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Living Lab Program for Climate Change and Conservation - Final Report

Project title: Assessing impacts of boat traffic and disturbance on eelgrass meadow health and biodiversity in Desolation Sound

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Eelgrass meadows provide many important ecosystem services, including shoreline stabilization, carbon uptake (Rohr et al., 2018), oxygen production, and sediment filtration (DFO, 2009). Eelgrass also functions as an ecosystem engineer, creating structural complexity and providing habitat for biodiversity including fish and the invertebrates they eat (Cole & Moksnes, 2016). Eelgrass provides nursery habitats for juvenile rockfish and salmonids (Rubin & Hayes, 2018), and healthy eelgrass beds support rich and productive food webs that include fish (Laurel et al., 2003), birds (Huang et al., 2015) and unique assemblages of invertebrates compared to adjacent habitats. Restoring eelgrass meadows throughout the park would greatly increase connectivity between patches, provide additional water filtration capacity to offset waste produced by boats, and serve as a nature based climate solution to sequester and store carbon.

Research findings

We visited 10 sites in and adjacent to Desolation Sound Marine Park (DSMP) in June and September 2024 (Figure 1). The primary research aim was to assess site-level conditions for suitability and condition of eelgrass meadows. We did this by measuring water quality, light levels, sediment condition and the presence and absence of eelgrass. The rationale was to assess whether sites with poor eelgrass could perhaps accommodate growth and recovery if restoration were to be undertaken. Sites considered potential restoration sites were: Theodosia Arm, Susan Inlet, Grace Harbour and Tenedos Cove, and we compared them with reference sites, Penrose Bay, Beulah Island, Feather Cove, Tenedos Island, Tenedos Lagoon, Melanie Point, Williams Island (Inside and Outside), Copplestone Lagoon and Roffery cove.

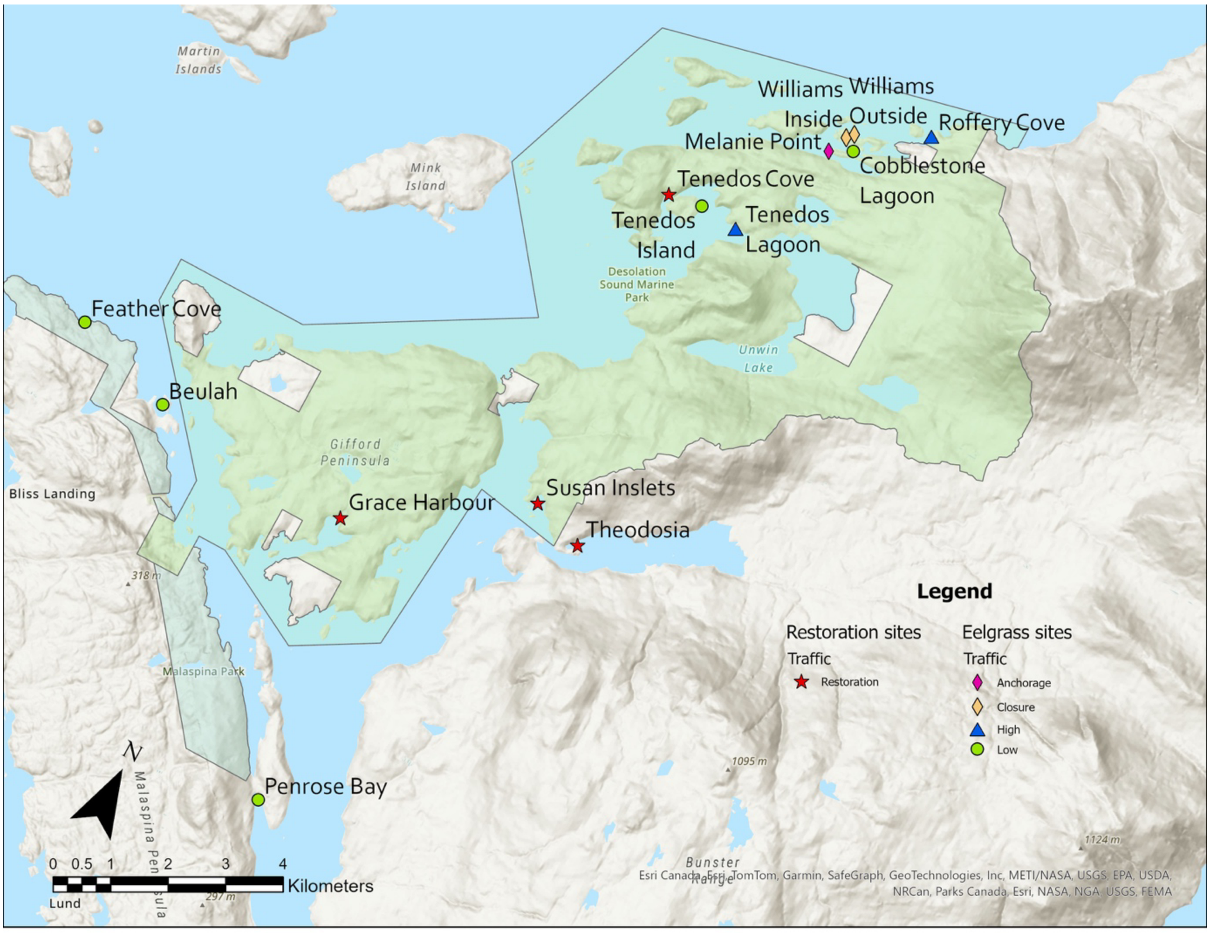

Figure 1: Map of sampling sites. Low traffic sites (green circles), high traffic (blue triangles), anchorages (pink diamond), potential restoration sites (red stars) and closures (yellow diamonds).

I. Water quality

- Temperature in June and September (Figure 2)
  - Ranged between 13 and 18°C in both the spring and fall and declined slightly with depth, particularly in the fall
  - The restoration sites, particularly Theodosia and Susan inlet, were a bit cooler, but still in a good range for eelgrass growth (optimal range is 10 to 25°C)
- Salinity in June and September (Figure 3)
  - For most sites, salinity ranged from 20-27 ppt in the spring and 20-30 ppt in the fall, within the range of ideal conditions for eelgrass growth
  - Theodosia had a significantly lower salinity of about 10 ppt at the surface, likely due to input of freshwater that tends to float above sea water
- Dissolved Oxygen in June and September (DO, Figure 4)
  - Potential restoration sites seemed to generally be on the higher end of DO in the spring, but lower end in fall

- The absence of eelgrass may result in higher levels of nutrient availability in the water column, which can lead to algal blooms and increased decomposition. This can reduce DO levels in the fall when microbial activity increases due to higher organic matter and nutrient availability.

- pH in June and September (Figure 5)
    - Theodosia and Susan inlets have lower pH compared to other sites in the fall, but is still within acceptable environmental limits
- Water Column Nutrient concentrations in September (Figure 6)
    - Nutrient concentrations were similar between potential restoration sites and existing eelgrass sites
    - Nitrate concentrations were similar across all sites, except in Penrose Bay where they were significantly higher (~64 uM NO_3, versus ~2-8 uM in all other sites)
    - Ammonium concentrations were similar across all sites, ranging from 12-32 uM
    - Theodosia, a potential restoration site, had the highest nitrite concentration (0.42uM) all others ranged from 0.2 to 0.32 uM
    - Most sites had phosphate levels between 0.4 and 1.6 uM except Tenedos Lagoon which was higher at 4.6 uM.

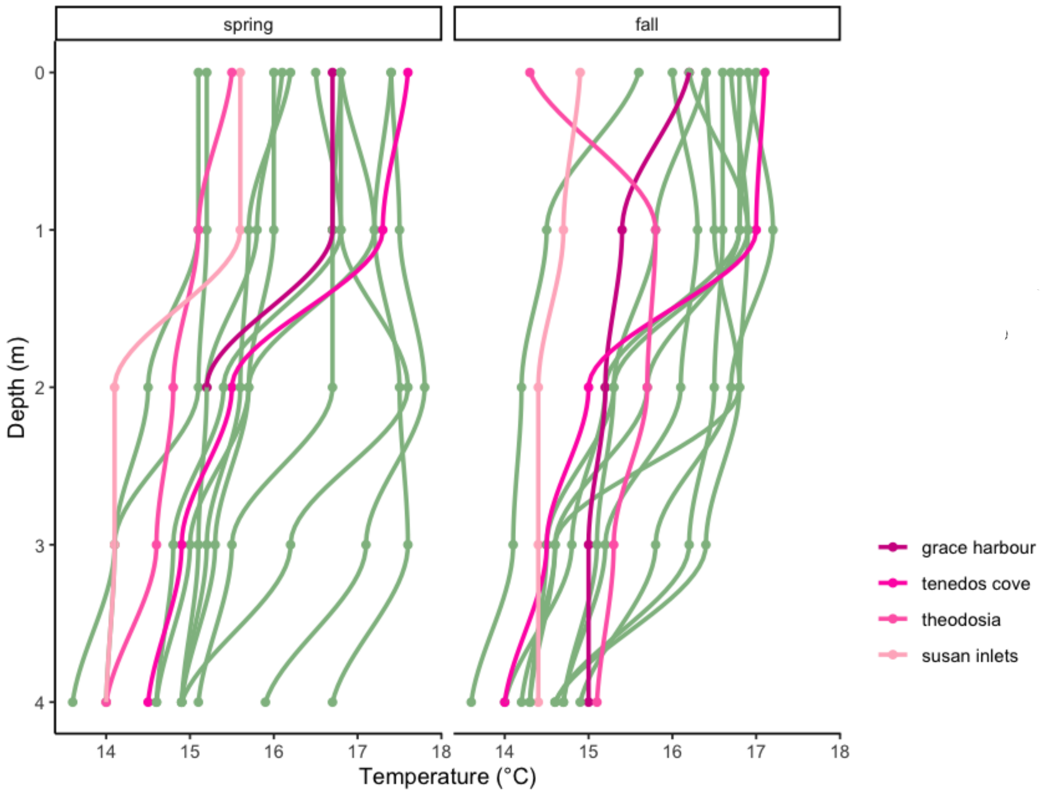

Figure 2: Temperature measurements at the time of sampling taken from YSI sensor. Pink curves are potential restoration sites. Green are the existing meadows.

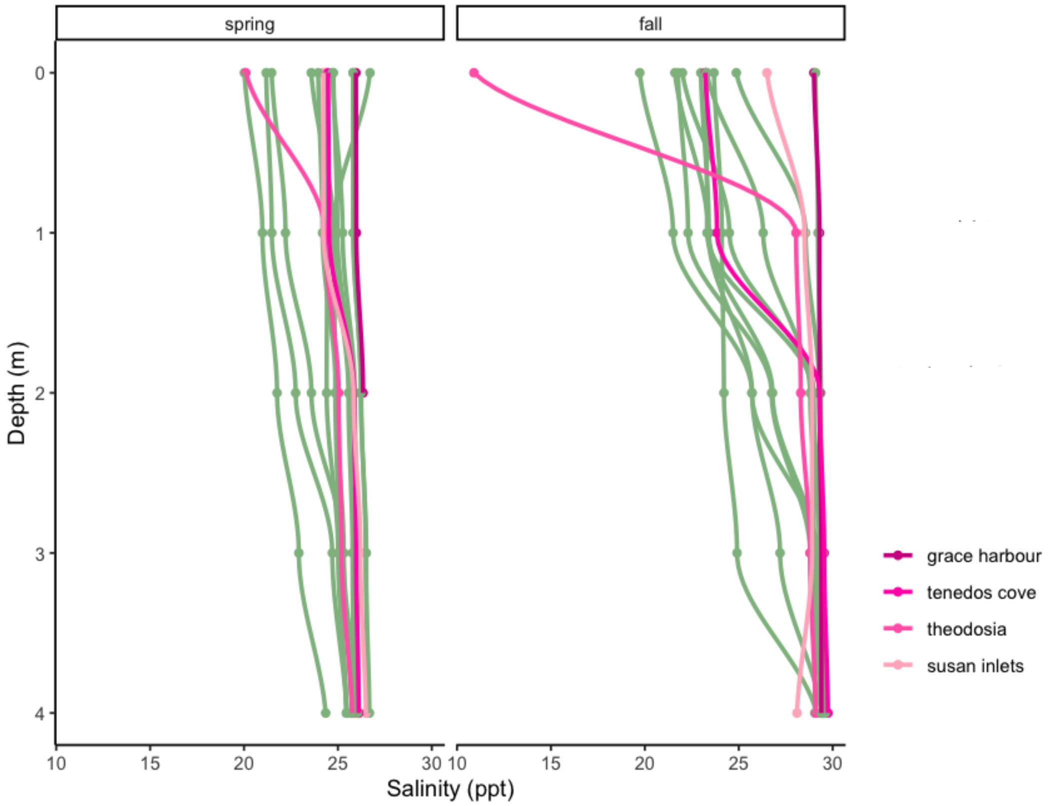

Figure 3: Salinity measurements at the time of sampling using the YSI sensor. Pink curves are potential restoration sites. Green are the existing meadows.

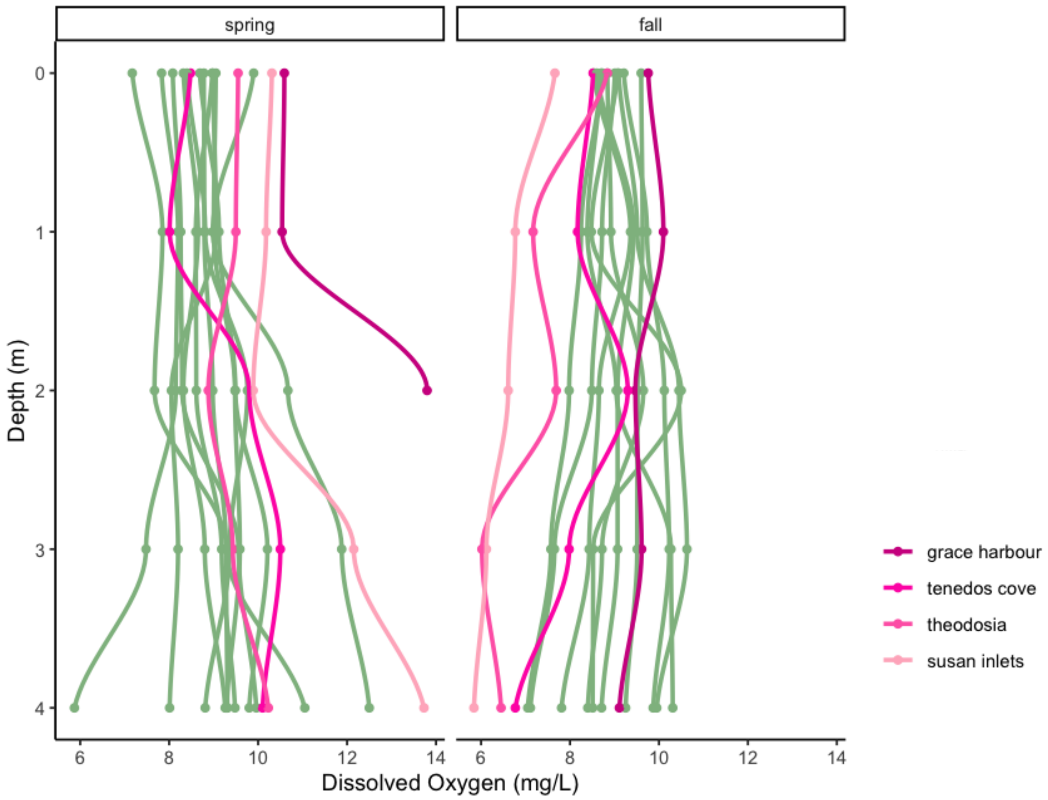

Figure 4: Dissolved oxygen at the time of sampling using the YSI sensor. Pink curves are potential restoration sites. Green are the existing meadows.

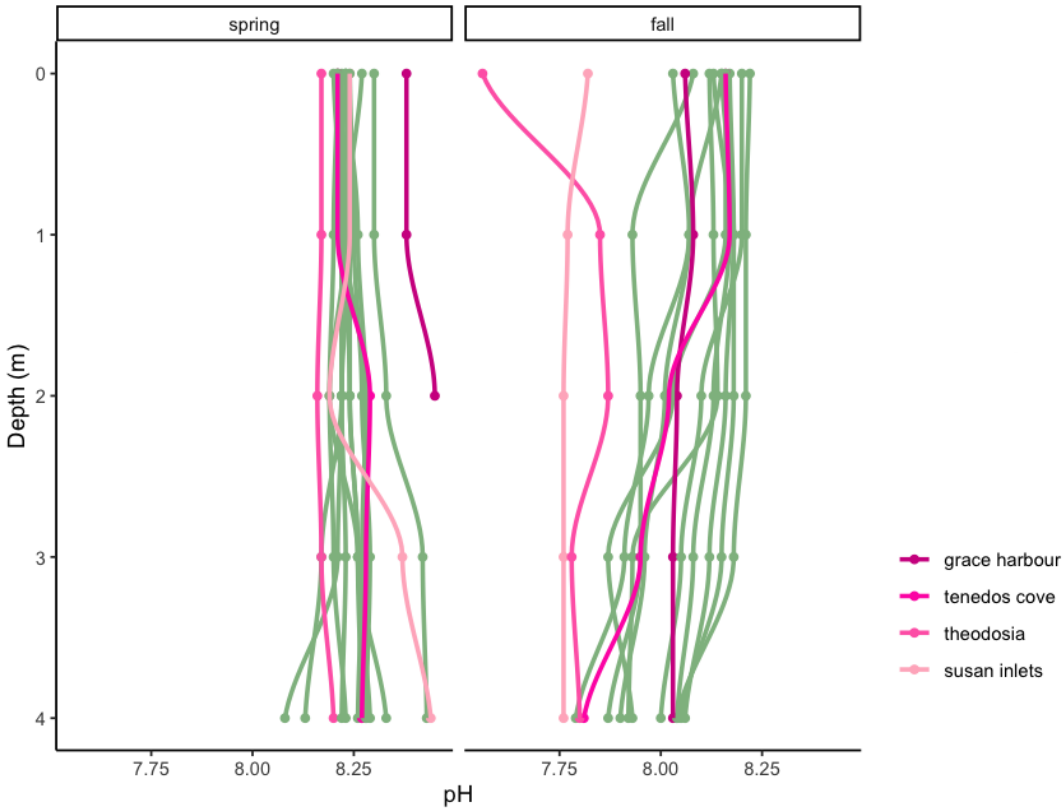

Figure 5: pH measurements at the time of sampling using the YSI sensor. Pink curves are potential restoration sites. Green are the existing meadows.

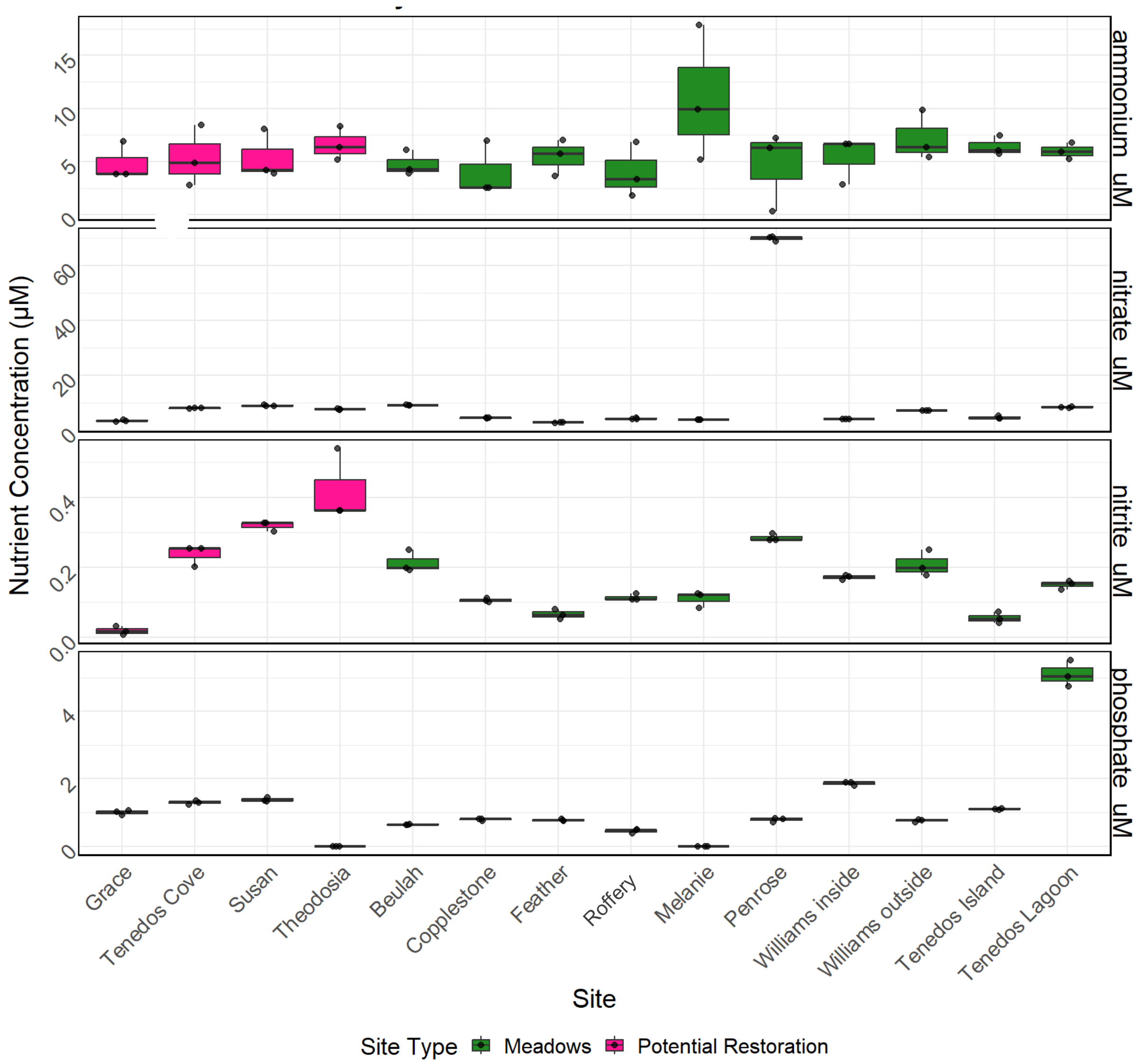

Figure 6: Water column nutrient concentrations (ammonium, top, by site. Conditions were compared between the four sites on the left (pink, potential restoration sites) compared to the 10 sites on the left (green, with existing eelgrass meadows)

II. Seasonal changes in temperature and light levels

- Temperature and light levels were overall similar across both existing meadows and potential restoration (Figures 7 and 8) and remained within optimal conditions for eelgrass growth

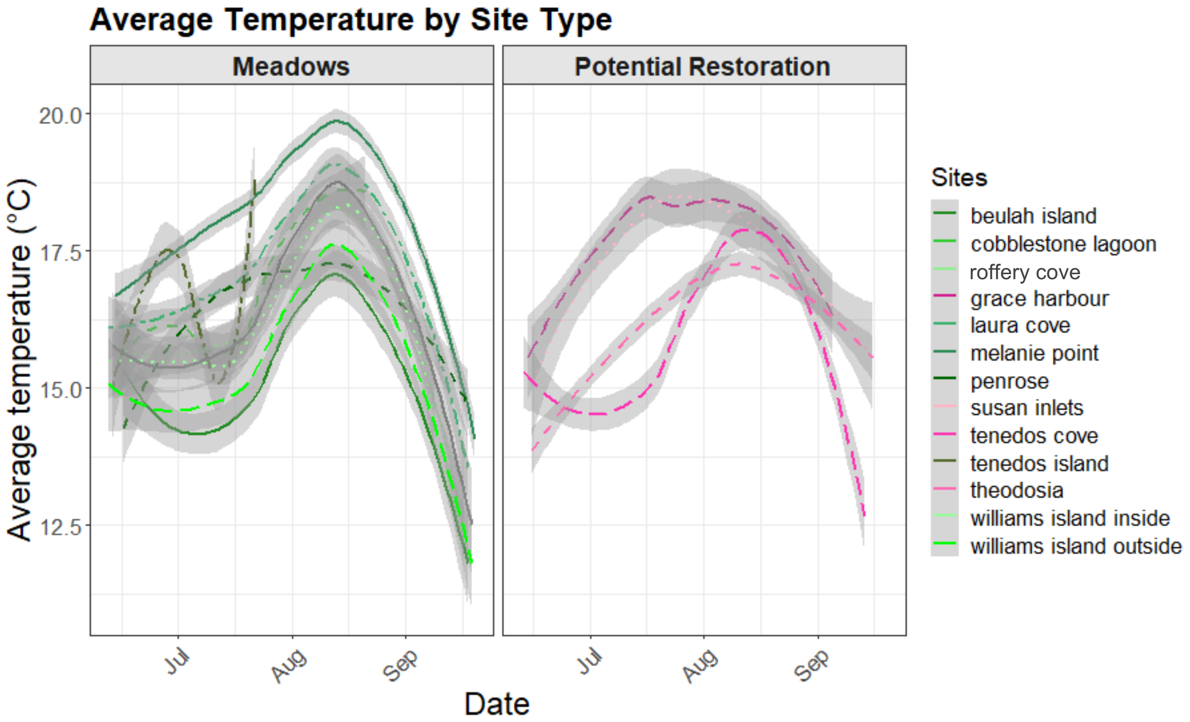

Figure 7: Average temperature across meadows (left) and potential restoration sites (right) over the summer as measured by HOBO data loggers.

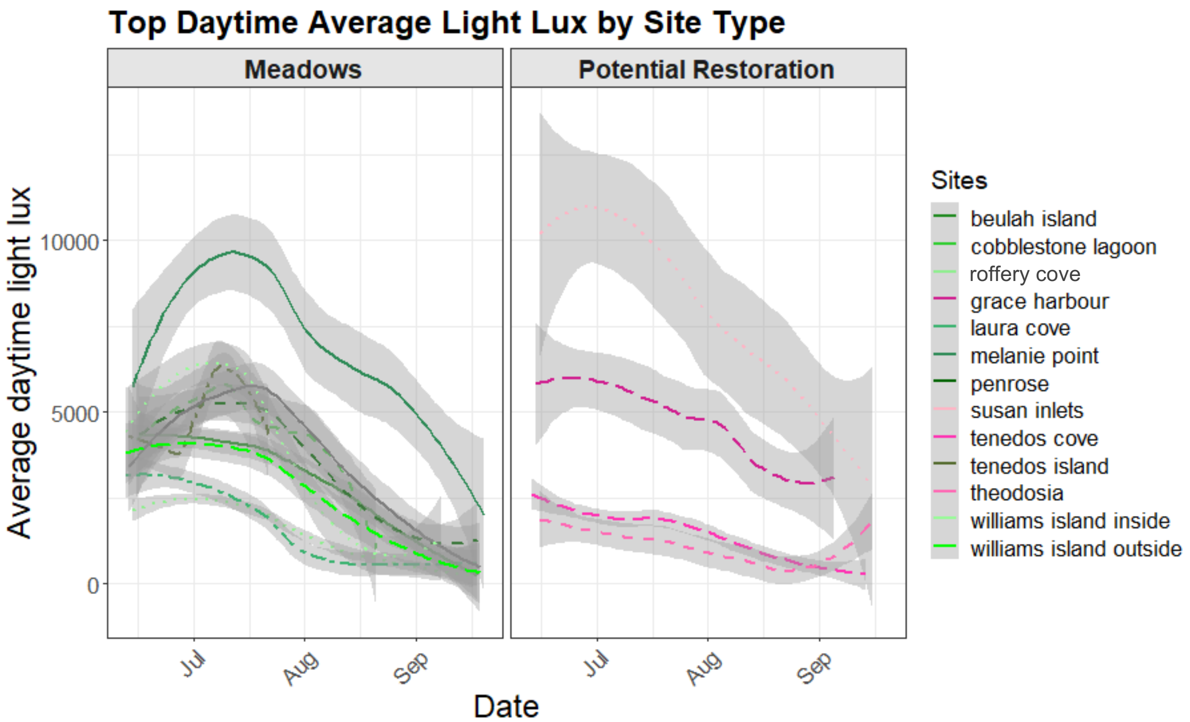

Figure 8: Average daytime light levels across meadows (left) and potential restoration sites (right) over the summer as measured by HOBO data loggers

III. Sediment Organic Matter and carbon content (Figure 9)

- We measured organic matter (OM) content as a proxy for organic carbon, based on empirical work by Christensen et al 2023. OM generally ranged from 1-10% except for Tenedos cove and Tenedos lagoon in the fall which were higher (up to 20%).

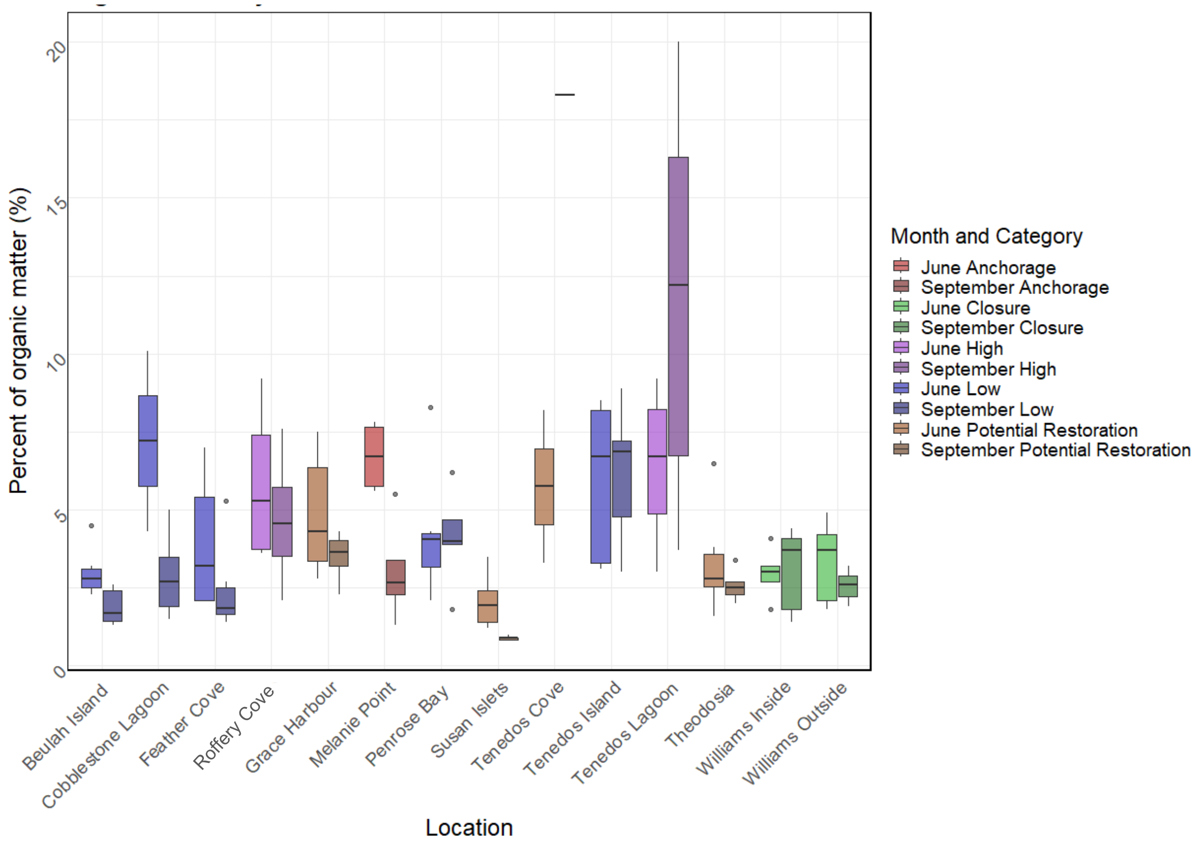

Figure 9: Organic matter content of sediments samples taken at each site in June and September

Methods summary

Site Selection

UBC researchers sampled the 10 sites selected previously to capture a range of eelgrass condition from healthy to potential candidates for restoration (Figure 1). In collaboration with BC parks and Tla'amin Nation, 4 potential restoration sites were identified for inclusion in this study. They were selected based on knowledge of site characteristics (i.e. depth, sediment that is likely to support eelgrass) Theodosia is outside of the park but was included due to its importance to the Tla'amin nation.

Table 1: Site location, BC Park management state with regard to boat use, and possible restoration status.

Site Name	Location	Boat Use	Group
Melanie point	In park	Anchorage	Boats anchoring
Williams island (Inside)	In park	Anchorage	Boats anchoring
Tenedos bay	In park	Anchorage	Boats anchoring

Williams island (outside)	In park	Anchorage	Boats anchoring
Roffery Cove	In park	High traffic	No boats anchoring
Tenedos island	In park	High traffic	No boats anchoring
Penrose bay	Outside park	Low traffic	No boats anchoring
Feather cove	Outside park	Low traffic	No boats anchoring
Beulah island	Outside park	Low traffic	No boats anchoring
Cobblestone lagoon	In park	Low traffic	No boats anchoring
Grace Harbour	In park	Restoration	Restoration
Tenedos Cove	In park	Restoration	Restoration
Susan Inlet	In park	Restoration	Restoration
Theodosia Arm	Outside park	Restoration	Restoration

Environmental conditions

I. Water quality

- Nutrients
    - Water from just above the bottom, near eelgrass meadows (if present) was collected from each site in a 15 ml falcon tube and kept in a cooler in the dark until processing later that day
    - Water was filtered through a 0.7 µm pore size Whatman GF/F filter to remove organisms and particulates before water was frozen for transport to the lab. Filtering prevents nutrients from organisms within the sample from contaminating the water by spilling nutrients upon cell lysis
    - Once in the lab, samples were tested for ammonia, phosphate, nitrite and nitrate levels using a standard spectrophotometric method (Hansen and Koroleff, 1999; García-Robledo, Corzo and Papaspyrou, 2014)
- Temperature, Dissolved oxygen, Salinity and pH
    - Measurements of temperature (degrees C), dissolved oxygen (mg/L), salinity (ppt) and pH were recorded at each site using a YSI ProQuatro Multiparameter Meter. These measurements were taken from the boat while divers collected sediment and water samples. At each sampling location, measurements were taken from the water surface and at every meter of depth until the seafloor was reached, allowing for a detailed profile of environmental conditions throughout the water column.

Table 2: Environmental conditions required for eelgrass growth

Biotic condition	Minimum	Maximum	Optimal	Source
Temperature (°C)	5	30	10-25	Short et al. (2006); Dennison et al. (1993), Nejrup & pederson (2007)
Salinity (ppt)	10	35	20-26	Orth et al. (2006); Thayer et al. (1984); Fisheries and Oceans Canada (2009)
Dissolved Oxygen (mg/L)	4	12	6-8mg/L	Short et al. (2006); Valiela et al. (1992)
pH	7.5	8.5		Fourqurean et al. (2012); Short et al. (2006)
Light Intensity (PAR µmol/m²/s)	10	200		Duarte (1991); Dennison et al. (1993)
Sediment Organic Matter (%)	1	10		Fourqurean et al. (2012); Kendrick et al. (2000)
Nitrogen (N) (µM)	5	40		Short et al. (2006); Fourqurean et al. (2012)
Phosphorus (P) (µM)	0.5	10		Short et al. (2006); Fourqurean et al. (2012)
Ammonium (NH_4^+) (µM)	0	20		Duarte et al. (1995); Fourqurean et al. (2012)

II. Seasonal changes in temperature and light levels

- Two HOBO Pendant (MX2202) loggers were deployed at each of the 14 sites. A 1-meter length of PVC pipe was zip-tied to a cinder block, with one HOBO logger attached to the tip of the PVC pole (1 m above the bottom) and the other attached to the base. This setup allowed for the measurement of light attenuation over the 1-meter distance. The cinder blocks were attached to a float bag and passed to divers once they entered the water. Divers then descended and placed the cinderblock in the middle of the eelgrass meadow (n = 10) or on the sediment in the middle of the potential restoration site (n = 4). A surface buoy marker (SBM) was then sent to the surface, where an attendant on a kayak recorded the GPS coordinates of the location. Loggers were deployed in June and collected data until September, recording temperature and light lux every 10 minutes.

III. Sediment organic matter content

- We collected 6 sediment samples from each site in a 15 x 30 m array (Figure 10). Sediment was initially frozen before being transported back to the lab. Sediment samples were then thawed, dried and homogenized. We filtered out and weighed the coarse material (>2 mm). A subsample of the finer fraction (<2mm) was burned in a muffle furnace

(Thermo-scientific Thermolyne Benchtop Muffle Furnace) at 500°C for 3 hours to measure the organic matter (OM) content of the sediment.

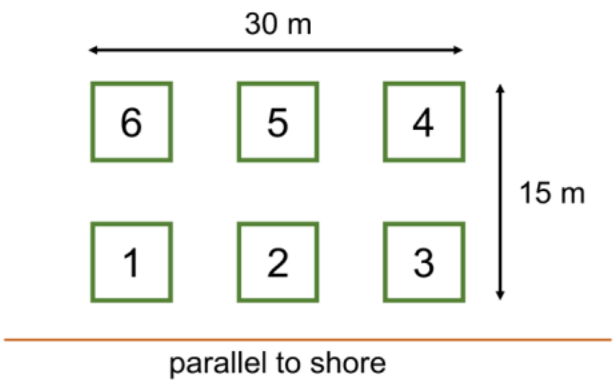

Figure 10: Sampling array

Key outcomes for BC Parks

BC Parks values eelgrass habitat and its maintenance to sustain ecological integrity, ecosystem services and value to park users. Assessment of eelgrass habitat serves to inform the Park's natural climate solution resources, because this habitat is a natural carbon storing system. Additionally, the assessment of environmental conditions allows Parks to consider management and restoration activities to improve eelgrass habitat. This information shows that the areas are environmentally favorable for eelgrass, and that management and restoration may therefore enhance eelgrass habitat.

Relevance to BC Parks management

In their ongoing management in the Park, BC Parks can directly use these data to inform their understanding of park environmental conditions. Additionally, they can use the methods to guide ongoing water quality monitoring efforts. This work lays a foundation for future work to more robustly assess carbon stores in the park and natural climate assets. This was an original goal of this project, but budget cuts required redirecting to restoration potential. Restoring and enhancing eelgrass is one way to increase the natural climate solutions potential of this marine park.

Project's challenges/opportunities

The project went as planned. We had minor equipment failures of several data loggers. One solution would be to duplicate loggers in the future, if budget allows. Otherwise, logistics and work were successful. Partnering with BC Parks staff and using their boat was essential to the success of our sampling.

Conclusions/next steps

We look ahead to deeper exploration of management actions that can improve and restore eelgrass habitat in the park through mitigation of boat anchoring and activity, exploring sediment conditions to ensure they are hospitable to eelgrass, and then testing restoration methods.

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