Apr 5th, 1:30 PM - 1:45 PM

**Warm water temperature regimes in eelgrass beds (Z. marina and Z. japonica) of Padilla Bay, WA**

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Warm water temperature regimes in eelgrass beds (Z. marina and Z. japonica) of Padilla Bay, WA.

Heath Bohlmann*, Jude Apple, Nicole Burnett, Suzanne Shull
Long Term Monitoring

- Water Quality
- Nutrients
- Weather
- Eelgrass
Long Term Monitoring
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- Eelgrass
Long Term Monitoring

- Water Quality
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- Weather
- Eelgrass

[Image of researchers collecting data in water with a map in the background, indicating the monitoring area.]
Ecological drivers of eelgrass health:
Temperature
Light availability
Nutrients
Marina:
PNW: Optimal 5-8 °C (Thom et al. 2003, cited in Kaldy, Shafer, etc.)
7 - 12 °C (Thom 2001b) based on positive carbon balance experiments
6 - 10 °C (Thom 2001c) P:R ratio
PNW: Stressed >15 °C (Thom et al. 2003)
PNW P max 12 °C (optimal growth is usually at a lower temp than P max (Lee 2007))

Temperate: Optimal 15.3 (+/-1.6) °C (Optimal range 11.5-26 °C)
Worldwide: Tolerates -1.5-30 °C
Photosynthetic max 23.3 (+/-1.6) °C (Lee 2007)

Japonica:
PNW/world: Optimal growth 18.5 (+/-3.5) °C
<8 °C inhibits growth
Tolerates short term exposure to 35 °C
Chronic exposure over 35 °C = death.
(Lee et al., 2007; Shafer et al., 2008, 2011; Kaldy et al. 2015)

Optimal temps for growth from literature

**PNW**
Z. marina 5-13 °C
Z. japonica 18.5-20 °C

**Worldwide**
Z. marina 15.3 (+/−1.6) °C
Z. japonica 18.5 (+/−3.5) °C

Questions:

- What are the temperatures regimes experienced by eelgrass in Padilla Bay?
- How do temperatures in Padilla Bay compare to the literature and to other areas (locally/regionally)?
- How might future warming influence eelgrass in Padilla Bay?
Eelgrass species distribution within the long term monitoring area.

Padilla Bay
4.4 km
Water Quality station (in channel)

3 transects
4.4 km in length
Intertidal through subtidal
48 temperature loggers
15 min sample interval
Hobo Pendant loggers
(±0.5°C)
Mounted on screw anchors
Radiation shield
(on intertidal loggers)
Installed level with sediment surface
2017 Temperature Data

1.6 million data points

Temperature (°C)

Select locations of data:

- **Lowest Z. japonica**
- **Highest Z. japonica**
- **Subtidal Z. marina**
- **Highest Z. marina**

4.4 km
**Zostera japonica mean temp. by elevation**

(relative to MLLW)

- **Highest Z. japonica** (0.63m)
- **Lowest Z. japonica** (-0.17m)

**Temperature (°C)**

- **May-Aug. Mean 20.7 °C**
  - (max 34.5 °C)
- **May-Aug. Mean 16.1 °C**
  - (Max 27.3)

**Z. j. optimal 15-22 (°C)**

**Month/Year**

2017

**Temperature (°C)**

- Black: Highest Z. japonica (0.63m)
- Magenta: Lowest Z. japonica (-0.17m)
Zostera marina mean temp. by elevation
(relative to MLLW)

Temperature (°C)

May-Aug.
Mean 19.7 °C
(max 32.3 °C)

May-Aug.
Mean 14.0 °C
(Max 19.2)

Z. m. optimal
(World) 14-17 (°C)

Z. m. optimal
(PNW) 5-13 (°C)

Highest Z. marina (0.48m)

Subtidal Z. marina (-1.49m)

Month/Year

2017

Site report

Vancouver, BC
Seattle, WA
Olympia, WA
Padilla Bay
Joemma State Park

Subtidal Z. marina temp. comparison
(May-Aug 2017)

Delano Beach data from:
Restoration and Monitoring Report Eelgrass (Zostera marina) Restoration in Puget Sound, WA.
Hart-Crowser, February 2018.
Subtidal Z. marina
(temperatures recorded May 2 - Aug 11, 2017)

Temperature (°C)

Z. m. optimal (World) 14-17 (°C)

Z. m. optimal (PNW) 5-13 (°C)

Padilla Bay
Mean 13.5 °C
(max 19.2 °C)

Joemma (South Sound)
Mean 12.9 °C
(max 17.8 °C)

Month/Year

Temperature (°C)
Select locations of Padilla Bay data:

- Highest density Z. japonica
- Highest density Z. marina

4.4 km

Shallower  Deeper
Percent time above 18 °C
Intertidal Z. japonica

Padilla Bay (0.0m)
Mean 60% (May-Aug)

Yaquina Bay (0.01m)
Mean 37% (May-Aug)

Yaquina Bay
Temp range 3.9 - 29.9 °C

Padilla Bay
Temp range 8.4 - 31.9 °C
Percent time above 18°C
Intertidal Z. marina

Yaquina Bay
Temp range 5.1 - 22.8 °C

Padilla Bay
Temp range 8.3 - 28.6 °C

<table>
<thead>
<tr>
<th>Month</th>
<th>Padilla Bay (0.0m)</th>
<th>Yaquina Bay (0.01m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>Mean &lt;1%</td>
<td>Mean 31% (May-Aug)</td>
</tr>
<tr>
<td>May</td>
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<td>June</td>
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<tr>
<td>Sept.</td>
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</tbody>
</table>

Yaquina Bay
Temp range 5.1 - 22.8 °C

Padilla Bay
Temp range 8.3 - 28.6 °C
Z. marina in warming temps.

Intertidal plants may be living near upper temp. range or have higher tolerance for summer heat stress.

Plants may be forced lower in the intertidal to mitigate for warmer temps.
**Z. japonica in warming temps.**

Currently within their optimal summer temp. range.

Plants may expand lower in the intertidal with warmer conditions but may be excluded from the highest elevations.
Z. japonica:
Mean temperatures in Padilla Bay during the summer are near optimal temps from the literature.

Z. marina:
Temperatures in Padilla Bay during the summer are warmer than optimal temps from the literature.
Mean subtidal temps from Padilla Bay are similar to those from southern Puget Sound.

Overall:
Probably a lot of variability of temps. both between and within eelgrass beds in the PNW, be thoughtful when comparing temperature regimes from different areas.
Thank you!

Jude Apple, Nicole Burnett, Suzanne Shull, WCC Interns, Padilla Bay Staff and Volunteers. Jeff Gaeckle, DNR/Hart-Crowser Staff and Volunteers. Kaldy et al. for comparative data.
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Monthly water temp. anomalies

Annual water temp. anomalies
Warm water temperature regimes in eelgrass beds (*Z. marina* and *Z. japonica*) of Padilla Bay, WA.

Heath Bohlmann, Jude Apple, Nicole Burnett, Suzanne Shull

Padilla Bay, WA has over 3300 hectares of eelgrass with vast areas of intermixed beds of the native *Zostera marina* and non-native *Zostera japonica*. Water temperature is thought to be one of the primary influences on eelgrass distribution, and long term monitoring shows that temperatures in Padilla Bay have increased substantially (mean increase >2°C) from 2011 through 2016. We were interested to see if changes in eelgrass distribution were correlated with the changes we observed in water temperature in Padilla Bay, however, our long term temperature monitoring station is located in a shallow channel within the eelgrass beds. Because of this sensor placement, we first needed to determine if these data were representative of temperatures experienced by eelgrass on the vegetated flats. To test this, we deployed 45 temperature loggers throughout the intertidal and subtidal distribution of *Z. marina* and *Z. japonica*. We found that temperatures recorded at our long term monitoring site greatly underestimated the high temperatures experienced by the intertidal eelgrass. In Padilla Bay, *Zostera marina* was exposed to temperatures above 8°C, the optimal temperature reported for *Z. marina* growth in the PNW, for over 90% of the time during the peak growing season (March – Sept.). Furthermore, *Z. marina* experienced extended periods of time above 15°C, temperatures thought to cause stress to local plants. Despite these elevated temperatures, *Z. marina* remain robust, suggesting that *Z. marina* in Padilla Bay may have a higher tolerance for warmer water temperatures than other beds in the PNW or may be living near the upper limits of tolerance for PNW plants. This study characterizes – on a fine spatial scale – the duration and intensity of temperatures extremes that eelgrass experience in shallow systems and ultimately provides insight into the health and performance of eelgrass in a warmer future ocean.

The premise is:

What are the temperatures experienced by eelgrass in Padilla Bay?

Are the temps we are recording at Ploeg are representative of the temps experienced by eelgrass on flats.

How does this compare to other areas with published temp data?

What are the implications for eelgrass in Padilla Bay knowing that temps are warmer than other areas in the PNW. Is this one of the reasons eelgrass is so productive here? Does this make Padilla more susceptible to warming water temps? What might we see if temps start becoming more unfavorable for eelgrass in Padilla (bi modal growth pattern with a drop in the summer)?