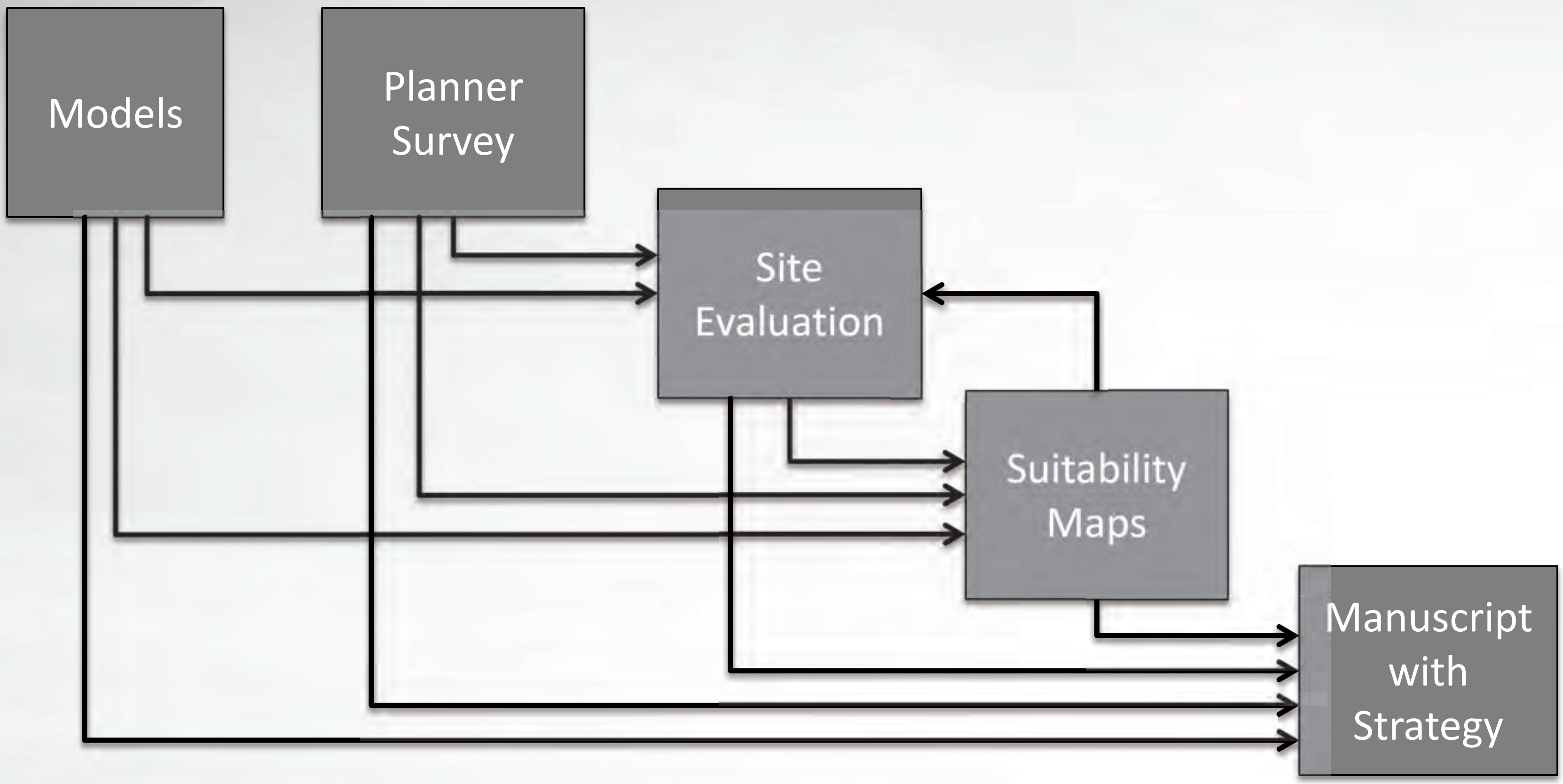
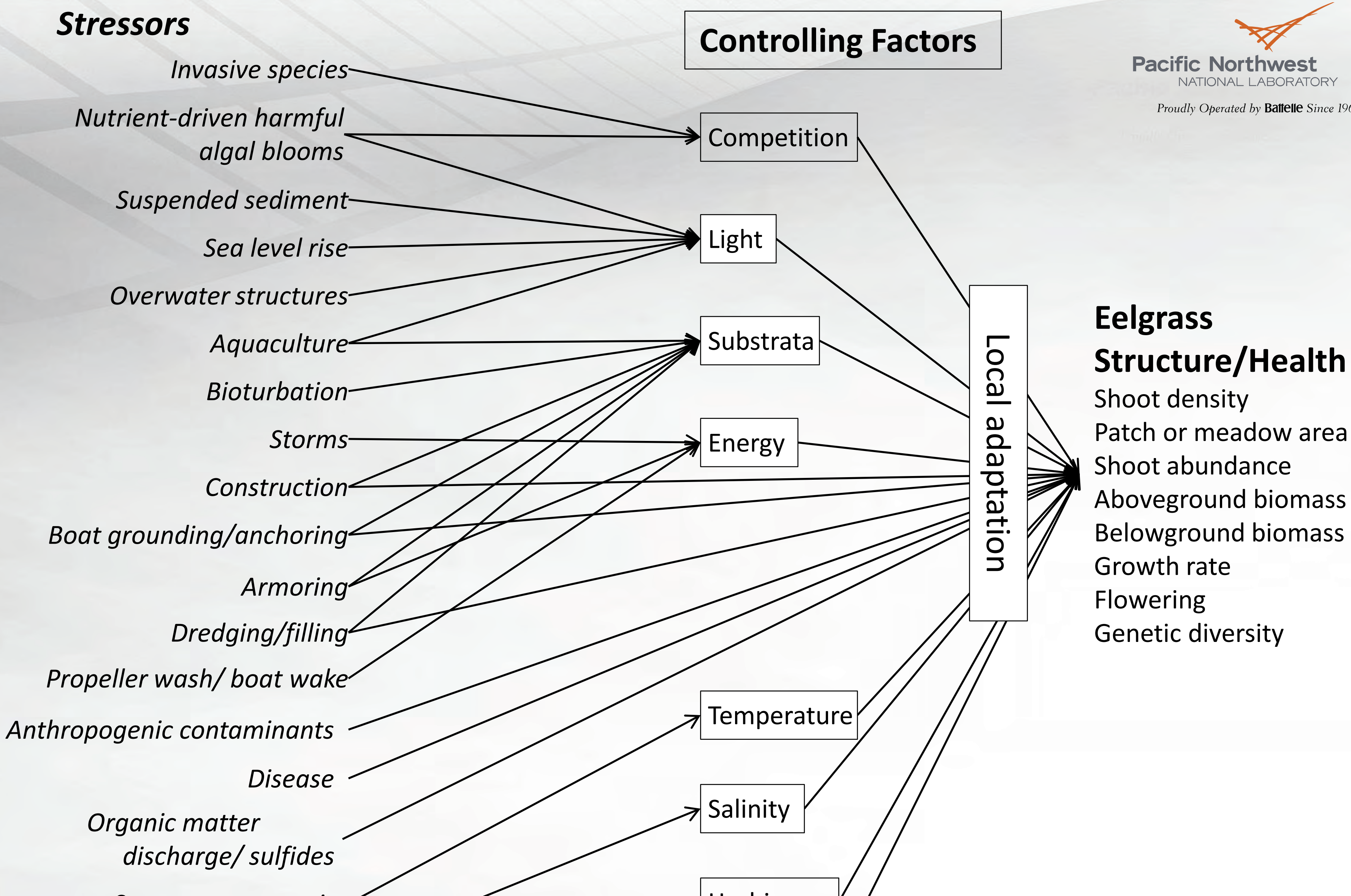


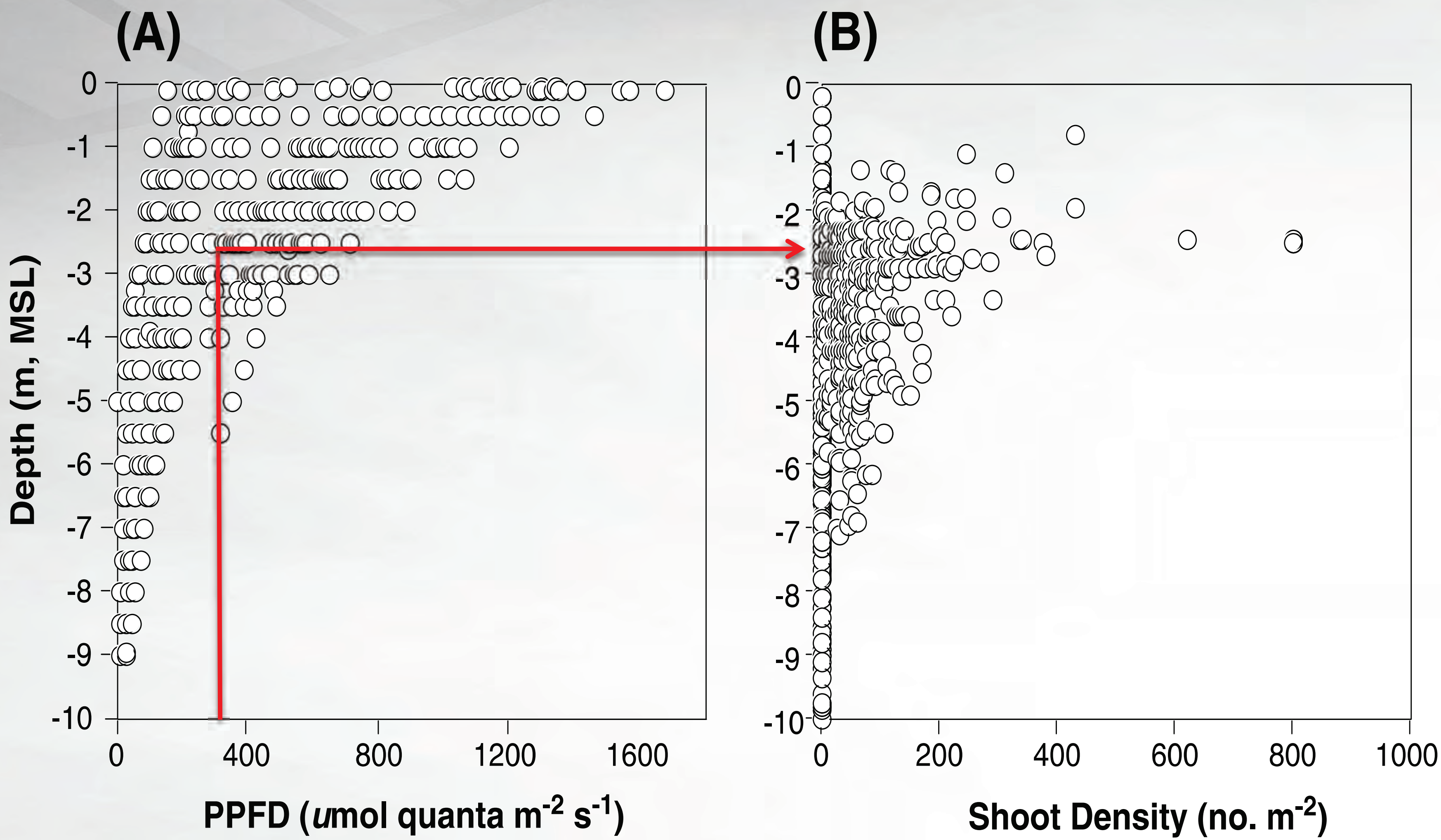


Eelgrass Stressor Study

(Thom et al. 2011)

Light, Depth and Eelgrass Density

(Thom et al. 2008. Estuaries and Coasts 31:969-980)



Minimum ~3mol quanta m^{-2} d^{-1}, during spring and summer

Temperature vs Leaf Net Productivity (NPP) and Respiration (R)

(Thom et al. in review)

*Maximum NPP 6-17°C

*Severe decline in NPP and increase in R above 25°C

*NPP:R greatest at about 5-9°C

*Growth declines with temp.

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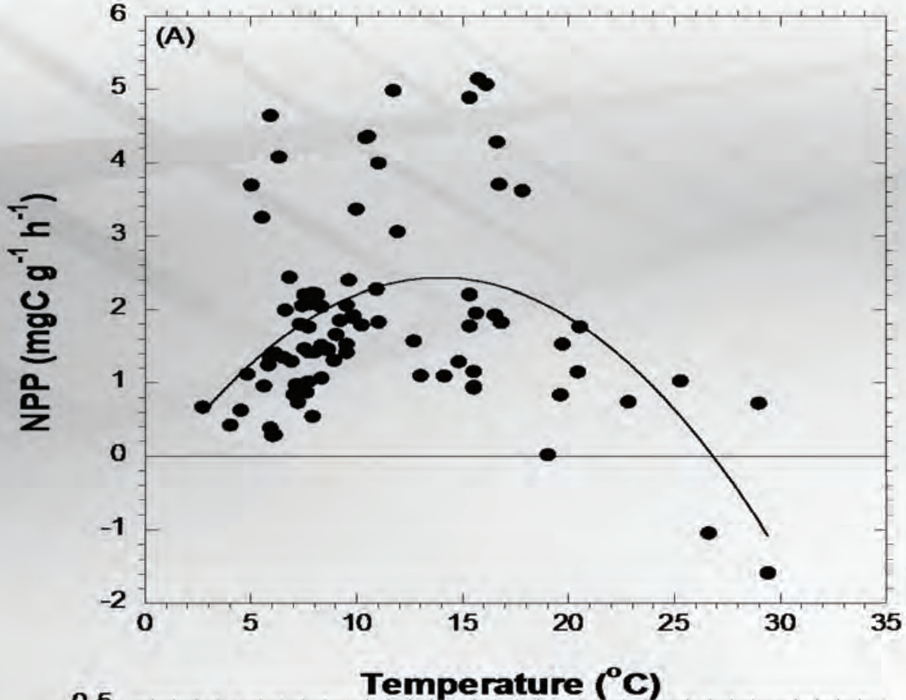

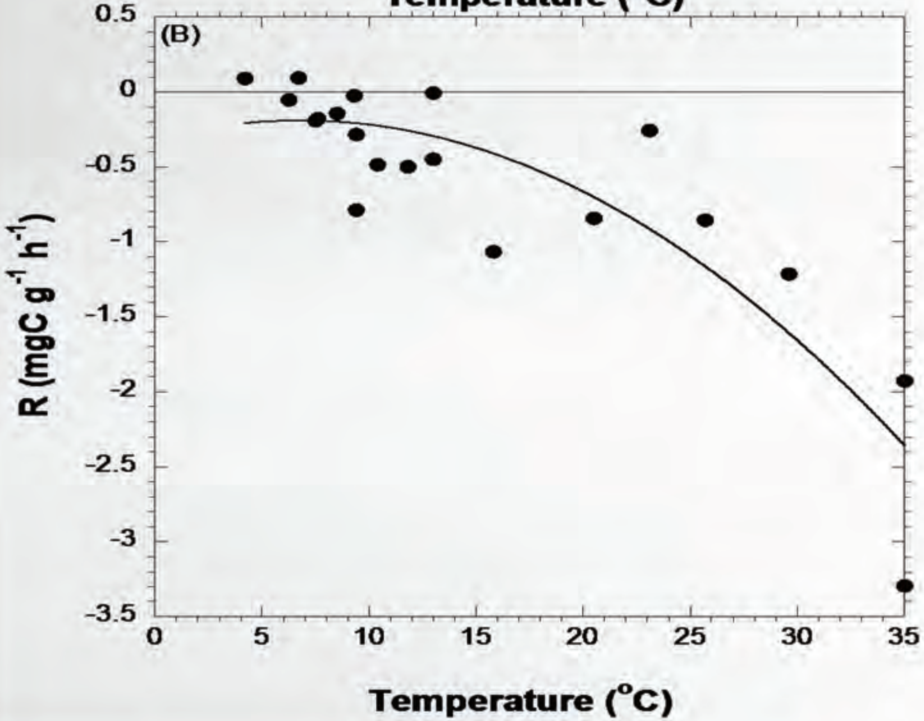

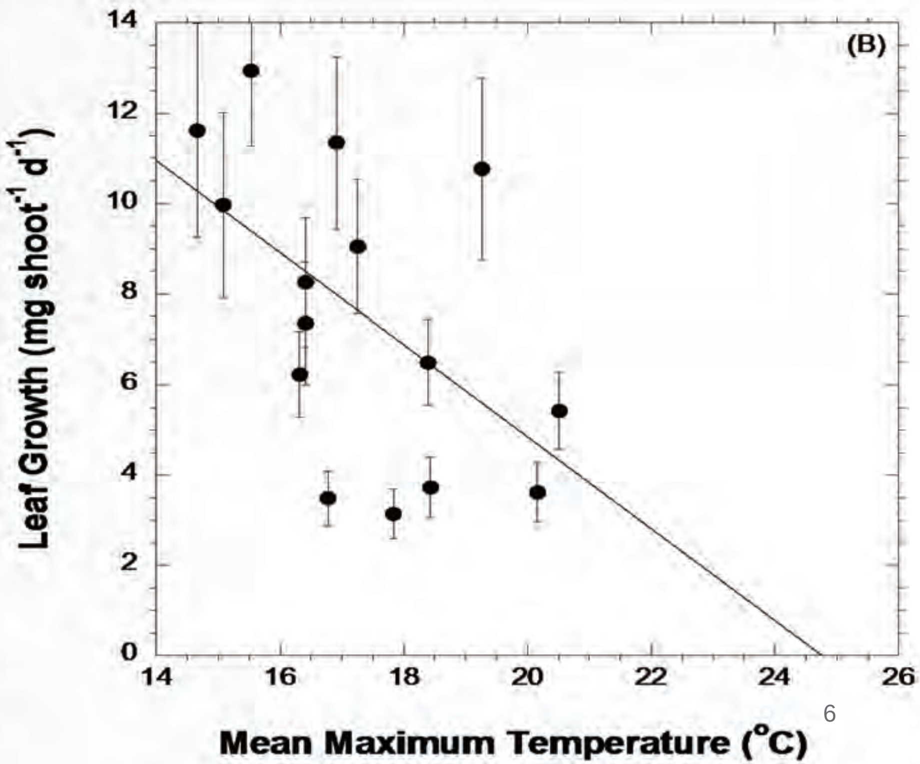

Eelgrass Biomass Growth Model

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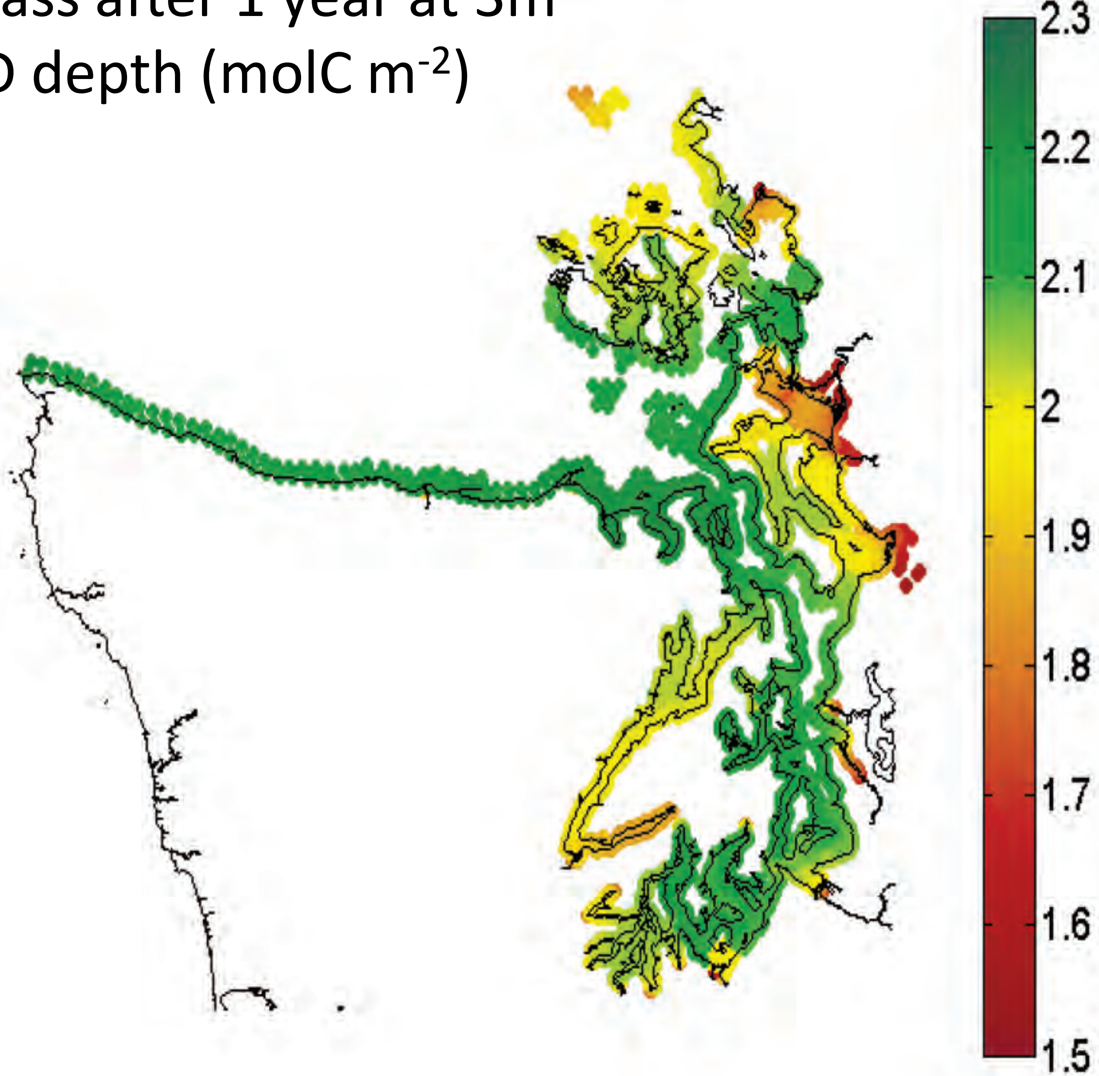
Biomass after 1 year at 3m NAVD depth (molC m^{-2})



(Initial biomass = 2.0 molC/m^2)

- Includes:
  - Light
  - Temperature
  - Salinity
  - Density dependence
  - Photosynthesis and respiration
- Indicates potential areas to investigate further for restoration
- One component of larger eelgrass habitat suitability model

Total Area by Depth Suitable for Eelgrass (Predicted growth ≥2.0 molC m^{-2})

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Depth Bin	Depth (m) NAVD88	Area (ha)*
1	-0.5 to -1.5	10,721
2	-1.5 to -2.5	75,523
3	-2.5 to -3.5	4,739
4	-3.5 to -4.5	3,762
5	-4.5 to -5.5	3,993
6	-5.5 to -6.5	2,737
7	-6.5 to -7.5	2,422
8	-7.5 to -8.5	1,513
9	-8.5 to -9.5	348
Sum		105,758

**Not corrected for substrata or disturbances/stressors*

**Does exclude elevation with high desiccation potential*

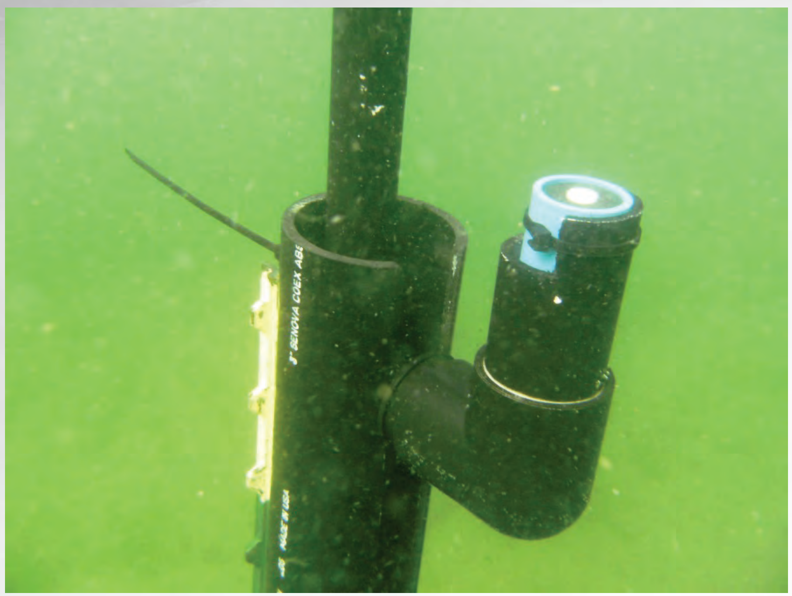
Present extent = 20,300ha

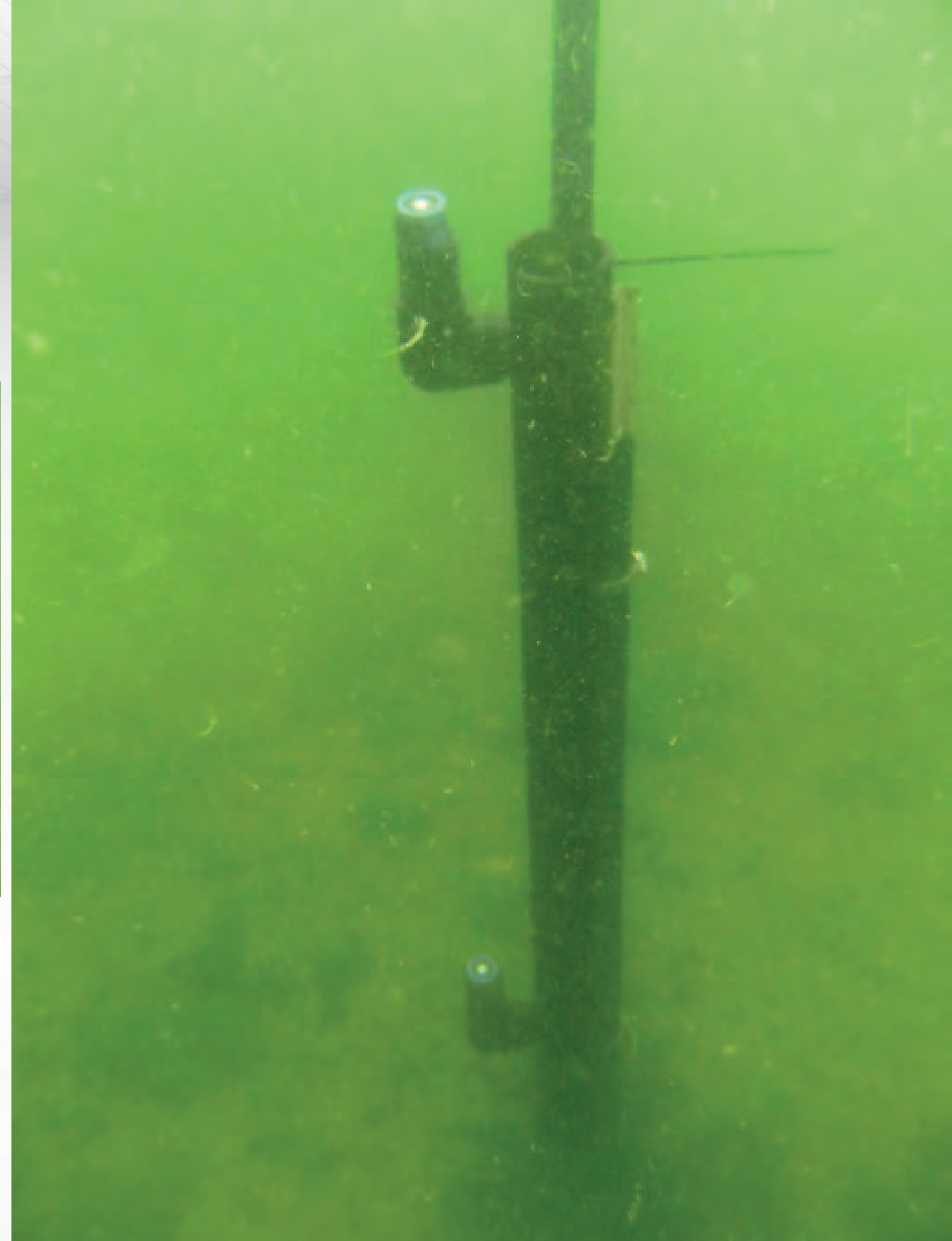
Test Plots

- 23 sites were examined
  - 12 with eelgrass
  - Genetic samples from 8 sites
- Test plots in 3 major regions
  - Larger sites
  - Landscape scale issues (e.g., south Sound)
  - Unexplained absence of eelgrass
- Plantings done 5-14 June 2013
  - 5 sites, total of 9 plots.


Donor stock from stockpile at
MSL and nearby meadows

Light & Temperature Sensors at all Sites





Test Planting Results (after 10 Months)

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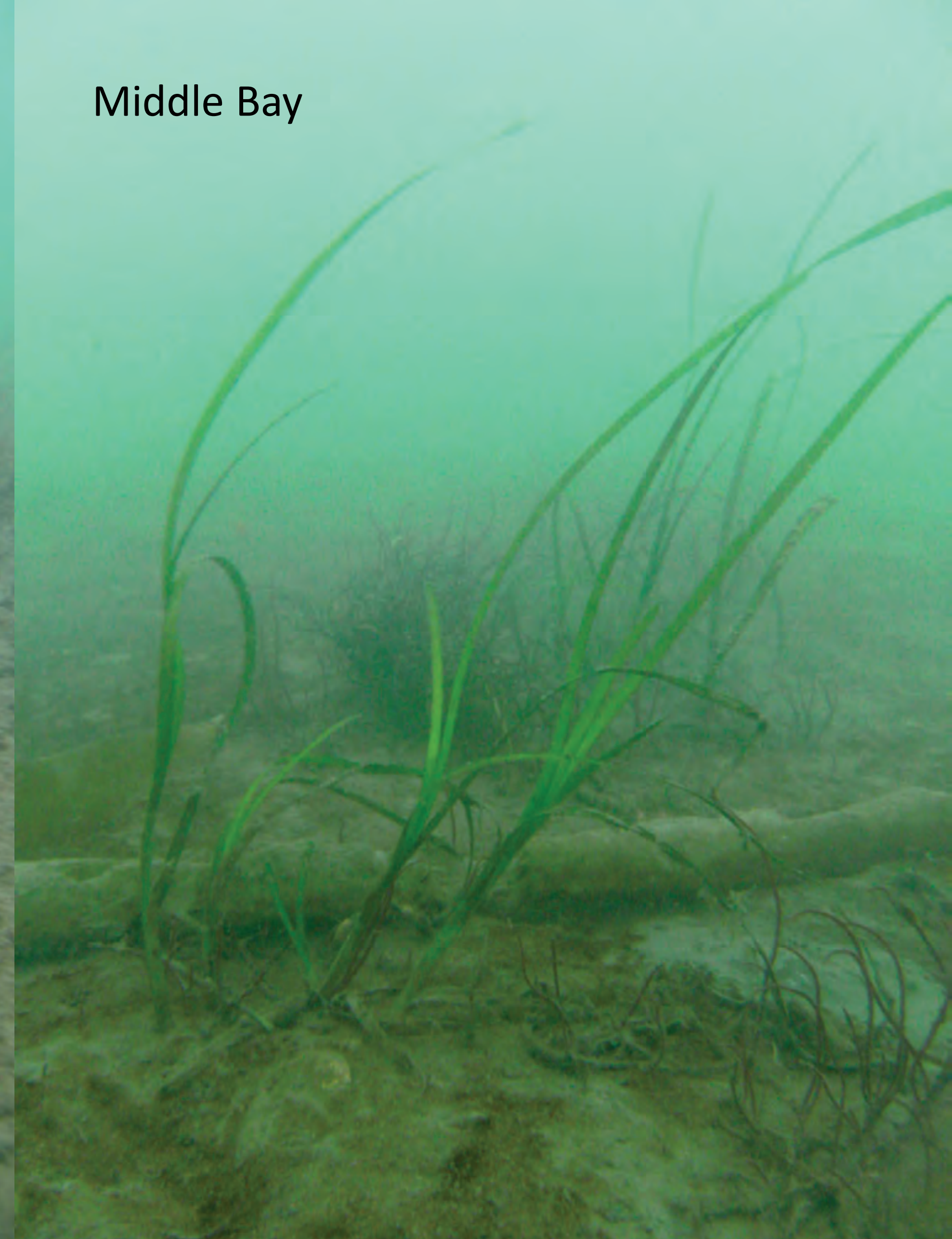
Site	Shoots planted	Area planted (m^2)	Shoots counted	Survival	Mean end density (shoots m^{-2})
Amsterdam Bay shallow	720	36	11	1.5%	0.31
Amsterdam Bay deep	720	36	14	1.9%	0.39
Joemma SP shallow	712	36	775	108.8%	21.53
Joemma SP deep	712	36	930	130.6%	25.83
Zangle Cove	872	45	539	61.8%	11.98
Liberty Bay (NW site)	600	30	8	1.3%	0.27
Liberty Bay (SE site)	720	36	3	0.4%	0.08
Westcott middle bay	472	25	81	17.2%	3.24
Westcott head of bay	448	25	0	0.0%	0.00

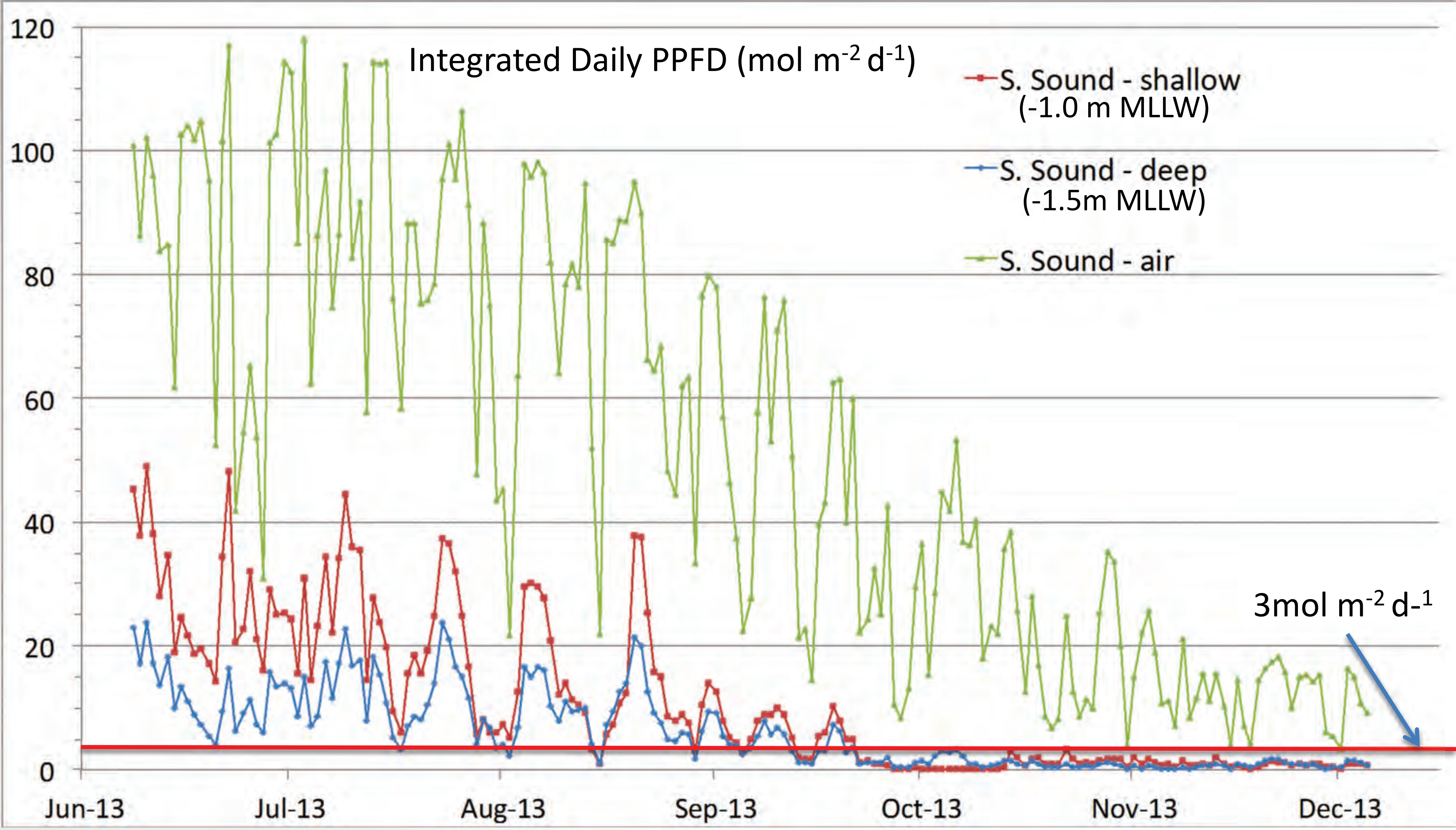
Westcott Bay

- Site of unexplained loss of ~16ha of eelgrass
- Head of Bay
  - Depths -4m to -6m
  - Five 5m long transects
  - Covered ~100m
  - 448 shoots
- Middle of Bay
  - Depths -5m to -9m
  - Five 5m long transects
  - Covered 56m
  - 472 shoots
- Observations
  - Head of Bay, all eelgrass gone
  - Middle Bay, about 25% remained

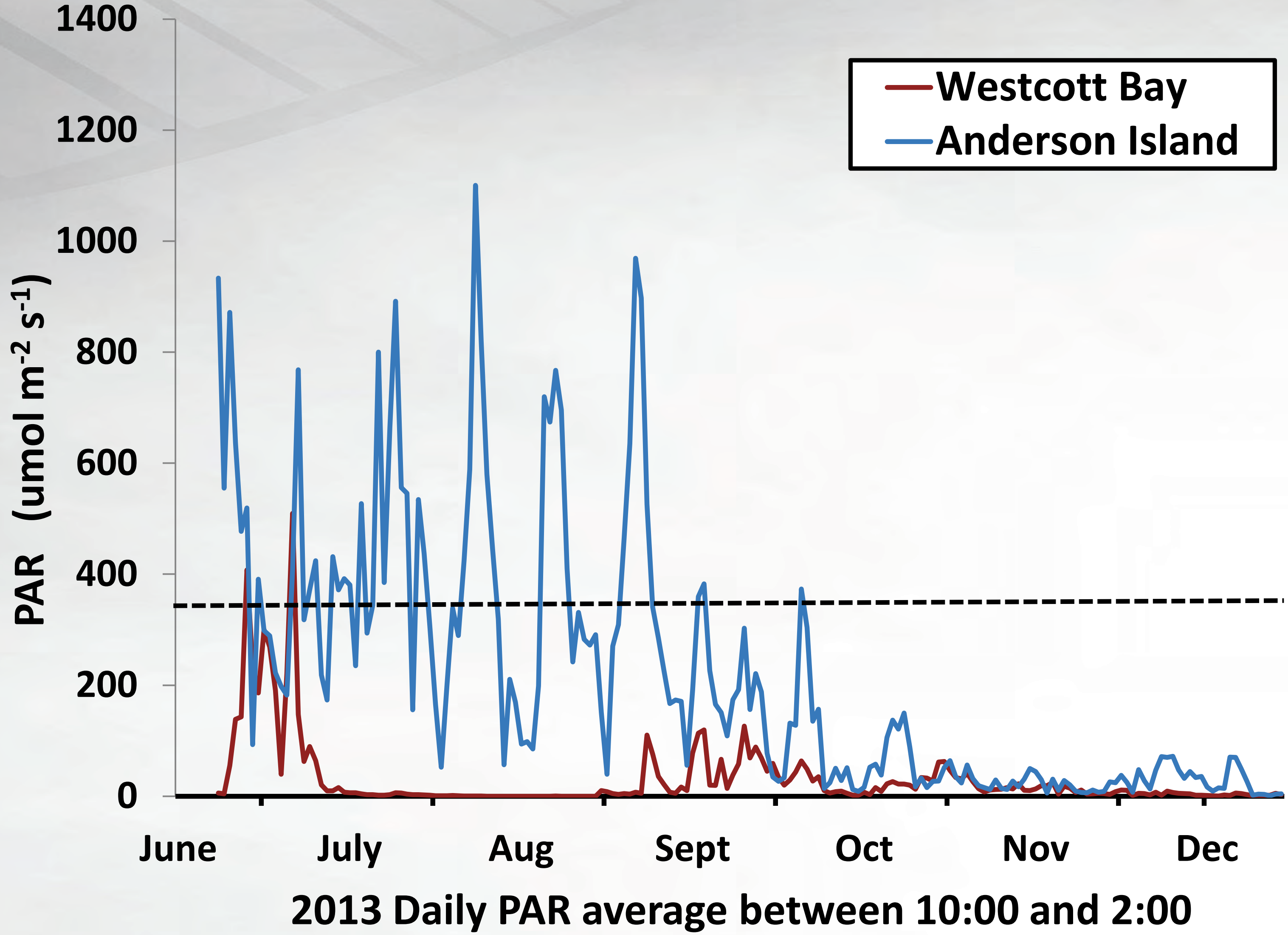

Head of the Bay

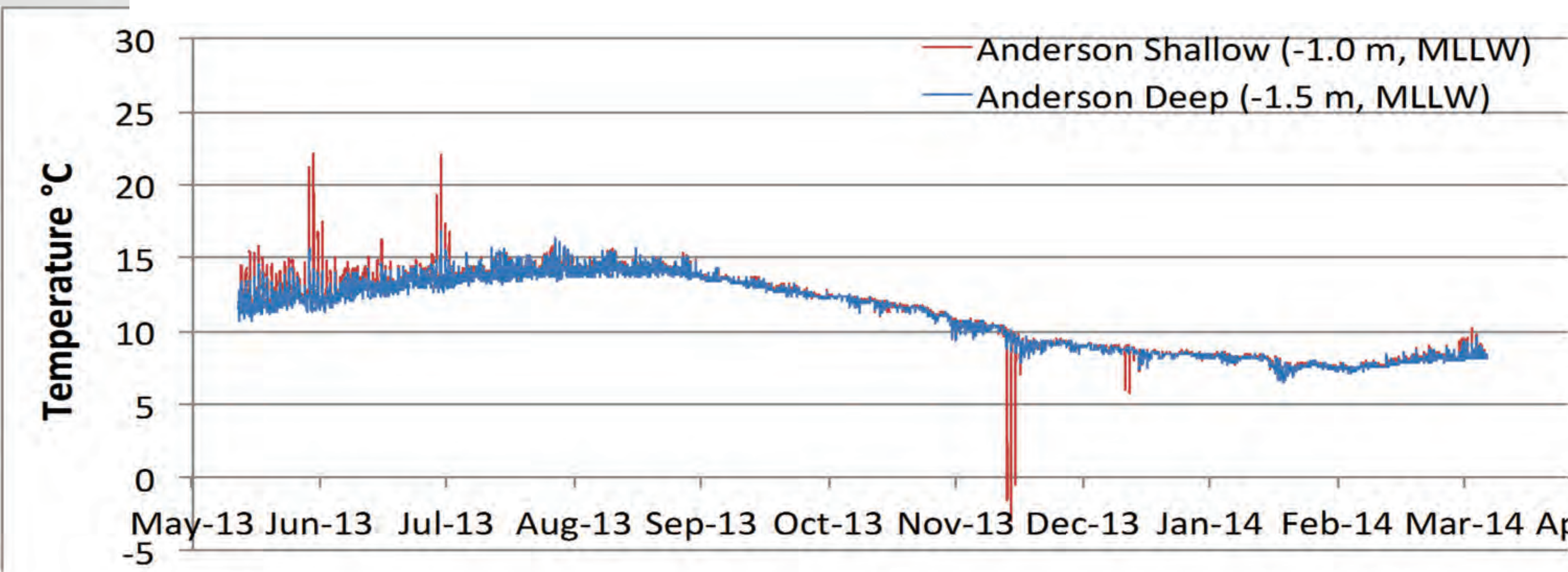

Middle Bay

Integrated Daily Photosynthetic Photon Flux Density in Eelgrass Zone – South Puget Sound

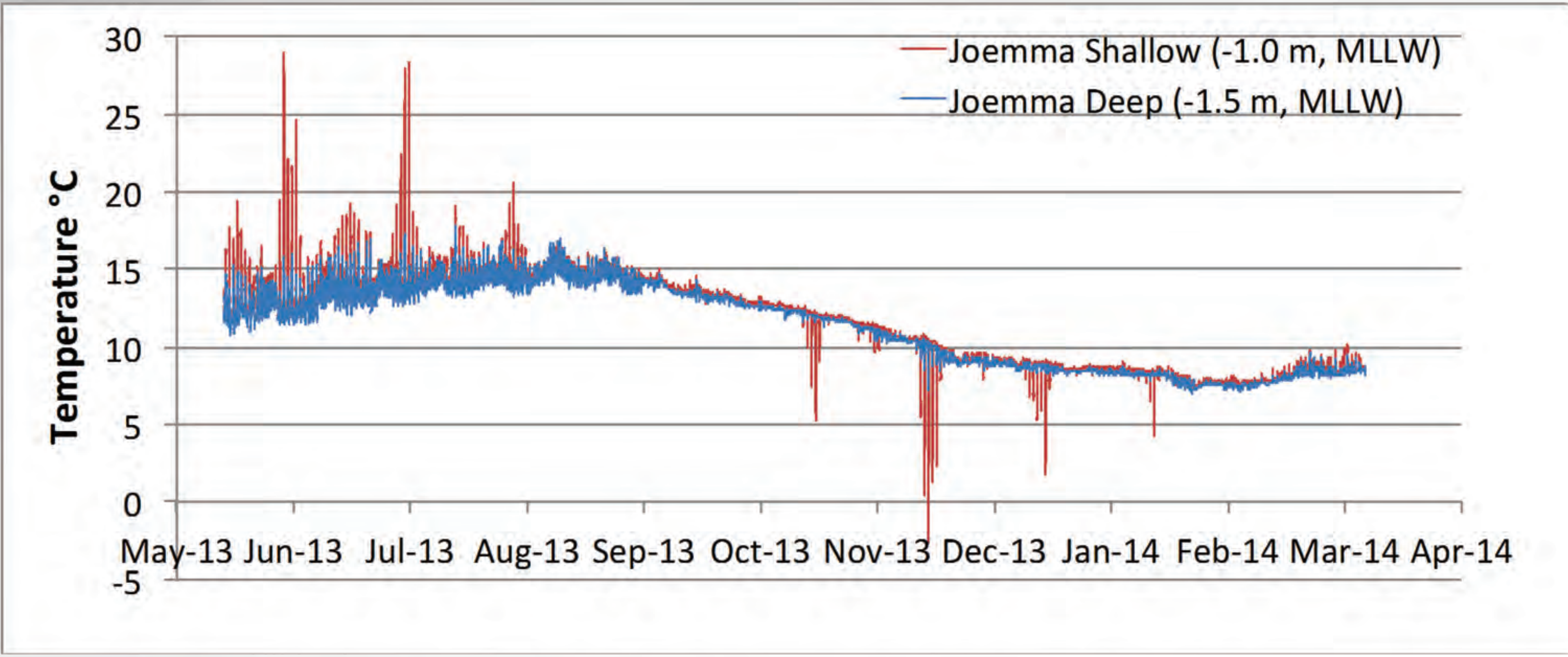


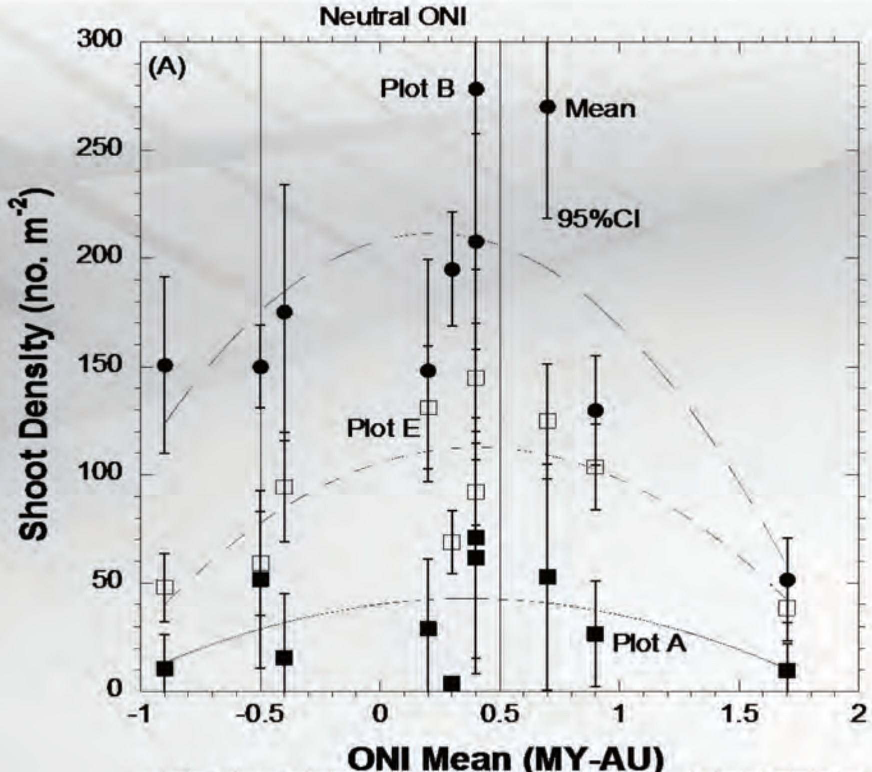
PAR at Eelgrass Canopy Depth

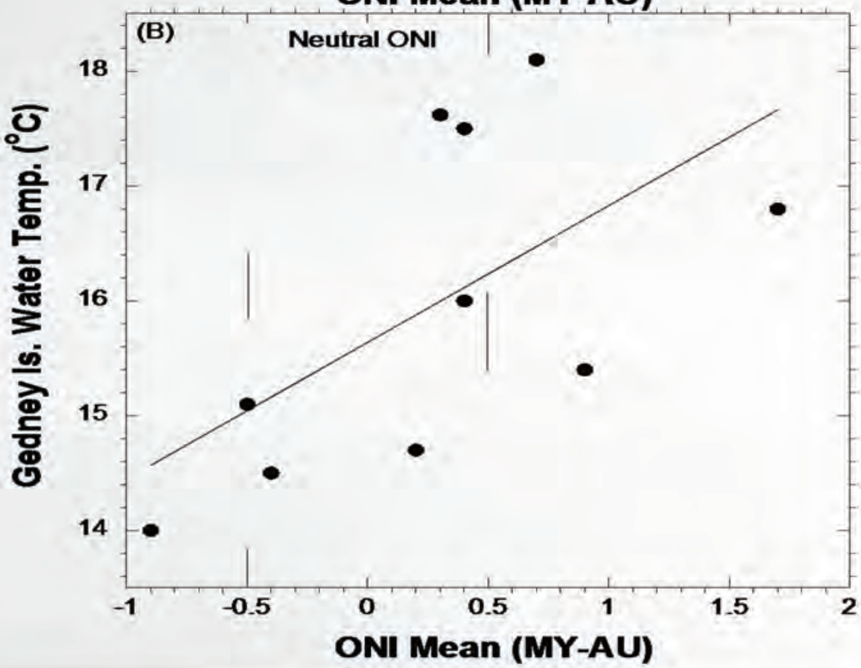



Anderson Shallow (-1.0 m, MLLW)
Anderson Deep (-1.5 m, MLLW)
Temperature °C
30
25
20
15
10
5
0
-5
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14

Joemma State Park







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Climate Variation and Eelgrass Density (Thom et al. in review)

Clinton Ferry Terminal
(Summer, 1997 – 2006)

- Greatest densities occur during neutral to slightly positive Oceanic Niño Index
- Variation may be driven by water Temperature and mean sea level

Survey Results

- Survey was sent out to 1,000 recipients
- A total of 147 responded; 50% categorized themselves as Natural Resource Manager, Marine Biologist, and Nearshore/Estuarine Scientist
- Over 80% of respondents considered themselves to have a “good” or “excellent” understanding of the functions and values of eelgrass, it’s abundance and distribution throughout Puget Sound, and the stressors that affect it.
- Dredging and filling, shoreline development and water quality were identified as having a large impact to eelgrass at discrete locations in PS, as well as in PS as a whole in its current state.
- 78% of respondents indicated that changing policies that protect eelgrass from direct impacts (dredging, overwater structures, mooring buoys) would enhance eelgrass in PS
- 90% of respondents indicated that changing policies that protect eelgrass from degrading environmental conditions (e.g. poor water quality, nutrient loading) would enhance eelgrass in PS
- 75% of respondents indicated that changing policies that require greater project compliance (e.g. larger mitigation ratios, higher transplant criteria) would enhance eelgrass in PS

Table 5.4. Stressors of Interest by Region and for Puget Sound

Region	Shoreline Length (miles)	Sites in Sampling Frame for Eelgrass Survey (sq miles)	Overwater Structure Area (acres)	Overwater Structure Density (acres/ shoreline mile)	Percent Shoreline Armored	305(b) Sediment Contaminant Occurrences in Eelgrass Survey areas[a][b]	303(d) Water Quality Occurrences[a][c]
Hood Canal	245	28	63	0.258	21.29%	0.14	2.34
North Puget Sound	250	98	184	0.736	31.71%	3.08	0.74
Saratoga-Whidbey	343	100	144	0.419	21.67%	0.21	0.30
South Puget Sound	206	25	66	0.322	26.96%	0.00	2.56
Central Puget Sound	734	81	803	1.095	47.61%	1.00	2.3
San Juan	454	33	90	0.199	4.29%	0.42	0.85
Straits	220	46	47	0.215	15.38%	0.00	0.61
Puget Sound	2,451	410	1,398	0.571	27.09%	1.04	1.09

(a). One site may have multiple contaminant issues.
(b). Count, class 2, 4, or 5 per square mile of eelgrass survey area.
(c). Count, class 5 per square mile of eelgrass survey area.

Emerging Restoration Strategy - *Is it stressors or recruitment issues…or both?*

Present (Site and Landscape) Conditions	Historic: *Unsuitable*	Historic: *Suitable*
Suitable	+Zm, then conserve/ enhance -Zm, then plant $$	+Zm, then conserve/ enhance -Zm, then plant $
Unsuitable	Create suitable habitat, abate stressors, then plant $$$$	Abate stressors, then plant $$$

Historic (Site and Landscape) Conditions

Implement Actions to Promote Resilient Populations(Thom et al. 2012. Estuaries and Coasts 34:78-91)

- Understand carrying capacity and limiting factors of various depths, sediment types in different regions and sites
- Improve ecosystem processes
  - Abate water quality issues on watershed/landscape scale
  - Abate excessive (unnatural) sources of suspended sediment
  - Remove obvious sources of stress and disturbance
- Plant minimum viable populations
  - Utilize appropriate genetic stocks
  - Plant at appropriate density
- Enhance sources of renewal
  - Plant near existing meadows
  - Enhance below-ground development
  - Improve chances of seeds reaching the restoring sites
- Adaptively manage sites

Summary

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- Large area *potentially* suitable for eelgrass that is currently barren of eelgrass
- Test plantings showed variable success in transplant survival indicating site suitability
  - Suitability may be driven by light, temperature, local adaptation, and ability to escape early mortality
  - Water quality may be affecting large regions, and needs further evaluation
- Regulatory actions should be implemented in areas where obvious improvement will take place
- Natural recovery appears to be occurring in some restoring areas (e.g., Nisqually Delta, Skokomish Delta)

Conclusions

- Restoring 4,000ha by 2020 is a *grand* challenge
  - Recruitment limitation (low seed production, slow rhizome spread)
  - Minimize donor stock impact
  - Natural variation in 'ocean conditions'
  - Climate change (R.Takesue et al.)
  - Human disturbances continue on site and landscape scales
  - Regulatory issues need to be resolved (disturbances, permits)
  - Loss of eelgrass continues in some areas (F. Short, WDNR)
- Can we expand the carrying capacity of the system for eelgrass?
  - Abatement of physical constraints and disturbances
  - Improvement in water clarity
- Consider a *trajectory* of net improvement through time in controlling factors and eelgrass area as an indicator of progress toward goal

Future

- Final manuscript June 2014 – with recommendations
- Additional funding to implement restoration efforts –
  - National Estuary Restoration Program grant (restoring deltas)
  - Port Gamble
  - State Restoration Fund
- Need to –
  - Define role of watershed conditions in degrading nearshore water quality
  - Investigate regulatory approaches to enhancing eelgrass recovery
    - Reduce disturbances on site and landscape scales
    - Facilitate permitting process
  - Enhance predictive capability of model
  - Resolve nearshore data needs (bathymetry, light conditions, water quality, phytoplankton, suspended sediment, eelgrass presence)
  - Understand spatial aspects of genetic variation

Funding Source and Contacts

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