Restoration Challenges: Regional Effects of Tidal Marsh Restoration

Suisun Marsh Science Workshop
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DWR
Four Topics:

1. Restoration effect on scalar dispersion
2. Restoration effect on tidal range
3. Modeling examples
4. Tidal marsh restoration: good, bad, both?
Take home’s

Tidal marsh restoration:
• Changes marsh “geometry”
• Affects tidal propagation over a wide area, in turn affecting:
  – Current motions
  – Tidal range
  – Scalar dispersion

Process understanding is the key to restoration success.
“Scalar dispersion”

*Tidal mixing of the “stuff” in the water*

- Scalars include:
  - Salinity
  - Sediment
  - Contaminants
  - Carbon
  - Biota
Forces that cause dispersion

• Tides
  • Meteorology
  • Coastal ocean conditions
  • Density gradients
  • Earth rotation
Tides cause tidal scalar dispersion through:

- Sheared flow
- Tidal trapping
- Tidal pumping
Restoration and dispersion

Tides cause tidal scalar dispersion through:

• Sheared flow
• Tidal trapping
• Tidal pumping

These change when we change geometry
1. Shear Flow Dispersion

Shear

Time = 0
1. Shear Flow Dispersion

Shear

Time $> 0$
1. Shear Flow Dispersion

Turbulence

Time > 0
1. Shear Flow Dispersion

Salinity Gradient

Fresher

Saltier

Stage

Flow

Flood

Ebb
1. Shear Flow Dispersion
1. Shear Flow Dispersion

Stage

Flow

Concentration Gradient
1. Shear Flow Dispersion
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Shear Flow Dispersion is Enhanced by:

- Sinuosity
- Bottom roughness
- Channel convergence
- Channel irregularities
2. Tidal Trapping

- Differential tidal propagation in geometric irregularities
Channel Flow

Stage

Breach Flow

Ebb

Flood

Flood

Ebb

Breach Flow

Stage

Channel Flow
Tidal Trapping

- Timing of tidal stage and tidal flow:

![Graph showing tidal stage and flows](image-url)
Tidal Trapping

• Timing of tidal stage and tidal flow:
Shear Flow Dispersion + Tidal Trapping

Channel Flow

Breach Flow

Stage

Flood

Ebb

Flood

Ebb

Channel Flow

Breach Flow

Stage
Shear Flow Dispersion + Tidal Trapping
Shear Flow Dispersion + Tidal Trapping

Channel Flow

Stage

Breach Flow

Ebb

Flood

Shear Flow Dispersion + Tidal Trapping

Flood

Ebb

Breach Flow

Stage

Channel Flow
Shear Flow Dispersion + Tidal Trapping

Channel Flow

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Breach Flow

Stage

Channel Flow

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Shear Flow Dispersion + Tidal Trapping

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Breach Flow

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Channel Flow
Shear Flow Dispersion + Tidal Trapping
Shear Flow Dispersion + Tidal Trapping

- Ebb Channel Flow
- Stage Breach Flow
- Flood Flood
- Shear Flow Dispersion
- Tidal Trapping

- SSC
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Breach Flow
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Channel Flow
Shear Flow Dispersion + Tidal Trapping

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Shear Flow Dispersion + Tidal Trapping
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Breach Flow

Concentration Gradient

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Shear Flow Dispersion + Tidal Trapping

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Shear Flow Dispersion + Tidal Trapping

Concentration Gradient

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3. Tidal Pumping

- “Net” flow caused by tidal flow asymmetry
Flood flow enters as a “jet”
Tidal Pumping

Ebb flow exits like a sink ("potential flow")
Tidal Pumping causes an “exchange” of water masses: What goes in, doesn’t come out.
Dispersion response depends on
Dispersion response depends on Breach Location.
Dispersion response depends on

Breach Size and Depth
2. Restoration effect on tidal range

• Levee breaches dissipate tidal energy by imparting additional friction.
• Tidal range is generally reduced.
Tidal Range Reduction Due to Levee Breach

Chadbourne Slough Levee Breach at Sunrise Club (Ebb tide)

Sunrise Club Flooded

Sunrise Club
280 acres

Suisun Marsh
3. Modeling examples

Levee breach effect on regional salinity.

1. Sunrise Club levee failure
2. Blacklock restoration
Average of DSM1 and DSM2 Simulation of July 2000
Regional Salinity Impact of Blacklock Levee Breaches

Black Lock Elevations
August 2002
Regional Salinity Impact of Blacklock Levee Breaches

RMA 2/11 Model Simulation

Two, fifty foot levee breaches
Regional Salinity Impact of Blacklock Levee Breaches

Colors represent the **percentage change** in salinity form Blacklock levee breaches.
Regional Salinity Impact of Blacklock Levee Breaches

1-3% higher salinity

1-3% lower salinity
Regional Salinity Impact of Blacklock Levee Breaches

Nurse Slough mouth:
- Tidal prism increases ~ 230 acft
- Tidal range decreases ~ $\frac{3}{4}$ inch

Net Montezuma Sl flow increases ~ 12 cfs
4. TM Restoration: good, bad, both?

Change geometry:

• change hydrodynamics and dispersive transport characteristics
• Tidal restoration areas will produce and consume scalars--bad, good, both.
If TM restoration produces carbon:

- Good: generally more bioavailable, fuels estuarine food web.
- Bad: Contributes to THMFP, contaminant food web accumulation
- Both? (Potency vs. proximity-- transport is the key)
- Research: carbon production, quality, transport
If TM restoration produces fish:

- Good: if they’re predominantly native
- Bad: if they’re predominantly non-native.
- Both will be produced.
- Research: Does TM structure and function favor native fish?
If TM restoration reduces tidal range:

- Good: Takes pressure off levees
- Bad: Affects managed wetland drainage
- Both: Depends who you ask!
- Research: location and design determine energy dissipation potential
If TM restoration methylates mercury:

- Bad: concern for human and wildlife health
- “Good:” *if* CH$_3$Hg$^+$ production/reduction relatively less than present.
- Both: hopefully
- Research: Land use and spatial extent of oxic-anoxic transition in water or sediment.
- Research: exposure to what source water, with what phyto concentration, for how long.
Take home’s redux

Tidal marsh restoration:

• Changes marsh “geometry”
• Affects tidal propagation over a wide area
• Produces and consumes good stuff and bad stuff.
• *Process understanding is the key to restoration success.*
Thank you

- Aaron Miller
- Brad Tom
- Kate Le
- Victor Pacheco
- Steve Culberson
- Jon Burau
- John DeGeorge