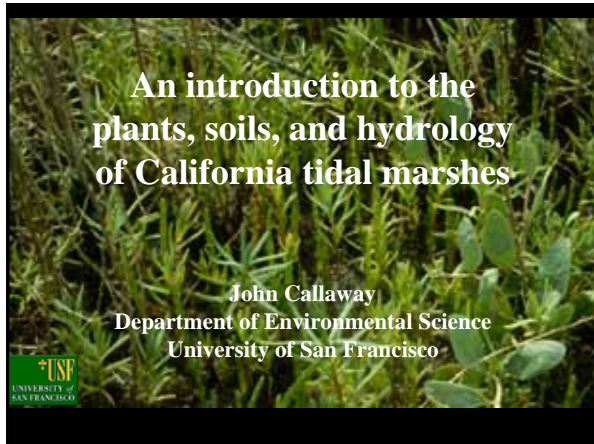


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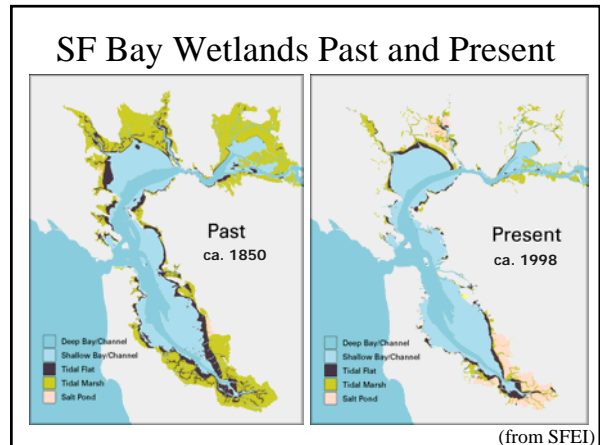
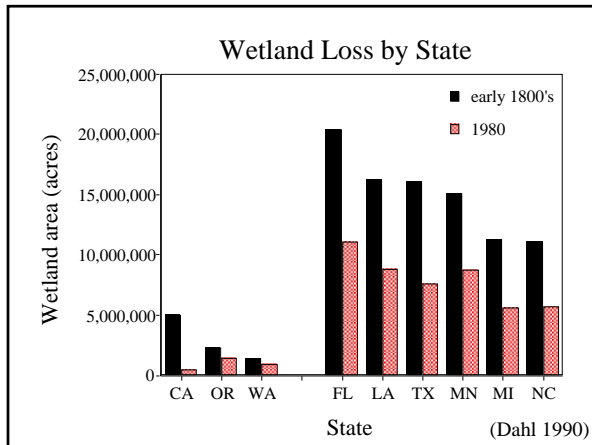
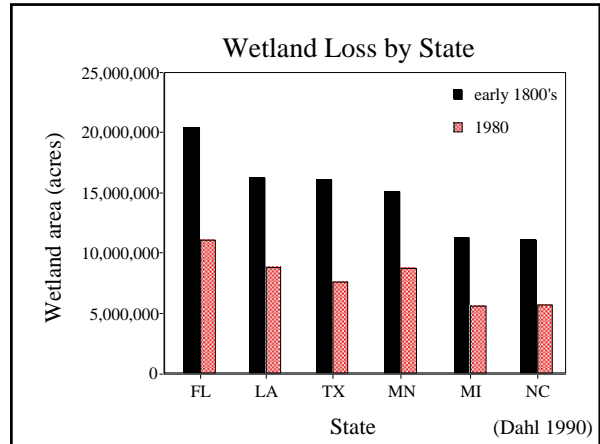
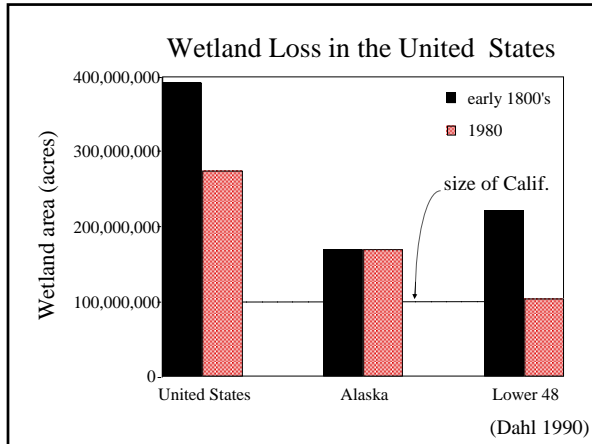


What's happened to California's wetlands?

What percentage of California's wetlands have been lost?

- a. 10 %
- b. 50 %
- c. 75 %
- d. 90 %
- e. 99 %

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- ## A Quick Introduction to Tidal Marshes
- Hydrology
 - tides
 - freshwater inputs
 - Soils
 - lack of oxygen
 - salinity
 - Vegetation
 - spatial patterns of distribution on a variety of scales
 - adaptations
 - common species

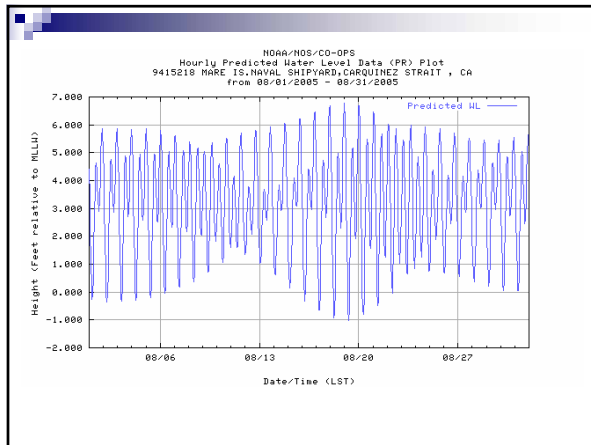
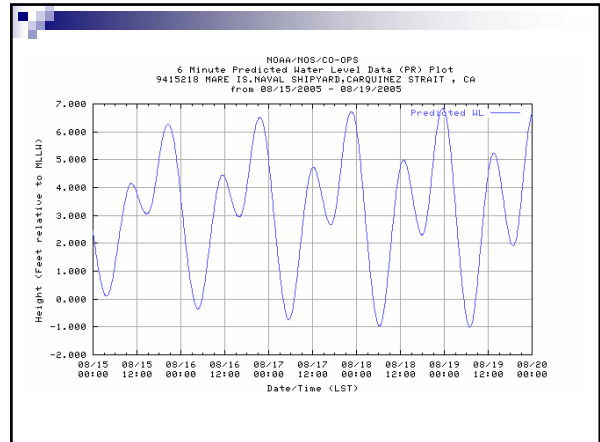
- ## Understanding Tidal Marsh Hydrology
- Hydroperiod
 - frequency of inundation
 - duration of inundation
 - depth of inundation
 - Critical hydrological factors
 - tides
 - freshwater inputs

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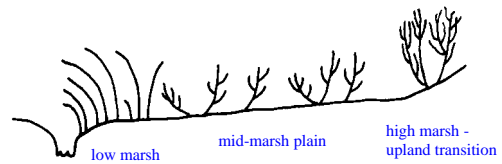
Tides

- Mixed, semi-diurnal tides on Pacific Coast
 - two highs and lows each day
 - different heights
- Elevation relative to the tides determines inundation regime
- Other coasts have different tidal patterns



Tidal Variation across the Marsh

regularly inundated → rarely inundated



Importance of Tidal Creeks




- deliver water, sediment and nutrients to marsh
- flush salts from soils
- more important in salt marshes than in brackish and freshwater marshes

Freshwater Inputs

- Large-scale variation up the estuary
- Similar patterns up larger drainages
- Finer-scale pattern within a marsh, and associated with any local freshwater inputs
- VERY DIFFERENT than other US tidal marshes (mediterranean climate)

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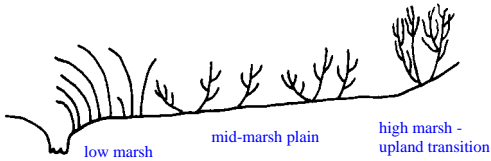
Spatial Variation in FW Inputs



- greatest input from Delta
- significant local inputs at many local rivers/creeks, including:
 - Napa R.
 - Petaluma R.
 - Alameda Creek
 - Coyote Creek

Salinity Variation across Salt and Brackish Marshes

more regular salinity —————> more variable salinity
(higher in summer and lower in winter)



low marsh mid-marsh plain high marsh - upland transition

Tidal Marsh Soils: Key Characteristics

- Fine texture (lots of clay and silt)
- Poorly drained
 - low oxygen levels (often no oxygen in soil)
 - low redox status
- High organic content
- Moderate pH
- Unusual biogeochemistry (anaerobic conditions)

Tidal Marsh Soil Biogeochemistry

- Driven by anaerobic processes
- Mix of aerobic and anaerobic zones in the soil
- Sequence of oxidation-reduction reactions
 - O_2 , NO_3^- , Mn^{4+} , Fe^{3+} , SO_4^{2-} , CO_2 (oxidized forms)
 - H_2O , N_2 , Mn^{2+} , Fe^{2+} , S^{2-} , CH_4 (reduced forms)
- Unusual nutrient dynamics
 - especially nitrogen

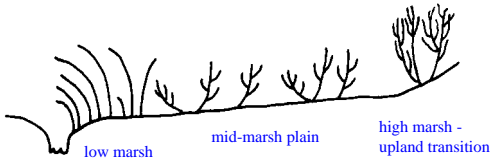
Tidal Marsh Soils

- Varying patterns across the marsh:
 - saturation/inundation
 - salinity
- Seasonal patterns as well, especially salinity

Spatial Variation in Soil Factors

lower soil oxygen —————> higher soil oxygen

less variable salt —————> more variable salt



low marsh mid-marsh plain high marsh - upland transition

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Plants: Key Factors Affecting Distribution

- Inundation (anaerobiosis, oxidation/reduction)
- Salinity (both summer stress and winter/spring lows for germination)
- Nutrients
- Competition
- History

Spatial and Temporal Variability

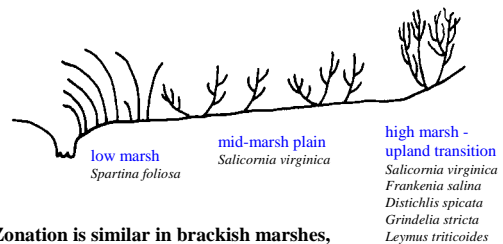
- Spatial scales of variability
 - estuarine-wide scale
 - drainage scale
 - within wetland scale
- Temporal scales of variability
 - climate change
 - inter-annual variation
 - seasonal changes (recruitment)

Tidal Marsh Plant Distributions

- Salt Marsh
- Brackish Marsh
- Freshwater Marsh

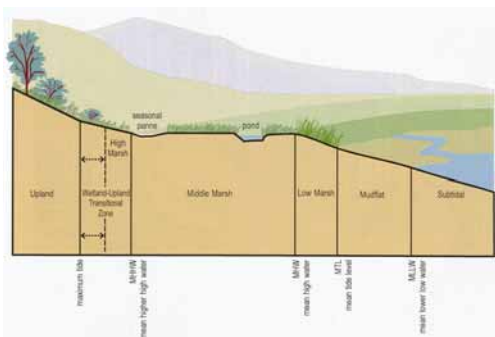
- Remember transitional-upland species!!

Simplified Salt Marsh Plant Zonation



Zonation is similar in brackish marshes, but less obvious, and even less obvious in freshwater marshes.

Plant Zonation

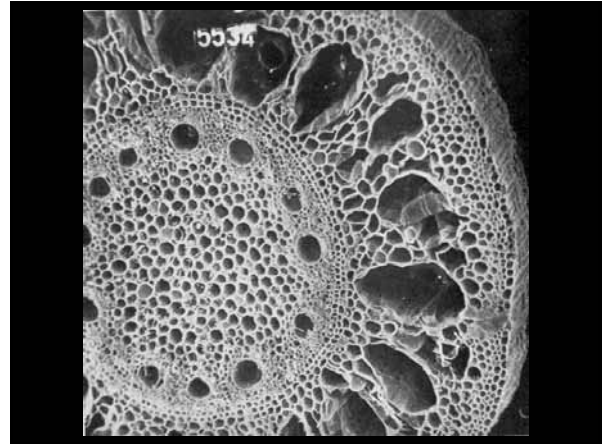
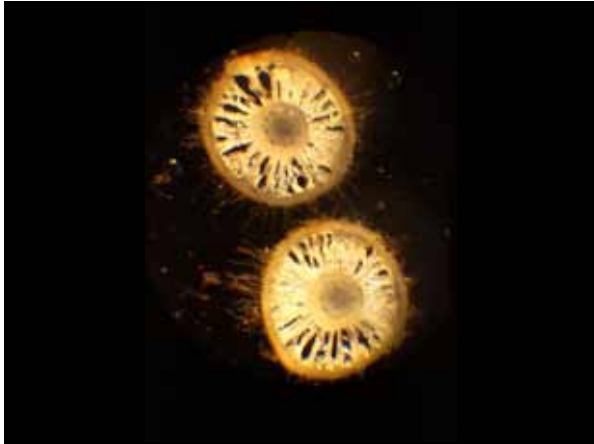


(PWA and Faber 2005)

Plant Adaptations

- Anaerobiosis
 - physical adaptations
 - aerenchyma and adventitious roots
 - physiological adaptations
- Salinity
 - secrete salt
 - other physiological adaptations

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- ### Salt Marsh Plants
- *Spartina foliosa* (cordgrass)
 - *Salicornia virginica* (pickleweed)
 - *Jaumea carnosa* (jaumea)
 - *Distichlis spicata* (saltgrass)
 - *Frankenia salina* (alkali heath)
 - *Cuscuta salina* (salt marsh dodder)
 - *Atriplex triangularis* (spearscale, fat-hen)
 - *Triglochin maritima* (seaside arrow-grass)
 - *Limonium californicum* (salt marsh rosemary, sea lavender)
 - *Grindelia stricta* (gumplant)
 - *Leymus triticoides* (creeping wildrye)

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Brackish Marsh Plants

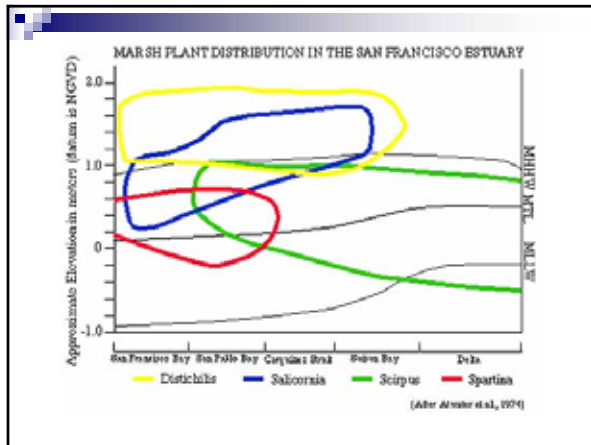
- *Scirpus maritimus* (NOW: *Bolboschoenus maritimus*)
- *Scirpus californicus* (NOW: *Schoenoplectus californicus*) (Calif. tule)
- *Scirpus acutus* (NOW: *Schoenoplectus acutus*) (hardstem bulrush, tule)
- *Scirpus americanus* (NOW: *Schoenoplectus americanus*)
- *Typha angustifolia* (narrowleaf cattail)
- *Typha latifolia* (broadleaf cattail)
- *Juncus* spp. (rush)
- *Salicornia virginica*
- *Distichlis spicata*
- *Jaumea carnosa*
- *Atriplex triangularis*
- *Baccharis pilularis* (coyote brush)
- *Rosa californica* (California rose)



Freshwater Marsh Plants

- *Typha angustifolia*
- *Typha latifolia*
- *Scirpus acutus*
- *Scirpus californicus*
- *Juncus* spp.
- *Polygonum* spp.
- *Sagittaria* spp.
- *Rubus* spp.
- *Salix* spp.
- *Lilaeopsis masonii*
- *Mimulus guttatus*
- *Lycopus americanus*
- *Calystegia sepium*
- AND MANY OTHER SPECIES!!

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Rare Tidal Marsh Plants

- *Cordylanthus maritimus* subsp. *palustris*
- *Cordylanthus mollis* subsp. *mollis*
- *Cirsium hydrophilum*
- *Aster lentus*
- *Lathyrus jepsonii* var. *jepsonii*
- *Lilaeopsis masonii*
- AND MORE...

Non-Native Tidal Marsh Plants

- *Spartina alterniflora* (and hybrids with *S. foliosa*)
- *Lepidium latifolium* (peppergrass)
- *Eichhornia crassipes* (water hyacinth)
- *Cotula coronopifolia* (brass buttons)
- *Polypogon monspeliensis* (rabbit's-foot grass)
- *Rumex crispus* (curly dock)
- *Phragmites australis* (common reed)
- AND MORE...

Plant Summary

- Mix of physical and biological factors that affect plant distributions, including inundation and salinity
- Diversity is reduced with higher salinity
- Diversity is higher in the upper marsh
- Creeks have strong role in salt marsh plant distribution, not so prominent in brackish and freshwater tidal marshes
- Upper marsh-transitional areas have many rare species, as well as many non-native invasives

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Acknowledgments

- CalPhotos: Plants (for photos)
<http://elib.cs.berkeley.edu/photos/flora/>
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on SF Bay wetland restoration)
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