Ameliorating ocean acidification: towards a model relating pCO2, irradiance and leaf area index of Zostera marina (eelgrass) in Padilla Bay, WA

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Ameliorating ocean acidification: Toward a model relating pCO$_2$, irradiance, and LAI of eelgrass ($Zostera marina$) from Padilla Bay, WA

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In the Salish Sea, anthropogenic CO$_2$ will exacerbate existing local ocean acidification due to upwelling.

http://pmel.noaa.gov/co2/files/coastalcarbondynamics.jpg
Seagrass meadows have been identified as potential short-term mitigators of ocean acidification.

\[ \text{LAI} = \frac{\text{Total leaf area}}{\text{Total ground area}} \]
Eelgrass is effective at taking up carbon since eelgrass are carbon-limited

![Graph showing Net Photosynthesis vs. Irradiance](image)

**Net Photosynthesis** (μmol O₂ mg Chl⁻¹ min⁻¹)

**Irradiance** (μmol photons m⁻² s⁻¹)

**pH:** 8.2

**pH:** 6.2

*Zimmerman et al. 1997*
Light varies throughout a day and could affect photosynthesis

Hückstädt et al. 2013
The amount of eelgrass varies in the Salish Sea
How do LAI, pCO$_2$, and irradiance interact to modify the carbonate chemistry?
We designed our pCO₂ light and leaf area index treatments to reflect ambient conditions.

**Initial pCO₂**
- **Ambient pCO₂**
  - (800 μatm)
- **Enriched pCO₂**
  - (2500 μatm)

**Light**
- Saturating Light
- Sub-saturating Light
- Dark

**Eelgrass Leaf Area Index**

\[
LAI = \frac{\text{Total leaf area}}{\text{Total ground area}}
\]
We predicted that eelgrass would take up carbon at a greater rate with more eelgrass and more light.

![Graph showing the relationship between leaf area index (LAI) and dissolved inorganic carbon (Hr⁻¹). The graph shows three conditions: dark, sub-saturating light, and saturating light. The graph indicates that as LAI increases, the dissolved inorganic carbon decreases.]
We also predicted that eelgrass would take up carbon at a greater rate with enriched pCO$_2$. 

![Graph showing the relationship between Leaf Area Index (LAI) and Δdissolved inorganic carbon Hr$^{-1}$ for Ambient and Enriched pCO$_2$ treatments.](image)
Carbon uptake increased at higher LAI but only when exposed to saturating light.
No differences were detected between pCO$_2$ levels.
Carbon uptake in the saturating light treatment led to increased pH.

The graph shows the relationship between ΔpH HR⁻¹ and Leaf Area Index (LAI). The equation for the line of best fit is Y = -0.004 + 0.04x, with r² = 0.28. The p-value is less than 0.001, and the F-Value is 23.62.
Implication: not all eelgrass meadows have sufficient LAI to mitigate ocean acidification
In Summary

1. Carbon uptake of eelgrass increased linearly with leaf area index only when light was saturating.

2. The change in pH can range between 0 and 0.2 units per hour based on LAI, water depth, and residence time.

3. We did not detect a change in the rate of carbon uptake between pCO$_2$ treatments.
Thus, eelgrass can potentially mitigate ocean acidification, however:

- Saturating light is needed
- Anthropogenic factors could decrease light attenuation
- There must be 2x more eelgrass than substrate
- There are also localized eelgrass declines

But further study is needed:
- Water depth and residence time must be explored
Hillary Thalmann, Katey Williams, Lynne Nowak, Mike Adamczyk, Jayshen Blows, Abby Ernest-Beck, Eric Wilson, Darby Finnegan, Brooke McIntyre, Cristina Villalobos, Gene Mckeen, Nate Schwarck, Andy Wilken and Joyce Foster
After Jokiel et al. 2014