Sediment conceptual model for San Francisco Bay

Katie McKnight, SFEI RMP Annual Meeting • Oct. 3, 2022

SFEI Project Team: Scott Dusterhoff, Alex Braud, Sam Shaw, Letitia Grenier, Melissa Foley, Jeremy Lowe, Lester McKee
Key considerations of sediment
Key considerations of sediment

**Baylands**
Tides transport and deposit sediment onto bayland habitats, resulting in vertical accretion of mudflats and marshes.
Key considerations of sediment

**Baylands**
Tides transport and deposit sediment onto bayland habitats, resulting in vertical accretion of mudflats and marshes.

**Contaminants**
Contaminants from urban runoff, wastewater discharge, and other sources stick to sediment particles and enter the Bay.
Key considerations of sediment

**Baylands**
Tides transport and deposit sediment onto bayland habitats, resulting in vertical accretion of mudflats and marshes

**Contaminants**
Contaminants from urban runoff, wastewater discharge, and other sources stick to sediment particles and enter the Bay

**Primary productivity**
Suspended sediment attenuates sunlight in the water column helping minimize algal growth and eutrophication
Key considerations of sediment

**Baylands**
Tides transport and deposit sediment onto bayland habitats, resulting in vertical accretion of mudflats and marshes.

**Contaminants**
Contaminants from urban runoff, wastewater discharge, and other sources stick to sediment particles and enter the Bay.

**Primary productivity**
Suspended sediment attenuates sunlight in the water column helping minimize algal growth and eutrophication.
What is meant by “sediment conceptual model”?
An abstraction of how sediment moves around at different scales within the Bay to organize existing information and highlight key knowledge gaps.
An abstracion of how sediment moves around at different scales within the Bay to organize existing information and highlight key knowledge gaps.
The need
The need

- **Synthesize current data**: sediment transport pathways and rates for current and future conditions

*Image credit: USFWS (CC BY 2.0)*
The need

- **Synthesize current data**: sediment transport pathways and rates for current and future conditions
- **Communication tool**: digestible conceptual model that focuses on magnitudes and uncertainties
The need

- **Synthesize current data**: sediment transport pathways and rates for current and future conditions
- **Communication tool**: digestible conceptual model that focuses on magnitudes and uncertainties
- **Clarify where to focus limited Bay RMP funds** to address questions regarding *sediment loading to the Bay* and *sediment delivery to marshes*
Objective

- Provide a conceptual-level, common understanding of dominant sediment processes for open Bay and tidal wetland planning
- Highlight key sediment process data gaps
Objective

● Provide a conceptual-level, common understanding of dominant sediment processes for open Bay and tidal wetland planning

● Highlight key sediment process data gaps

Funder

● Supplemental Environmental Project funds (Bay RMP)
Intended audience

- Bay sediment management community
- Bayland restoration practitioners
- RMP stakeholders and Bay water quality management community
Building on previous efforts

- Bay Sediment Budget: Sediment Accounting 101 (Schoellhamer et al. 2005)
- Conceptual model of sand transport in Bay (Barnard et al. 2013)
- Baylands Goals Update conceptual model (2015)
- Sediment transport at marsh edge (Lacy et al. 2019)
- USACE Regional Dredged Material Management Plan - Gaps Analysis
  - Will identify research priorities that support sediment placement decisions

- BCDC/SCC Sand Mining Studies Sand budget & transport analysis
  - Updating the contemporary sand (and silt/mud) budget at Bay and subembayment scales

- Bay RMP Watershed Dynamic Model
  - New tool for estimating sediment supply to marshes from adjacent watershed

- Bay RMP 2020 Sediment Monitoring & Modeling Strategy
  - Including more data sources and more overall data synthesis
Project Advisors

Technical Advisory Committee

- John Callaway (USF)
- Jessie Lacy (USGS)
- Dave Schoellhamer (USGS, emeritus)

Management Advisory Committee

- Tom Mumley (SFBRWQCB)
- Xavier Fernandez (SFBRWQCB)
- Christina Toms (SFBRWQCB)
- Brenda Goeden (BCDC)
- Jennifer Siu (EPA)
- Luisa Valiela (EPA)
- Tessa Beach (USACE)
- Julie Beagle (USACE)
Conceptualizing sediment at three scales
Conceptualizing sediment at three scales

1. Bay scale
Conceptualizing sediment at three scales

1. Bay scale
2. Subembayment scale
Conceptualizing sediment at three scales

1. Bay scale
2. Subembayment scale
3. Marsh-mudflat scale
The focus today

1. Bay scale

3. Marsh-mudflat scale
Bay-scale conceptual model

Methods & preliminary results
Methods: Bay-scale conceptual model

Compile existing Delta loading, tributary loading, and subembayment flux estimates

- Current and future conditions

Primary data sources:
- Ganju and Schoellhamer 2006
- McKee et al. 2013
- Delta Modeling Assoc 2015
- Schoellhamer et al. 2018
- Livsey et al. 2020
- Stern et al. 2020
- Anchor QEA 2021
- Dusterhoff et al. 2021
- Work et al. 2022 (in preparation)
Methods: Bay-scale conceptual model

Compile existing Delta loading, tributary loading, and subembayment flux estimates

- Current and future conditions

Categorize net fluxes by relative magnitude

- Current - seasonal flux (wet years, dry years)
- Future - annual flux (wetter future, drier future)

Primary data sources:
- Ganju and Schoellhamer 2006
- McKee et al. 2013
- Delta Modeling Assoc 2015
- Schoellhamer et al. 2018
- Livsey et al. 2020
- Stern et al. 2020
- Anchor QEA 2021
- Dusterhoff et al. 2021
- Work et al. 2022 (in preparation)
Methods: Bay-scale conceptual model

Compile existing Delta loading, tributary loading, and subembayment flux estimates

- Current and future conditions

Categorize net fluxes by relative magnitude

- Current - seasonal flux (wet years, dry years)
- Future - annual flux (wetter future, drier future)

Develop graphical depiction of net fluxes around the Bay by relative magnitude and relative uncertainty (i.e., data richness)

Primary data sources:
- Ganju and Schoellhamer 2006
- McKee et al. 2013
- Delta Modeling Assoc 2015
- Schoellhamer et al. 2018
- Livsey et al. 2020
- Stern et al. 2020
- Anchor QEA 2021
- Dusterhoff et al. 2021
- Work et al. 2022 (in preparation)
Bay scale: Current conditions (Avg. Net Flux)
Bay scale: Current conditions (Avg. Net Flux)
Bay scale: Current conditions (Avg. Net Flux) - Wet season

Wet year, Wet season

Dry year, Wet season
Bay scale: Current conditions (Avg. Net Flux) - *Dry Season*

**Wet year**, Dry season

**Dry year**, Dry season
High-level “take homes”

- Sediment delivery into and out of the Bay is much higher in Wet years
- Limited understanding of flux between subembayments and at Golden Gate due to lack of monitoring & modeling data
Bay scale: Future conditions (Avg. Net Annual Flux)

Wetter Future

Drier Future

- Subembayments & Golden Gate
- Local Tributaries & Delta

Data Richness:

- Low
- High

Mid Century
Late Century
Bay scale: Future conditions (Avg. Net Annual Flux)

High-level “take homes”

- Sediment delivery to North Bay could be much higher in Wetter future compared to Drier future
- No modeled prediction of future flux between subembayments and at Golden Gate
Marsh-mudflat scale conceptual model

Methods & preliminary results
Methods: Marsh-mudflat conceptual model

Illustrate general processes and pathways with a narrative description

- Relative differences based on geography and timescale
- Will be sparse due to limited data

Primary data sources:
- Takesue & Jaffe 2013
- Jones & Jaffe 2013
- Takekawa et al. 2013
- Lacy et al. 2015
- van der Wegen et al. 2016
- Lacy et al. 2018
- Allen et al. 2019
- Elmilady et al. 2019
- Stantec & SFEI 2019
- van der Wegen et al. 2019
- Lacy et al. 2020
Methods: Marsh-mudflat conceptual model

Illustrate general processes and pathways with a narrative description

- Relative differences based on geography and timescale
- Will be sparse due to limited data

Identify data gaps

- Emphasize high magnitude fluxes with the greatest uncertainty

Primary data sources:

- Takesue & Jaffe 2013
- Jones & Jaffe 2013
- Takekawa et al. 2013
- Lacy et al. 2015
- van der Wegen et al. 2016
- Lacy et al. 2018
- Allen et al. 2019
- Elmilady et al. 2019
- Stantec & SFEI 2019
- van der Wegen et al. 2019
- Lacy et al. 2020
Marsh - mudflat scale: Current conditions

- Marsh
- Bay sediment pool
- Mudflat
- Upland sediment sources

Development on baylands prohibits wetland migration with sea level rise
Marsh - mudflat scale: Current conditions

Levees prevent sediment deposition
Seasonal sediment loads from source watersheds
Development on baylands prohibits wetland migration with sea level rise
Marsh - mudflat scale: Current conditions

1a Seasonal sediment loads from source watersheds
1b Levees prevent sediment deposition

2a Restored salt ponds deposit tributary and tidal sediment through levee breaches
2b Fine sediment carried into the Bay
2c Some sediment from source tributaries deposits directly onto adjacent mudflats

Upland sediment sources
Development on baylands prohibits wetland migration with sea level rise
Marsh-mudflat scale:  Current conditions

Wind waves and currents deposit Bay sediment on mudflats (3a) and out into deep Bay (3b).

Levees prevent sediment deposition (1b).

Seasonal sediment loads from source watersheds (1a).

Restored salt ponds deposit tributary and tidal sediment through levee breaches (2a).

Some sediment from source tributaries deposits directly onto adjacent mudflats (2c).

Fine sediment carried into the Bay (2b).

Development on baylands prohibits wetland migration with sea level rise.
Marsh-mudflat scale: Current conditions

1a. Seasonal sediment loads from source watersheds
1b. Levees prevent sediment deposition
2a. Restored salt ponds deposit tributary and tidal sediment through levee breaches
2b. Fine sediment carried into the Bay
3a. Shoreline erosion transports sediment to mudflats and Bay sediment pool
3b. Wind waves and currents deposit Bay sediment on mudflats (3a) and out into deep Bay (3b)
4a. Sediment transported by tides and wind waves onto marsh plain
4b. Some sediment from source tributaries deposits directly onto adjacent mudflats
4c. Sediment deposited during tidal slough overtopping

Development on baylands prohibits wetland migration with sea level rise.
High-level “take homes”

- Sediment transport and deposition from watersheds onto bayland habitats is not linear

- Limited data for many of the processes described at the marsh-mudflat scale, which will be critical to fill to manage sediment under changing conditions
Marsh -scale variables affecting sediment transport:

- Elevation
- Levees/shoreline hardening
- Channel density/complexity
- Sediment supply/wave energy
- Vegetation density
- Concavity/convexity

It’s not so simple!

Pete Kauhanen
Next steps
Next steps

- Technical advisory committee and management advisory committee to **review final draft in November**
Next steps

● Technical advisory committee and management advisory committee to review final draft in November

● Report will be released
Next steps

- Technical advisory committee and management advisory committee to **review final draft in November**
- **Report will be released**
- **Use as a communication tool** towards a shared conceptual understanding of sediment magnitudes and uncertainties in SF Bay
Next steps

- Technical advisory committee and management advisory committee to **review final draft in November**
- **Report will be released**
- **Use as a communication tool** towards a shared conceptual understanding of sediment magnitudes and uncertainties in SF Bay
- **Use data gaps identified in the report to help make the best use of limited resources** to address questions regarding sediment flux and deposition in the Bay and sediment delivery to marshes
Thank you

Katie McKnight
San Francisco Estuary Institute
katiem@sfei.org

SFEI Project Team:
Scott Dusterhoff, Alex Braud, Sam Shaw, Letitia Grenier,
Melissa Foley, Jeremy Lowe, Lester McKee