

San Francisco Bay Sand Studies

Presentation to BCDC Committee July 12 2024

Presented by Independent Science Panel Members

(David Schoellhamer and Bob Battalio)

INDEPENDENT SCIENCE PANEL (ISP)

- Bob Battalio, PE, Environmental Science Associates (retired)
- Dr. Craig Jones, Integral Consulting
- Dr. John Largier, UC Davis at Bodega Marine Laboratory
- Dr. David Schoellhamer, US Geological Survey, Emeritus
- Dr. Paul Work, PE, US Geological Survey, Emeritus

List of Studies

- Sand Budget (SFEI; support from USGS and Deltares)
- Modeling (Anchor)
- Fingerprinting (UT et al; support from USGS)
- Supporting
 - (USGS): Delta sediment discharge; Sediment cores, Bathymetric change
 - (Deltares): Morphodynamic bedform interpretation; 'Ring Analysis' and 'SedTrails' analyses
- Summary Report (Independent Science Panel; ISP): Description of the studies including scoping and review, and summary interpretation of findings, data gaps and next steps)

Sand budget

MQ1: Is sand mining at existing lease areas, at permitted levels, having a measurable or demonstrable impact on sediment transport and supply within San Francisco Bay?

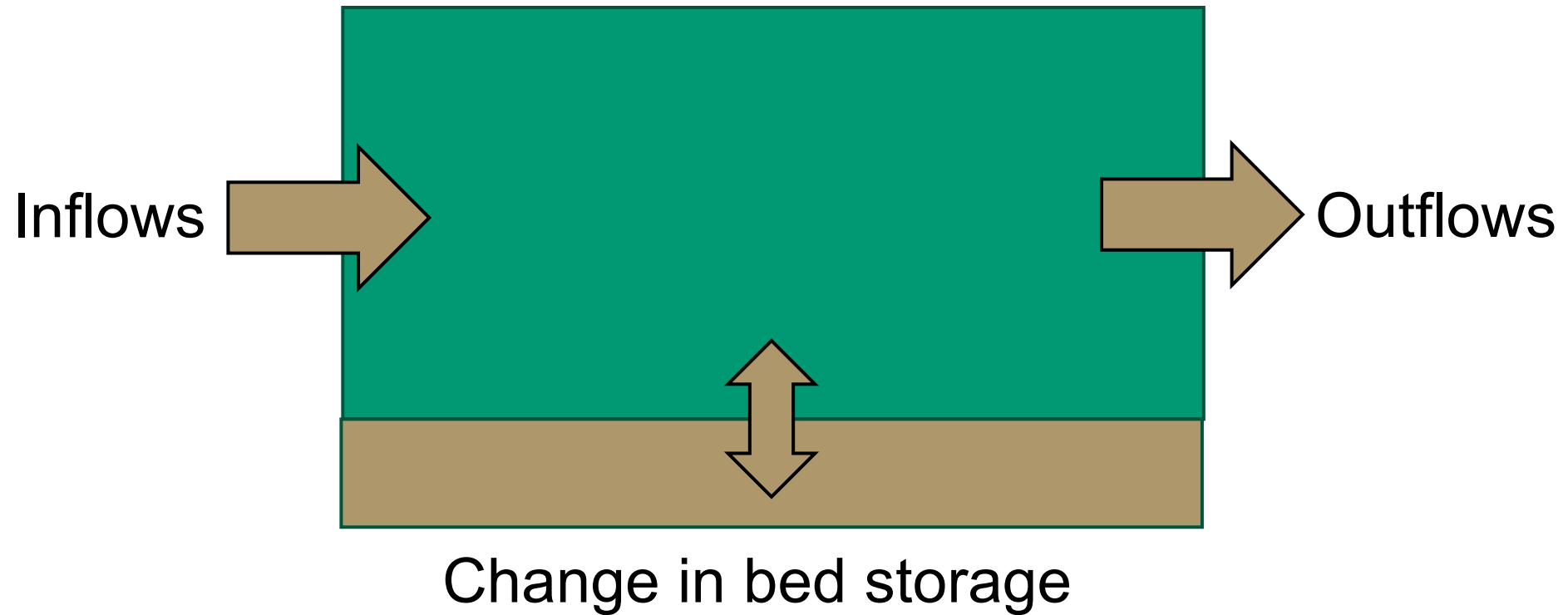


Research to Understand Impacts of Bay Sand Mining on Sand Transport in San Francisco Bay and the Outer Coast:

Sand Budget and Sand Transport in San Francisco Bay

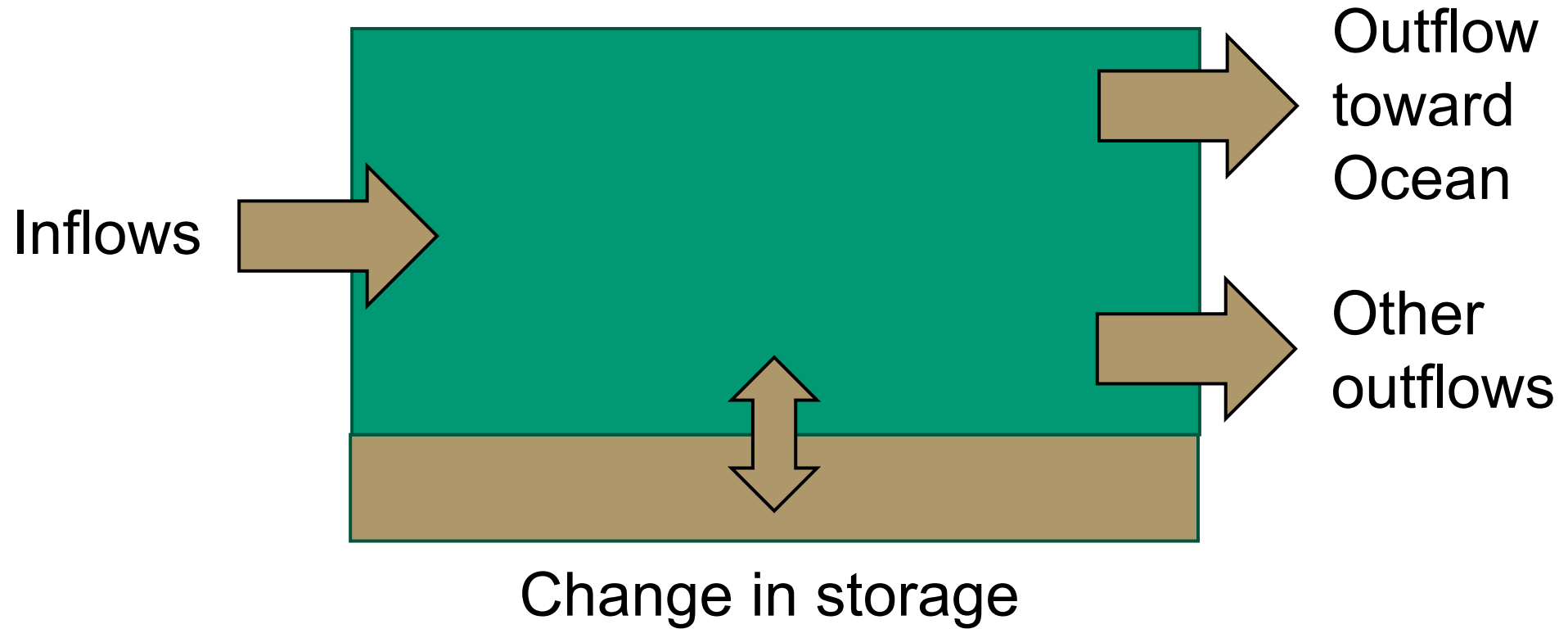
Lester McKee and others

Sand budget



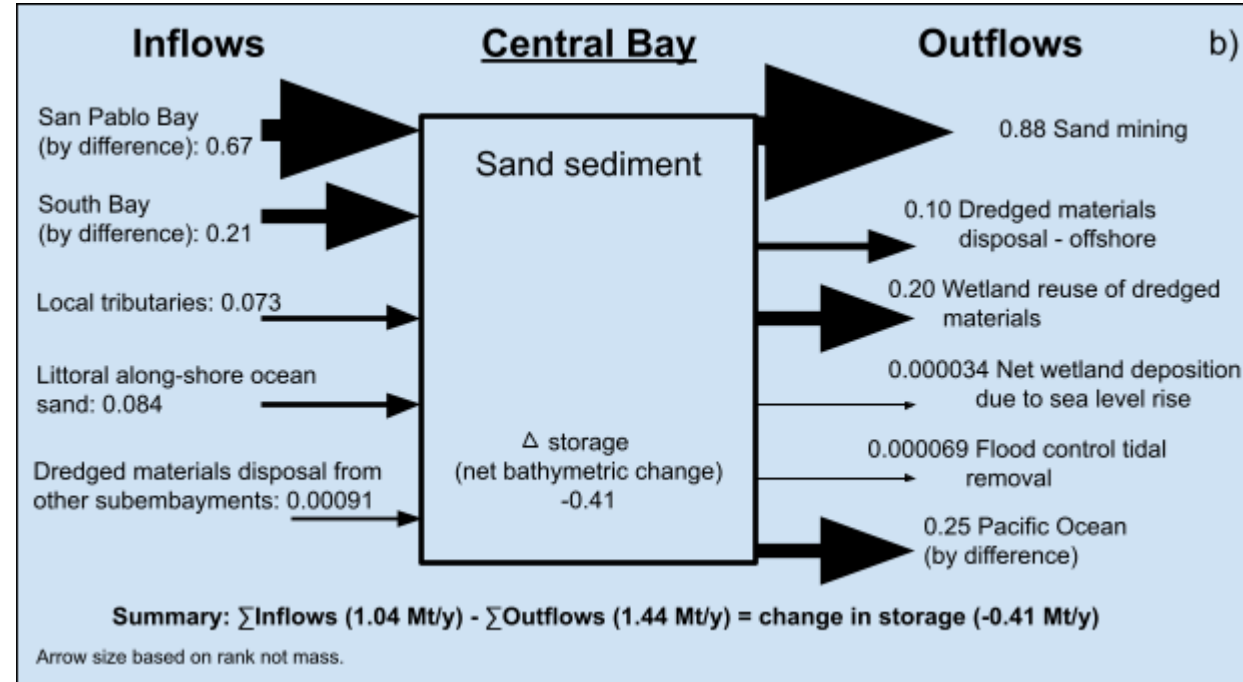
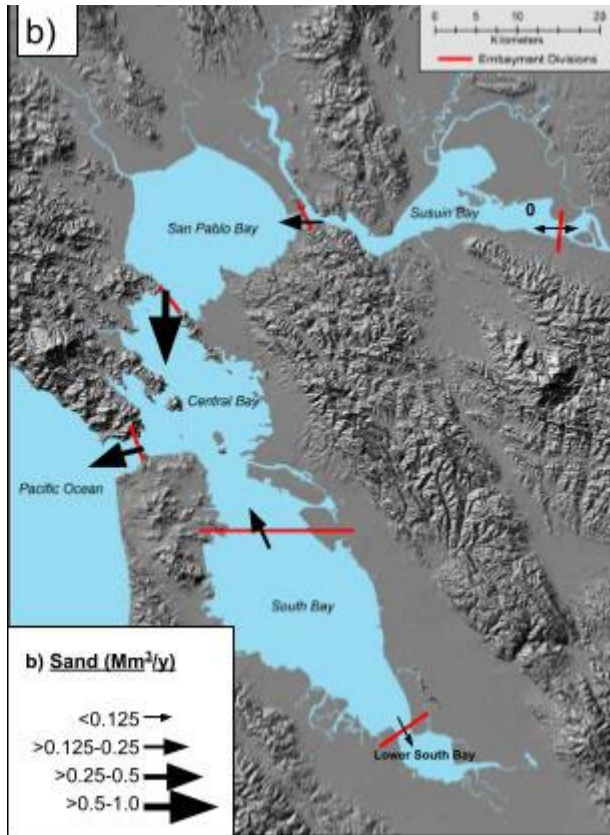
$$\text{Change in bed storage} = \text{Inflow} - \text{Outflow}$$

Sand budget



$$\text{Outflow toward Ocean} = \text{Inflows} - \text{Other outflows} - \text{Change in storage}$$

Sand budget: Highlights



- Sand mining large term: affects budget
- Sand transport at Golden Gate uncertain: 0.25 Mt/yr (~200,000 cy/yr)
OUT best estimate, range 0.66 IN to 1.1 OUT

Numerical modeling

MQ1: Is sand mining at existing lease areas, at permitted levels, having a measurable or demonstrable impact on sediment transport and supply within San Francisco Bay?

MQ2: What are the anticipated physical effects of sand mining at permitted levels on sand transport and supply within San Francisco Bay and the Outer Coast?

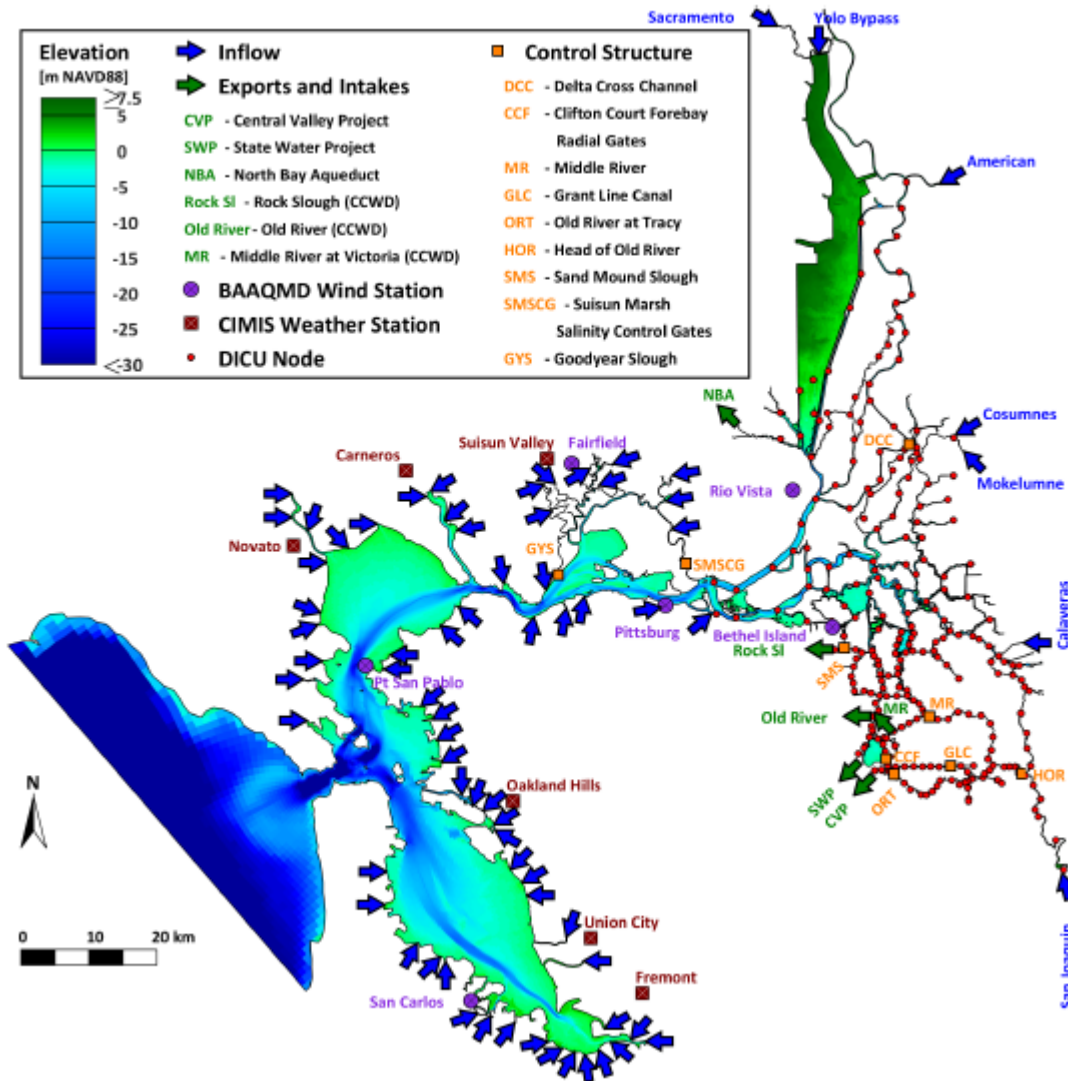
May 2023
San Francisco Bay Sand Mining Science Studies



Modeling Sand Transport and the Effect of Sand Mining in San Francisco Bay

Aaron Beever and others

Numerical modeling



- UNTRIM
- Three-dimensional, tides, wind waves, salinity, four sediment grain sizes, tributary inflow from SFEI,
- Calibrated to water level, salinity, and suspended sediment.
- Low and high flow years simulated with and without sand mining

Numerical modeling: Highlights

- Net sand transport at Golden Gate toward Ocean (~80,000 cy/yr, less than budget ~200,000 cy/yr)
- “over the 1-year time periods evaluated in this study, the effects of sand mining on the transport of sand through Suisun Bay were limited to the vicinity of the mining areas”
- “The total transport of sand out of the Golden Gate was predicted to decrease by 59% and 32% as a result of sand mining during the high-outflow and low-outflow years”

Fingerprinting Study Area

(aka Stratigraphy, Sand Provenance study)

Sediment characteristics:

Minerology → mountain source

Zircon → age → mountain source

Luminescence → age since 'daylighted'

Fingerprinting sand and its transport history through San Francisco Bay: Implications for sand mining and its environmental effects

Matthew A. Malkowski (UT-Austin)

Zachary T. Sickmann (UT-Dallas)

Bruce Jaffe (USGS)

Theresa Fregoso (USGS)

David Mohrig (UT-Austin)

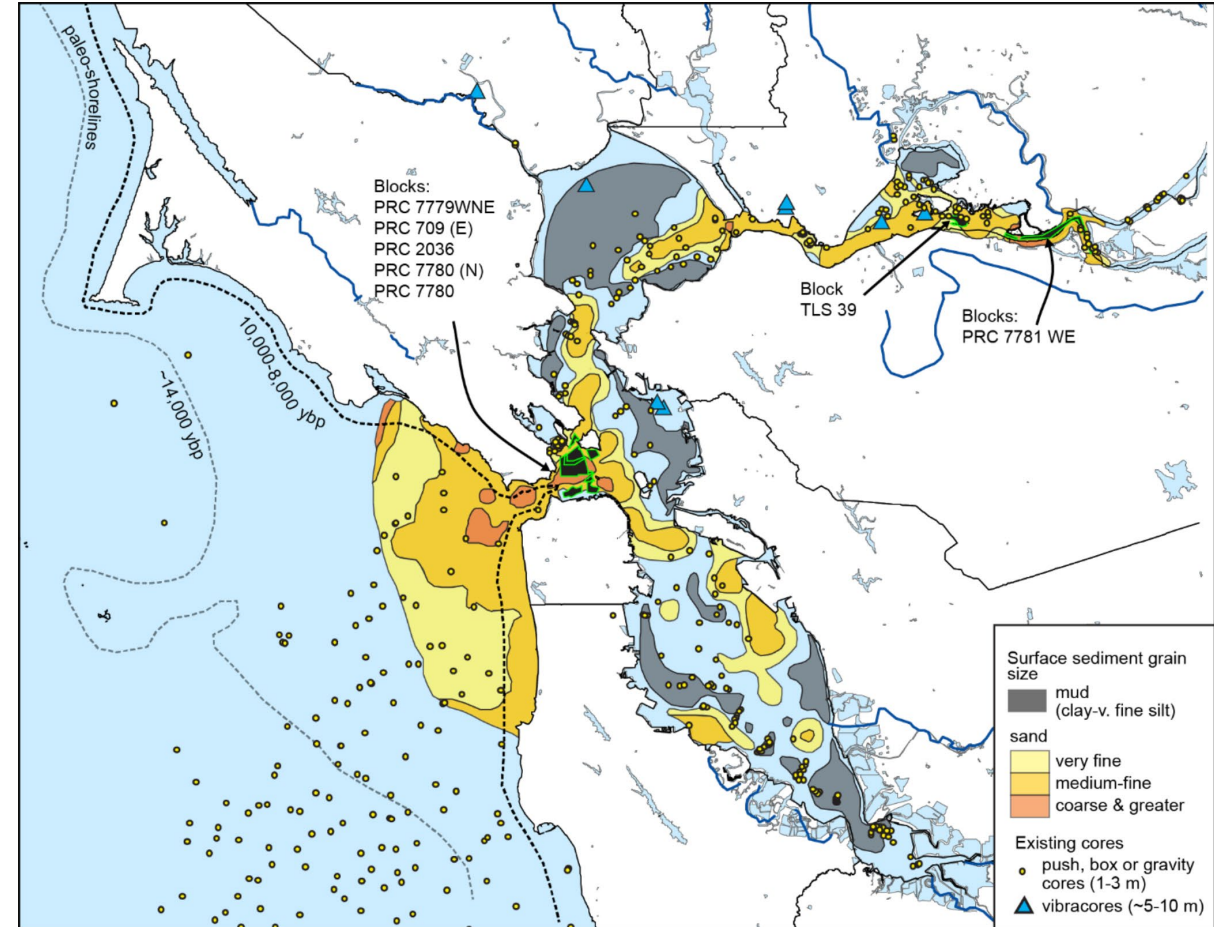


Figure 1. Overview map of the San Francisco Bay Area highlighting grain size distribution, sand mining lease blocks, and the locations of select cores collected since 1990. Dashed lines along coast delineate approximate extent of paleo-shorelines.

Source: Stratigraphy Proposal by Stanford, UT and USGS, 2021

Fingerprinting study

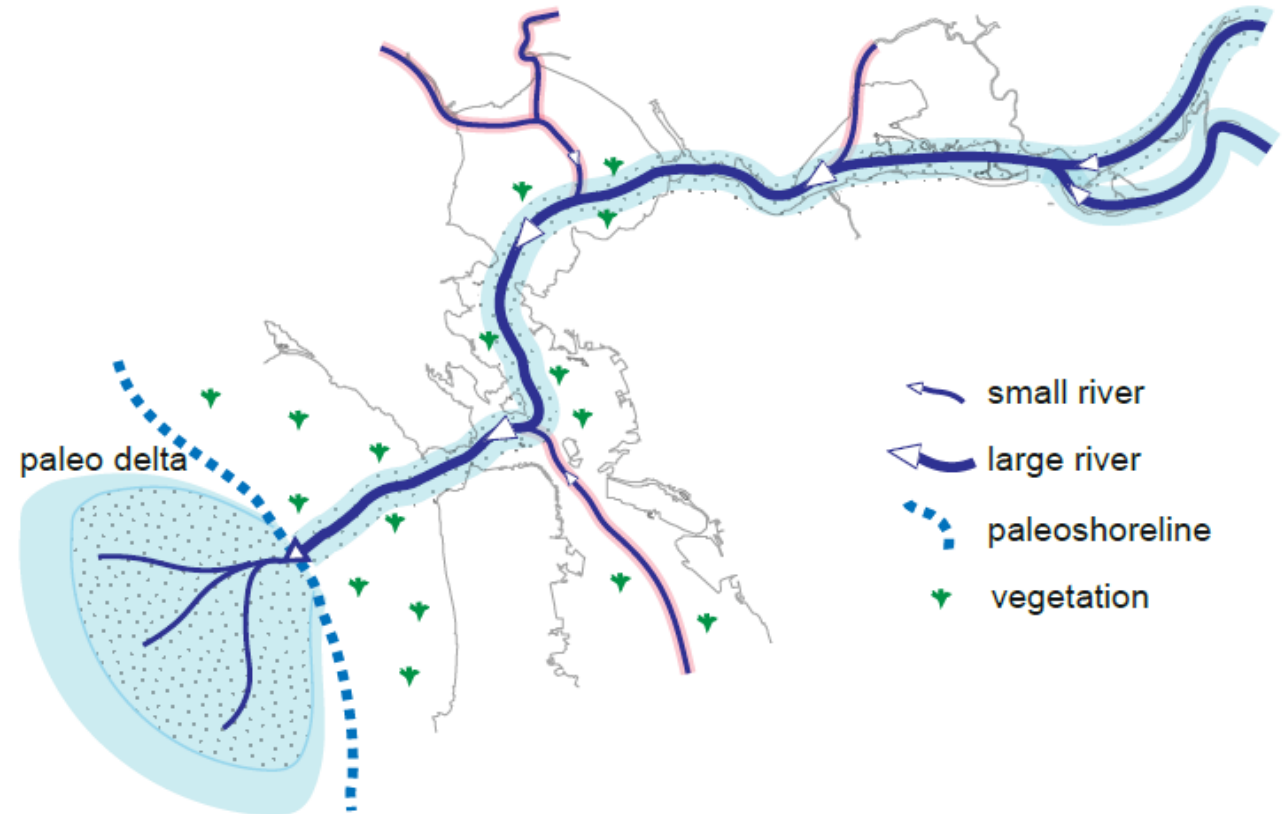
MQ Tier 2, 1b: What is the source of mined sand in the lease areas?

- Suisun Bay: Deposited from local Coast Range drainages.
- Central Bay: Eroded from outer (Pacific) coast, previously from Sierran Range and Coastal Range.

MQ Tier 2, 1b: Is it “relic” sand, or “new” sand transported into the system?

- Sand is relic
- Some sand is exposed to hydraulic forcing and is in transit
- Some sand is below the Bay floor and not in transit

Late Pleistocene - early Holocene sand routing

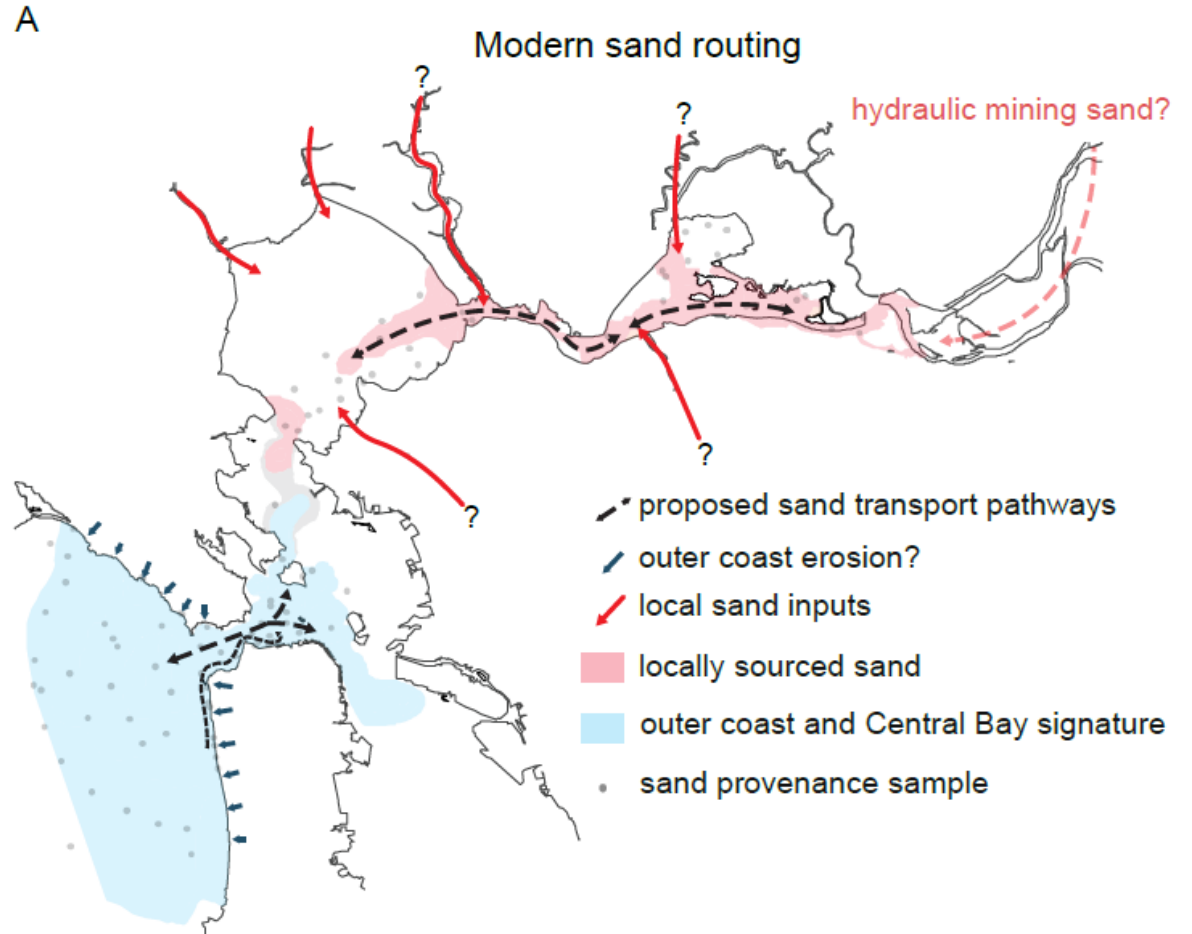


Source: Figure 14B

Fingerprinting study

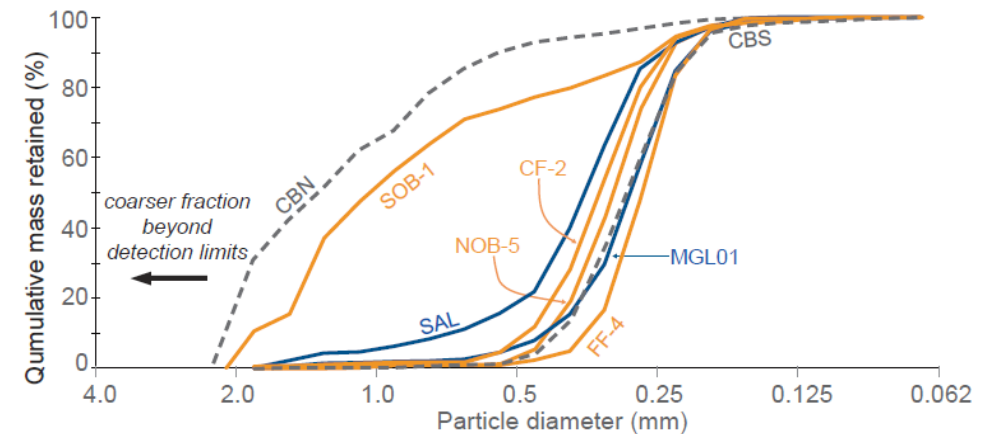
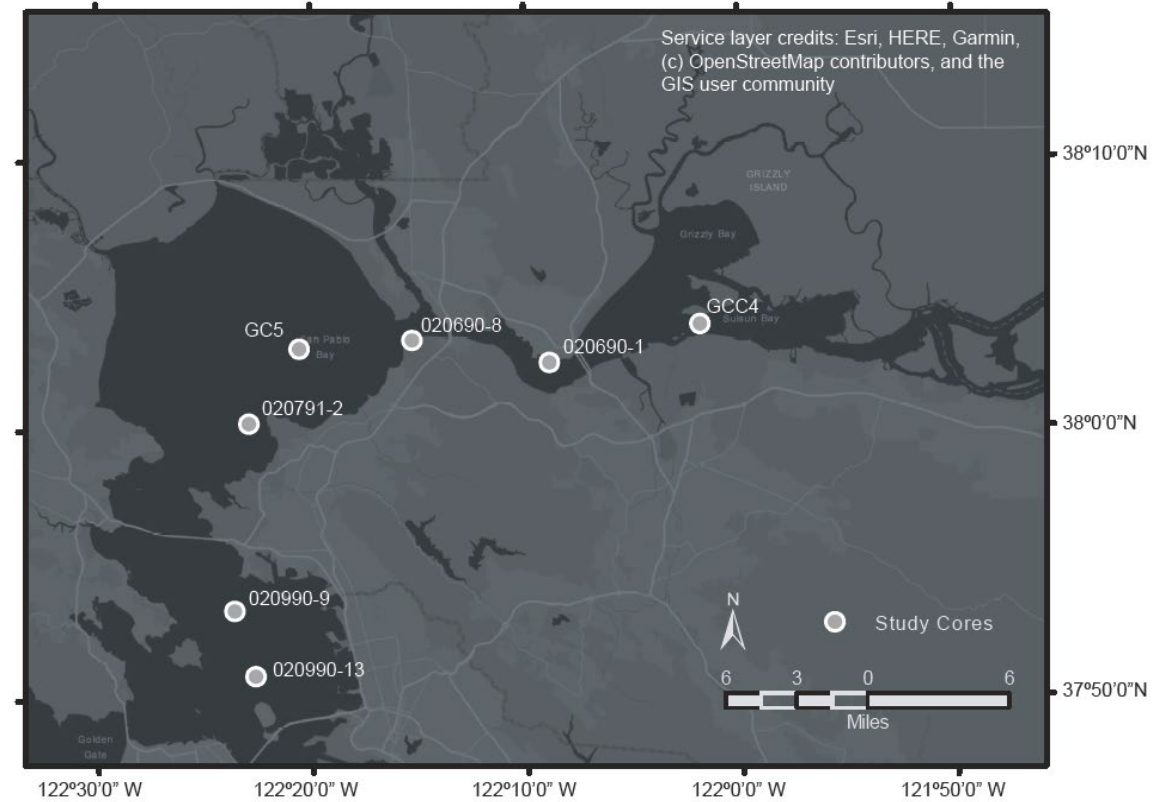
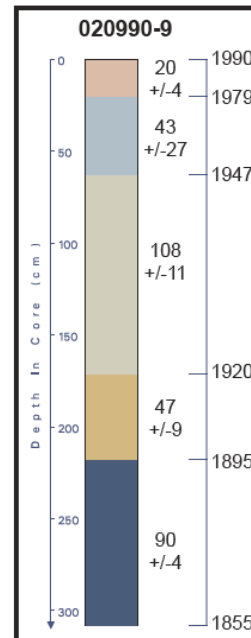
MQ Tier 2, 1e: Does mining in lease areas have the same effects on sand transport pathways? Should these areas be examined separately?

- Can be treated separately: Different sand sources and spatial connections (Figure 14A).
 - Suisun Bay – red: Local sources and transport between Suisun, San Pablo and north Central Bays
 - Central Bay – blue: Ocean source and transport exchange between Bay and Ocean tidal shoals, as well as adjacent beaches.



USGS Support

- Sediment transport boundary condition at east Suisun Bay
- Bathymetric change mapping and volume calculations for Sediment Budget Study
- Cores and analysis for Fingerprinting Study



Deltares - Morphodynamic interpretation

Central Bay sand transport driven by tidal exchange through Golden Gate with sand migrating between Bay mining areas (flood tide shoals) and the San Francisco Bar (ebb tide shoals) in the Pacific Ocean. Additional sand transport by waves along the shore and into Bay

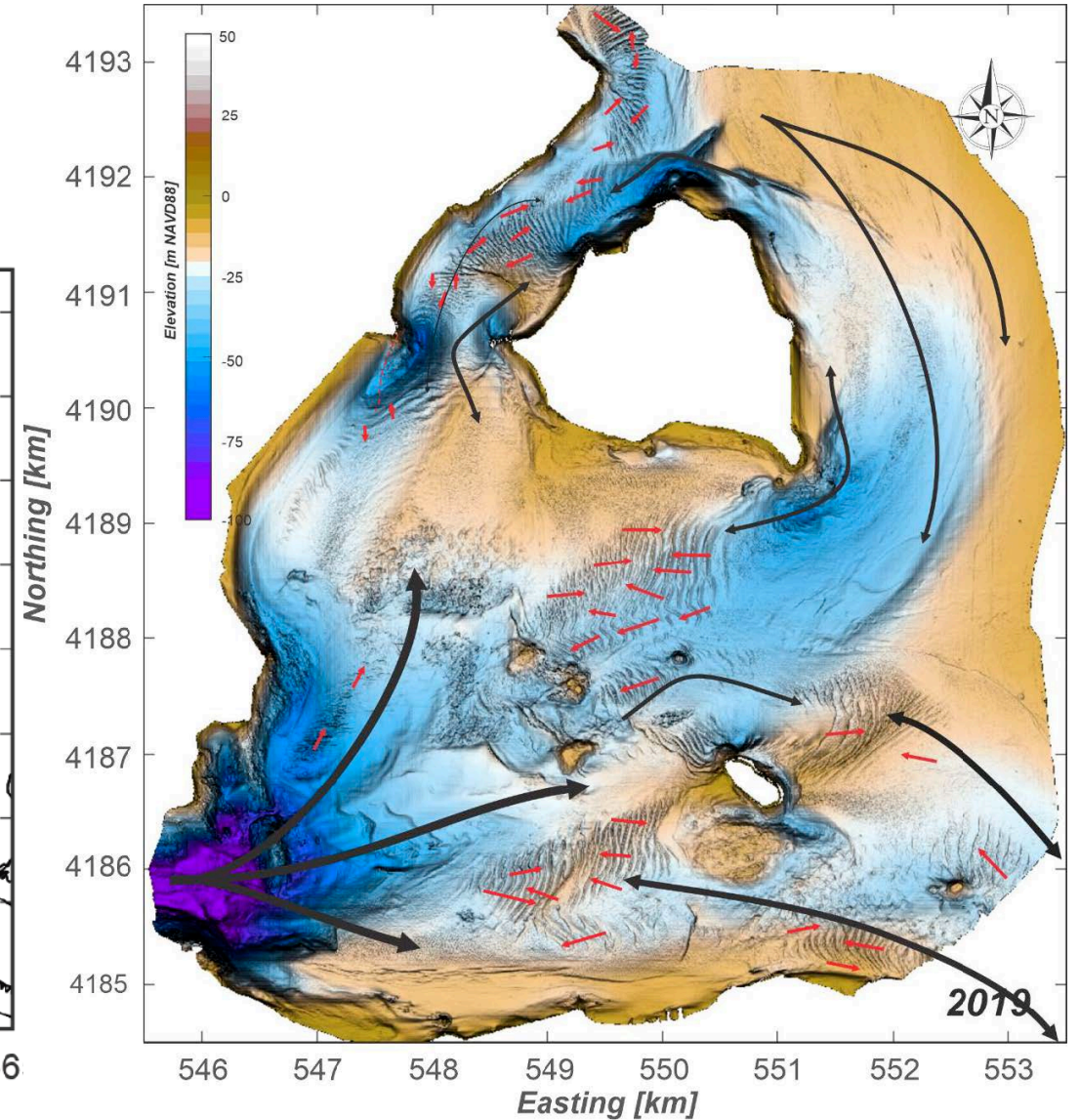
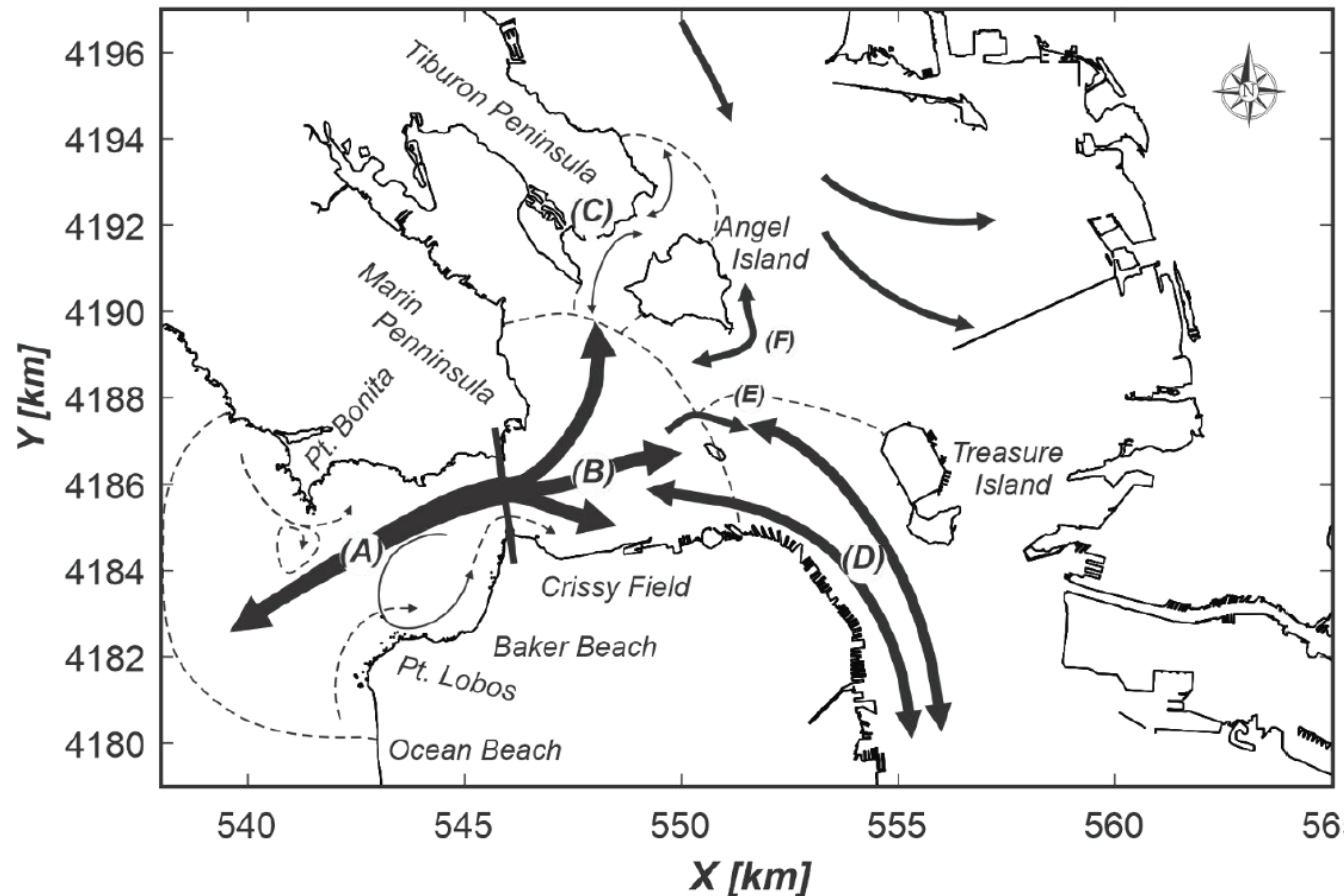


Figure 5-3: Conceptual depiction of the sediment transport patterns in Central Bay.

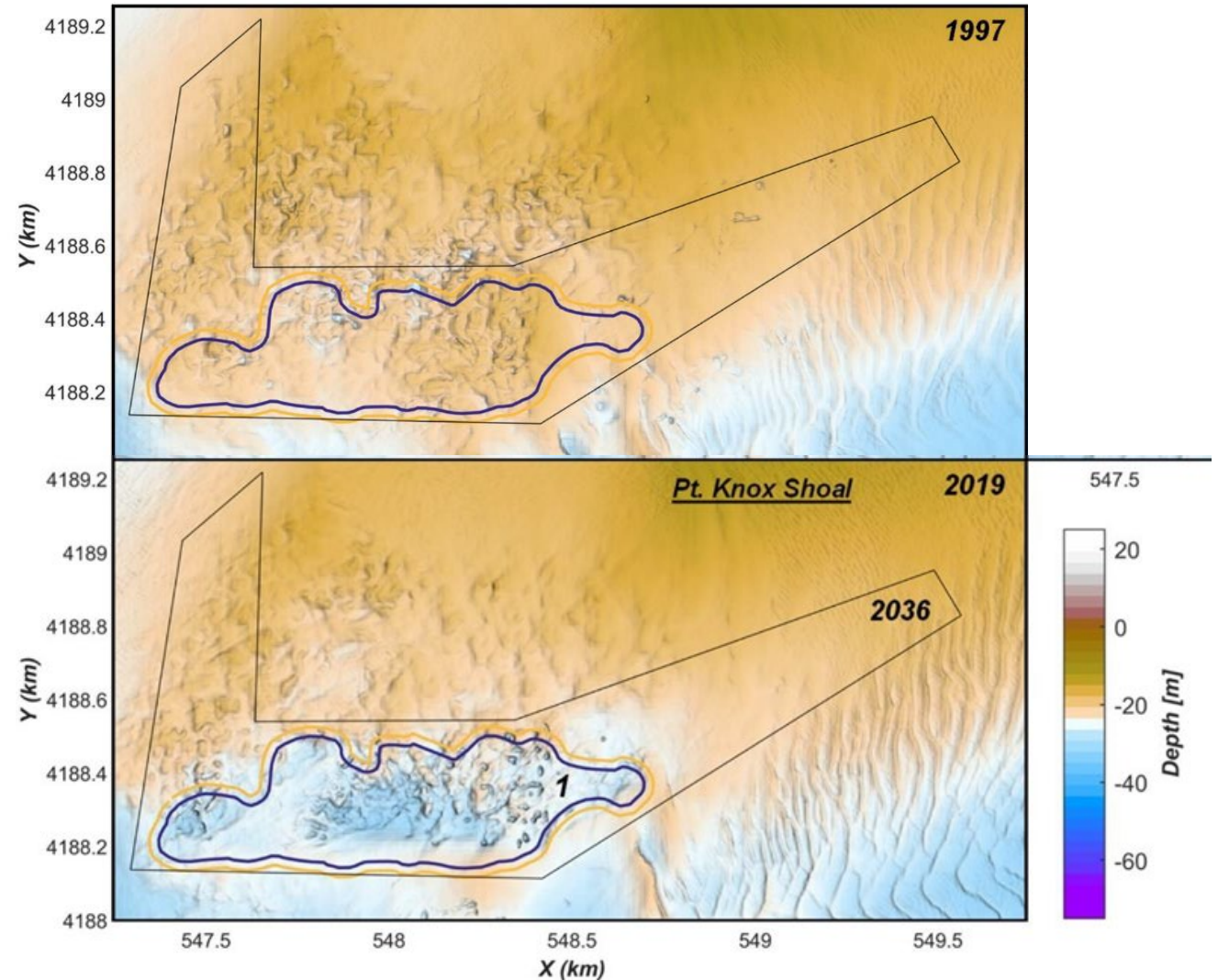
Deltares: Bed changes in Mining areas

Mining changes bed geometry, replacing natural bed forms (sand waves) with depressions and a lower bed – See Figure (tan is higher, blue is lower):

- Top, 1997
- Bottom, 2019

Diffusion (smoothing) of the bed depressions is limited within the time frame of the study

Infill of depressions is limited to less than 30% except for two central Bay areas (55% and 100%).



ISP Summary

1. Local Scale:

- Depressions, removal of sand waves and bed lowering where sand replenishment is low (Suisun Bay and north Central Bay mined areas 7779 West and 7780 North) (11% to 28% replenishment)
- Reduced sand transport where sand replenishment is high (south Central Bay mined areas 709 South) (91% to 351% replenishment)
- Central Bay site 2036 (55% replenishment)

2. Regional Scale

- Sand mining exceeds sand supply
- Mined sand is 'relic' (delivered to the Bay thousands of years ago).
- Suisun Bay and Central Bay lease areas can be analyzed separately due to apparent limited sand transport connection.
- Sand is exchanged between the Central Bay sand mining areas and sand shoals and beaches on the Pacific side of the Golden Gate. Exchange is driven primarily by the ebb and flood of the tides with contribution from wave-driven sand transport into the Bay along the shore.
- Erosion of beaches due to sand mining was not investigated.

ISP – data gaps

1. Exchange of sand between the Bay and Pacific Ocean
2. Sand supply to Bay beaches
3. Sand transport pathways
4. Variation of sand transport caused by grain size

Discussion

