Climate-Linked Anomalies Force Eelgrass (*Zostera marina* L.) Variability in the Pacific Northwest: Recent Evidence from the Columbia River Estuary

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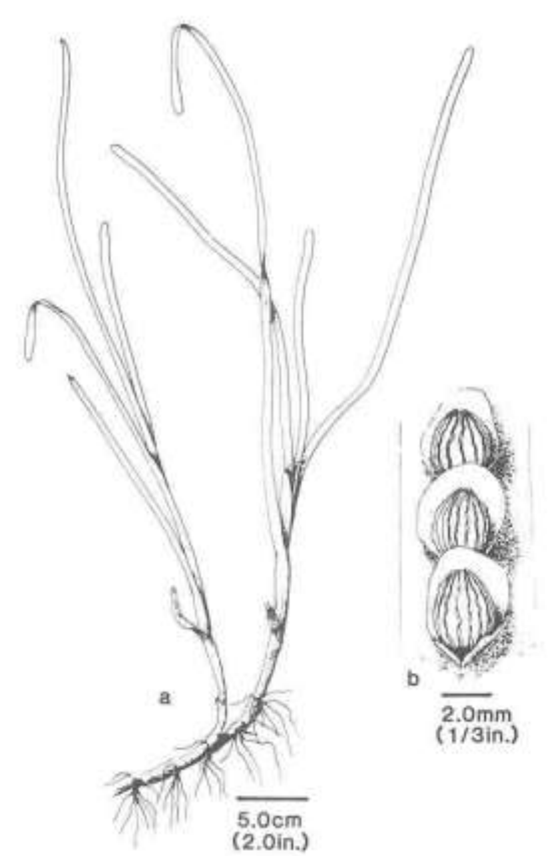
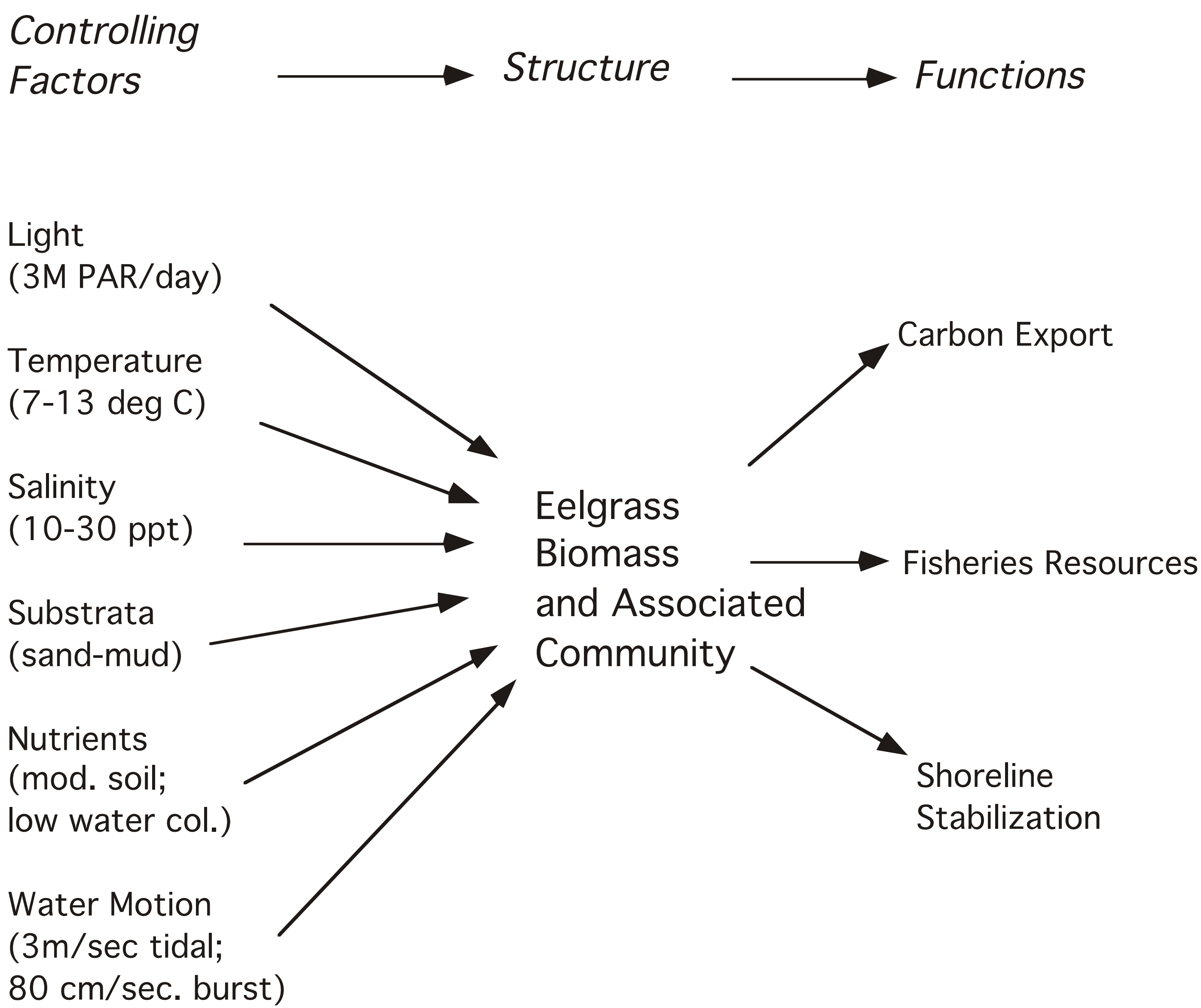


Eelgrass

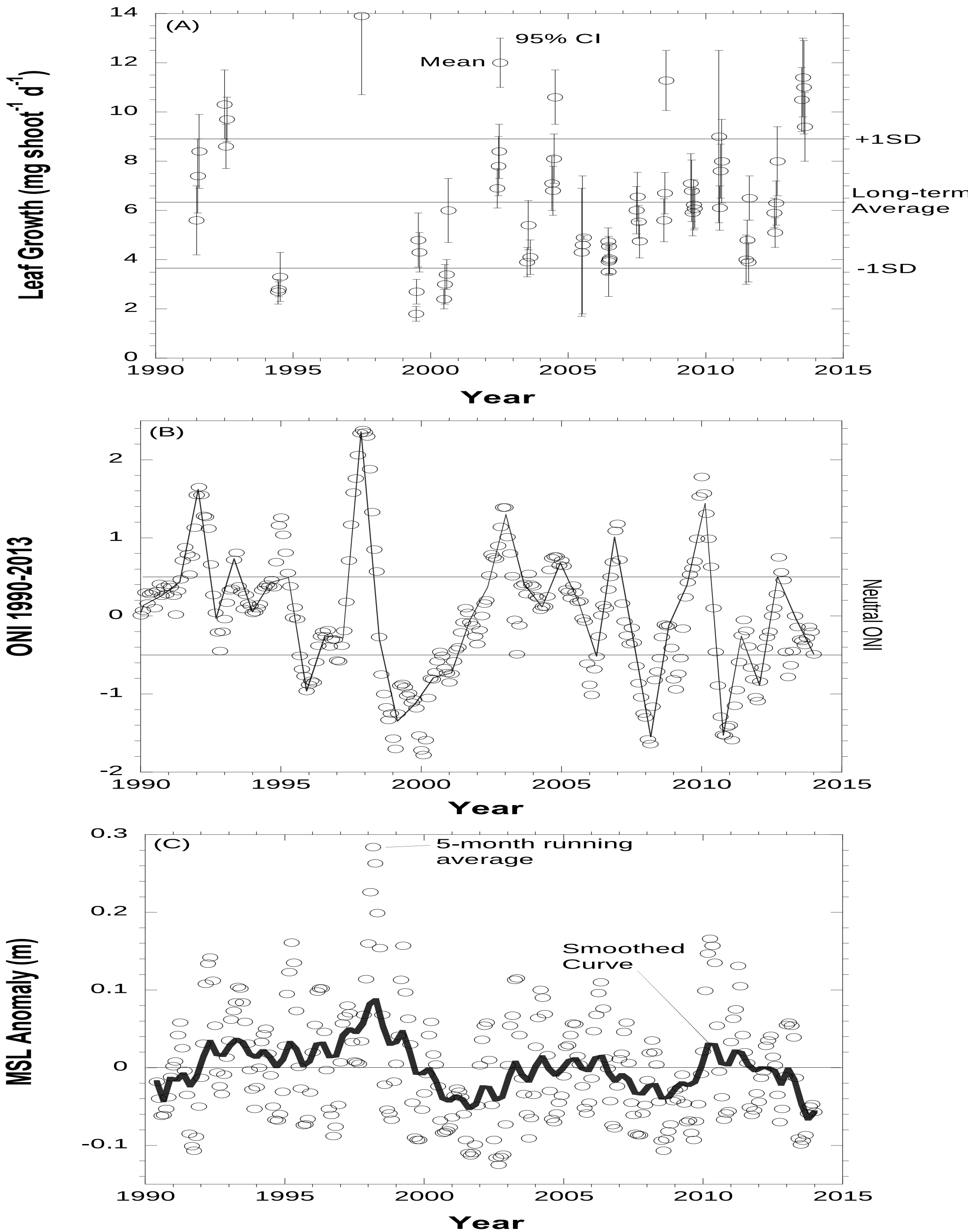
(Zostera marina)

- Most widespread of ~60 seagrass species
- One of 5 species in the PNW
- Flowering/rooted plant that forms meadows
- Spreads by rhizomes and seeds

Conceptual Model




Mouth of Sequim Bay, WA
(Eelgrass growth rate in 21
of 24 summers since 1991)
Sampling sites



Water level and ENSO effects on eelgrass growth rate

(Thom et al. 2014. J. Coastal Res. 68:1-11)

-Deviations in desiccation and heat stress allowed plants to grow faster or slower

-Sea level variation forced by anomalous events near the equator was the mechanism behind the changes

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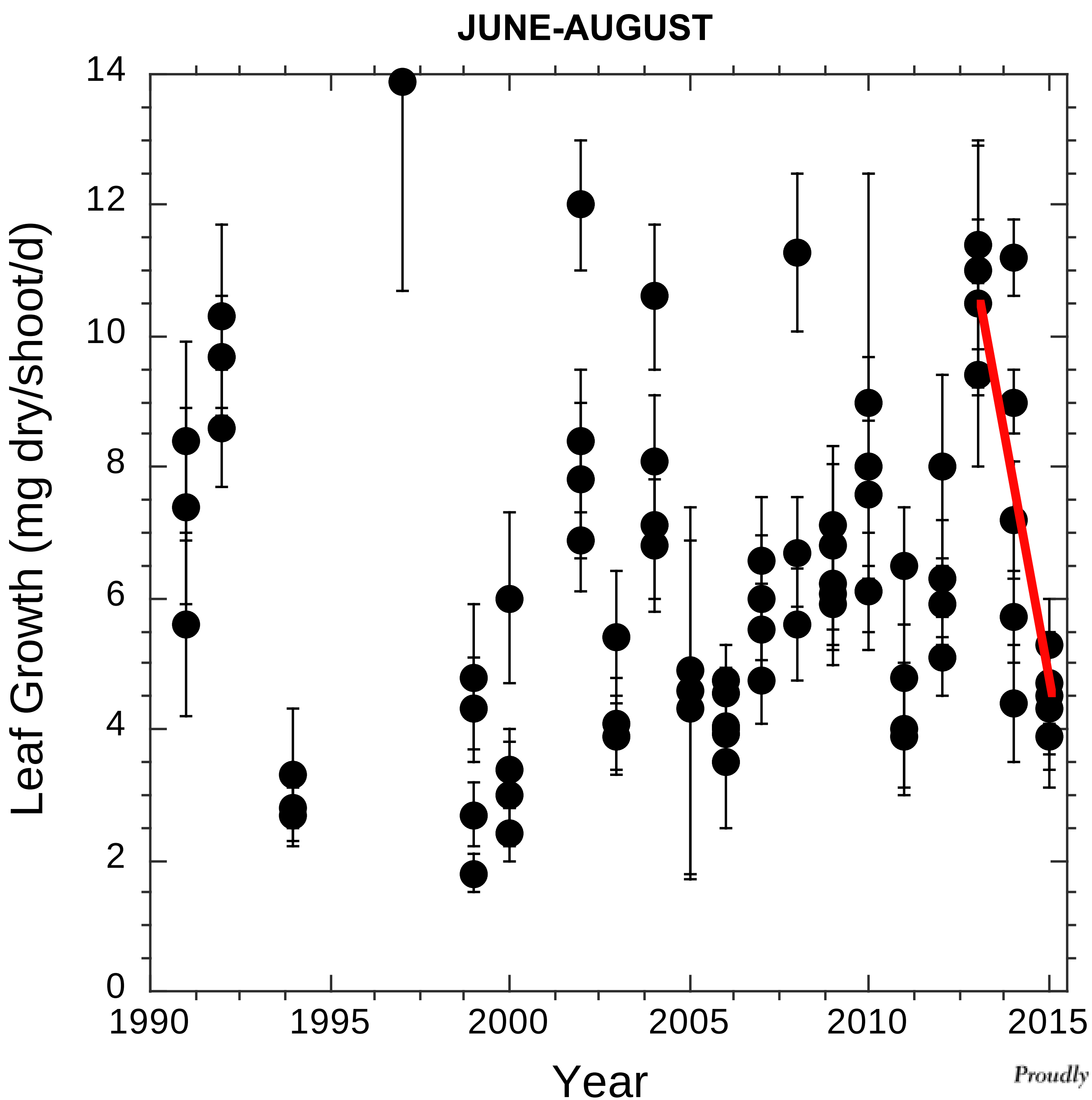

2015 among lowest growth rates recorded since 1991

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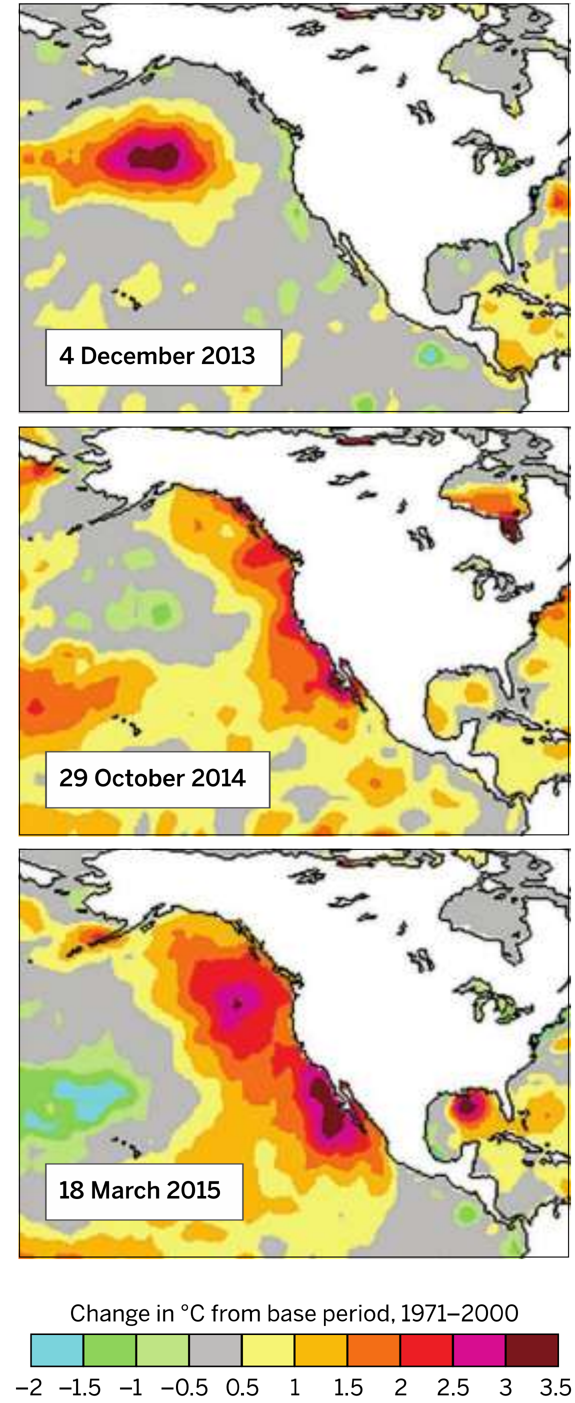
'The Blob' invades Pacific, flummoxing climate experts

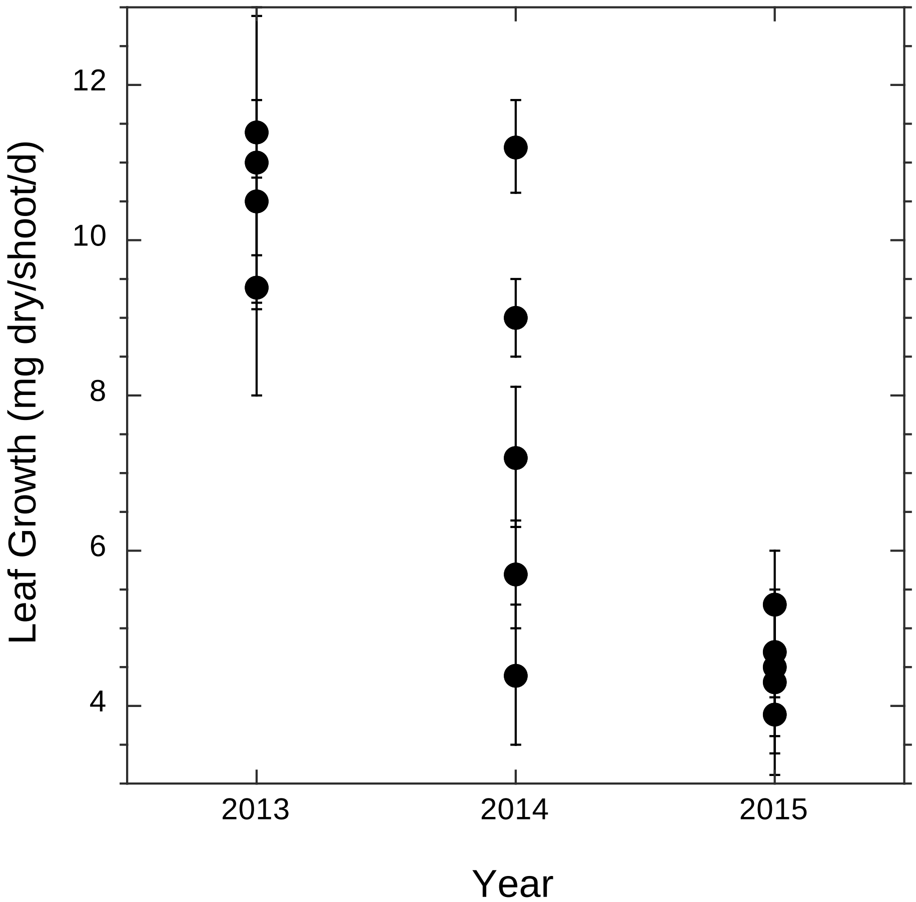
Persistent mass of warm water is reshuffling ocean currents, marine ecosystems, and inland weather

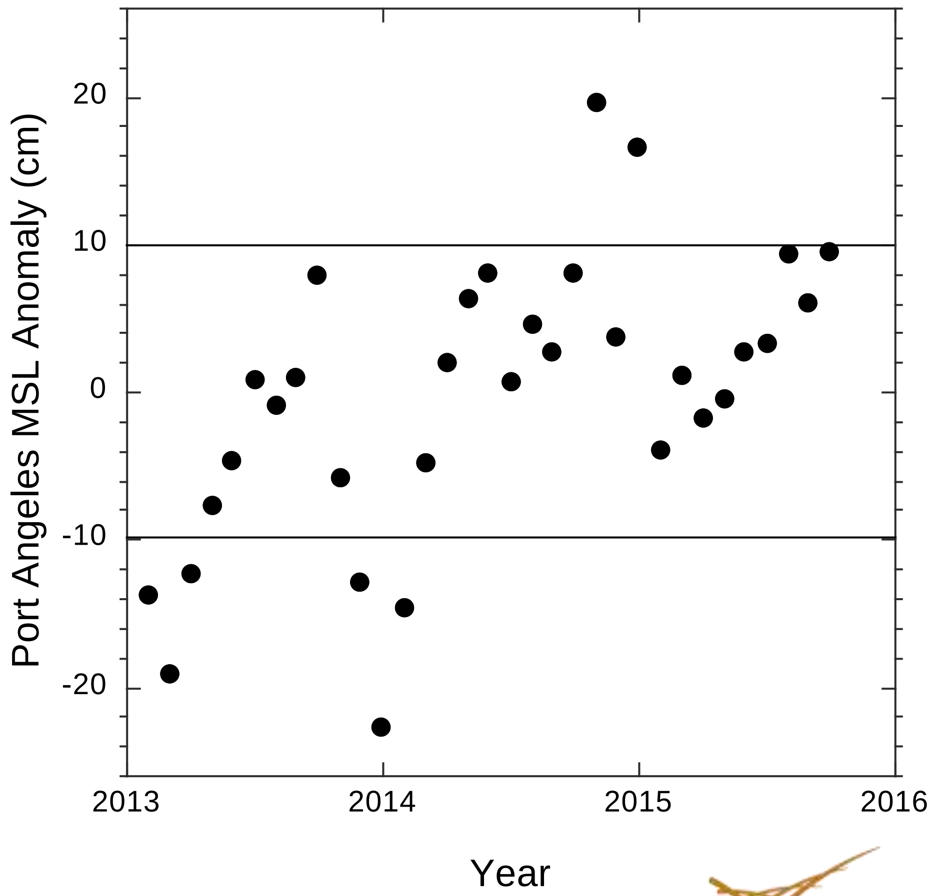
Kintisch, E. 2015. Science 348:17-18

Bond et al. 2014. Causes and effects of the warm anomaly in the NE Pacific. Geophysical Research Letters 42:3414-3420



Leaf growth and water level 2013-2015.





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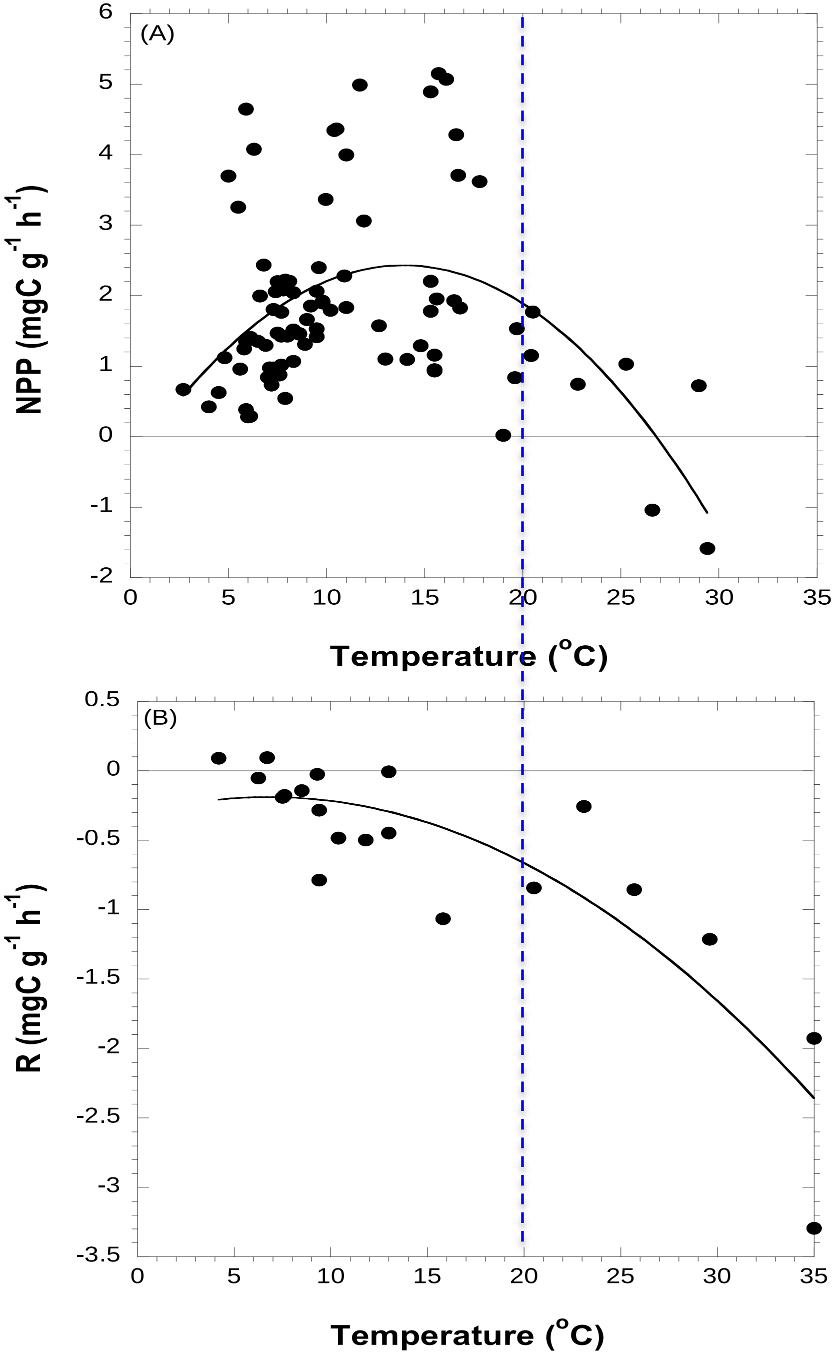
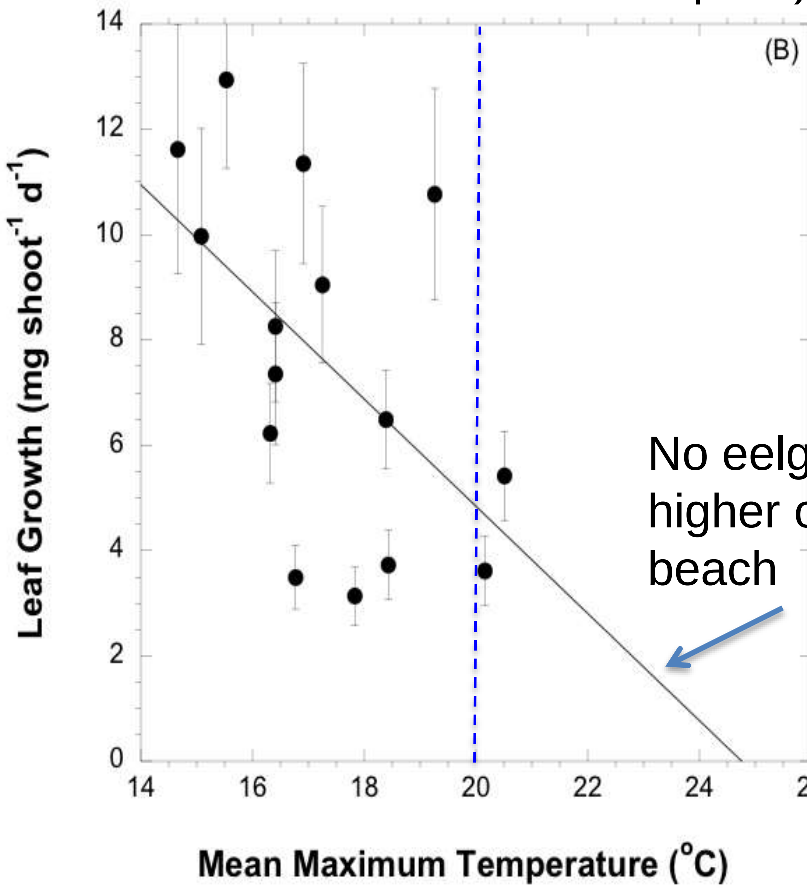
Light & Temperature

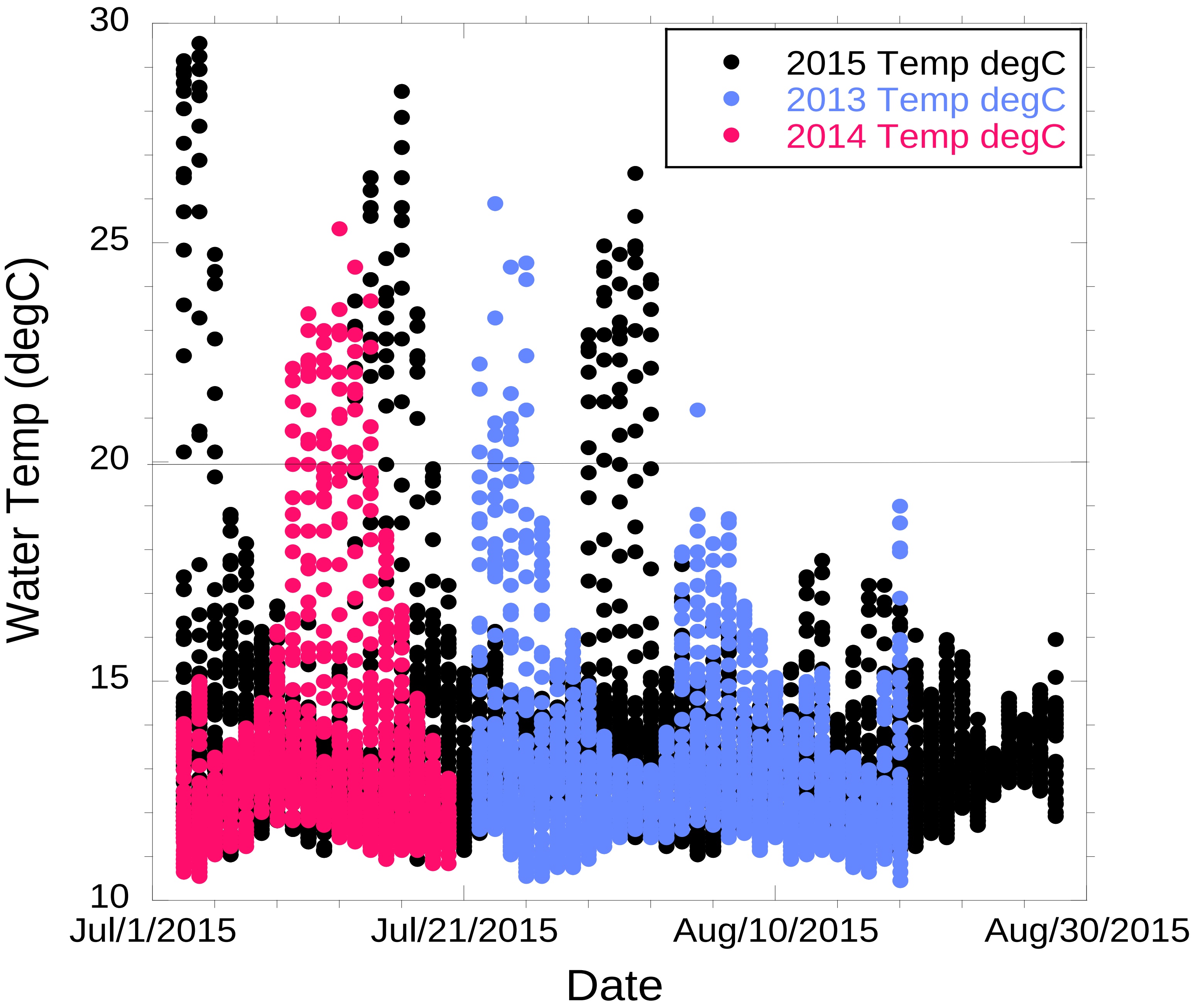
(Thom et al. 2014. J. Coastal Res; Thom et al. 2008 E &C)



(82 cm difference in depth between deepest and shallowest plots)

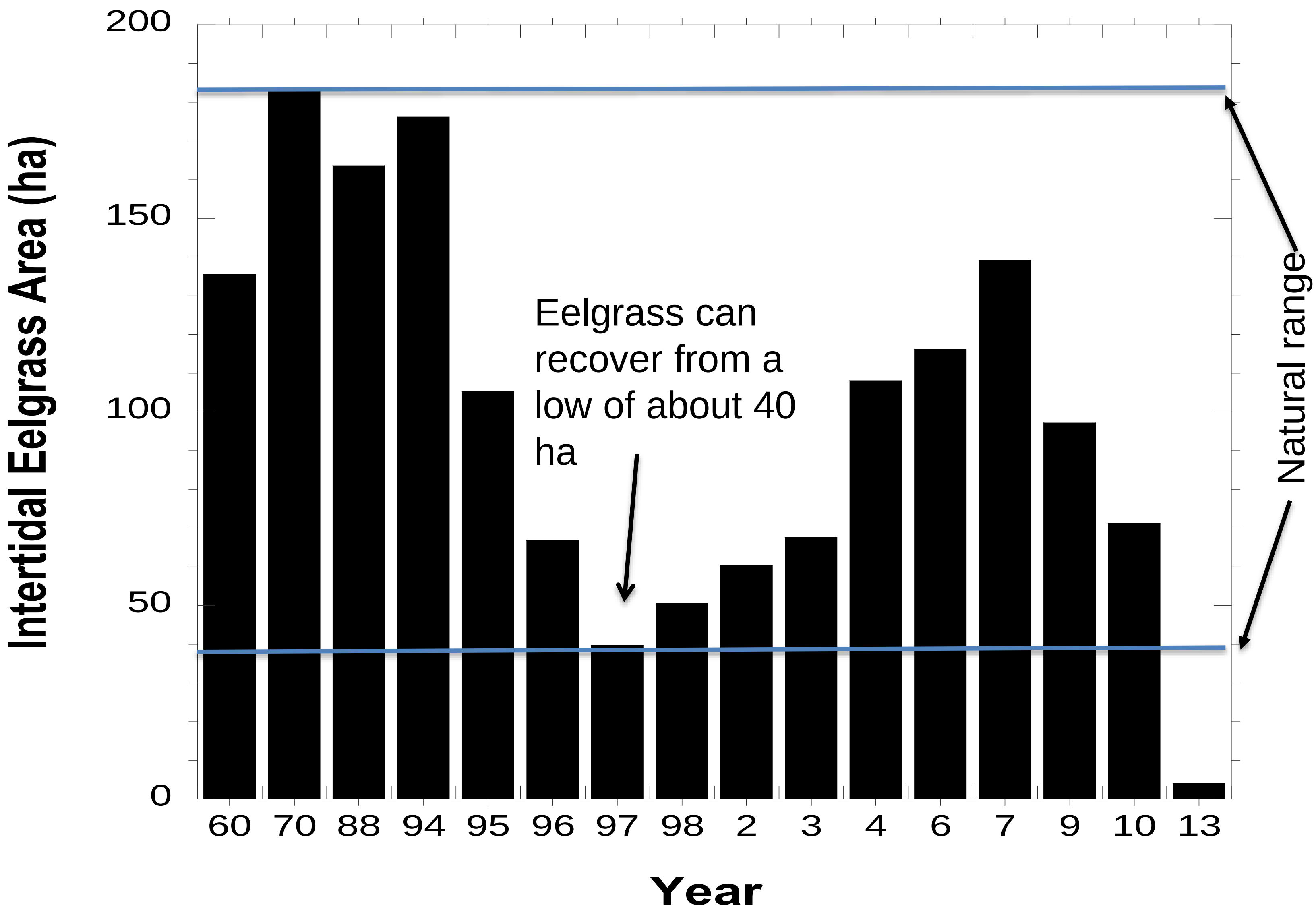


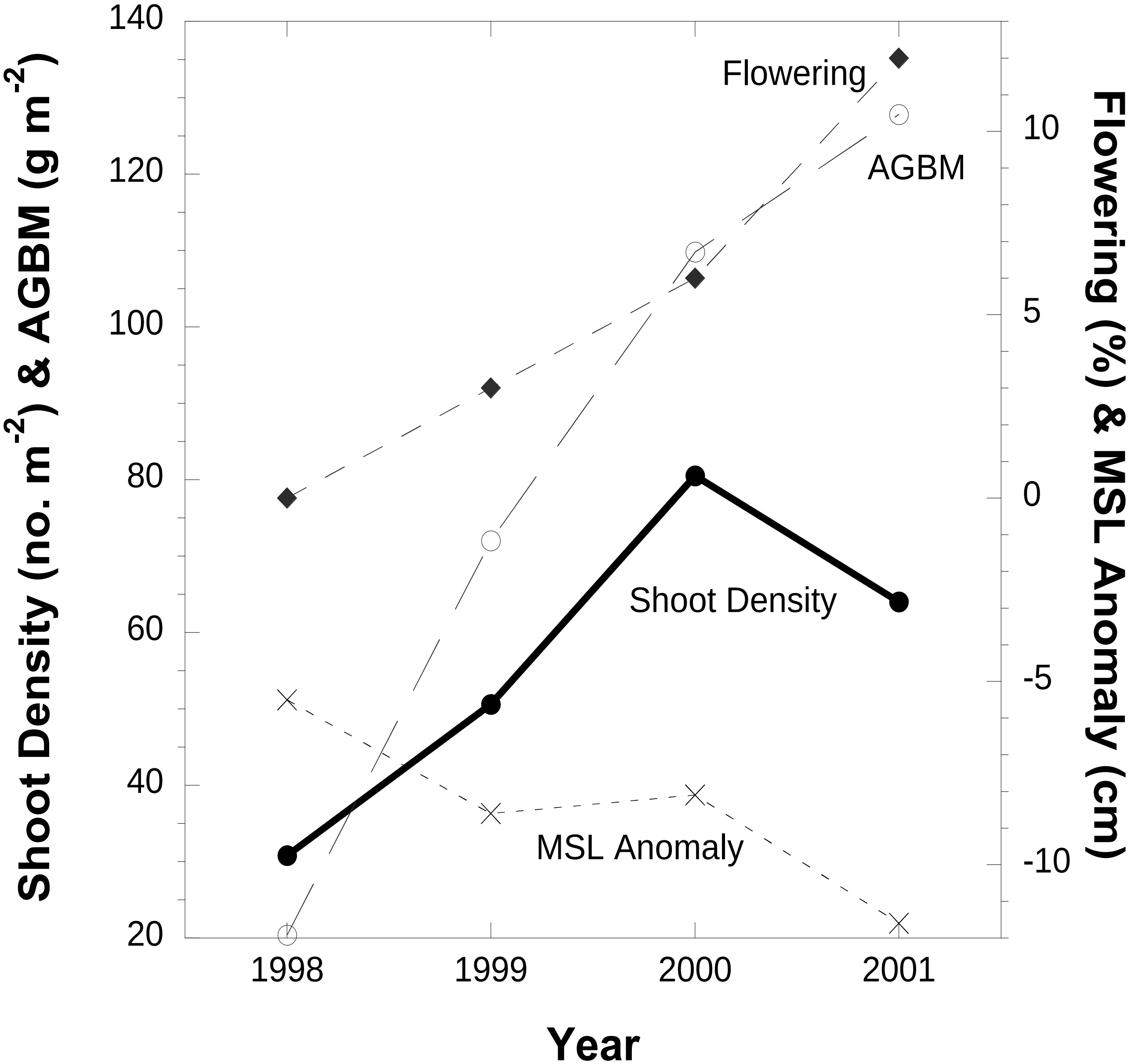
No eelgrass higher on beach


2015 Temp degC
2013 Temp degC
2014 Temp degC
Water Temp (degC)
30
25
20
15
10
Jul/1/2015
Jul/21/2015
Aug/10/2015
Aug/30/2015
Date

Morro Bay, CA

Morro Bay Eelgrass Area (Intertidal) (source, 2013 State of the Bay Report. Morro Bay NEP)



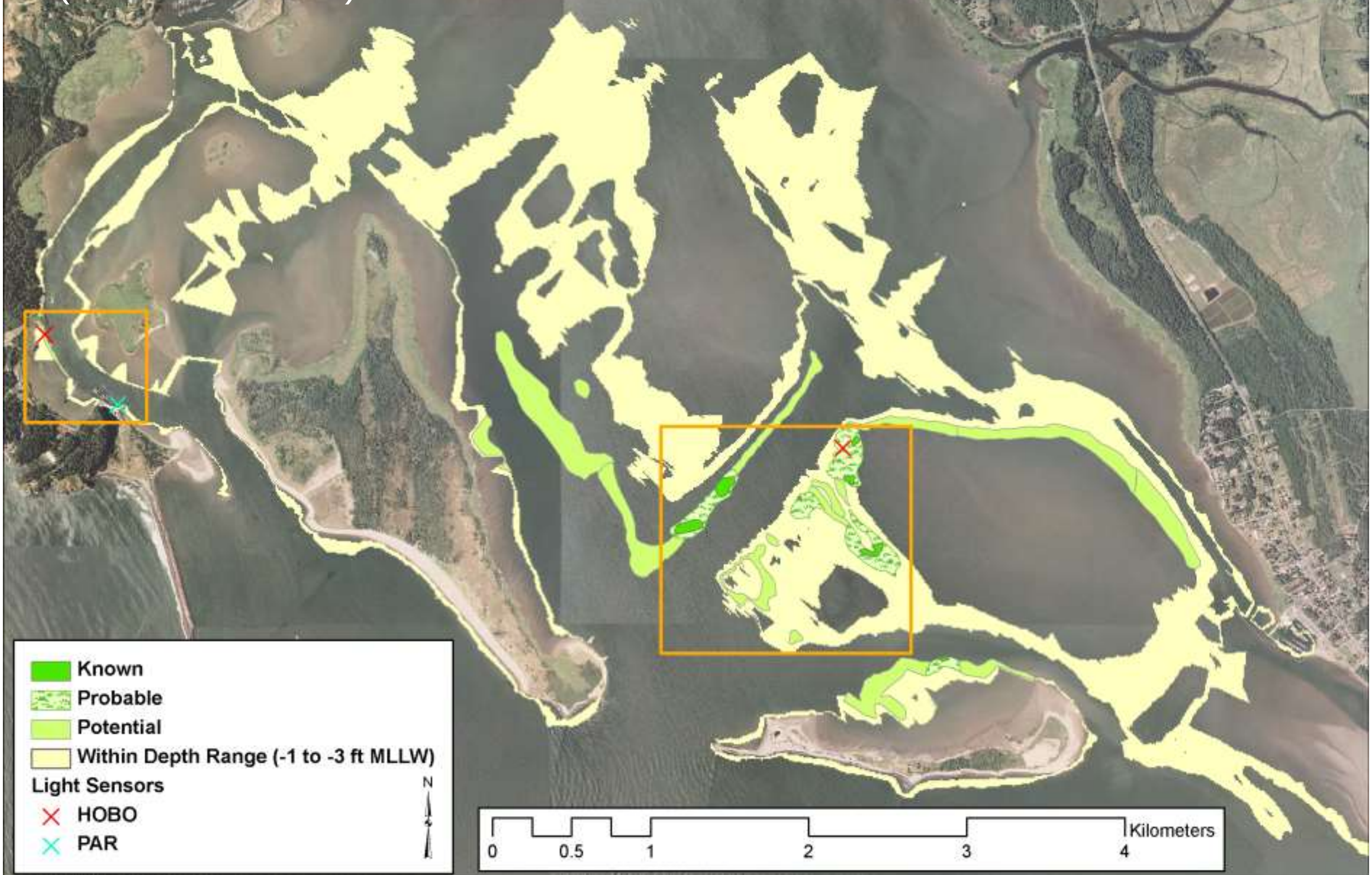


Outer Coast

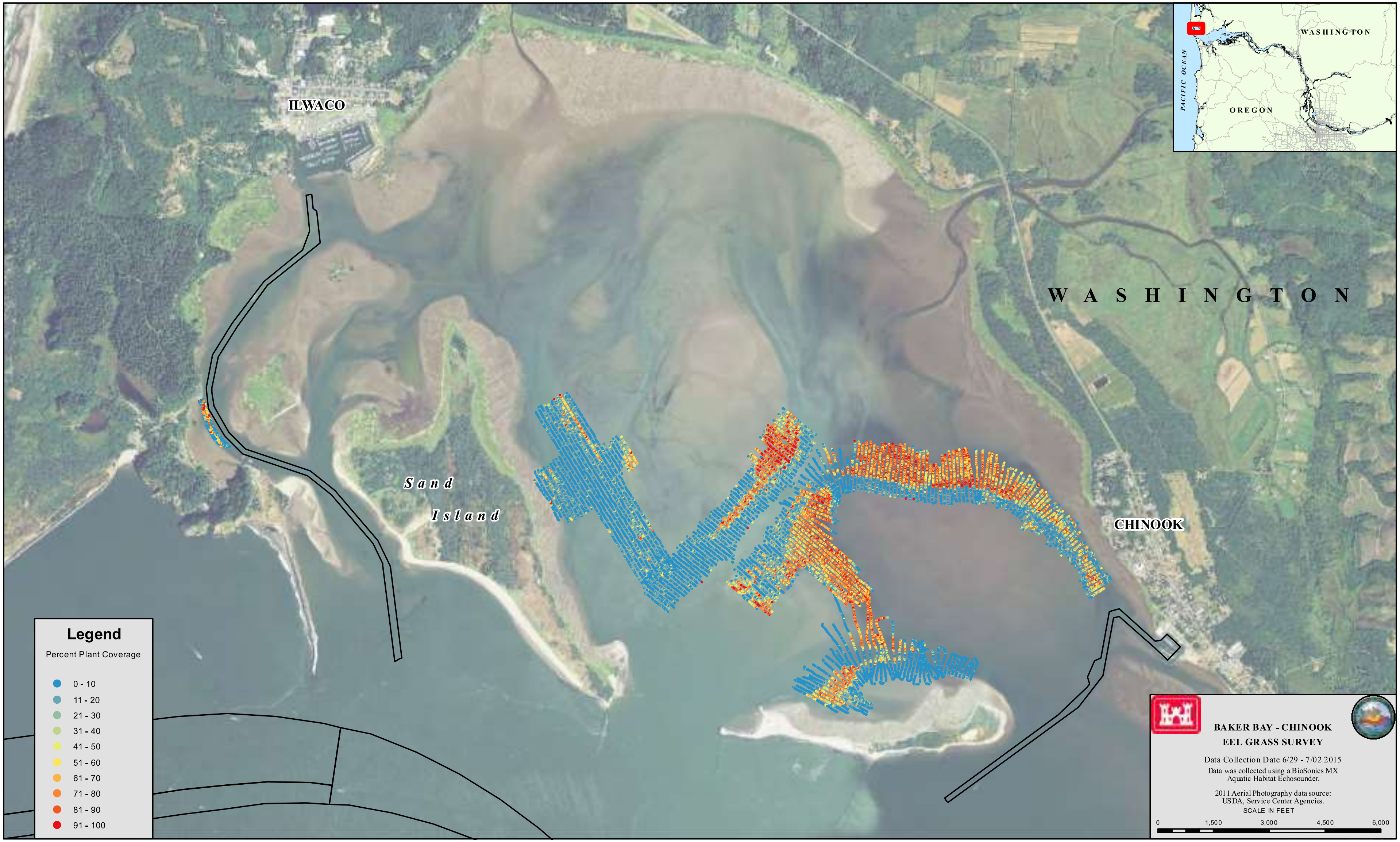
Willapa Bay,
6 sites; average of 120 samples/year

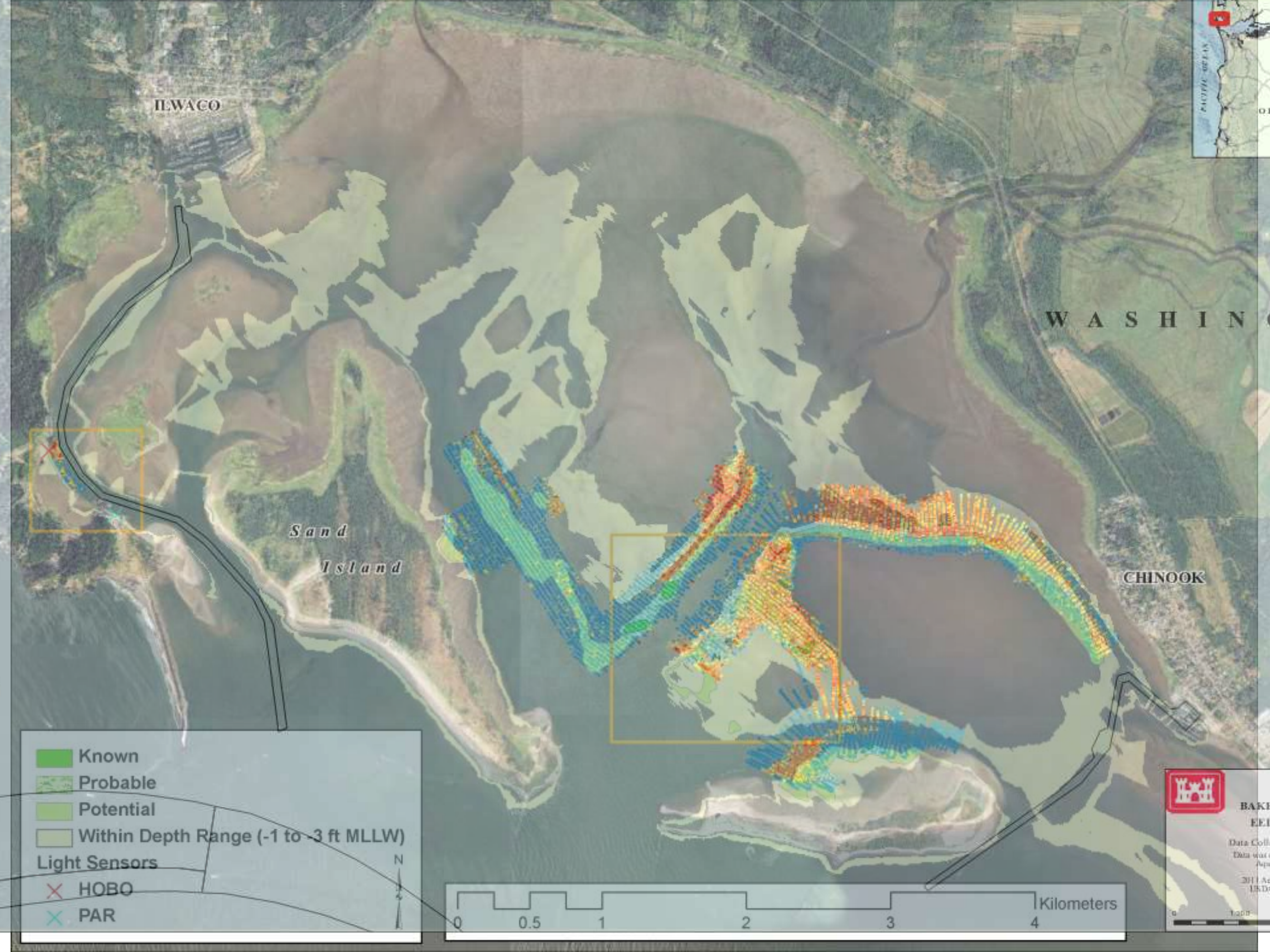
(Thom et al. 2003; 2014)

Baker Bay, Columbia R. estuary based on 2007 modeling & field surveys (Judd et al. 2009)



Baker Bay, Columbia River Estuary 2015 – Eelgrass (Deborah Shafer ERDC and Portland COE)





ILWACO
WASHIN
Sand Island
CHINOOK
Known
Probable
Potential
Within Depth Range (-1 to -3 ft MLLW)
Light Sensors
HOBO
PAR
N
0 0.5 1 2 3 4
Kilometers

Zostera japonica in Ilwaco channel replaced *Zannichellia palustris* in 2015 (A. Borde)

Tolerates long-term exposre to salinity 5-35psu (Shafer et al. 2011 Aquatic Botany)

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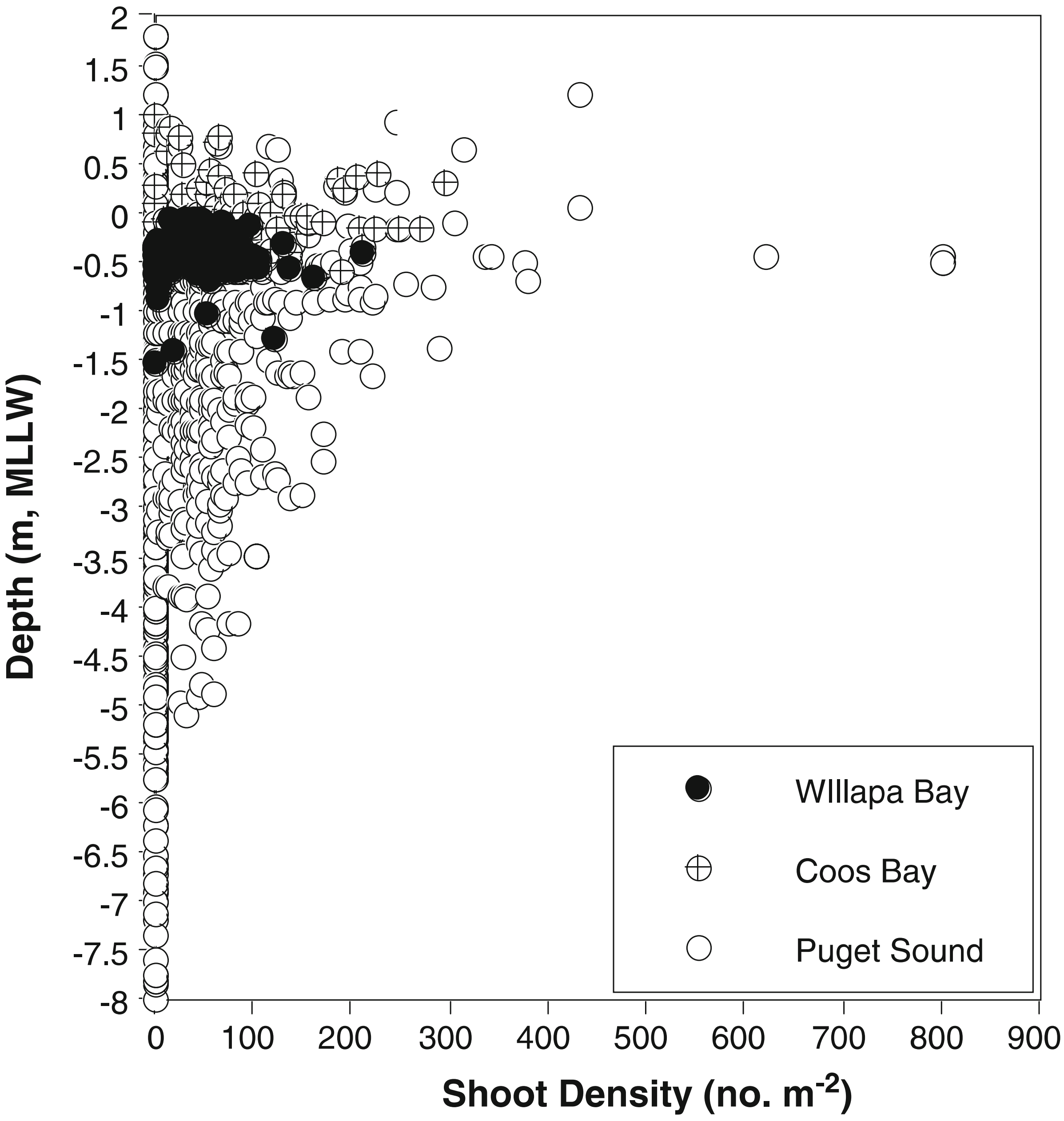
Science Question

- Anomalous climatic events allow us to judge the resilience of ecosystems to short term/pulsed disturbances and well as hints towards ecosystem response to longer term shifts in conditions (Thom et al. 2012 Estuaries and Coasts 35:78-91)

- *Question*: Did the low river flows in 2014-15, which allowed greater salinity intrusion (distance and duration) into the estuary, facilitate expansion of eelgrass distribution in the lower estuary?



Depth v. eelgrass shoot density

(Thom et al. 2008. Estuaries)

PPFD of $3 mol\ m^{-2}\ d^{-1}$ during growing season is required

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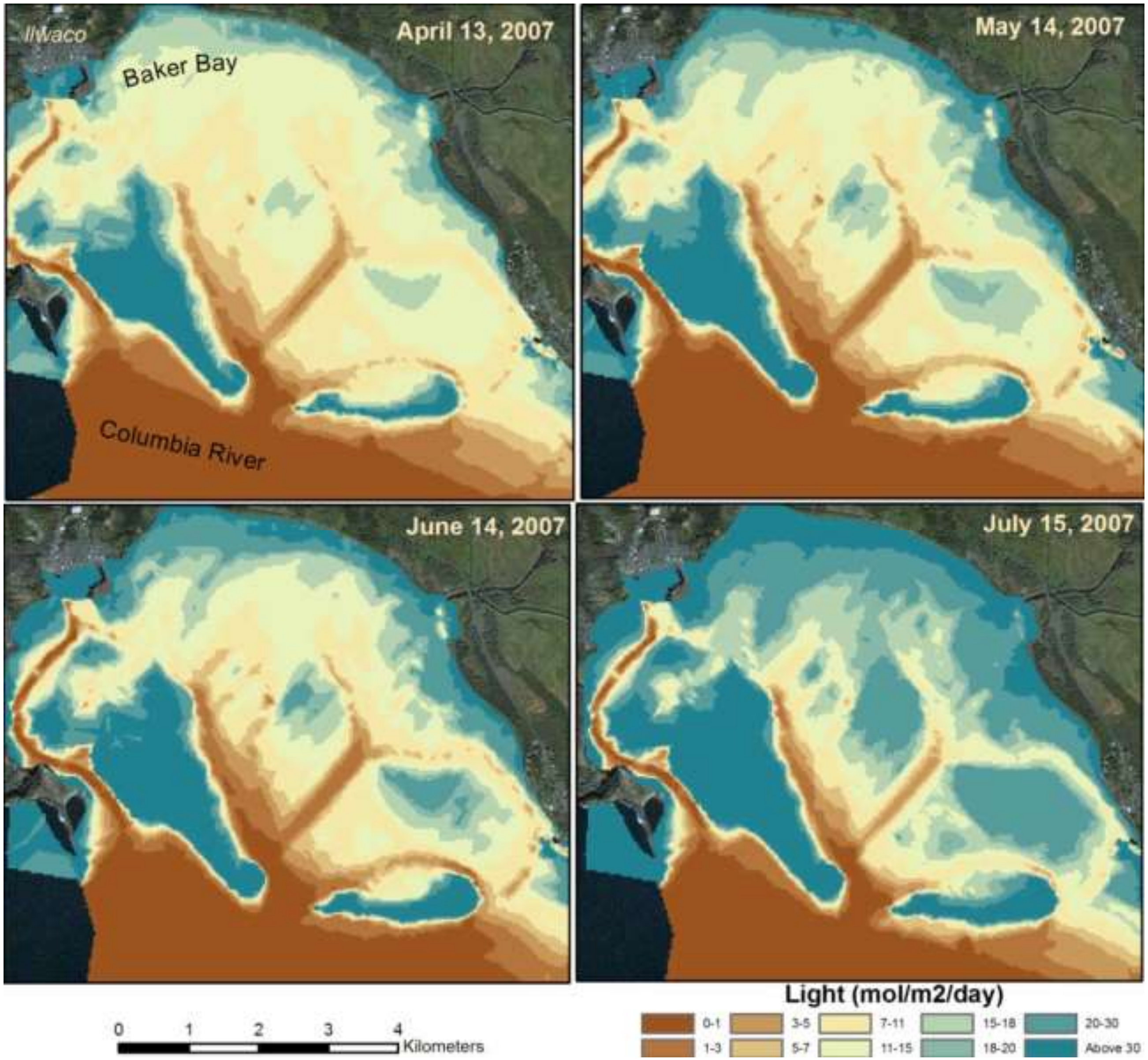
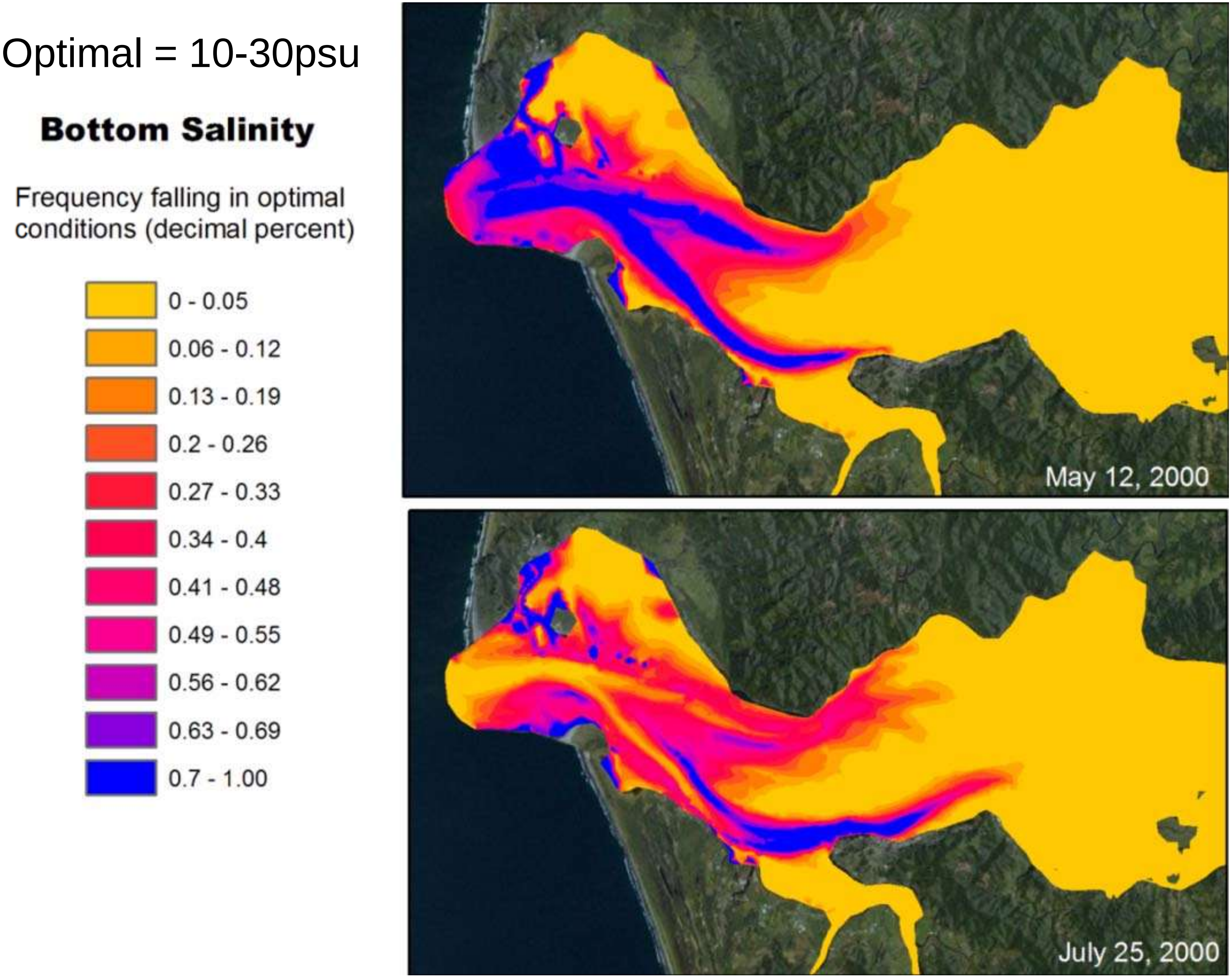
Modeled Photosynthetic Photon Flux Density in 2007 based on in situ sensors, profiling, water samples, and satellite sensing (Judd et al. 2009)



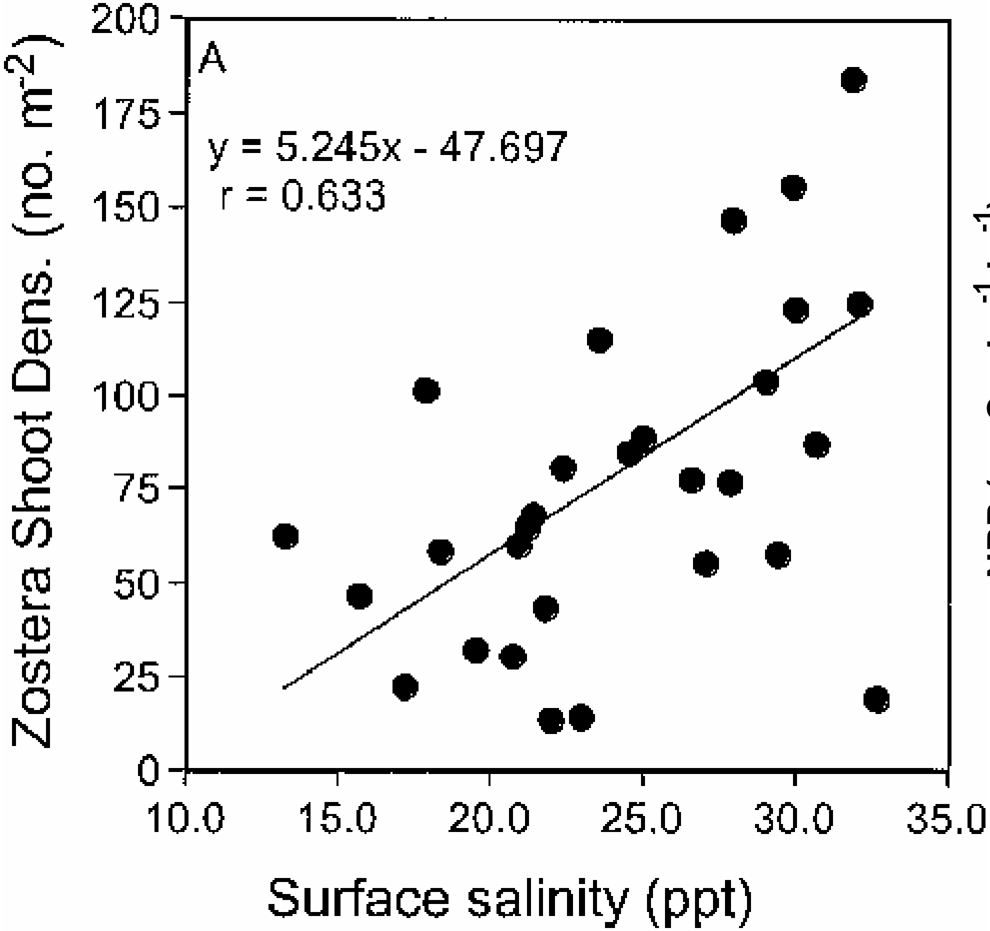
PPFD>4mol m^{-2} d^{-1} for the entire period of April-July 2007…so light limitation may not be a major factor in Baker Bay

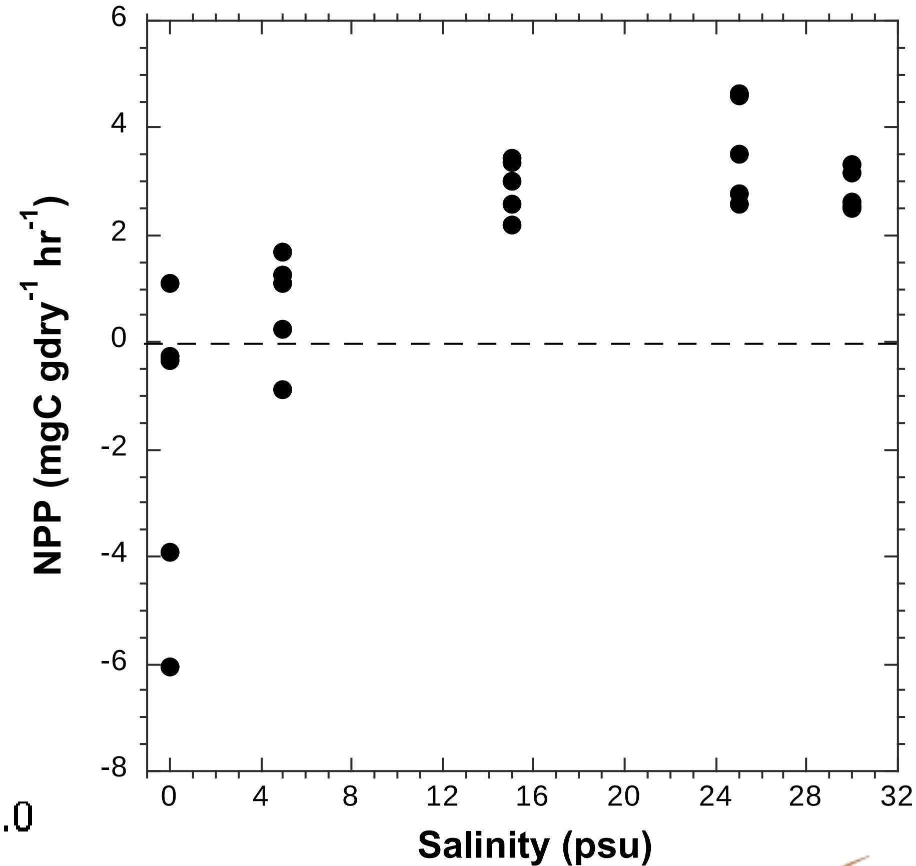
Modeled salinity in 2000. (Judd et al. 2009)

Optimal = 10-30psu



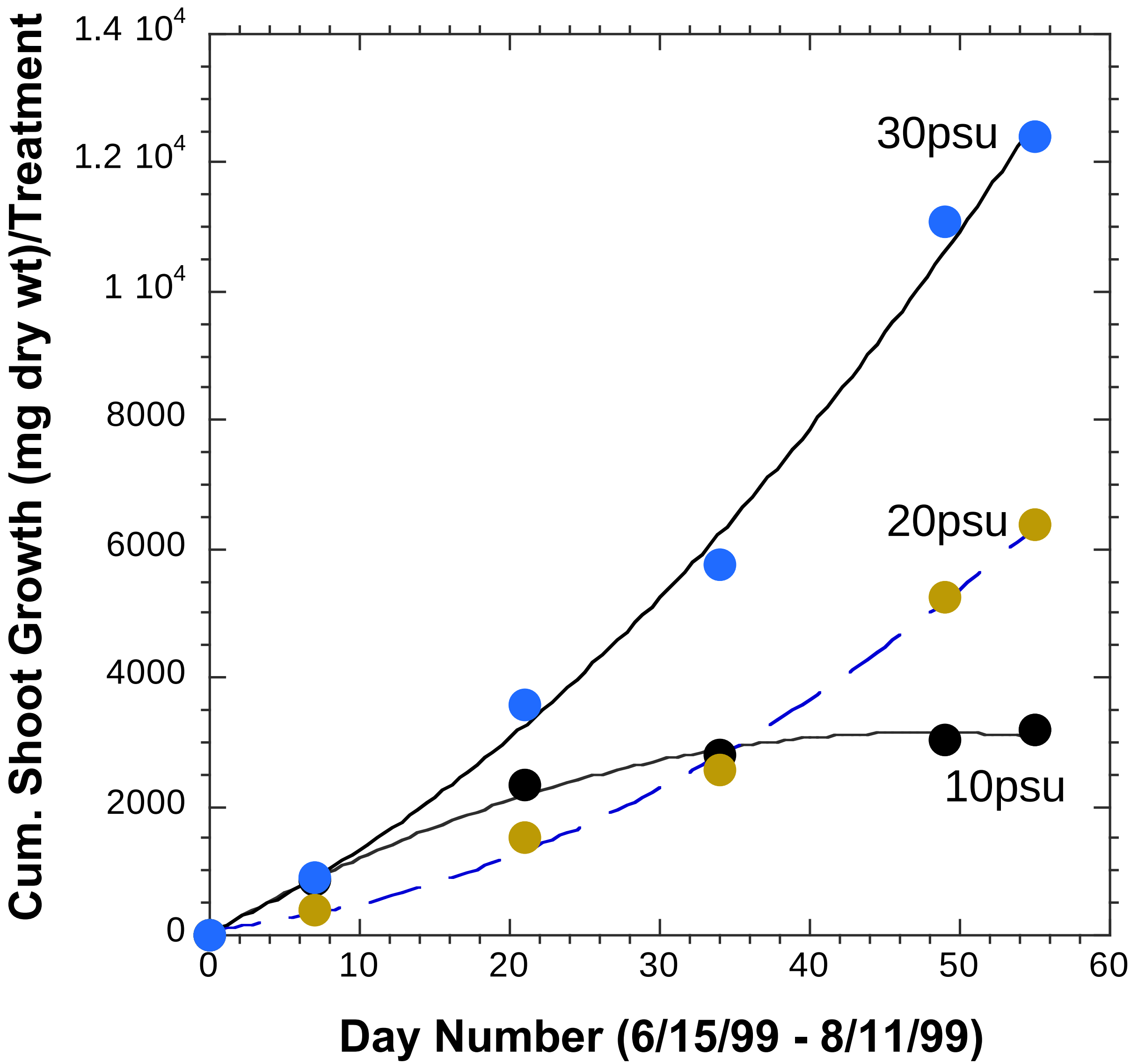
Salinity v. Eelgrass Density and Net Primary Productivity (NPP)





(Thom et al. 2003. Estuaries)

Cumulative Shoot Biomass Production in Tanks



Summary:

5psu min. for some survival

30psu max. growth

50 shoots/treatment

38% died at 10psu

0% died at 20 & 30psu

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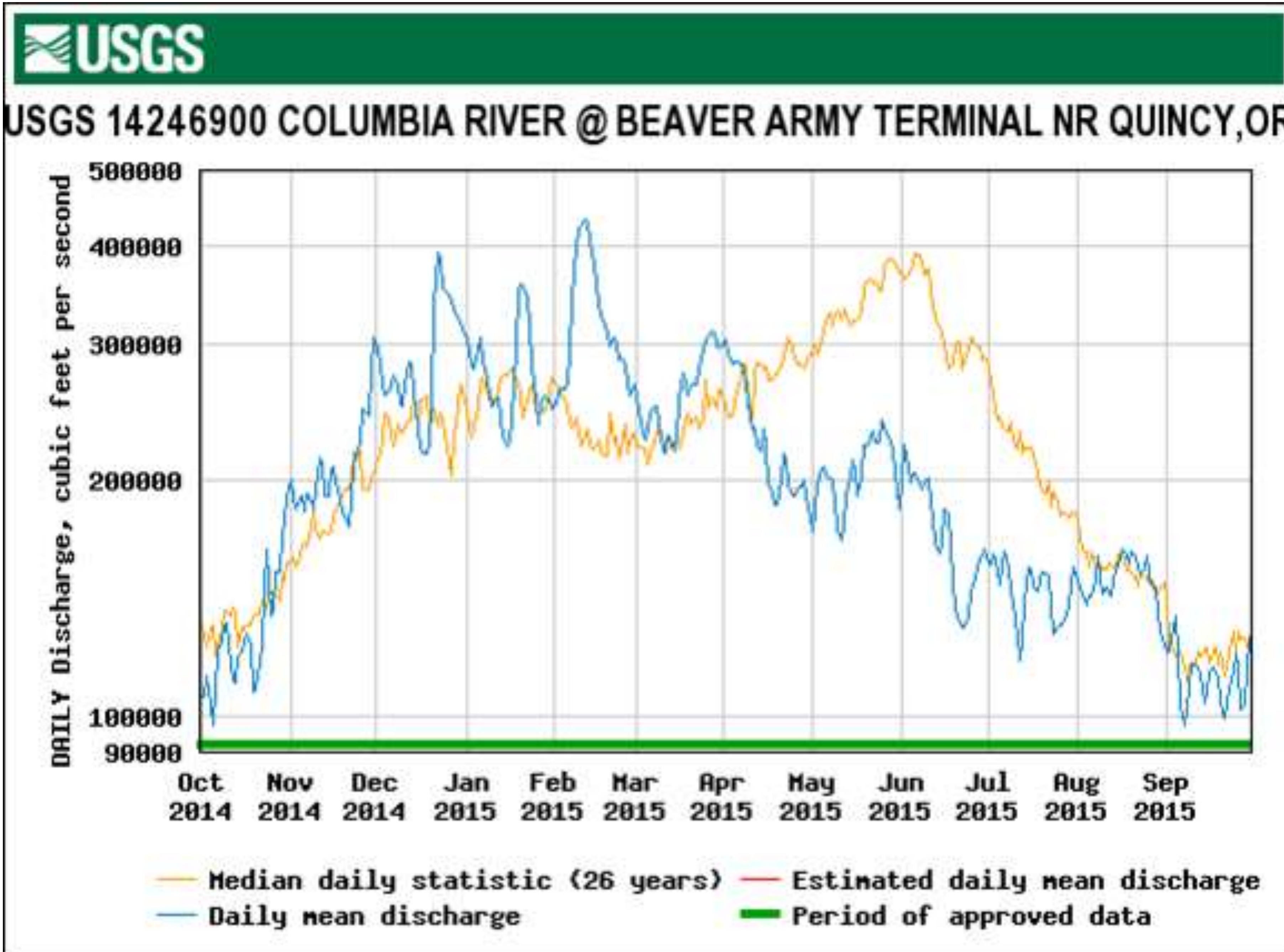
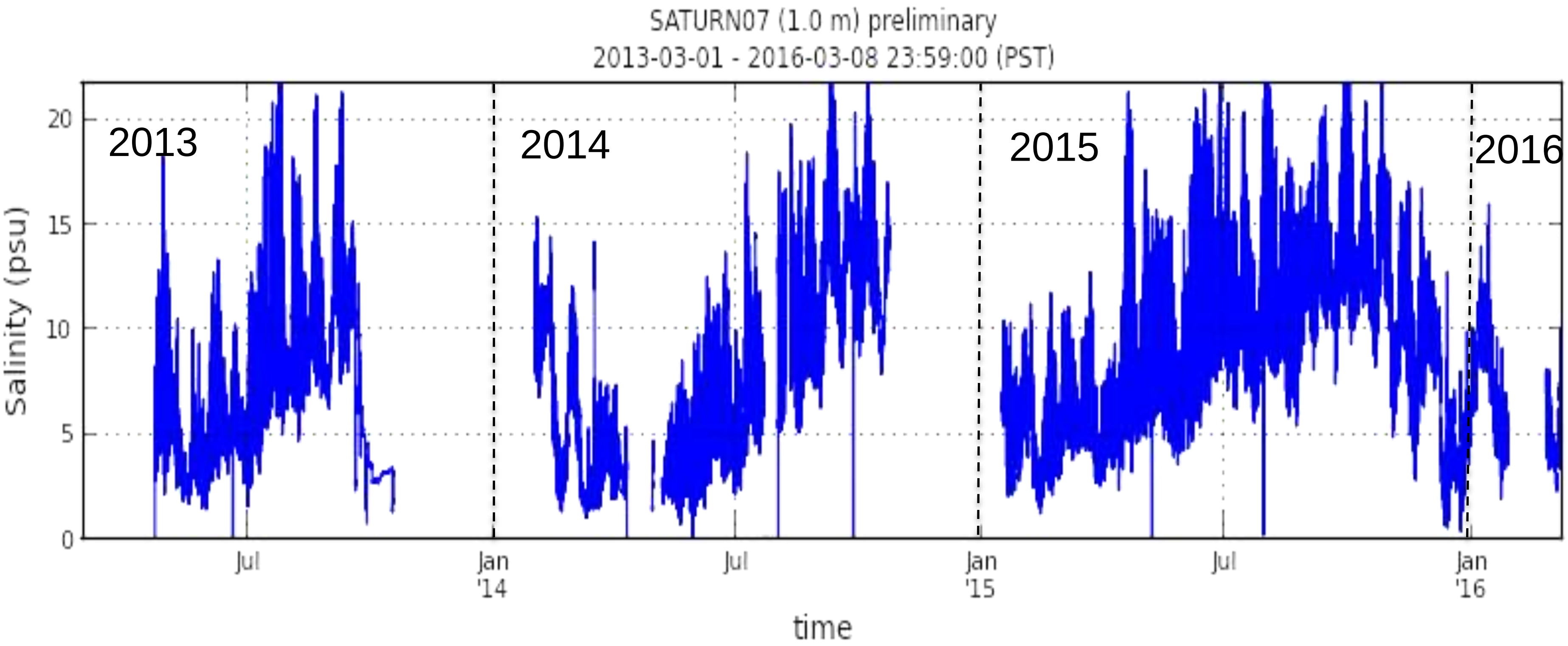
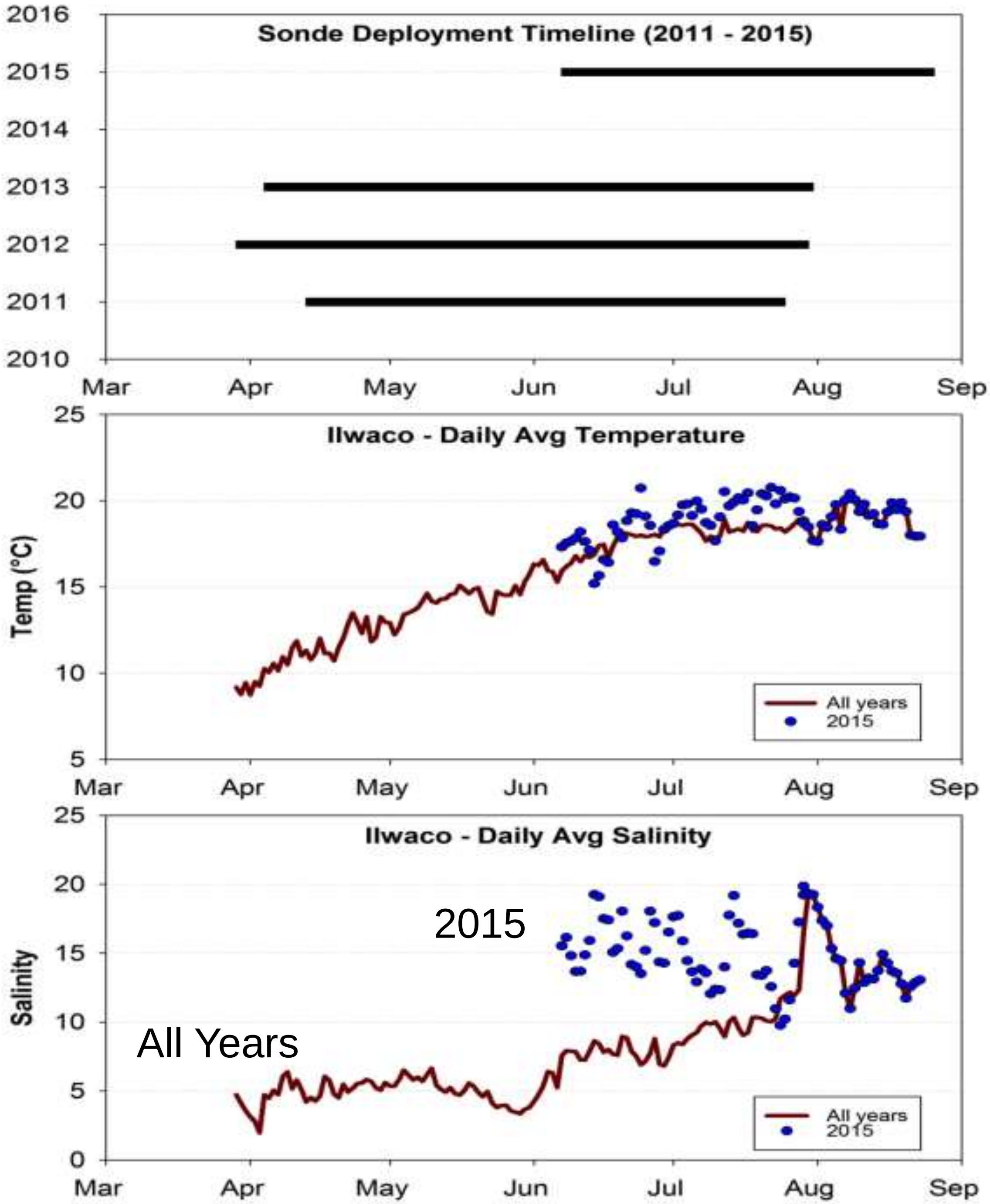

USGS
USGS 14246900 COLUMBIA RIVER @ BEAVER ARMY TERMINAL NR QUINCY,OR
DAILY Discharge, cubic feet per second
500000
400000
300000
200000
100000
90000
Oct 2014
Nov 2014
Dec 2014
Jan 2015
Feb 2015
Mar 2015
Apr 2015
May 2015
Jun 2015
Jul 2015
Aug 2015
Sep 2015
Median daily statistic (26 years)
Estimated daily mean discharge
Daily mean discharge
Period of approved data

Salinity variation in Baker Bay



Salinity at Ilwaco channel sonde mooring

(J. Needoba)



Temperature was somewhat higher in 2015, generally less than 20^{o}C

More suitable salinities in 2015 (~15psu during growing season)

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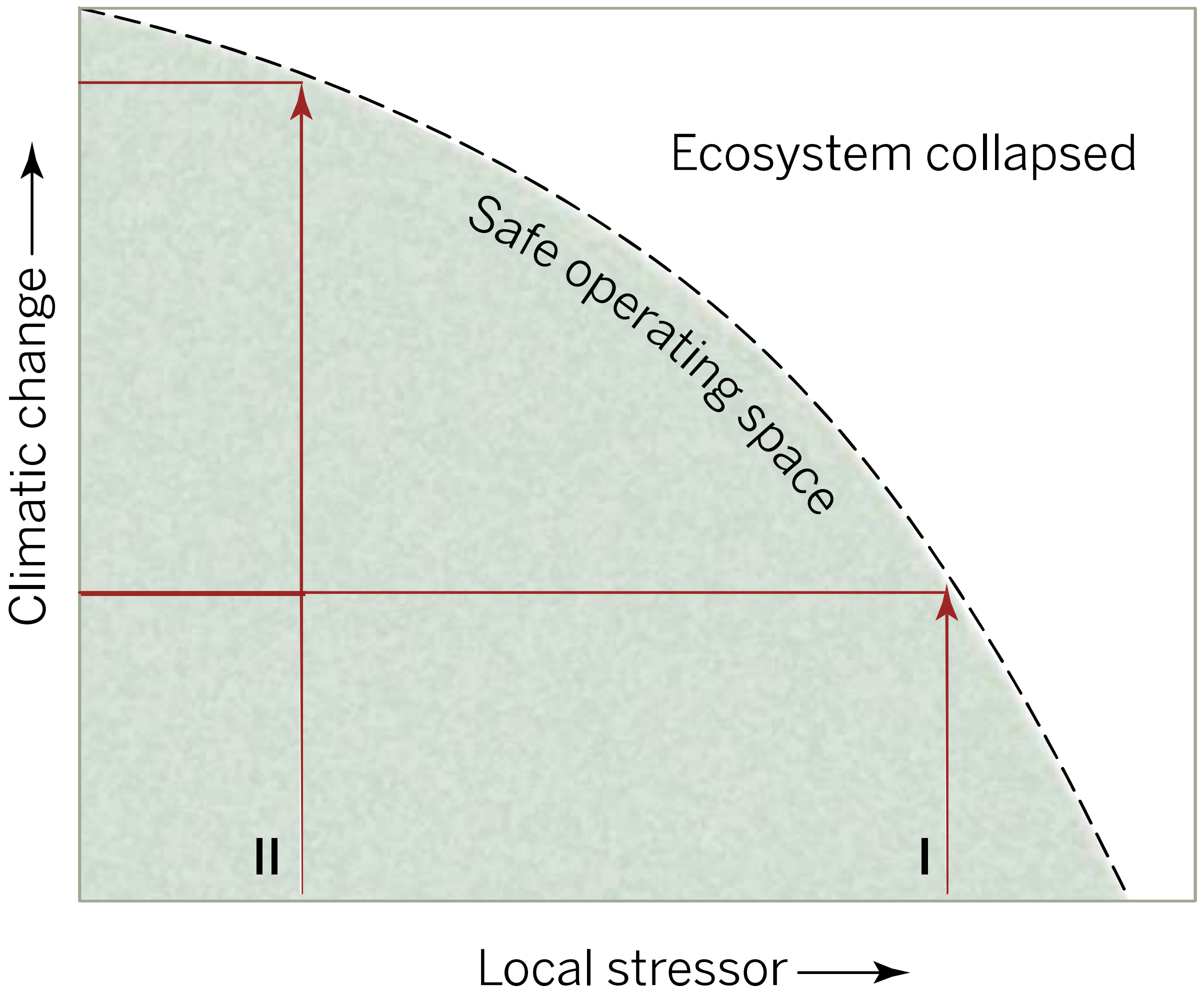
Historical Information on Eelgrass

- *Thomas 1983* - There may have been extensive eelgrass beds [at the river mouth] subtidally, since black brant, which feed on this plant, were formerly common and are now uncommon. (Thwaites, ed. 1959. Original journals of the Lewis and Clark expedition, 1804-1806)
- *NOAA Nautical Chart 640, 1851* – 'Grass' noted in outer estuary.
- *Sherwood et al. 1990* – Salinity intrusion length was greater in 1868 than present. Salinity 1-5psu probably occurred throughout Cathlamet Bay in autumn.
- *Judd et al. 2009* – Eelgrass area could be expanded in the lower estuary but salinity is not ideal.

Summary

- *Question*: Did low river flows facilitate expansion?…*Apparently*
- *Implications:*
  - First location so far (we have seen) where salinity appears to be the critical factor forcing large interannual eelgrass variation
  - Suggests that eelgrass (native and introduced) in the CRE is responsive and resilient to anomalous climatic and oceanographic variation…i.e., minimum viable populations present
  - Lower flows could expand eelgrass as long as temperature does not increase and light remains suitable
  - Long term monitoring of water properties was very helpful; having concordant annual eelgrass monitoring would have helped a lot
  - Application of the numerical eelgrass model would help too
  - Eelgrass may be one of the most useful indicators of lower estuarine conditions in response to climate change and flow manipulations
  - Natural ‘experiments’ are useful in teasing out potential interactive effects of forcing factors as well as understanding aspects of resilience (e.g. tipping points, return time)

Safe Operating Space
(Scheffer et al. 2015. Science 347:1317-1319)



Reduce local & regional stressors to enhance carrying capacity and promote resilience to climate variation and change

Funding: WSDOT, EPA, NOAA, BPA, LCEP
Assistance: Summer Interns (USDOE)

Thank You for Listening!

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