Estuarine Response to Climate Change

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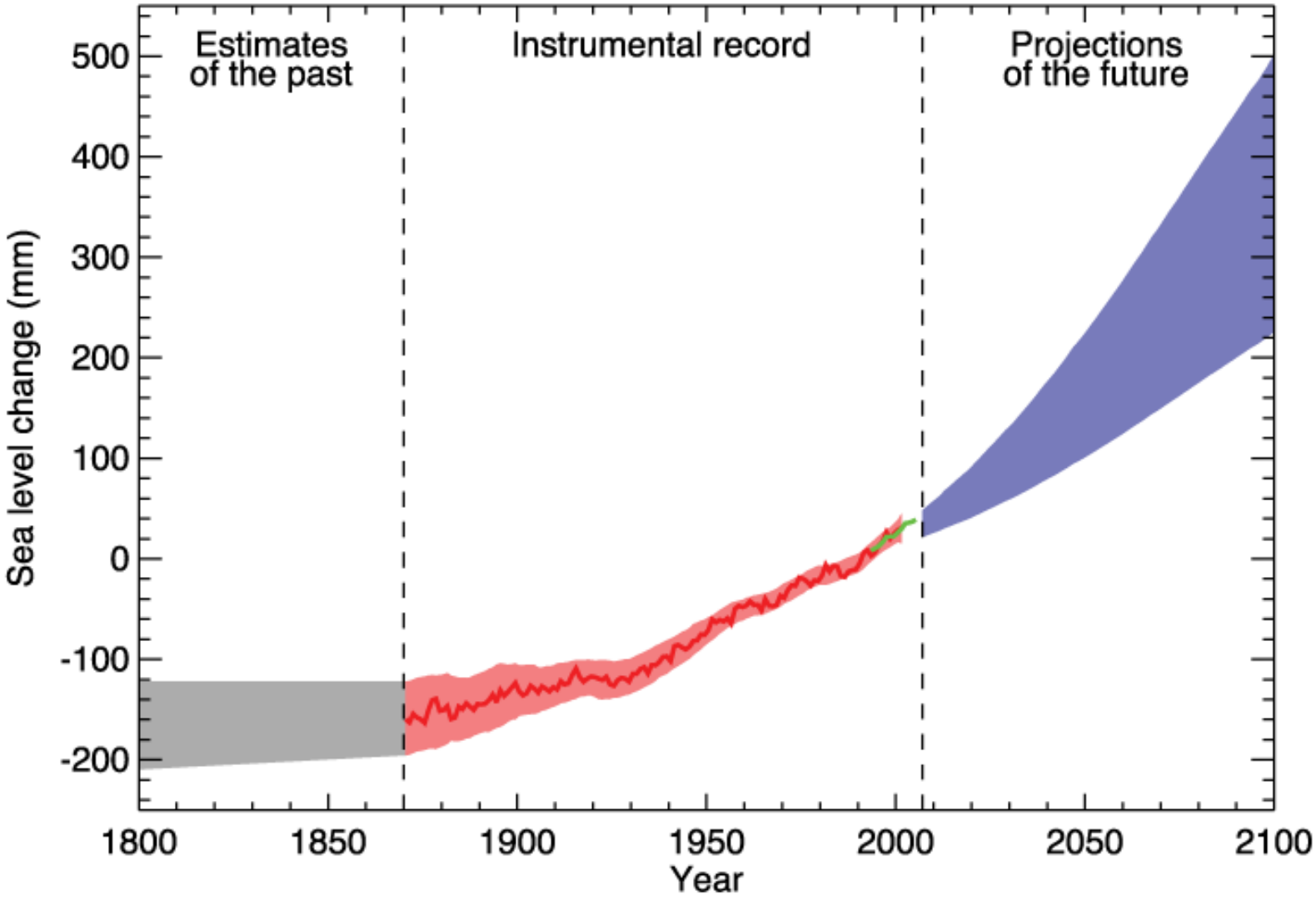
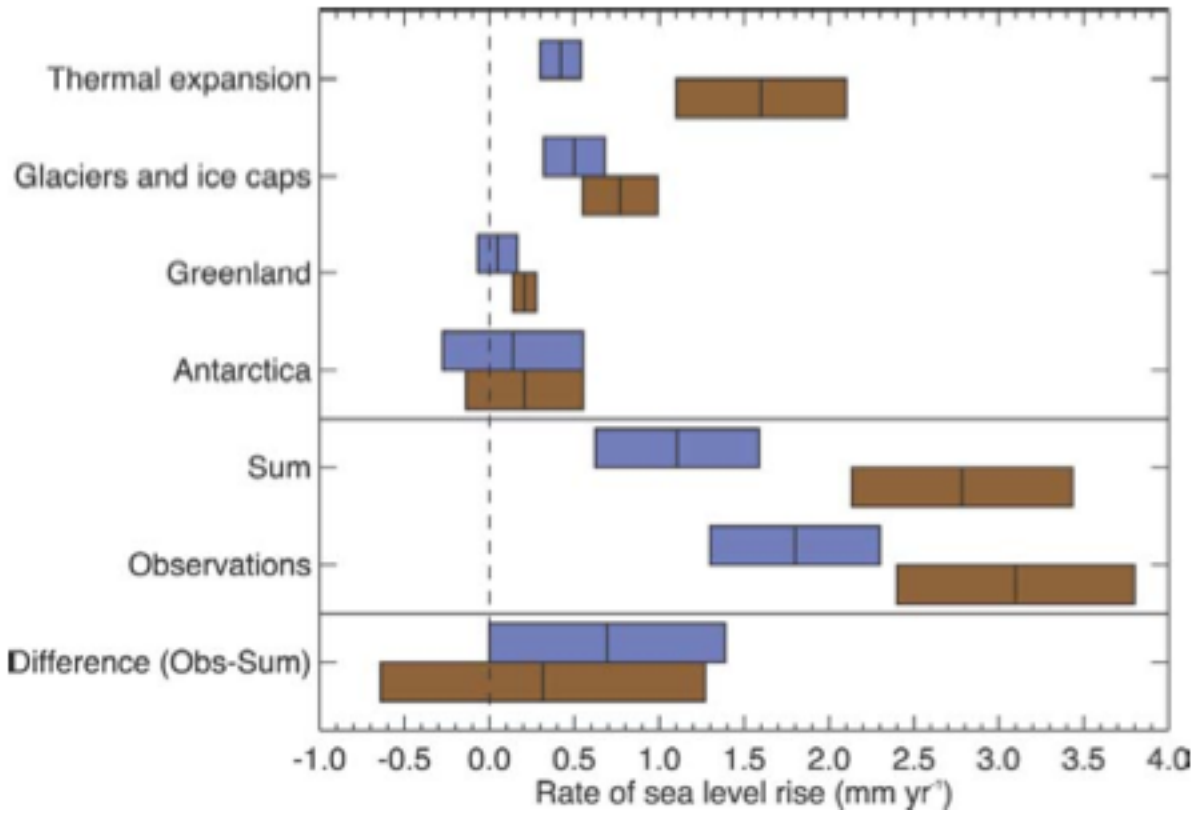
SC2
SKAGIT CLIMATE SCIENCE
CONSORTIUM

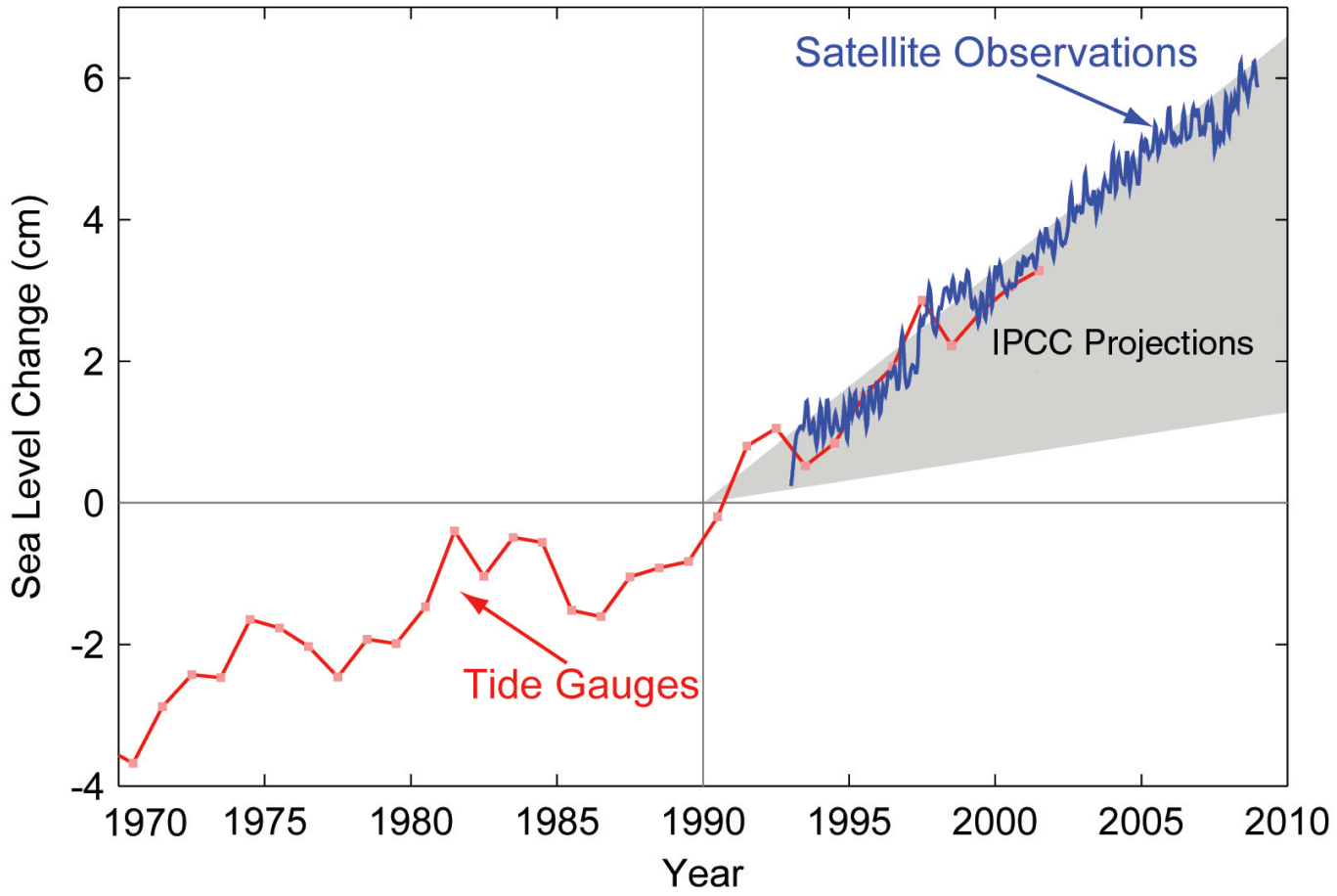
The Eustatic Component of SLR



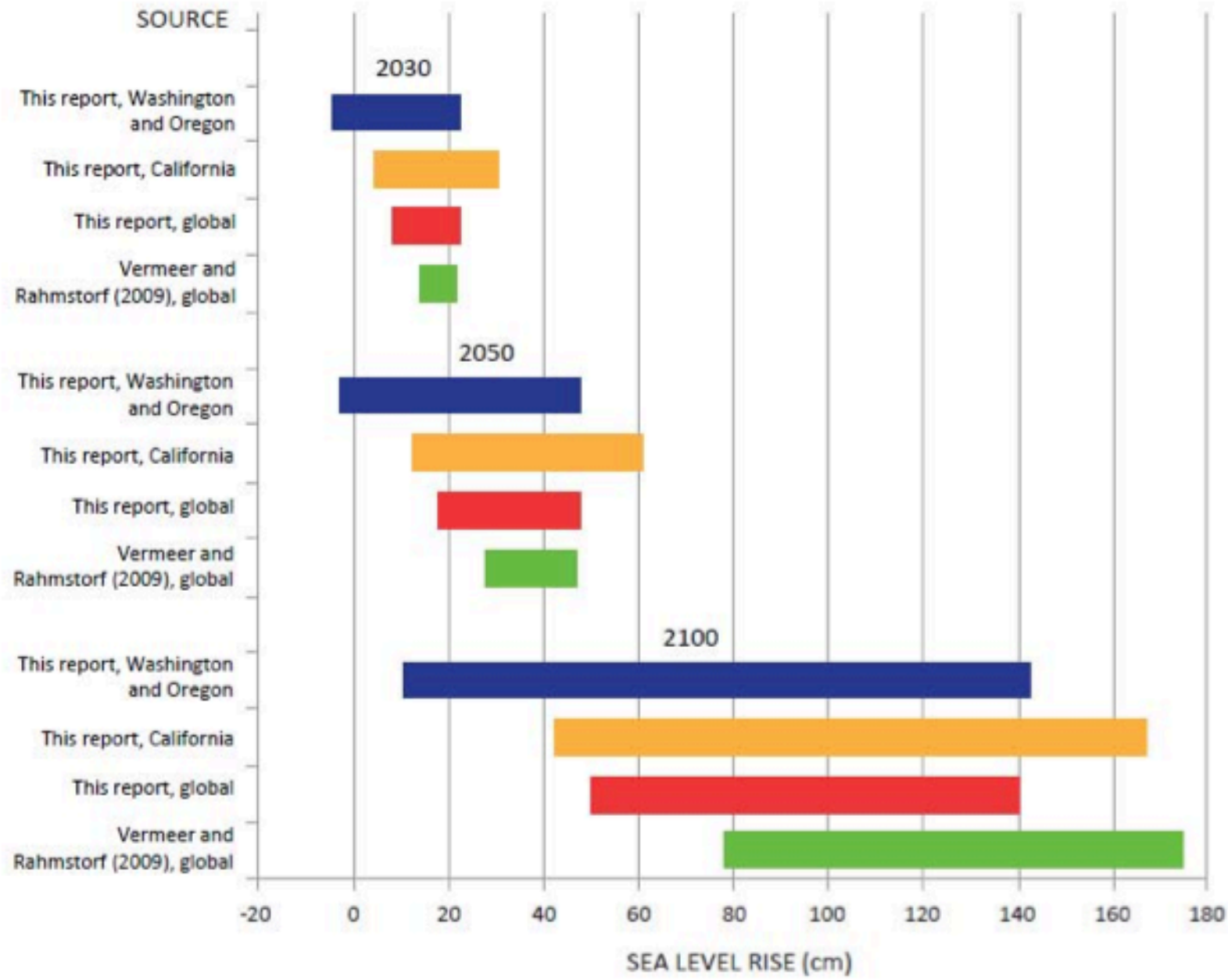


IPCC (2007) estimates of the primary contributions to global mean sea-level change for 1961 to 2003 (blue) and for 1993 to 2003 (brown), compared to the observed rate of global sea-level rise from tide gages and satellite altimetry. The bars represent the 90 percent error range. The relative contributions of these components has changed in recent years, as discussed in this report. SOURCE: Figure 5.21 from Bindoff et al. (2007).

Current Rates = 3.2 mm/year



Sea level change during 1970-2010. The tide gauge data are indicated in red (Church and White 2006) and satellite data in blue (Cazenave et al. 2008). The grey band shows the projections of the IPCC Third Assessment report for comparison.

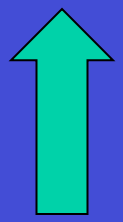


NAS. 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future

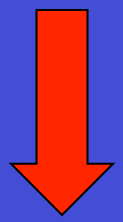
Wetland Response to Rising Sea Levels

- Accrete at a rate that keeps pace with SLR

For an estuary we must also consider the "Relative Component"

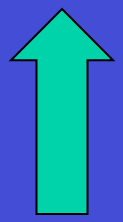


- O.M. Production (above and belowground)
- Allogenic Sediment Deposition

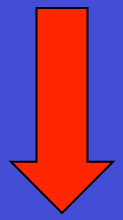


- Deep Subsidence (or uplift)
- Shallow Subsidence (Primary Compaction and Decomposition)

Relative Sea Level Rise



- O.M. Production (above and belowground)
- Allogenic Sediment Deposition



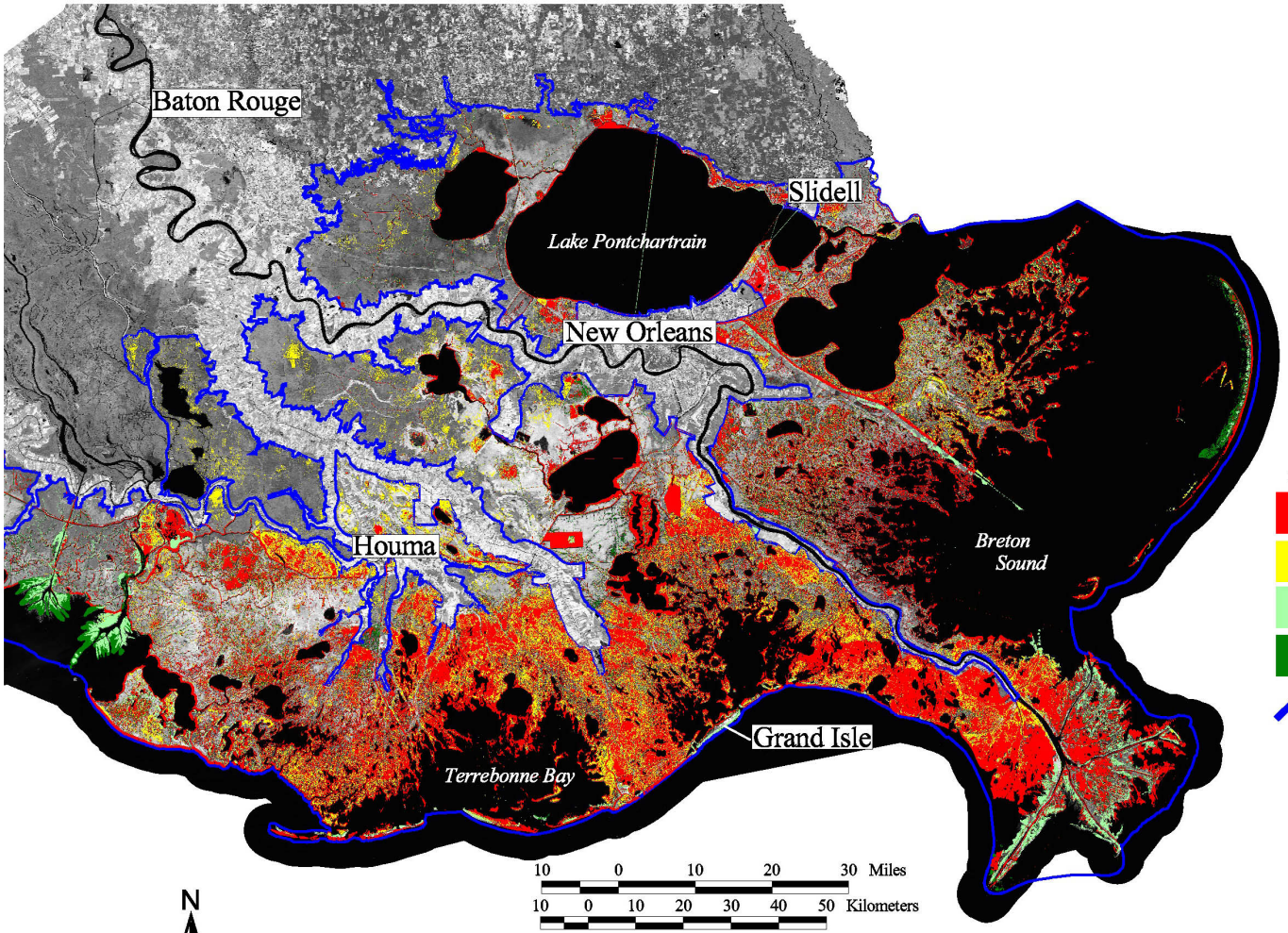
- Eustatic Sea Level Rise
- Deep Subsidence (or uplift)
- Shallow Subsidence (Primary Compaction and Decomposition)

Wetland Response to Rising Sea Levels

- Accrete at a rate that keeps pace with SLR
- Habitat switching, convert to open water

100+ Years of Land Change for Southeast Coastal Louisiana

USGS science for a changing world



LEGEND

- Land Loss 1932 - 2000
- Predicted Land Loss 2000 - 2050
- Land Gain 1932 - 2000
- Predicted Land Gain 2000 - 2050
- Louisiana Land Change Study Boundary

SUMMARY

Coastal Louisiana has lost an average of 34 square miles of land, primarily marsh, per year for the last 50 years. From 1932 to 2000, coastal Louisiana has lost 1,900 square miles of land, roughly an area the size of the state of Delaware. If nothing is done to stop this land loss, Louisiana could potentially lose approximately 700 square miles of land, or about equal to the size of the greater Washington D.C.-Baltimore area, in the next 50 years. Further, Louisiana accounted for an estimated 90 percent of the coastal marsh loss in the lower 48 states during the 1990s. The area shown on this map represents over 75 percent of the total land loss for coastal Louisiana.

Backdrop is 2000 TM panchromatic band.

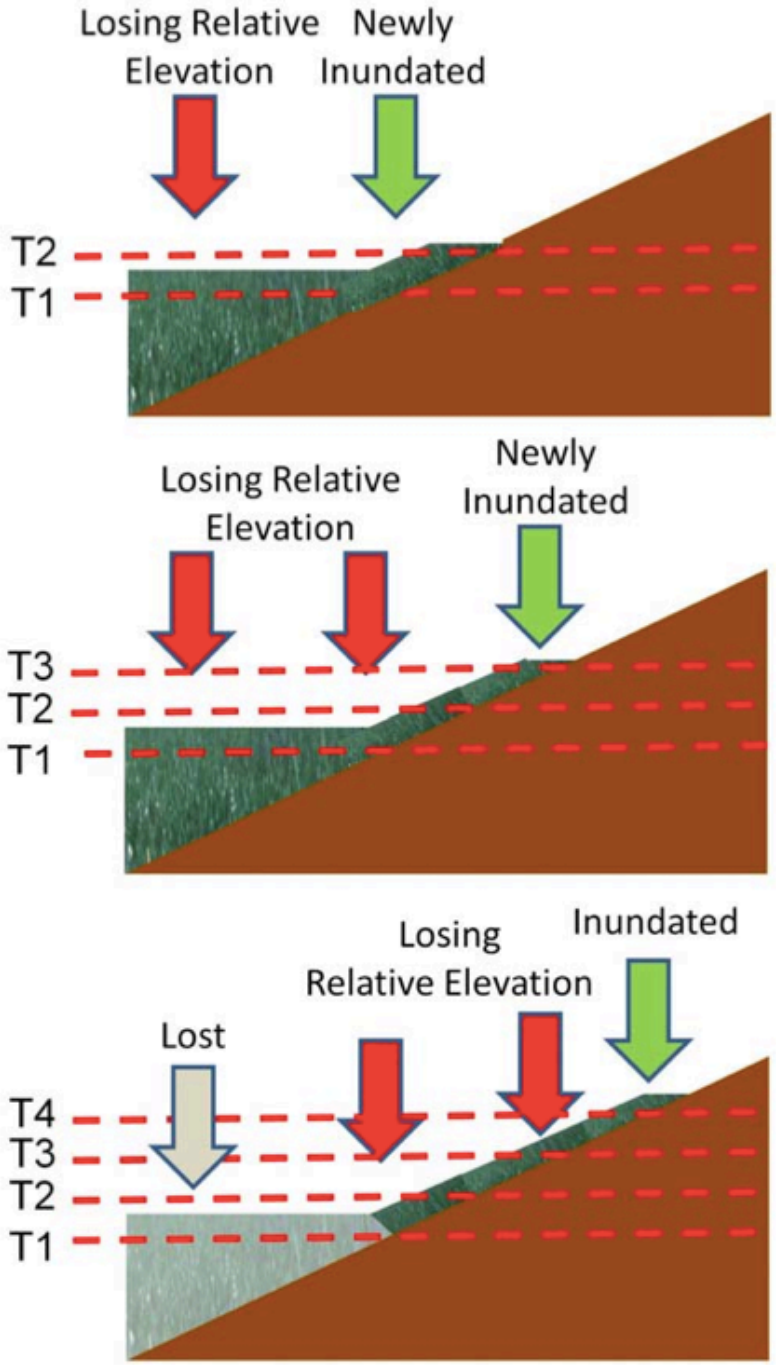
Prepared By:
U.S. Geological Survey
National Wetlands Research Center
Lafayette, LA

US Army Corps of Engineers

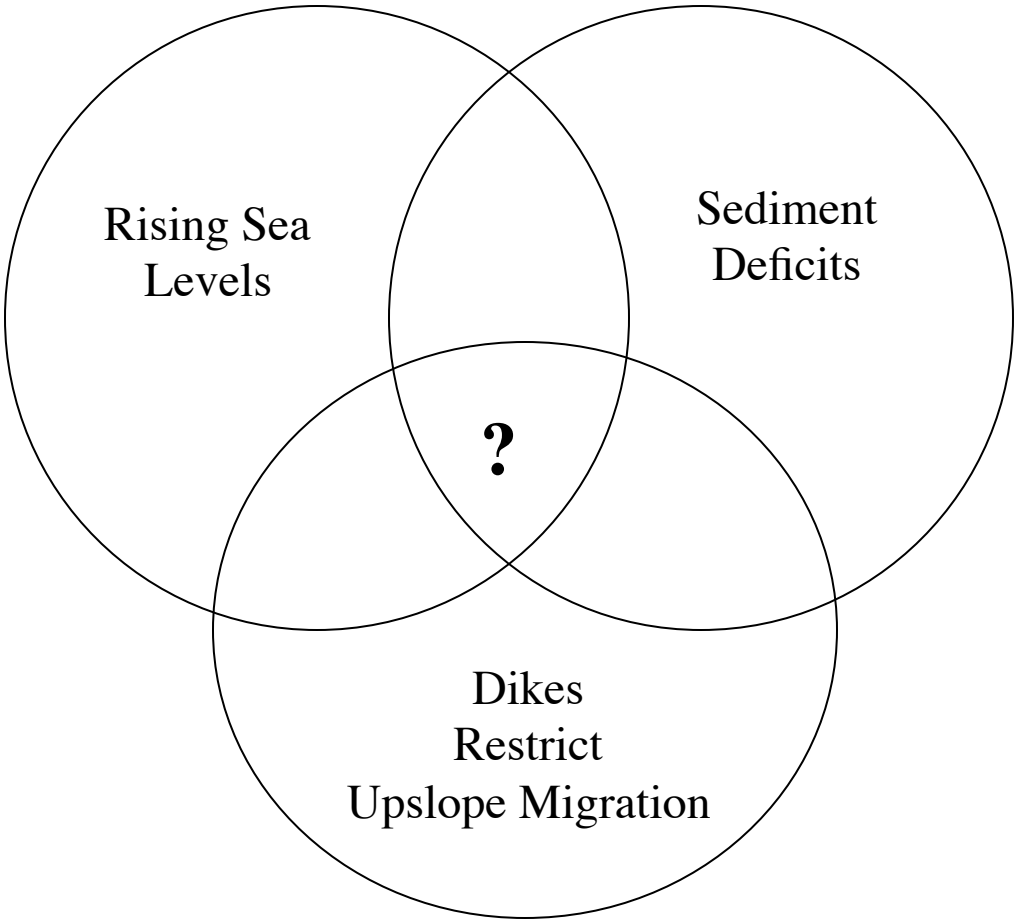
Map ID: USGS-NWRC 2003-02-0373

Wetland Response to Rising Sea Levels

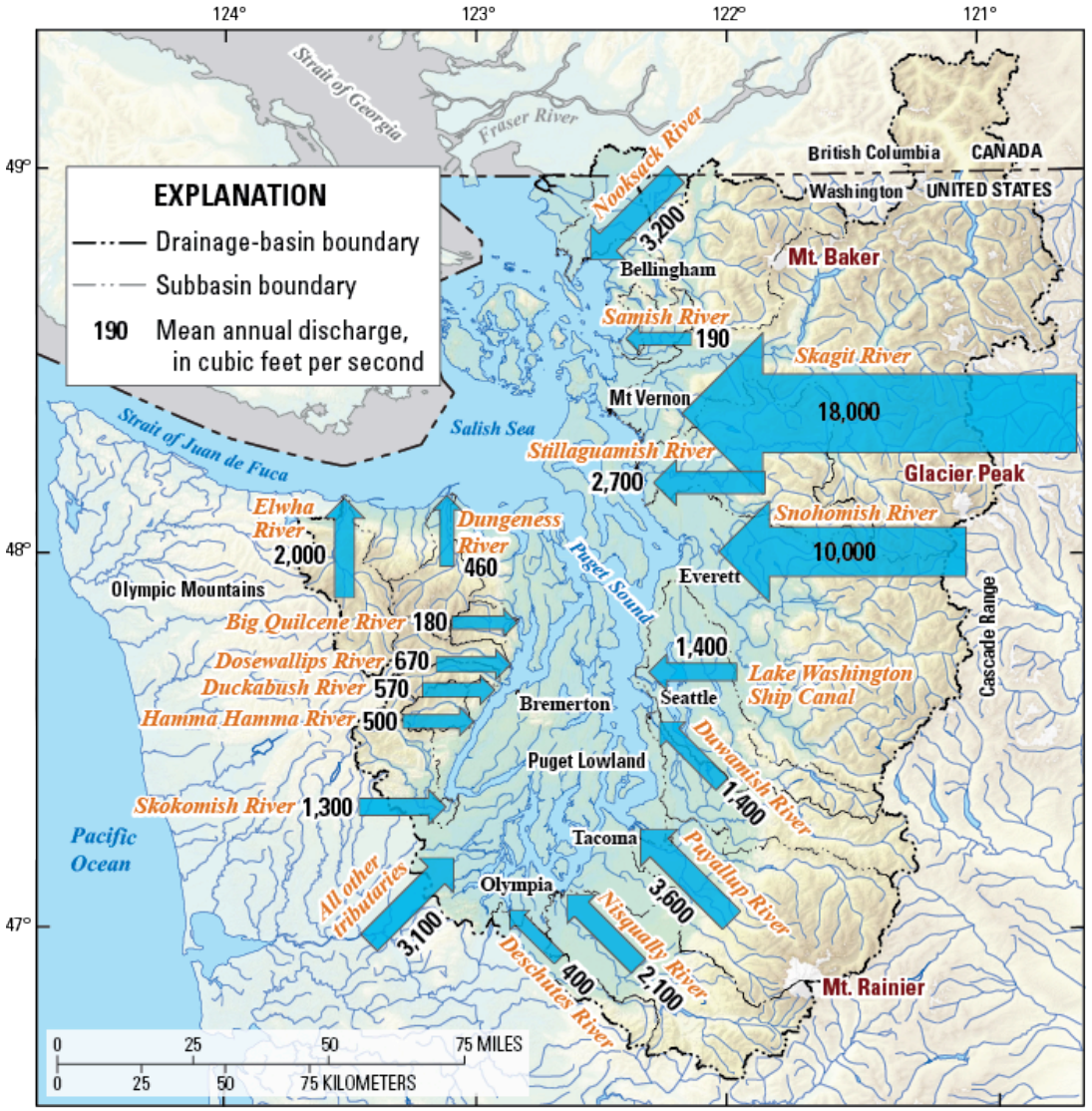
- Accrete at a rate that keeps pace with SLR
- Habitat switching, convert to open water
- Migrate upslope (no net loss?)


Losing Relative Elevation
Newly Inundated
T2
T1
Losing Relative Elevation
Newly Inundated
T3
T2
T1
Losing Relative Elevation
Inundated
Lost
T4
T3
T2
T1

Estuaries at Risk?

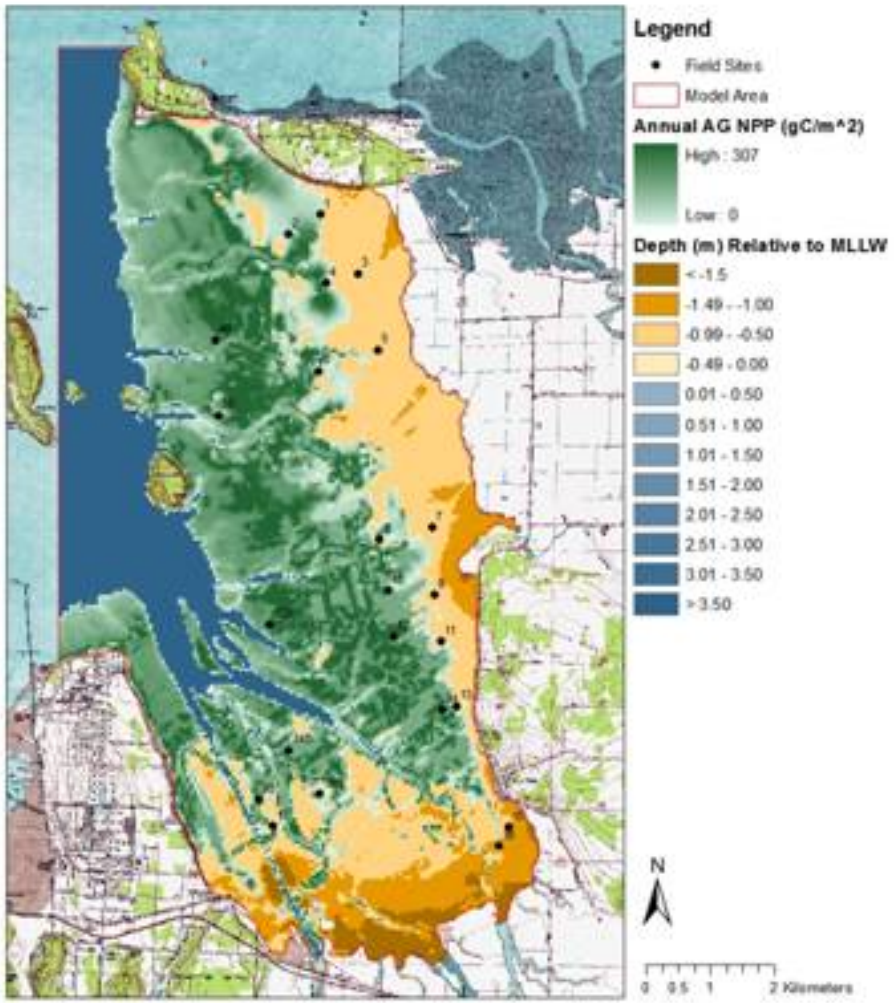


Case Studies

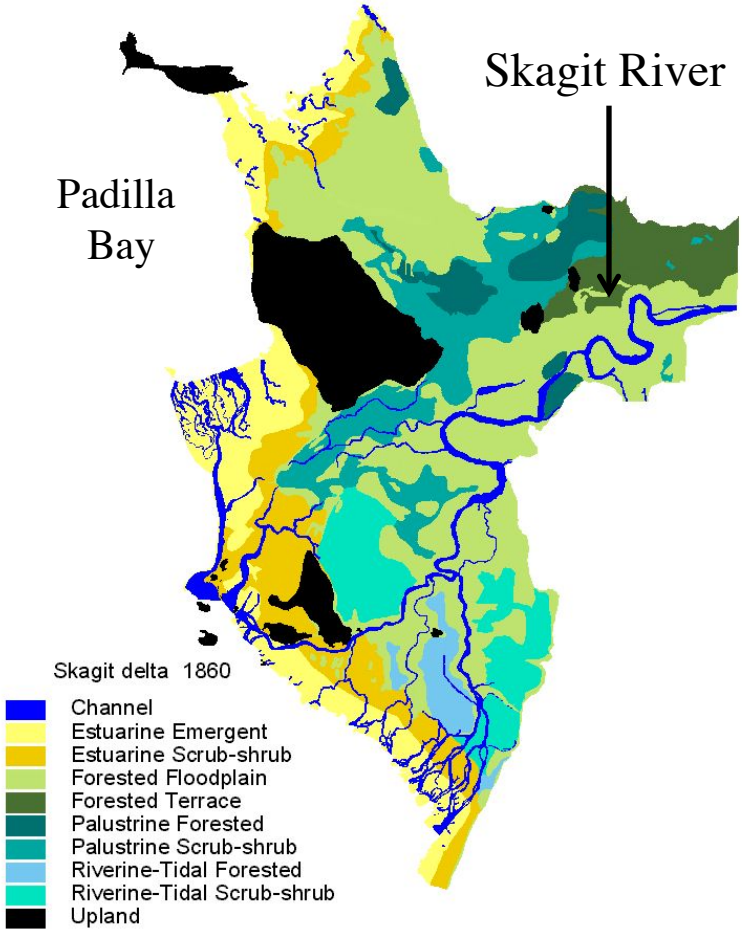


Padilla Bay

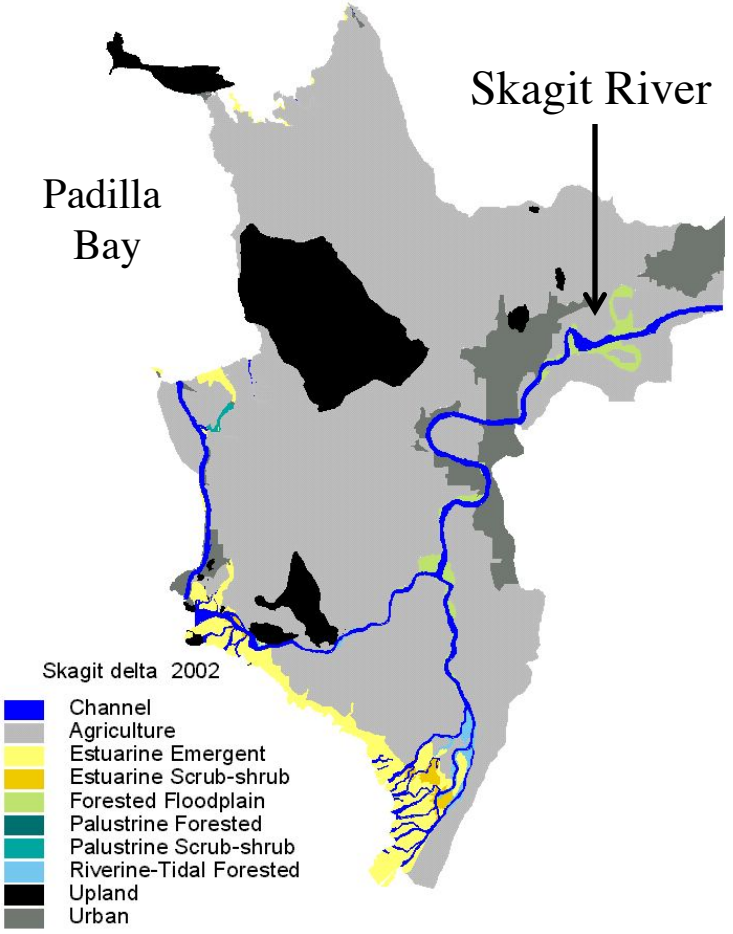
- 3000 ha intertidal eel grass
- - 3.0 - + 0.75 m MLLW



Skagit delta 1860

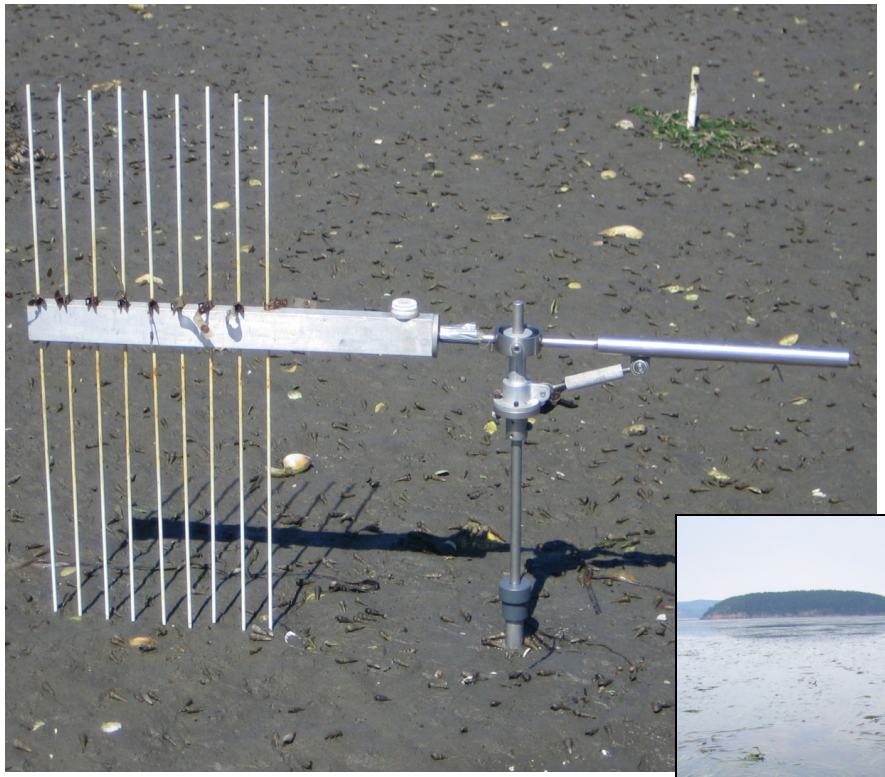


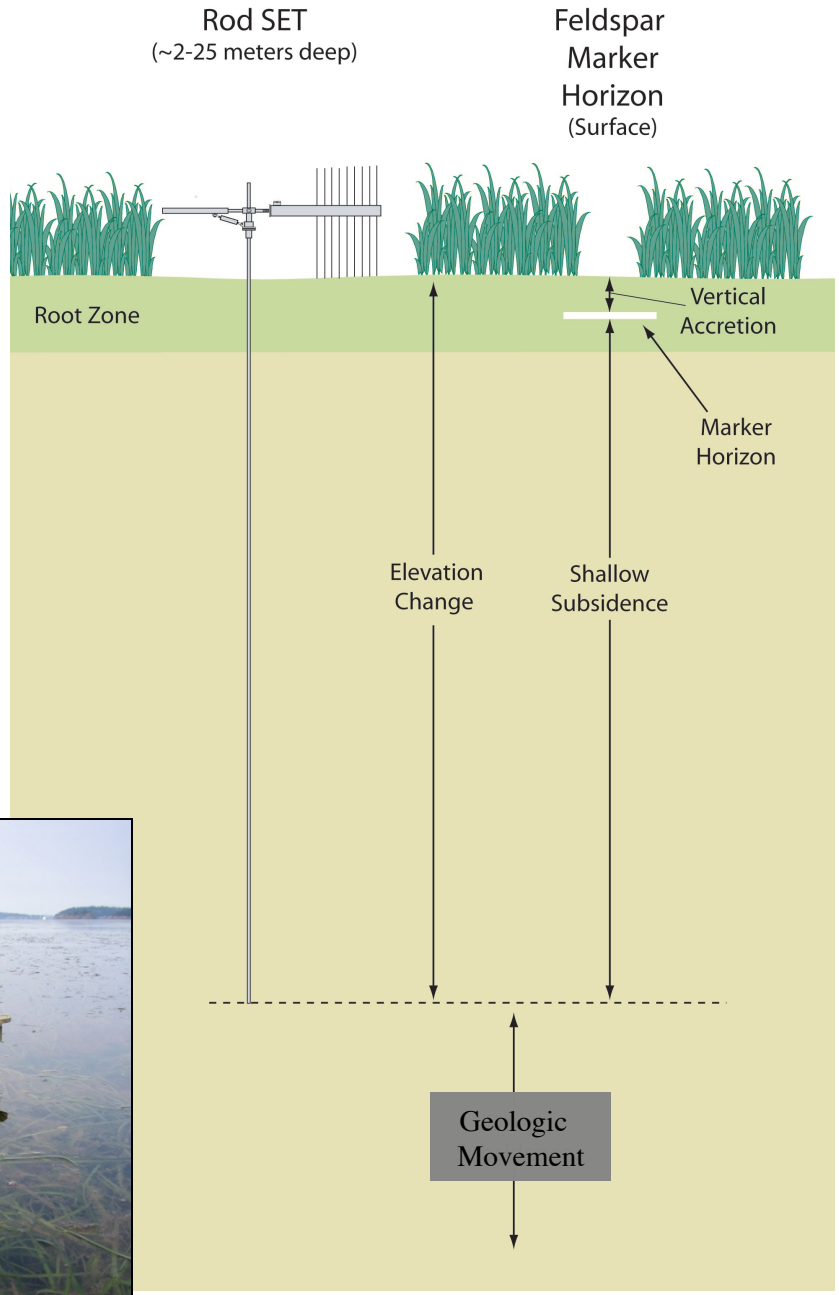
Skagit delta 2002

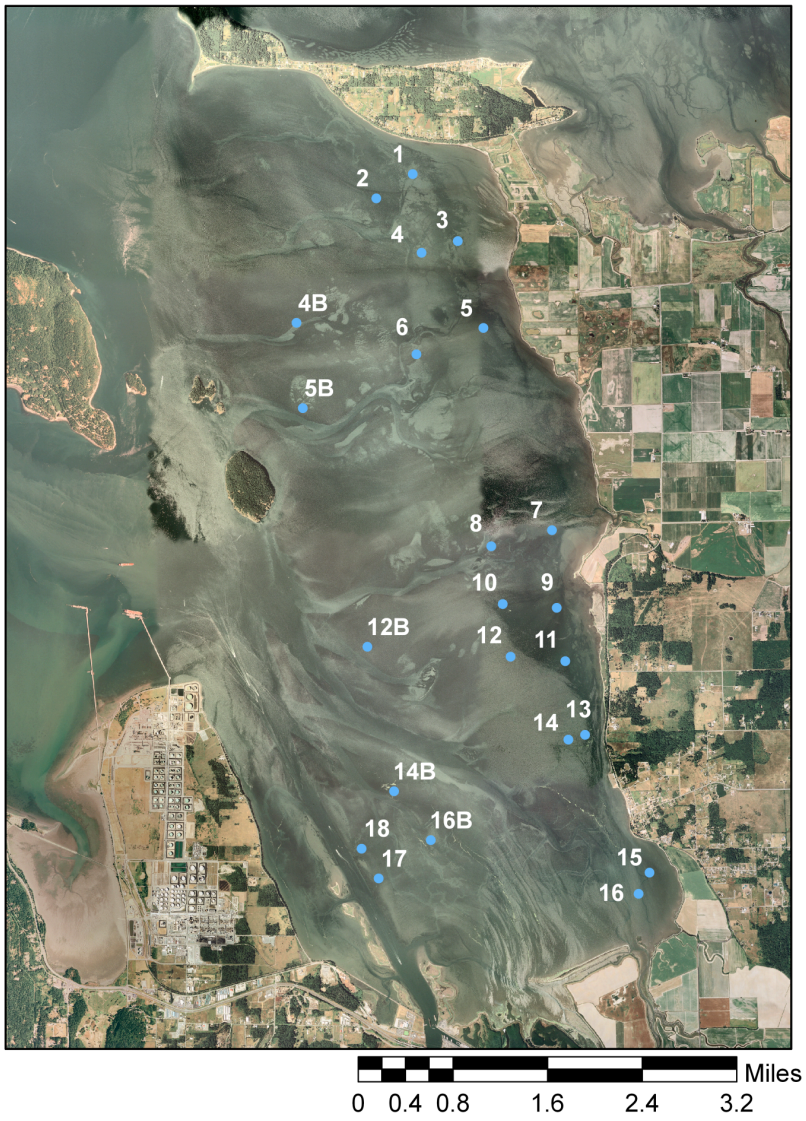


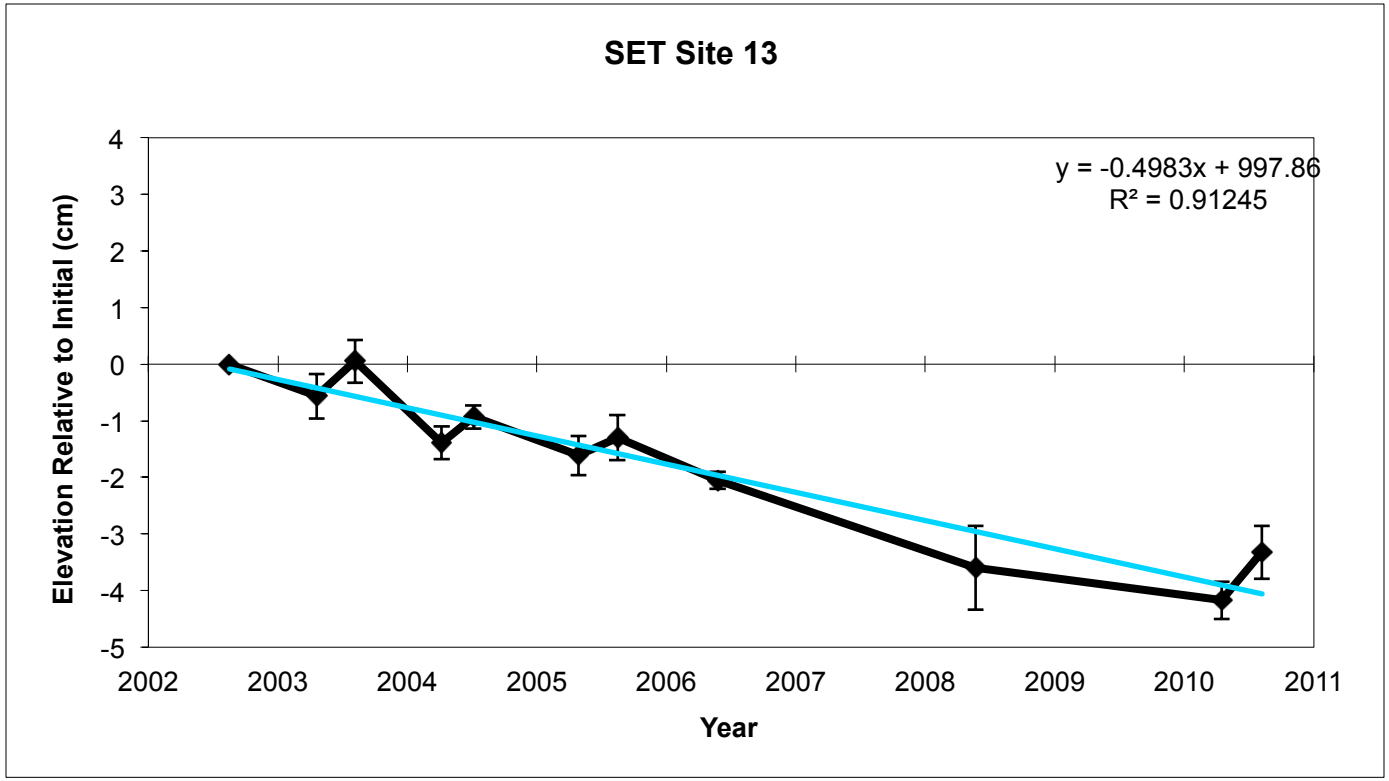
1) **Cutoff from historical sources of sediment**
2) **No opportunity for upslope migration**
3) **An increasing rate of sea level rise**

Sediment elevation tables






1
2
3
4
4B
5
6
5B
7
8
10
9
12B
12
11
13
14
14B
16B
18
17
15
16
Miles
0 0.4 0.8 1.6 2.4 3.2


SET Site 13
y = -0.4983x + 997.86
R² = 0.91245
Elevation Relative to Initial (cm)
4
3
2
1
0
-1
-2
-3
-4
-5
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year

Rate of elevation change

1 site exhibited significant elevation gain

9 sites exhibited no significant elevation change

9 sites exhibited significant elevation loss

Mean = -0.22 ± 0.27 cm/yr

Surface elevation deficit =

sediment elevation change – sea level rise + geologic uplift

mean sediment elevation change = - 0.22 cm/yr

sea level rise = 0.32 cm/yr

geologic uplift = 0.09 cm/yr

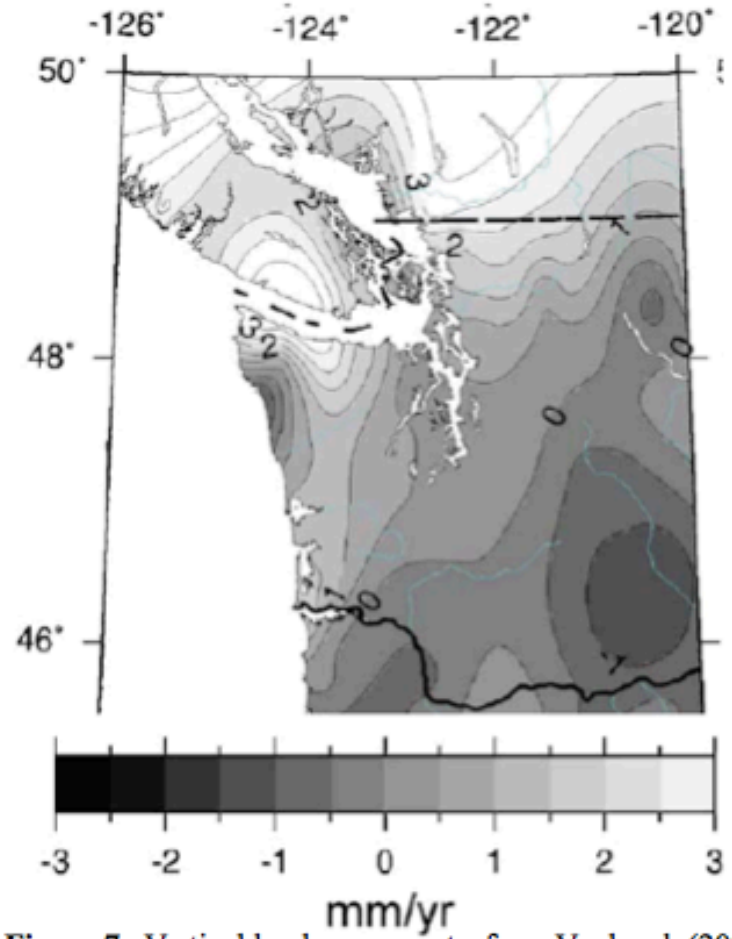


Figure 7. Vertical land movements, from Verdonck (2006).

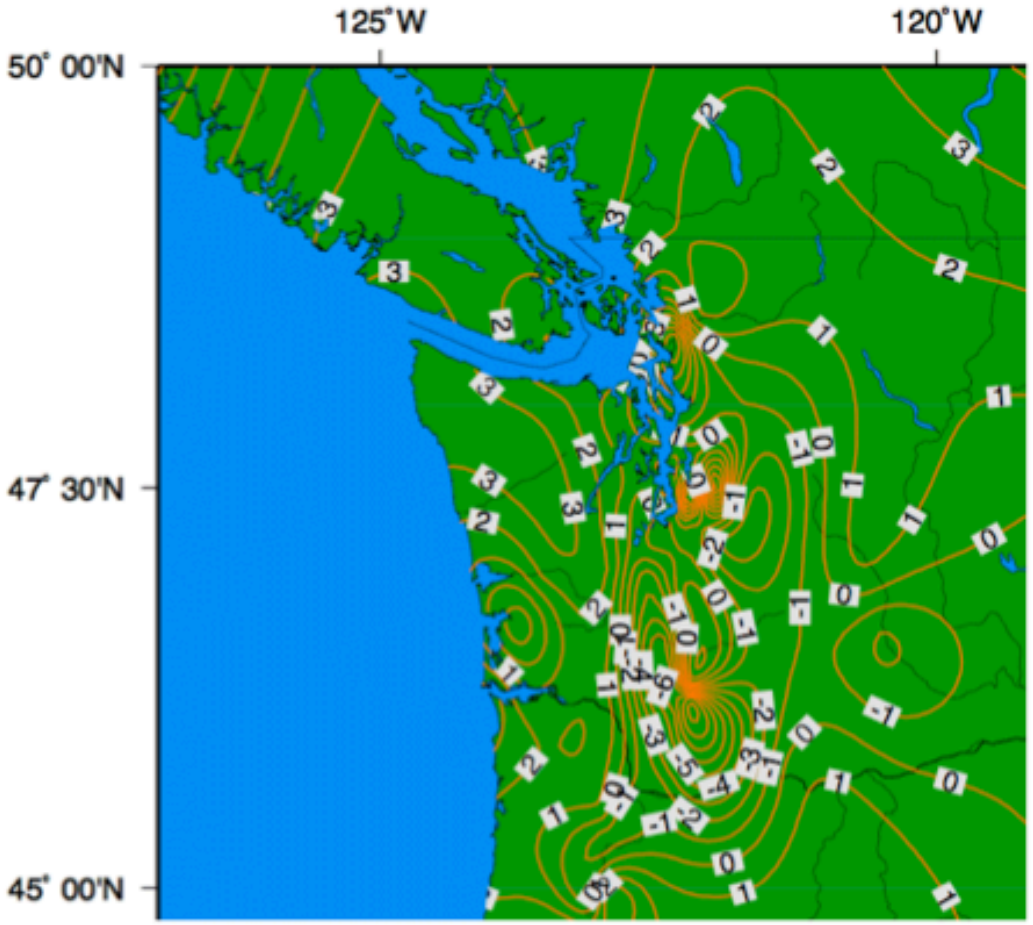


Figure 8. GPS derived current annual vertical deformation rates (mm/year), from Pacific Northwest Geodetic Array, Central Washington University, November 2007, www.geodesy.org

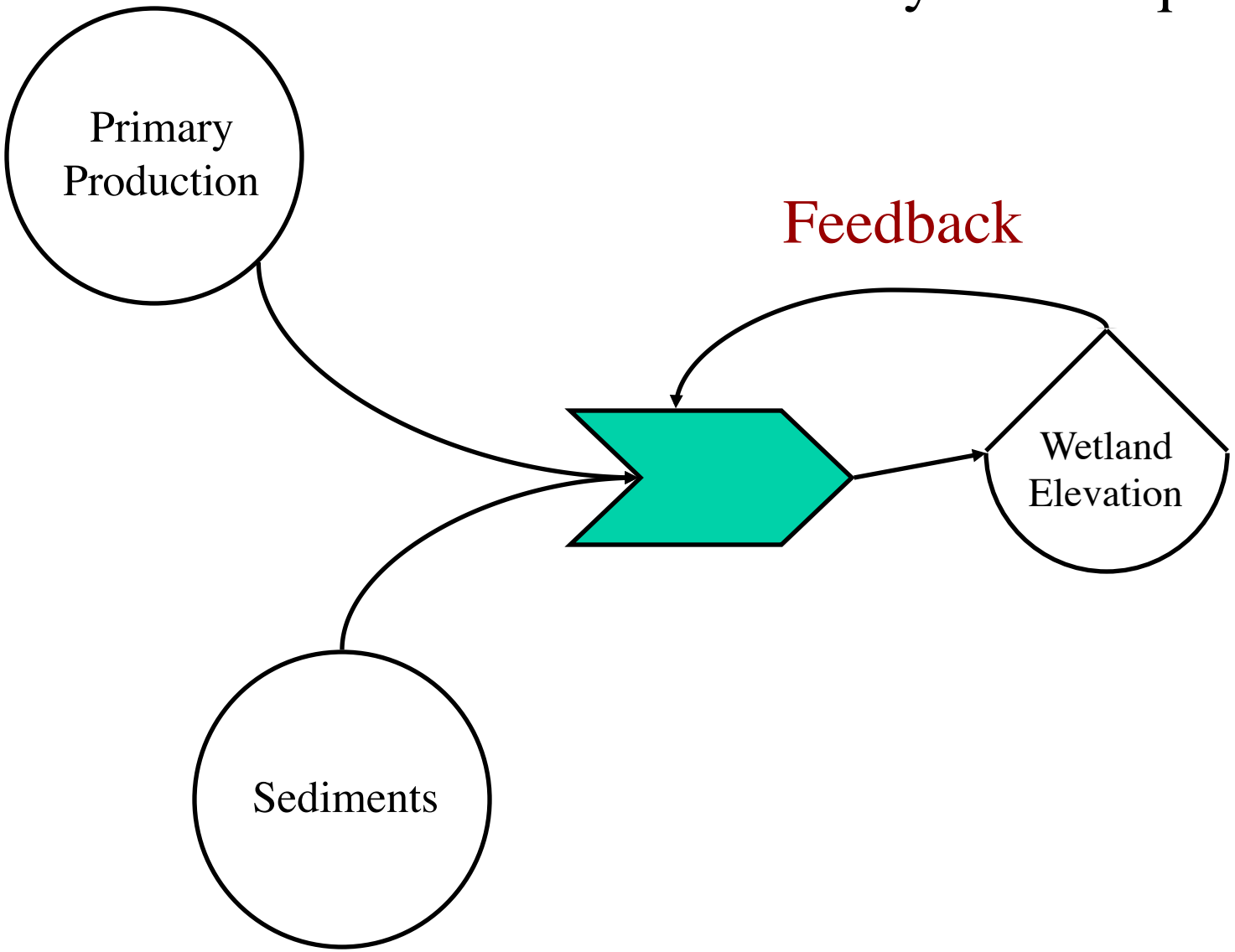
Surface elevation deficit

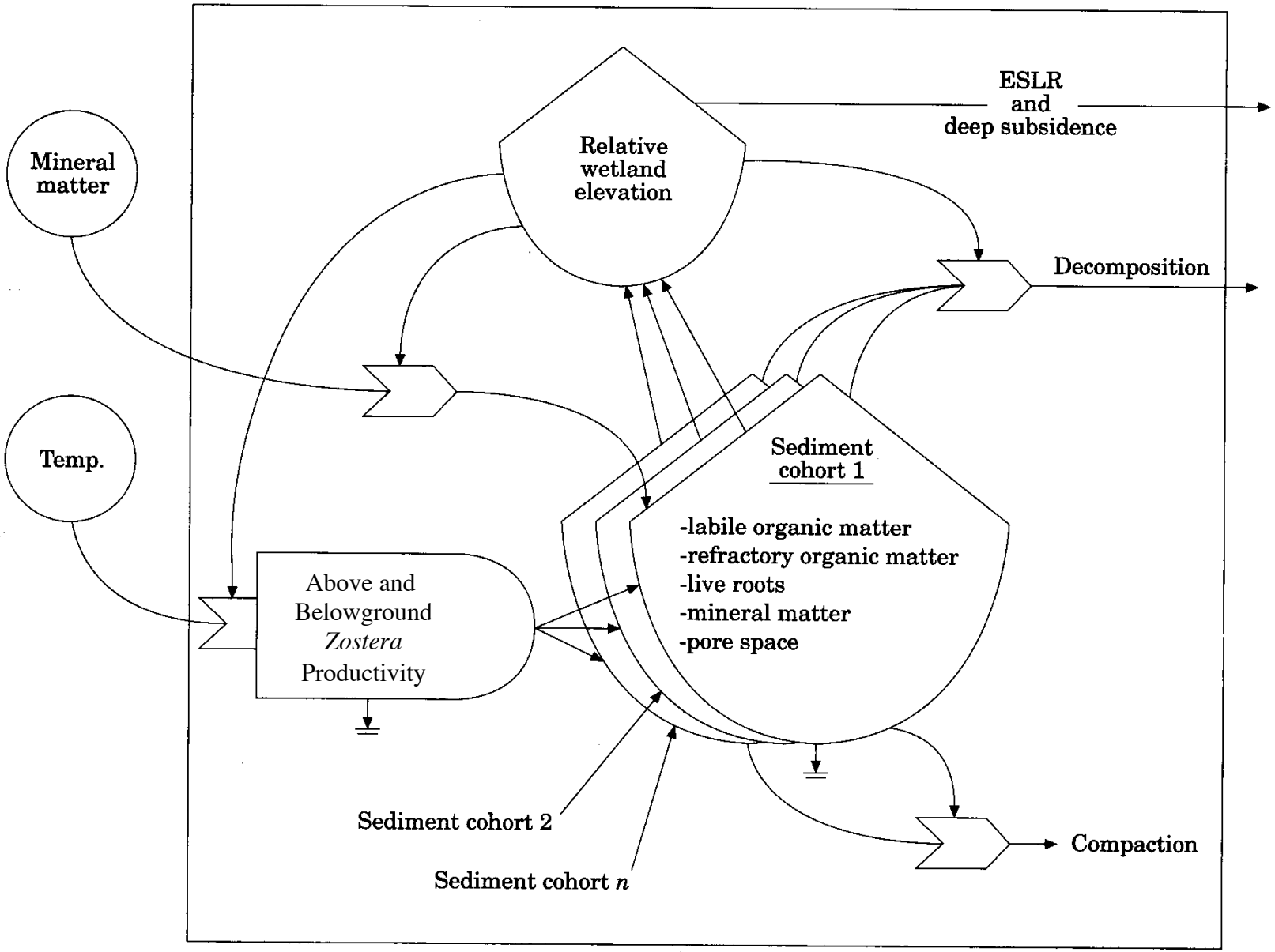
ALL sites exhibit a surface elevation deficit

Mean = -0.45 ± 0.27 cm/yr

Elevation gain is NOT sufficient to keep pace with sea level rise

A Dynamic Equilibrium

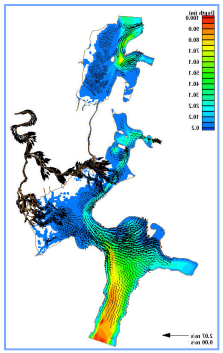


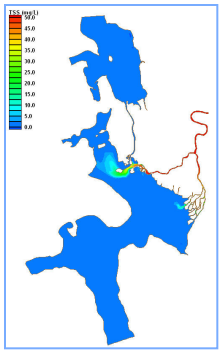

Mineral matter
Temp.
Relative wetland elevation
ESLR and deep subsidence
Decomposition
Sediment cohort 1
-labile organic matter
-refractory organic matter
-live roots
-mineral matter
-pore space
Above and Belowground *Zostera* Productivity
Sediment cohort 2
Sediment cohort *n*
Compaction

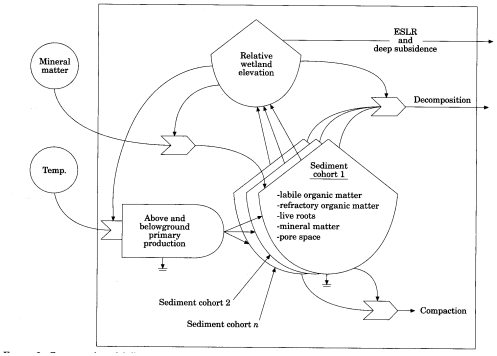
1. Data Collection For Model Development, Initialization, Calibration, and Validation

↓

2. Model Development







Hydrodynamic Model

Sediment Transport Model

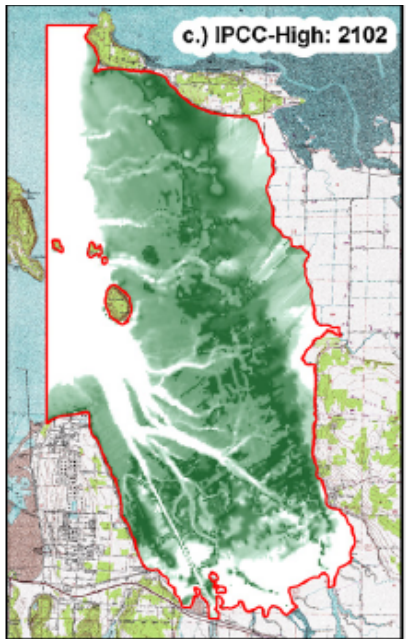
Relative Elevation and Habitat Model

↓

3. Sea Level Rise and Restoration Scenarios

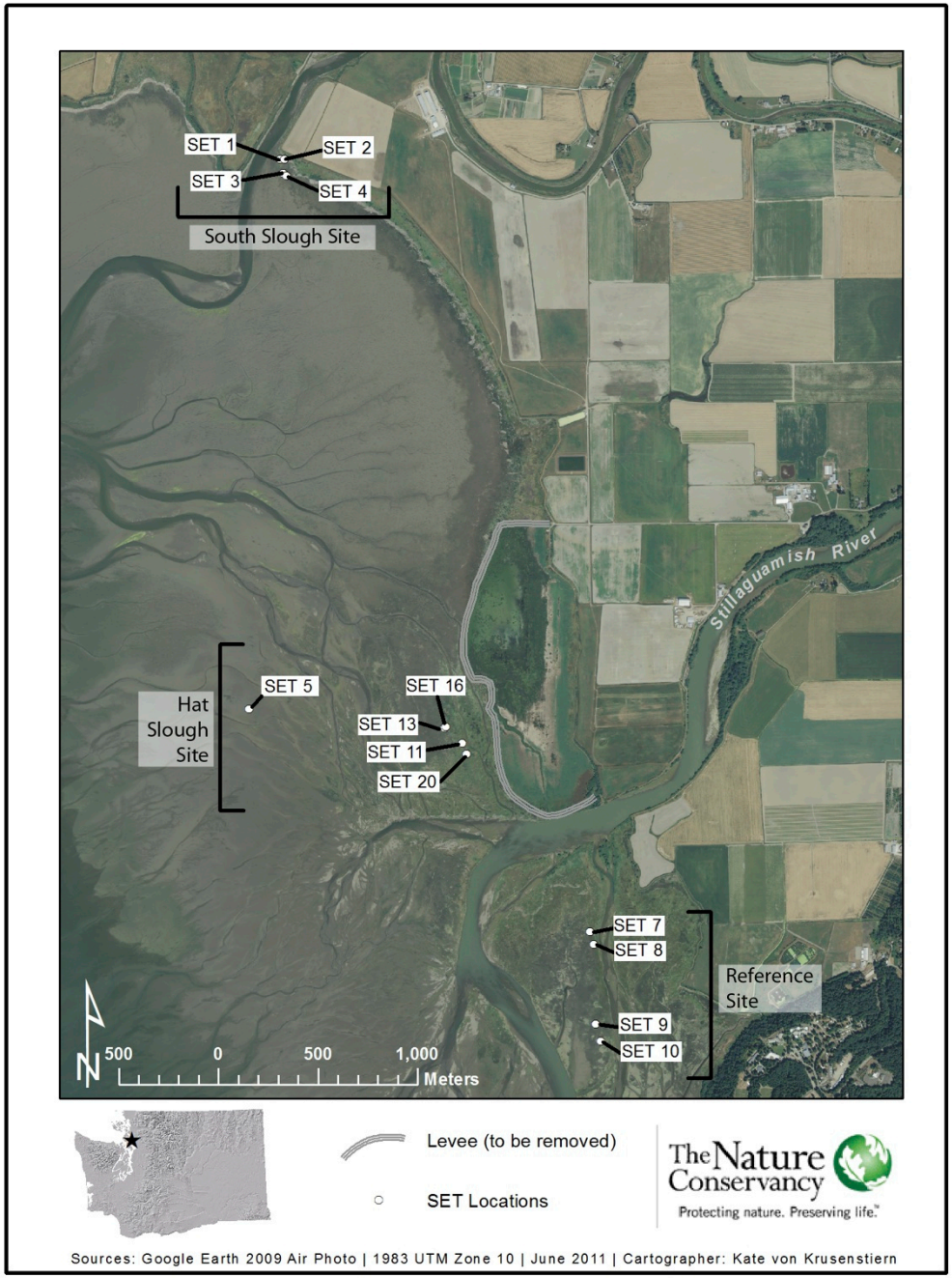
Current

Future

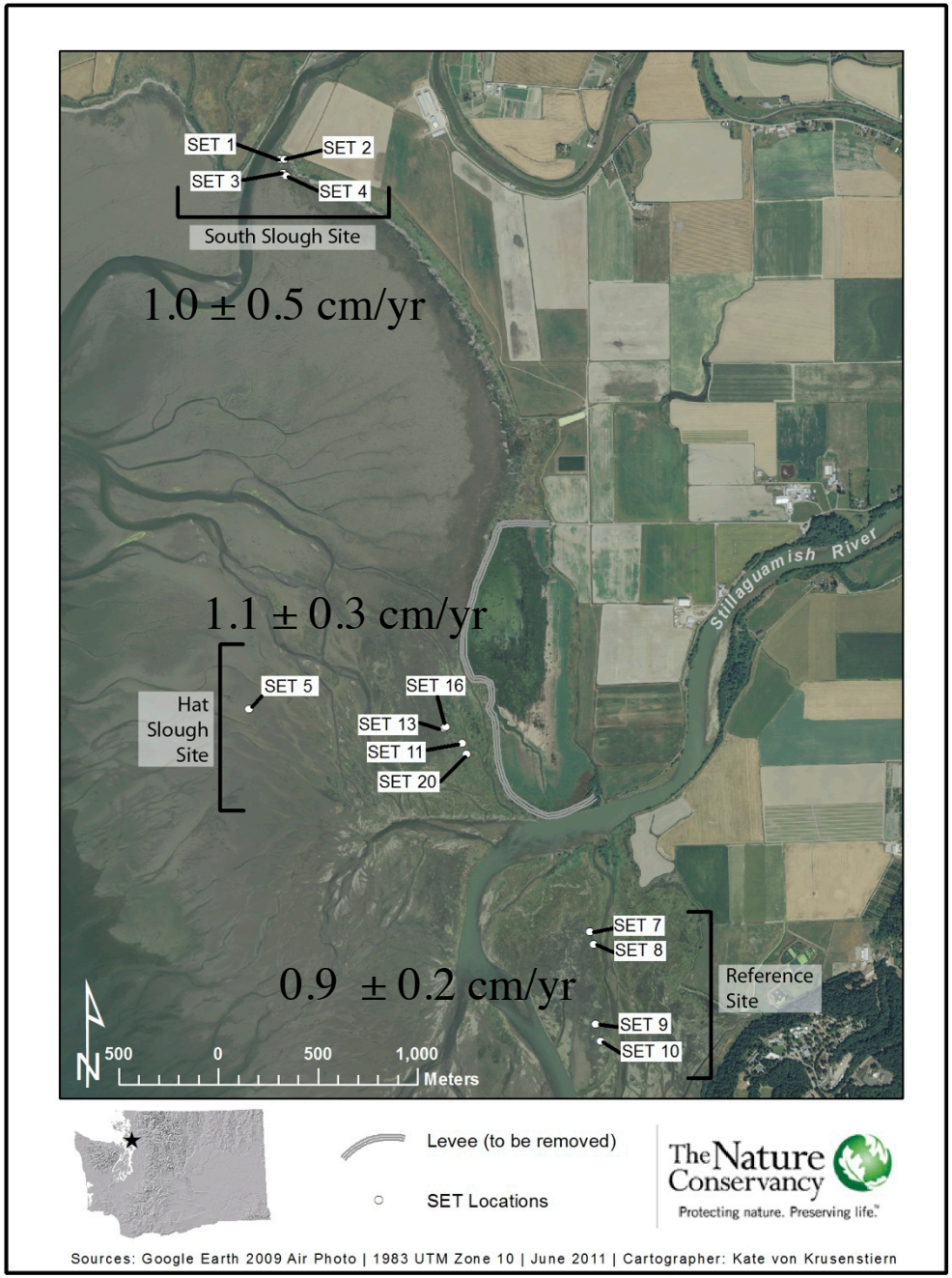


Rate of sea level rise = 0.33 cm/yr 0.56 cm/yr 1.27 cm/yr

Kairis and Rybczyk (2010)



Sources: Google Earth 2009 Air Photo | 1983 UTM Zone 10 | June 2011 | Cartographer: Kate von Krusenstiern


SET 1
SET 2
SET 3
SET 4
South Slough Site
1.0 ± 0.5 cm/yr
Stillaguamish River
1.1 ± 0.3 cm/yr
Hat Slough Site
SET 5
SET 16
SET 13
SET 11
SET 20
SET 7
SET 8
Reference Site
0.9 ± 0.2 cm/yr
SET 9
SET 10
N
500 0 500 1,000
Meters
Levee (to be removed)
SET Locations
The Nature Conservancy
Protecting nature. Preserving life.
Sources: Google Earth 2009 Air Photo | 1983 UTM Zone 10 | June 2011 | Cartographer: Kate von Krusenstiern

Maximizing System Resilience

- Measure and monitor current conditions (models too).
- Maximize opportunities for sediment delivery and trapping (open the system to pulsing).
- If connected, protect. If disconnected, connect.
- Allow for upslope migration.