Regional Sediment Management Science Workshop: Sediment in San Francisco Bay

Co-sponsored by BCDC and USGS
April 19-20, 2010 at USGS, Menlo Park, CA

Purpose

- **Discuss recent scientific results related to sediments and sediment processes in San Francisco Bay.**

- **Identify and prioritize key data gaps, and contribute knowledge and ideas toward formulation of a science strategy for sediment management in the San Francisco Bay Region.**

- **Review status of active research and research plans on sediment processes in San Francisco Bay.**

Dave Cacchione
CME and USGS Emeritus
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17 Science Presentations – 30 minutes each
2 Roundtable Panel Discussions – 1 hour each

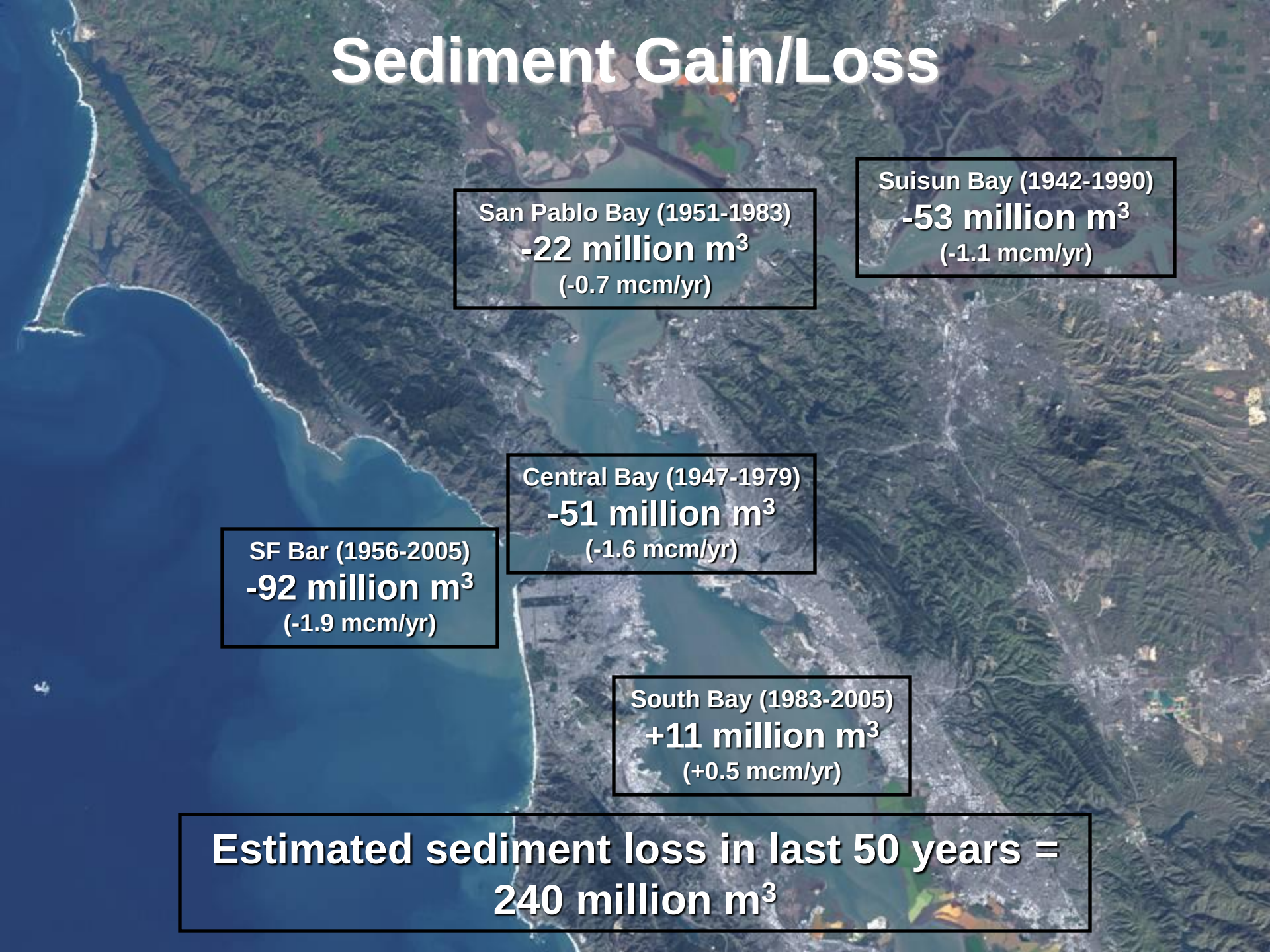
- **Historical Sedimentation and Watershed Inputs**
  (Bruce Jaffe; Sarah Pierce; Robin Grossinger; Laurel Collins; Peter Downs; Peter Baye)

- **Sediment Characteristics and Transport Measurements**
  (Dave Schoellhamer; Patrick Barnard; Steve Monismith; Jessie Lacy)

- **Numerical Modeling of Sediment Transport**
  (Michael MacWilliams; Edwin Elias & Li Erikson; Gary Brown & Megan Kaun; Yu-Ji Chou)

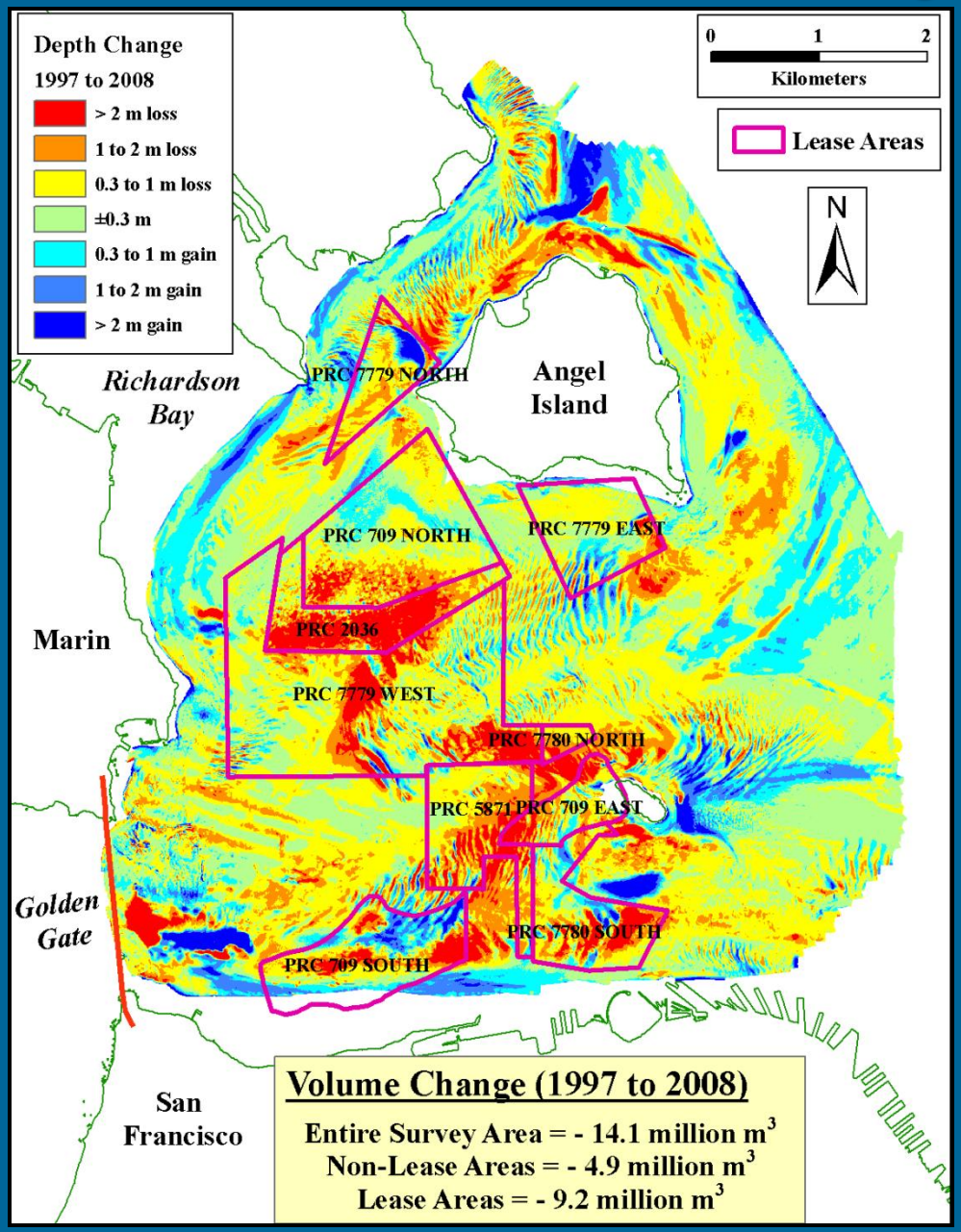
- **Wetland Sedimentation and Processes**
  (Josh Collins; John Calloway; Jeremy Lowe)

Sediment Gain/Loss

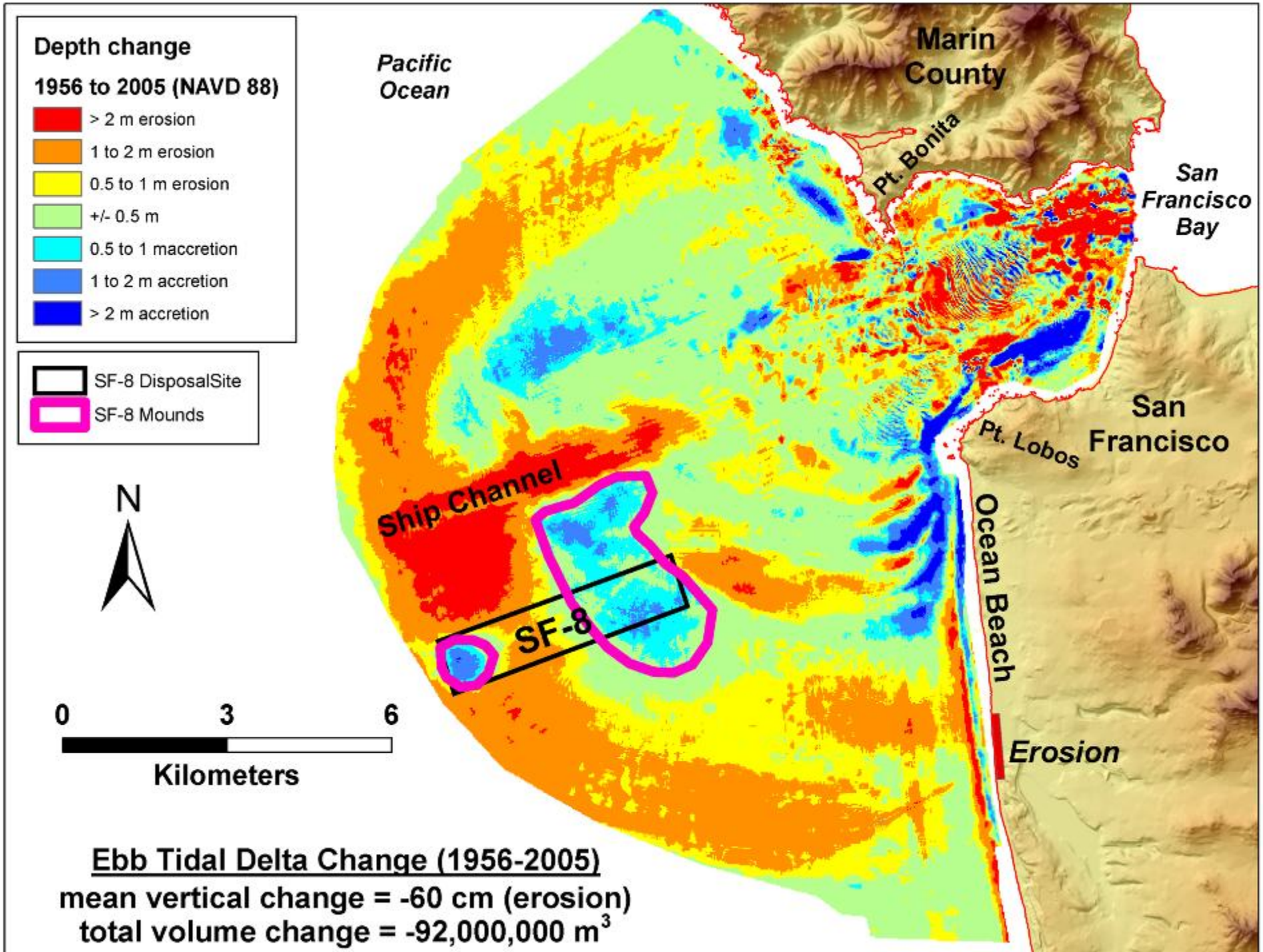


Estimated sediment loss in last 50 years = 240 million m^3

1997-2008 Bathymetric Change



- ~3-fold increase in rate of erosion (-3.2 cm/yr) from 1947-1979 change analysis (Fregoso et al., 2008)
- Lease sites lost sediment at a rate 5 times higher than rest of study area
- 10.8 million m^3 of sediment was removed by aggregate mining from 1997-2008
- No borrow pit mining or dredging was performed in this area from 1997-2008
- 85% of sediment removed was not naturally replenished



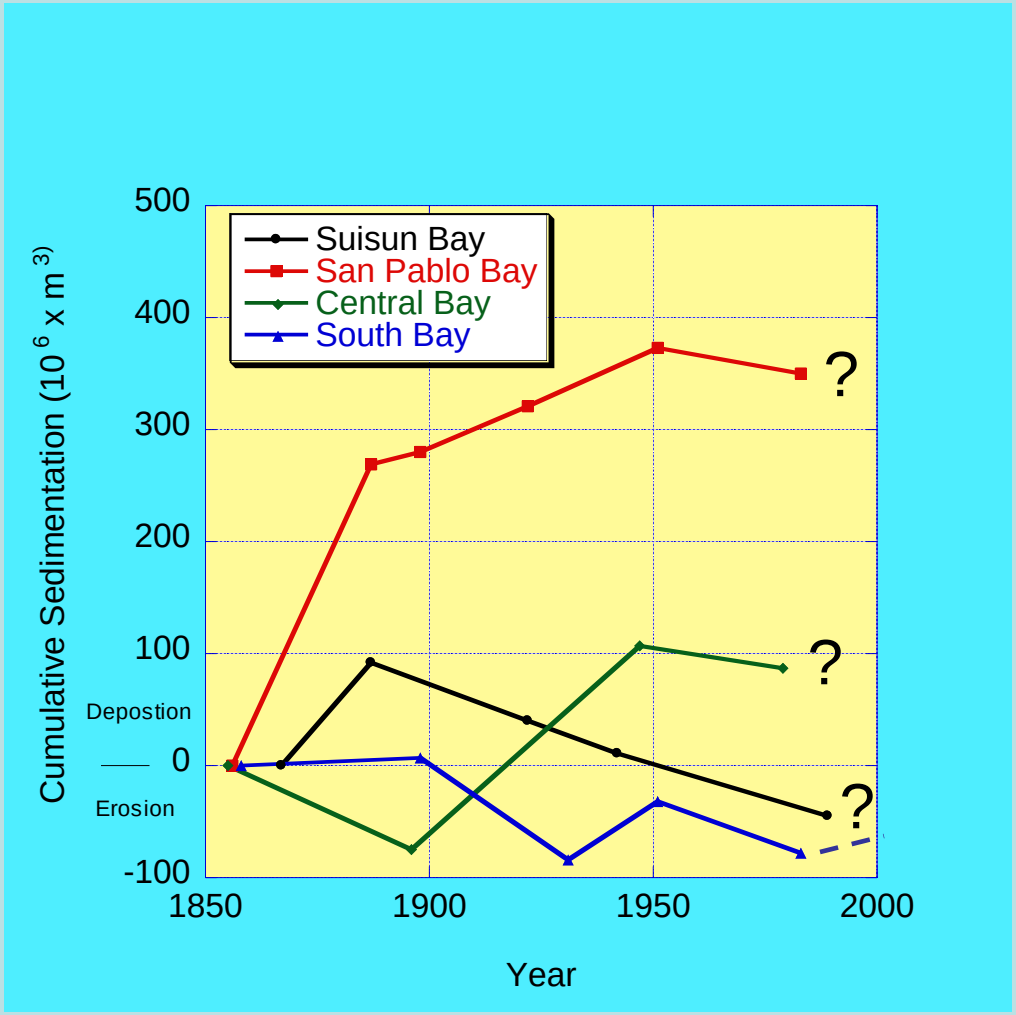
Ebb Tidal Delta Change (1956-2005)

mean vertical change = -60 cm (erosion)

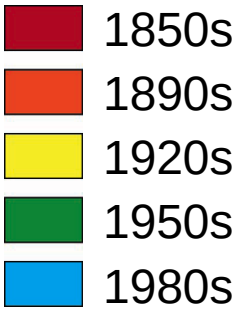
total volume change = -92,000,000 m^3

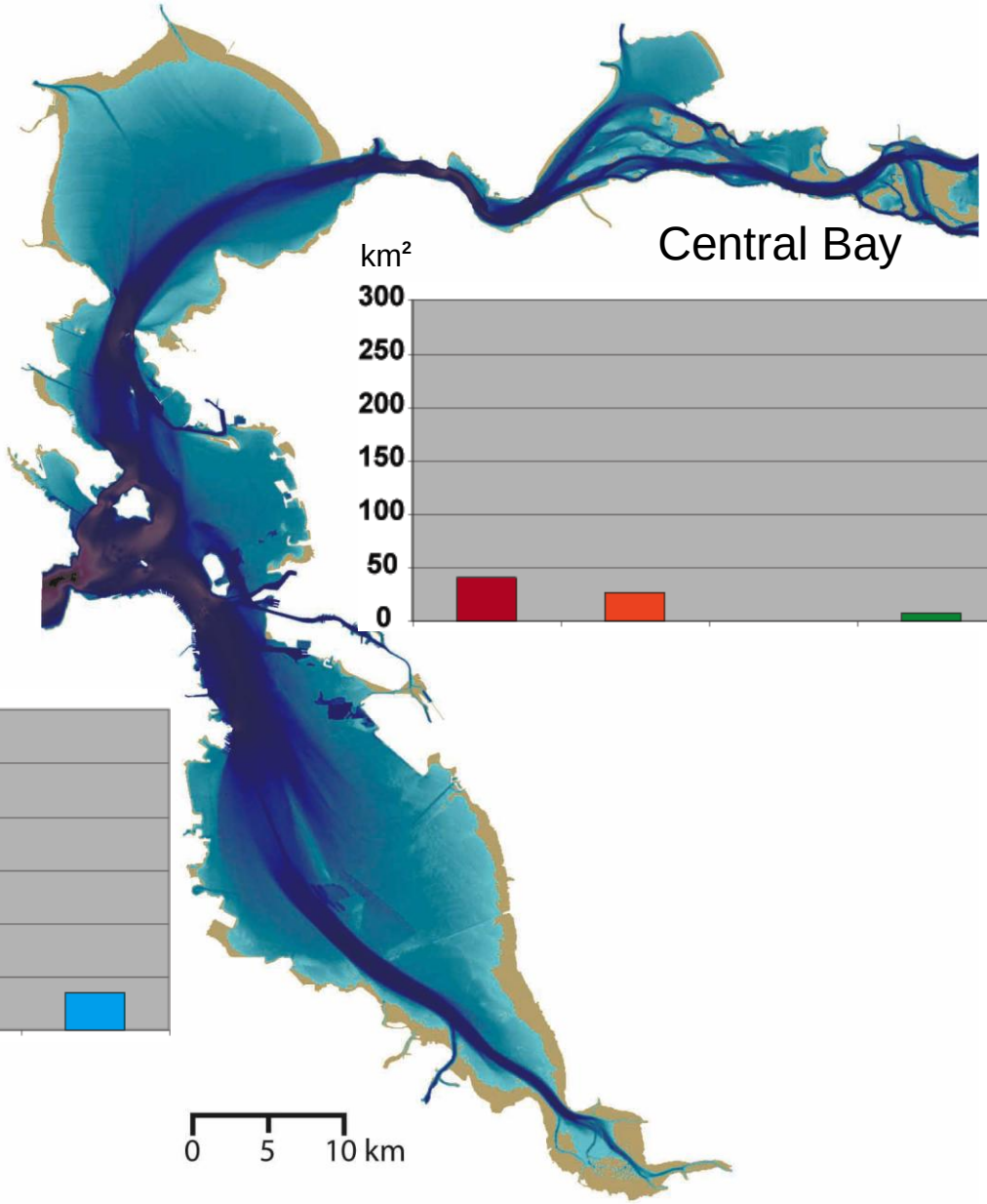
Will the various Bay regions continue to erode? What will the effects of Sea Level Rise be?

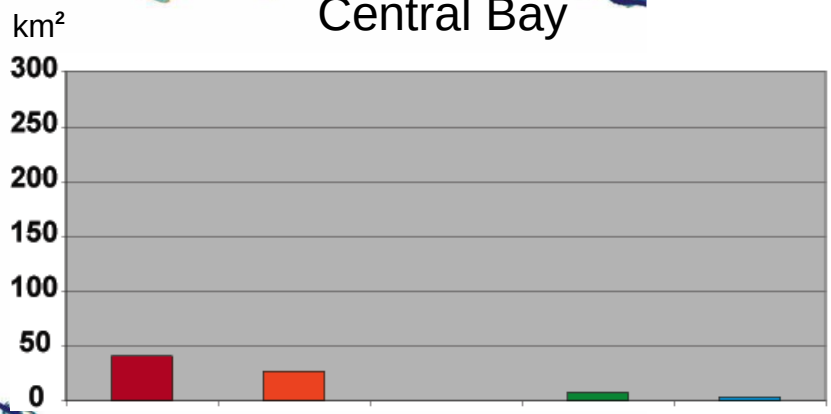
- South San Francisco Bay had net deposition from 1983 to 2005
- No data for other bays

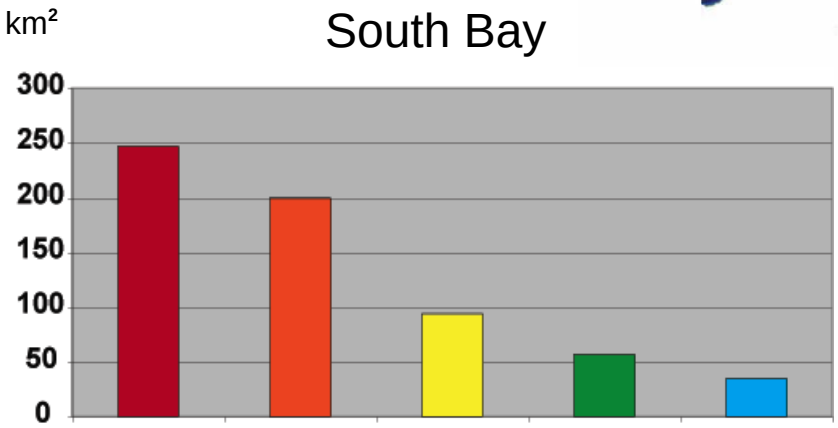


Marsh area decrease >90%

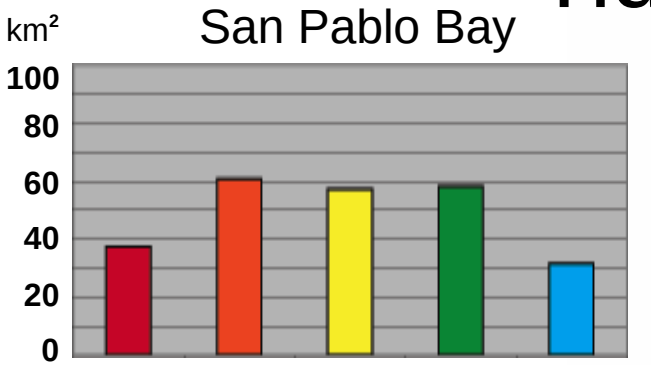


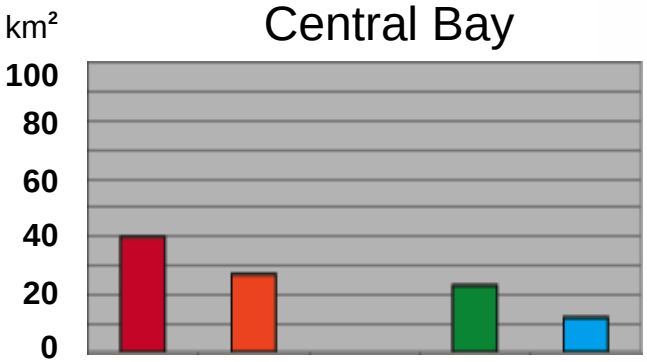


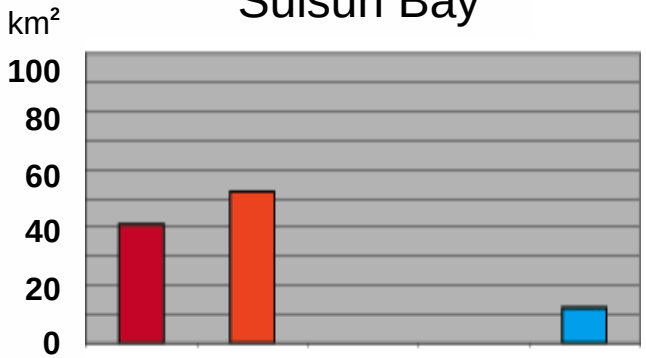


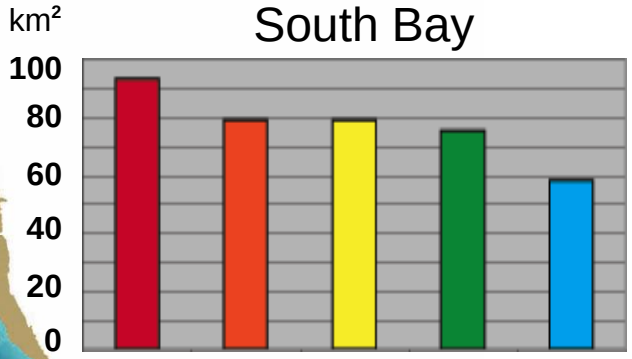


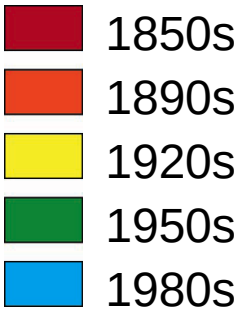
Tidal flat area decrease >50%

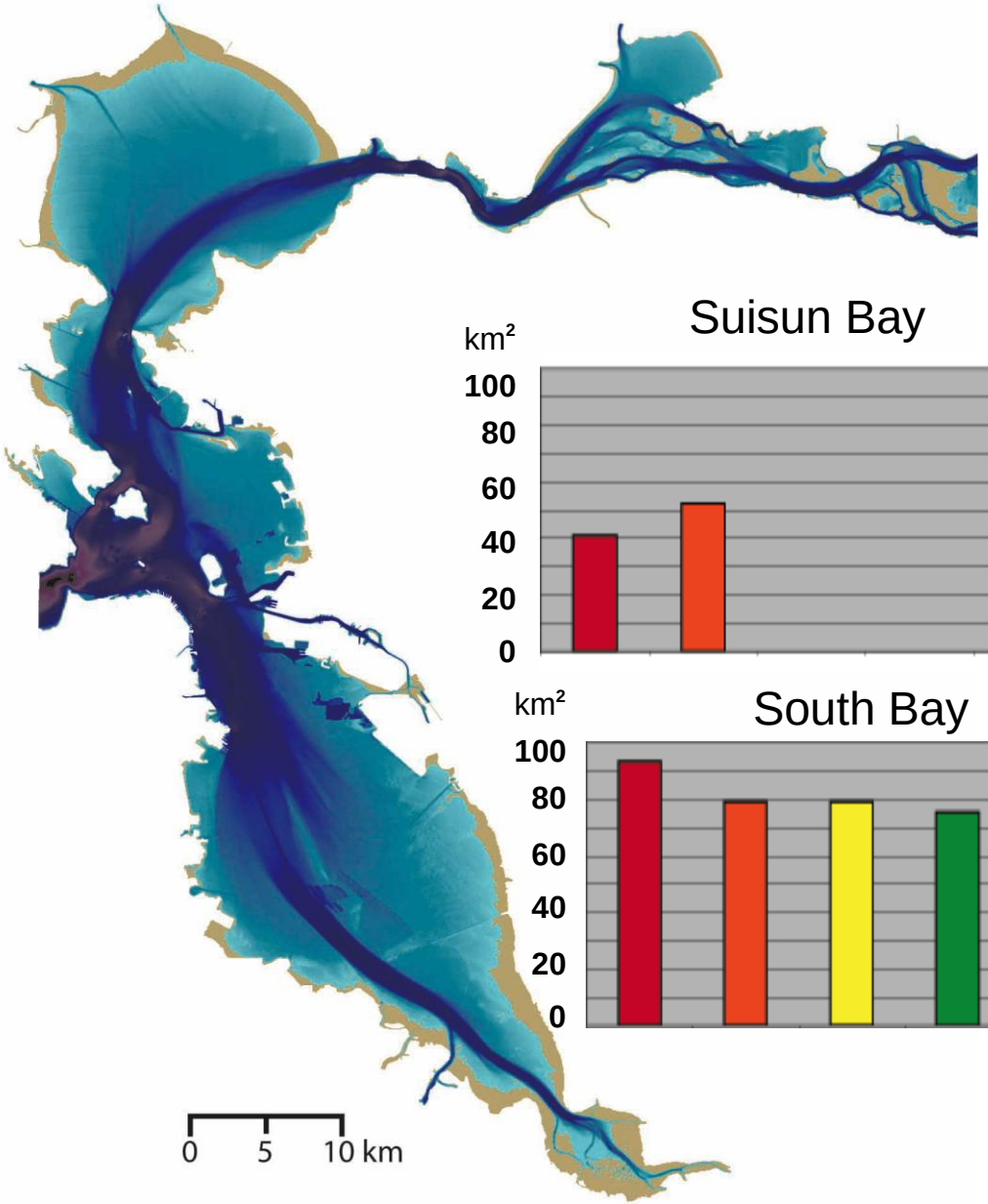












Sediment Input from Local Watersheds

- Estimated modern sediment input to SF Bay from local tributaries is > 50% (increased channel incision; loss of marshlands to development)

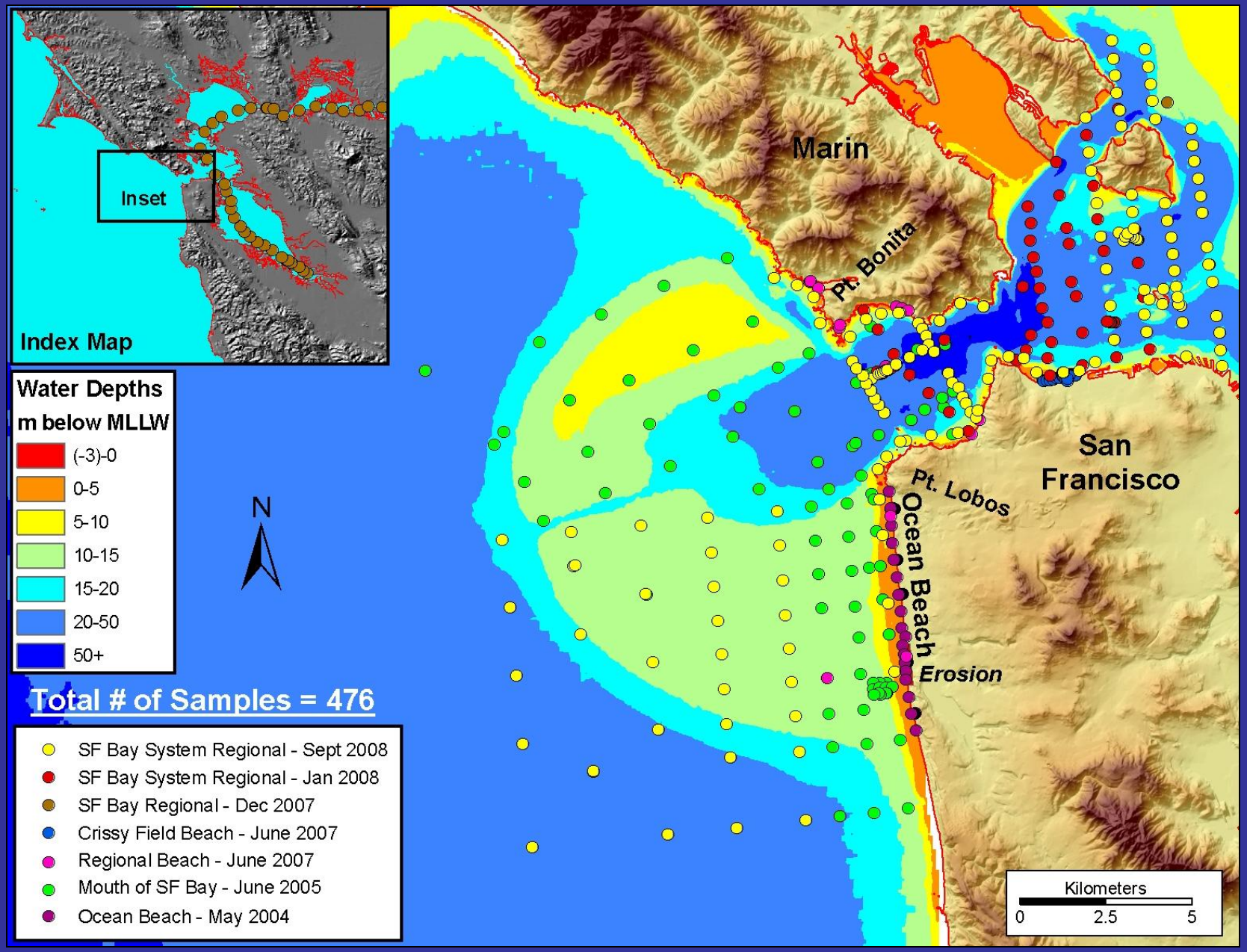
- 50% of discharge & 90% of load are transported in just a few days of the year.

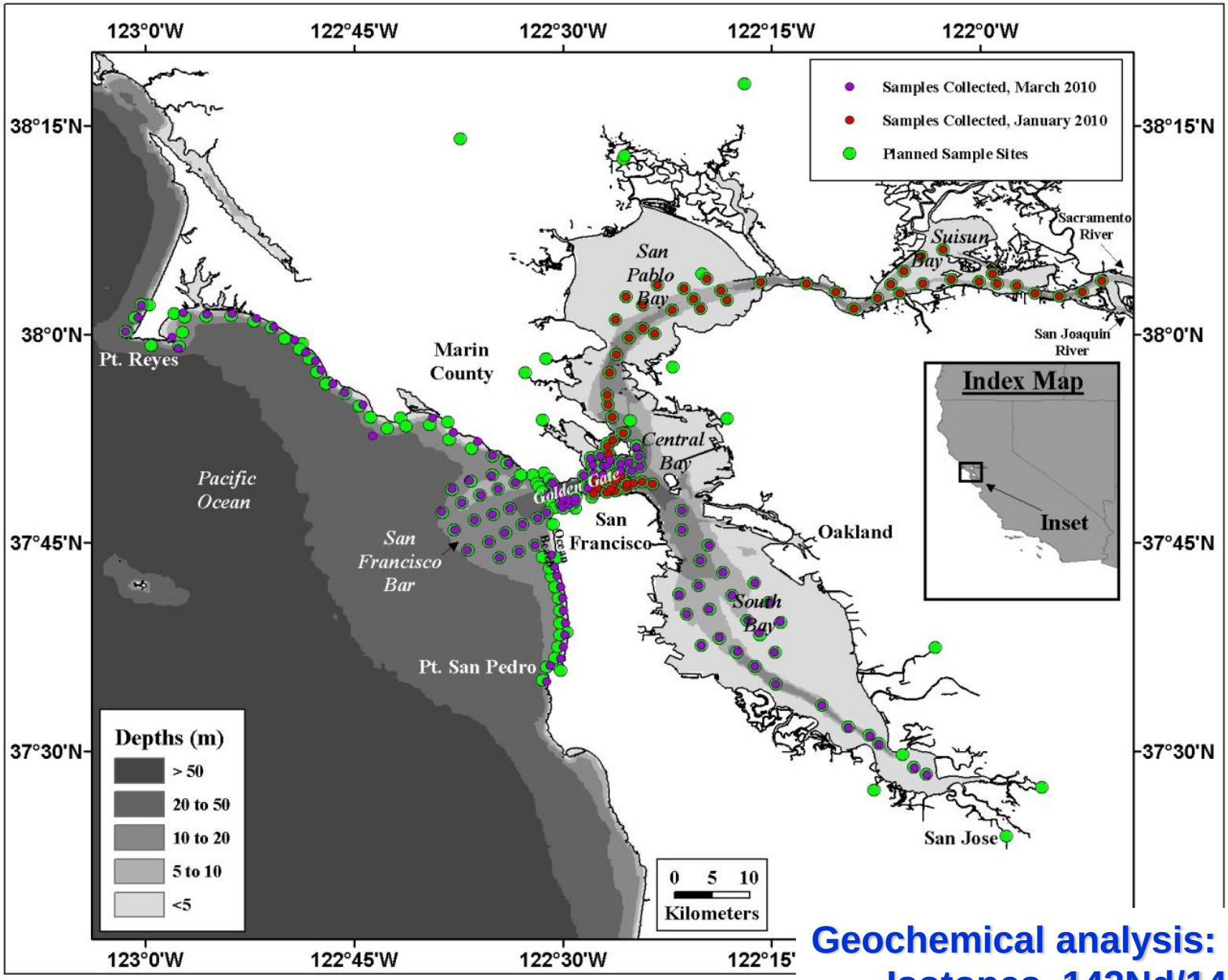
- ~35% of load is from urbanized watersheds.

- 29 USGS stream gage locations around SF Bay capture 52% of drainage area.

- Retaining sediment in marshes may prove crucial during accelerating sea level rise. “Warping” -- historical practice of using stream-borne sediment to raise marsh elevations & make more useful for farming.

Recent Sediment Sampling



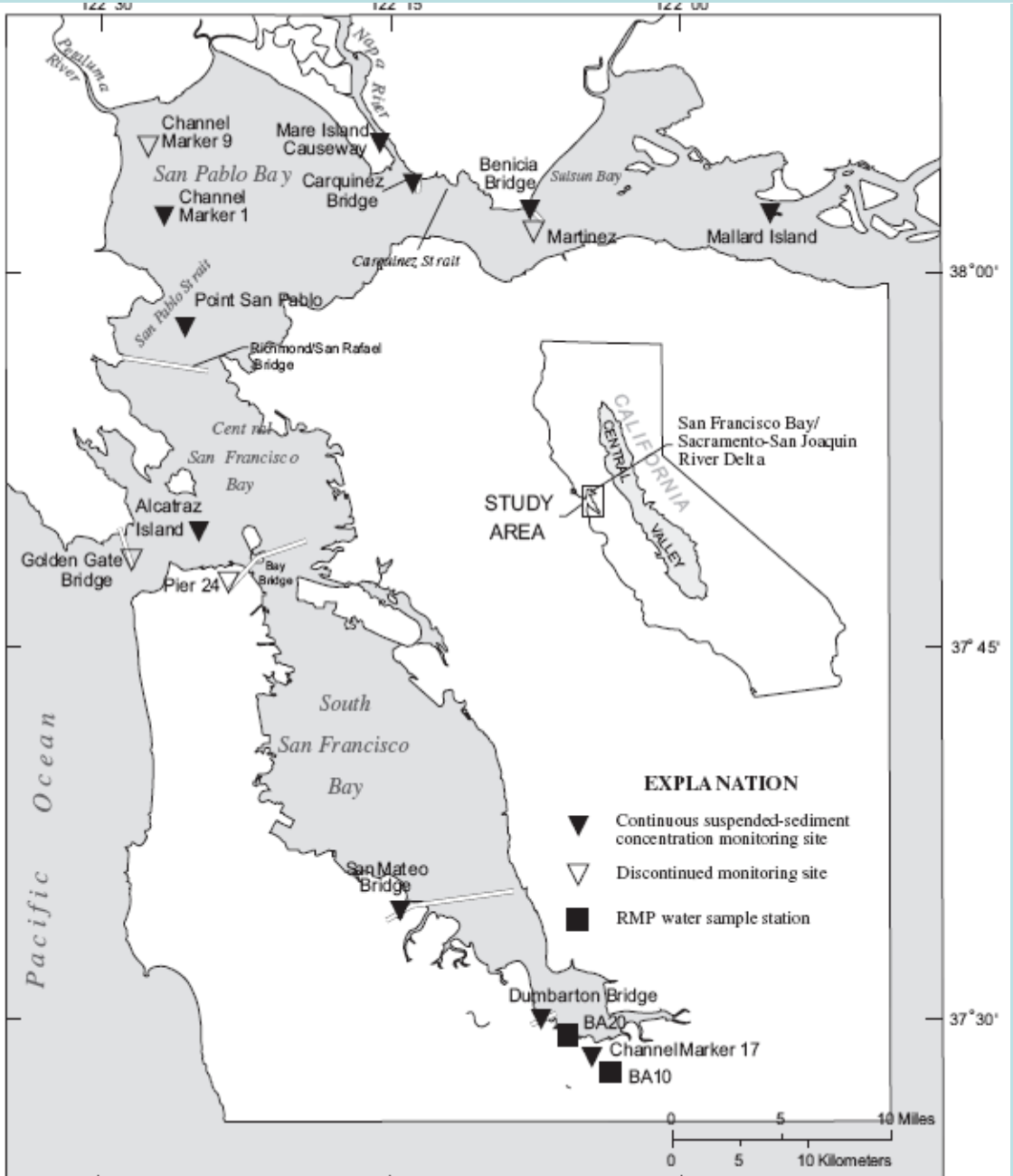


USGS Provenance Studies

Geochemical analysis:

- **Isotopes, 143Nd/144Nd and 87Sr/86Sr**
- **X-ray diffraction; Heavy minerals**
- **Rare earth elements**

Long-Term Monitoring of Suspended Sediment Concentrations (SSC) -- USGS



▼ operational

▽ discontinued

SSC measured since 1991 at selected stations.

Hydrodynamic and Sediment Transport Modeling

- **Delft 2-D and 3-D – USGS and Delft Hydraulics Laboratory**

Modeling of currents, waves, SSC, sediment flux, bed morphology.

- **UnTRIM – MacWilliams (www.rivermodeling.com); USACE**

3-D hydrodynamic model simulates field-scale flows on unstructured grids. Particle tracking model for SSC and erosion/deposition.

- **ROMS – USGS and others**.

3-D community model used to compute waves, currents, and sediment transport.

- **SUNTANS – Stanford Coastal Ocean Model**

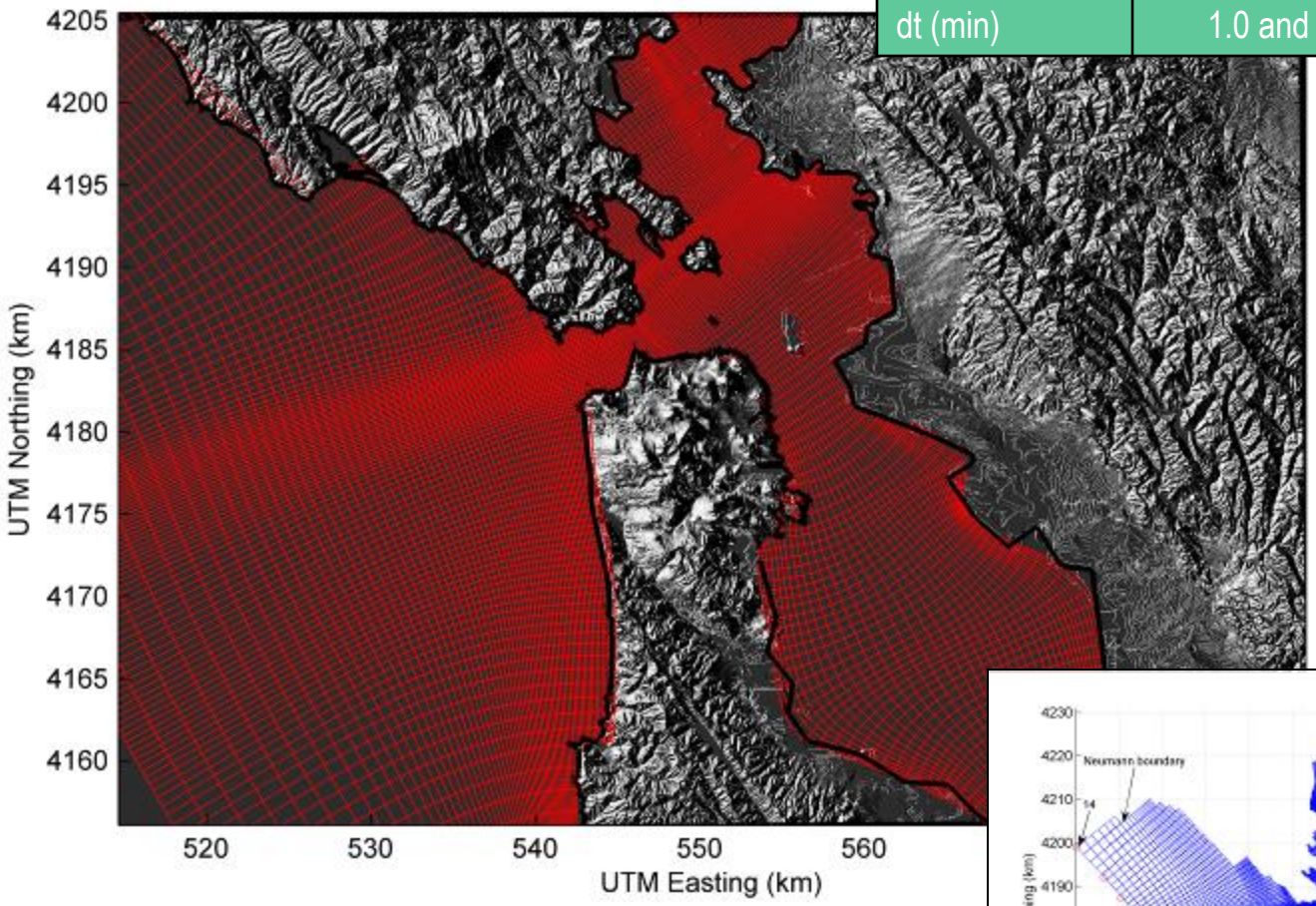
Unstructured grid; allows wetting/drying; high res transport scheme to capture salinity & temp gradients; avg res ~200m; 60 vertical layers; boundaries at ocean and delta.

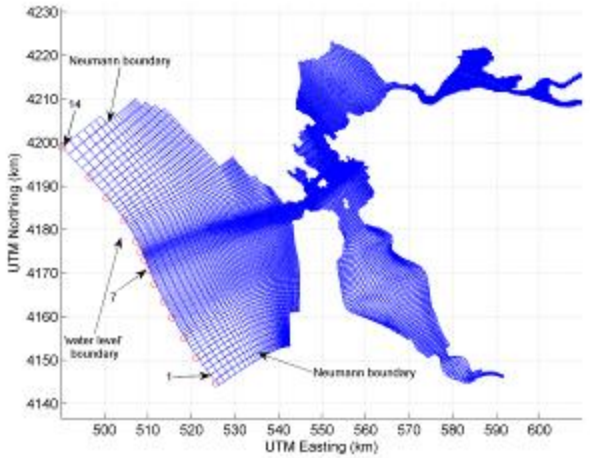
- **ADaptive Hydraulics Model (ADH) – ERDC (Brown)**

Model has variable grid resolution to improve estimation of whatever needs to be resolved; wetting/drying; sediment flux calculations.

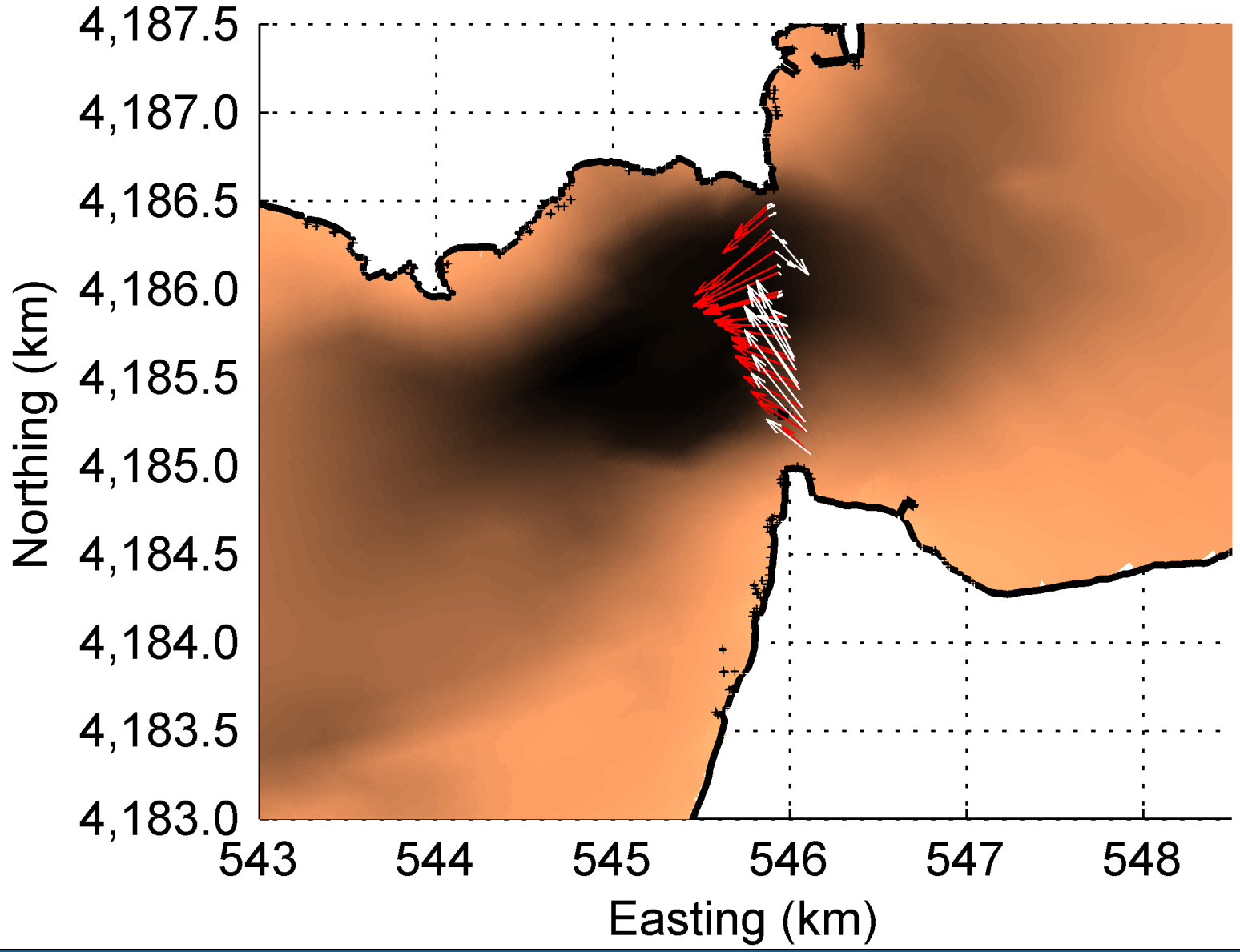
Delft3D Modeling

# cells	44,148
cell size	30 m to 1.3 km
dt (min)	1.0 and 0.5

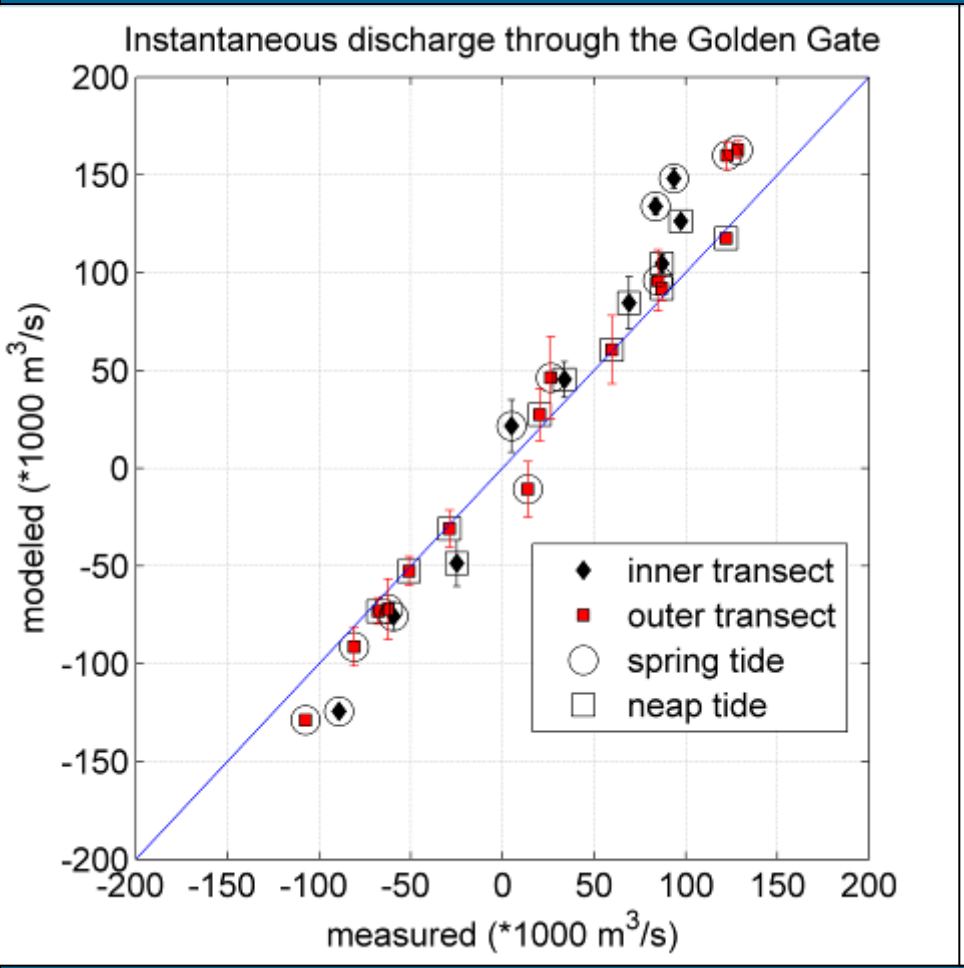


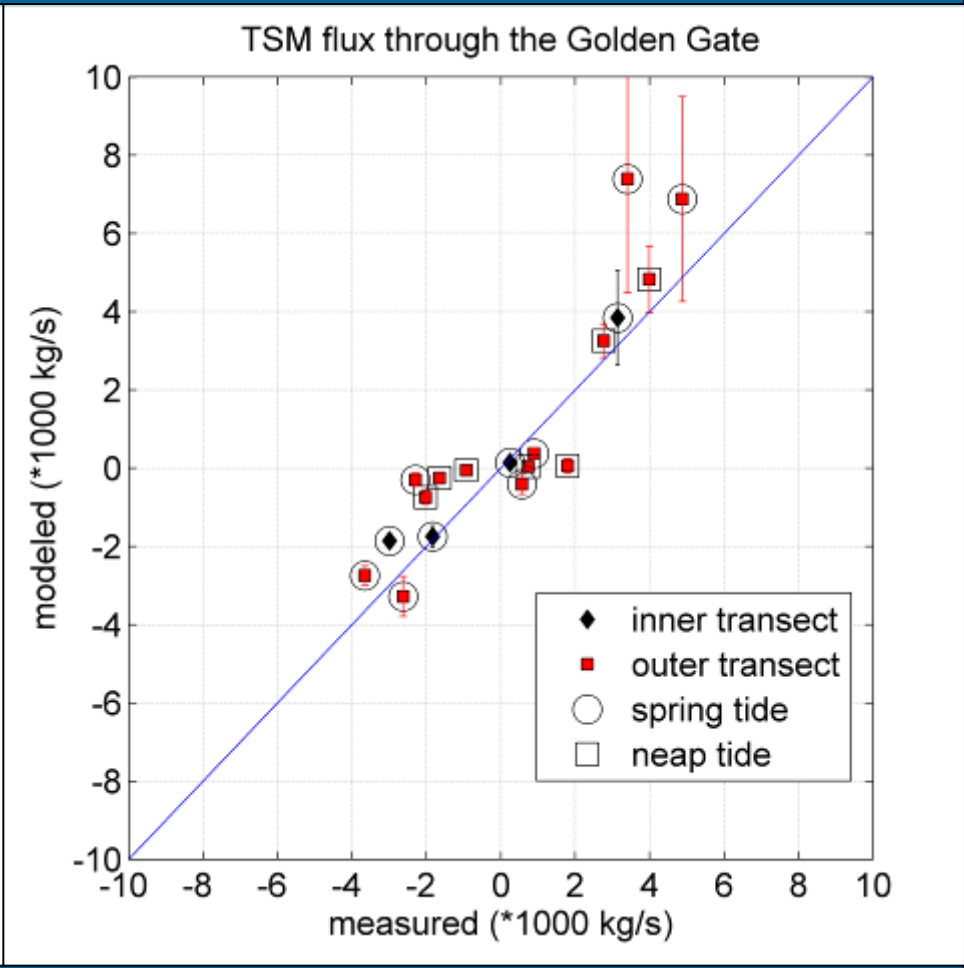


Net Sediment Flux



Golden Gate Model-Data Results

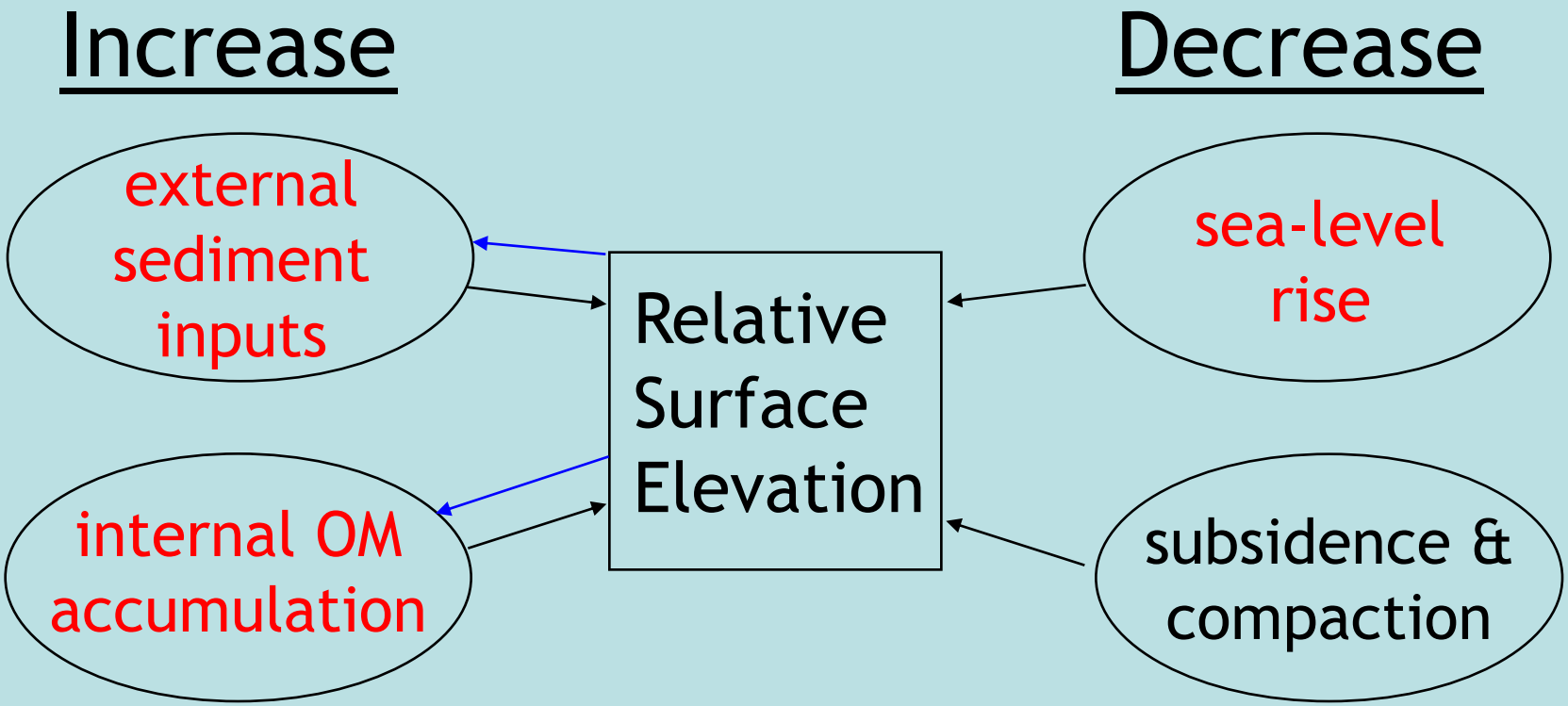




San Francisco Bay Wetlands

- What are rates of sediment accretion in well established tidal wetlands in San Francisco Bay?
- How do these compare to newly restored wetlands?
- Can we predict the ability of wetlands to withstand changes in sediment availability and sea-level rise from current sedimentation rates?

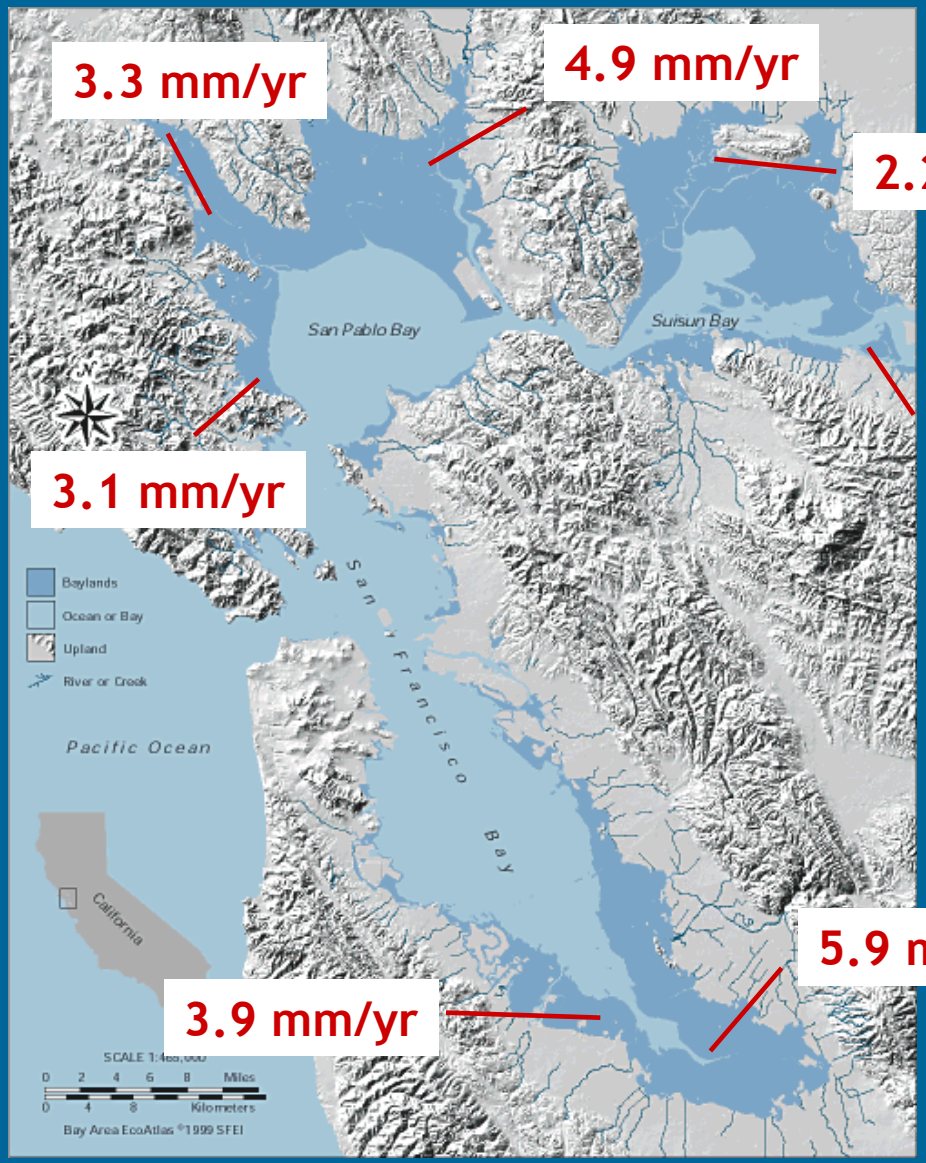
Factors Affecting Wetland Elevation and Inundation Rates



Short-term Sediment Accretion Rates
using feldspar markers: **MID-MARSH LOCATIONS**

North Bay rates based on one year of data

South Bay rates based on six years of data

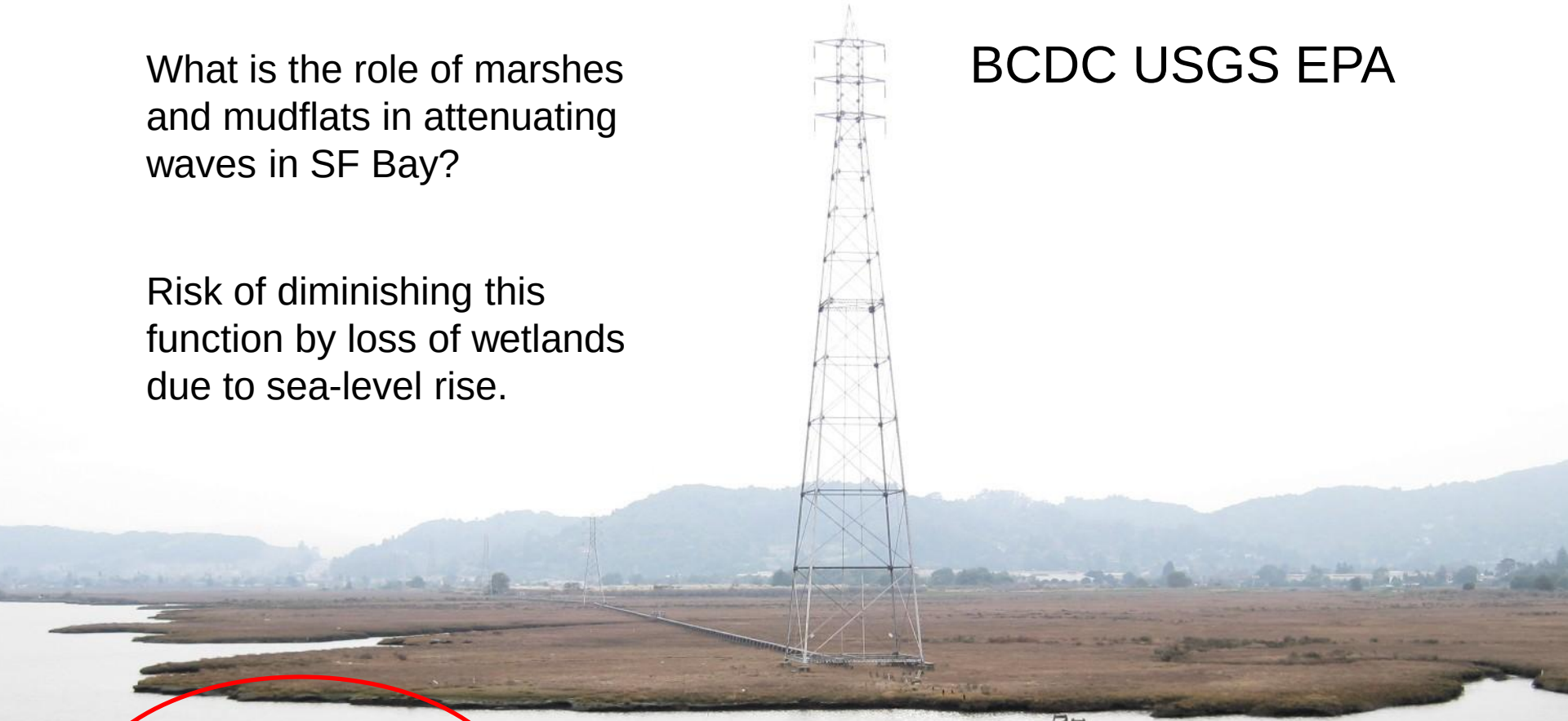


Wave attenuation in Corte Madera Bay

What is the role of marshes and mudflats in attenuating waves in SF Bay?

Risk of diminishing this function by loss of wetlands due to sea-level rise.

BCDC USGS EPA



Wave measurements

Jessie Lacy

Bathy/Topo

Bruce Jaffe

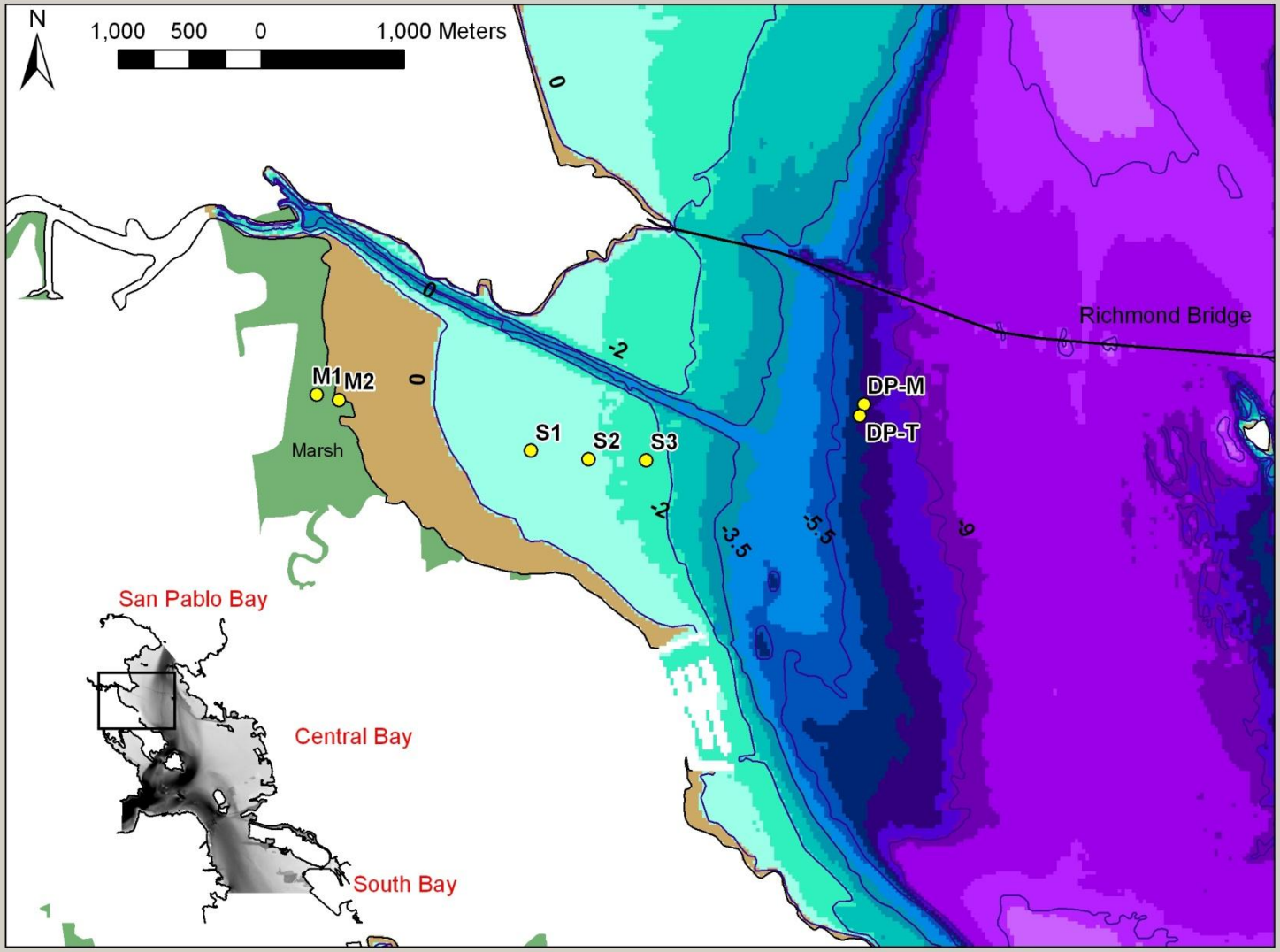
Rob Kayen

Delft 3D Modeling

Bruce Jaffe

Mick van der Wegen (UNESCO)

Instrument deployment
Jan 22-Mar 23, 2010



S stations

ADV, OBS

0.5-1.5 m MLLW

M stations

Bursting pressure sensor

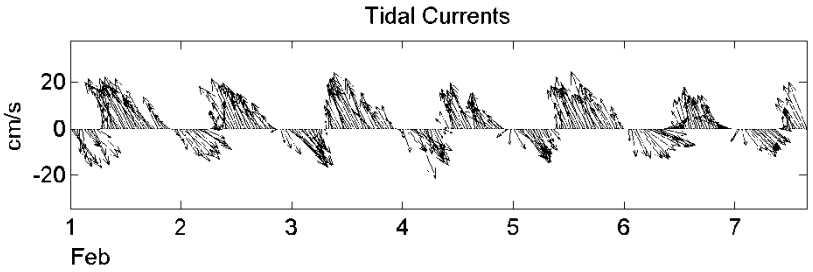
DP

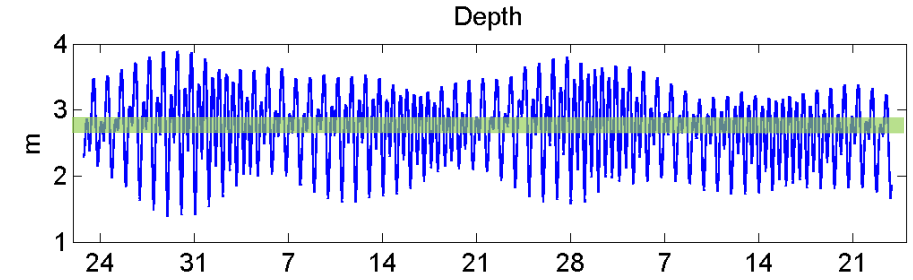
ADCP, top & bottom CTD

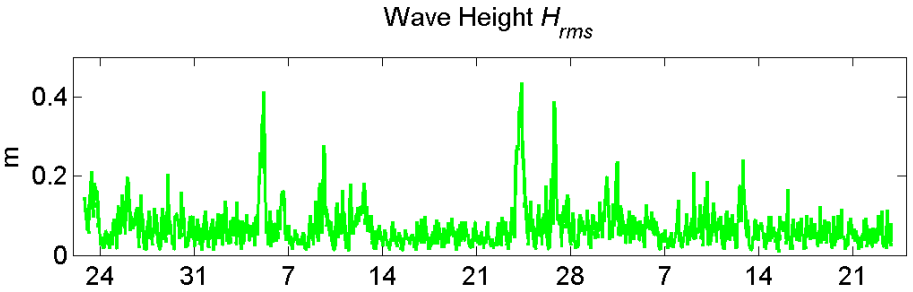
bottom OBS

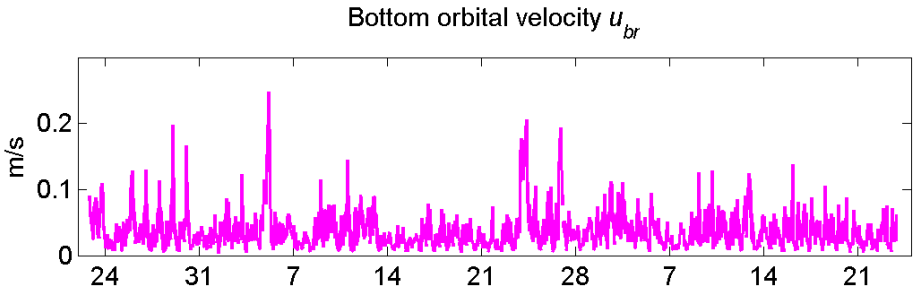
Data from S3 ADV

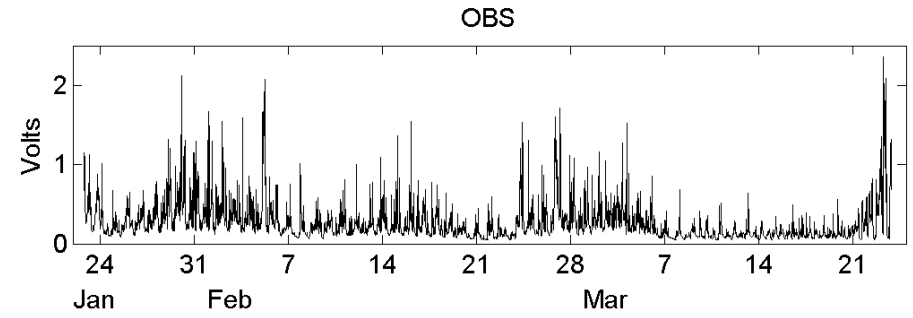
25 cm above the bed











- 3 events with wave heights > 0.3 m.
- Wave Period 2-3 s.
- Peaks in ub and SSC at low tides.
- Clear spring-neap signal in OBS voltage.

What Do We Need for Better Understanding of Sediment in San Francisco Bay (panel review)

SubTidal Zones

- Data on transition zones from watershed to bay habitats. Can bedload make it? What's happening to coarse load sediment supply? Where is it? How is it transported through the system, and where will it end up in the Bay?
- Data on fine sediment transport. A new USGS Provenance study is focusing just on the coarse (sand and gravel) fraction. USGS measurement stations for SSC could be upgraded to measure currents (and flux).
- Map of subtidal surface grain size for entire bay (and must account forseasonal variability). Possibly use acoustic measurements and classification schemes.
- Direct measurements of currents, waves, and sediment flux for increased understanding of transport and exchanges between Bay sub-regions, and for model input and validation. Last large-scale current measurements from 1980's.
- Improved and validated numerical modeling of hydrodynamics, sediment transport, and sea level rise scenarios in SF Bay.

What Do We Need for Better Understanding of Sediment in San Francisco Bay (panel review)

Watersheds and Wetlands

- Data on export of sediment from watershed through wetlands into Bay ("Connectivity"). Can USGS make sediment measurements at stream gages again? Only 29 stream gages now operate in Bay/Delta tributaries (` 50% coverage). Need data on size fractions of stream loads (fine and coarse).

- Studies of effects of major events like floods, drought, fires. Evidence now that streams provide substantial sediment (~50%) into Bay. Need to obtain data on sediment input from urbanized watersheds.

- Need to develop better understanding of effects of SL rise on tidal mudflats & marshes. Include measurements of waves on cohesive sediment, and runup onto marshes.

- Numerical models need to incorporate analysis of upstream 'back-water' flooding to account for spatial and temporal sediment input into Bay.

- Comprehensive analysis and inventory of bay beaches. Are they being lost? Do they provide sediment to the subtidal zones?

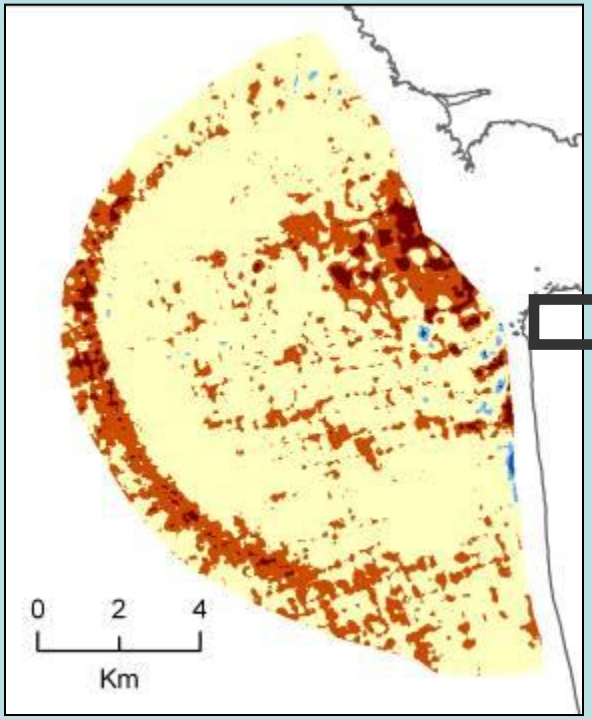
First Steps - Regional Sediment Management

- Some Funding has been allocated – LTMS, CSMW, CIAP
- BCDC - USGS Science Strategy Workshop
- New Studies Underway
- Management Strategy Kickoff Workshop -- Summer/Fall ??


Thank you!

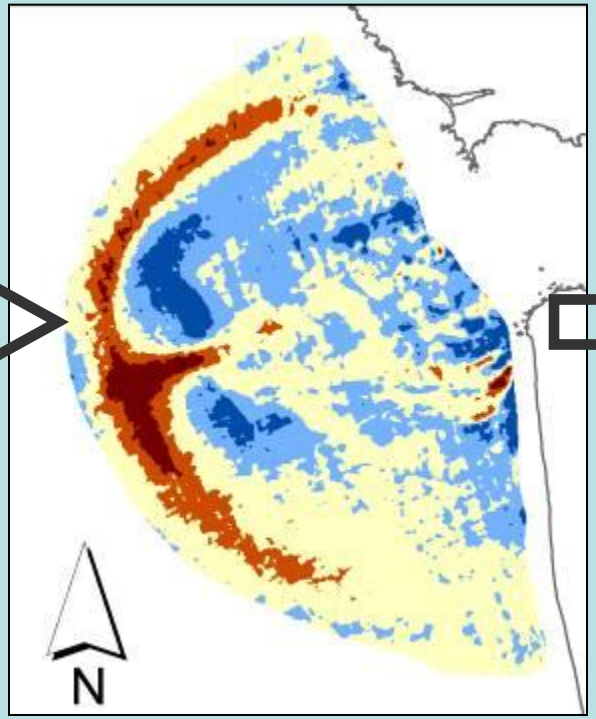
SF Bar Bathymetric Change

1873 to 1900



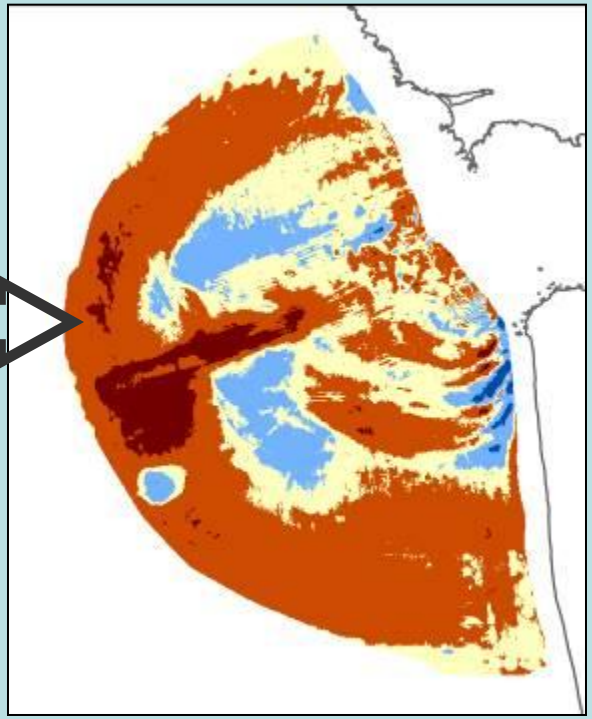
Depth Change
- > -2 m
- -1 to -2 m
- no sig change
- +1 to 2 m
- > -2 m

1900 to 1956



Depth Change
- > -2 m
- -0.8 to -2 m
- no sig change
- +0.8 to 2 m
- > -2 m

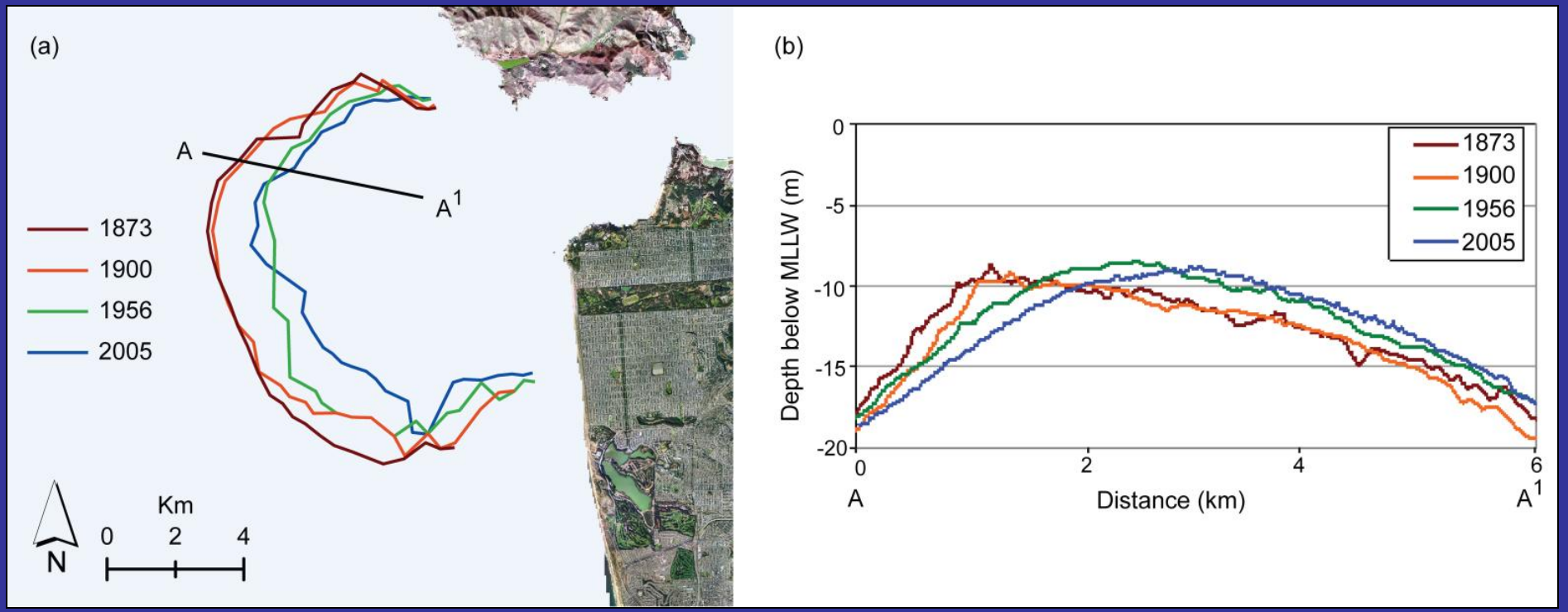
1956 to 2005



Depth Change
- > -2 m
- -0.42 to -2 m
- no sig change
- +0.42 to 2m
- > -2 m

K. Dallas

SF Bar Bathymetric Change



- Crest contracted radially 1 km
- Bar eroded vertically 80 cm
- From 1900-1956 changes consistent with a reduction in tidal prism and increased sediment supply
- From 1956-2005 changes reflect reduced sediment supply and/or tidal prism
- Survey of the SF Bar was recently completed in 2009 for the California State Waters Mapping Project

P. Barnard *K. Dallas*

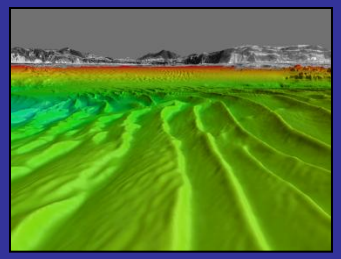
Sediment Inputs from Watershed

- 50% of discharge & 90% of load are transported in just a few days of the year
- ~35% of load is from urbanized watersheds
- Estimated modern input to SF Bay from local tributaries is > 50% (increased channel incision; loss of marshlands to development)
- 29 USGS gage locations around SF Bay captures 52% of drainage area
- “warping” historical practice of using stream-borne sediment to raise marsh elevations & make more useful for farming

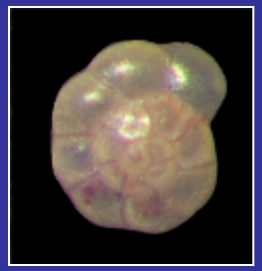
Provenance Study Approach

Objective: Apply multiple approaches to identify the source and pathways of beach-sized material in the San Francisco Bay Coastal System

Funding: USGS and California Sediment Management Workgroup (CSMW)



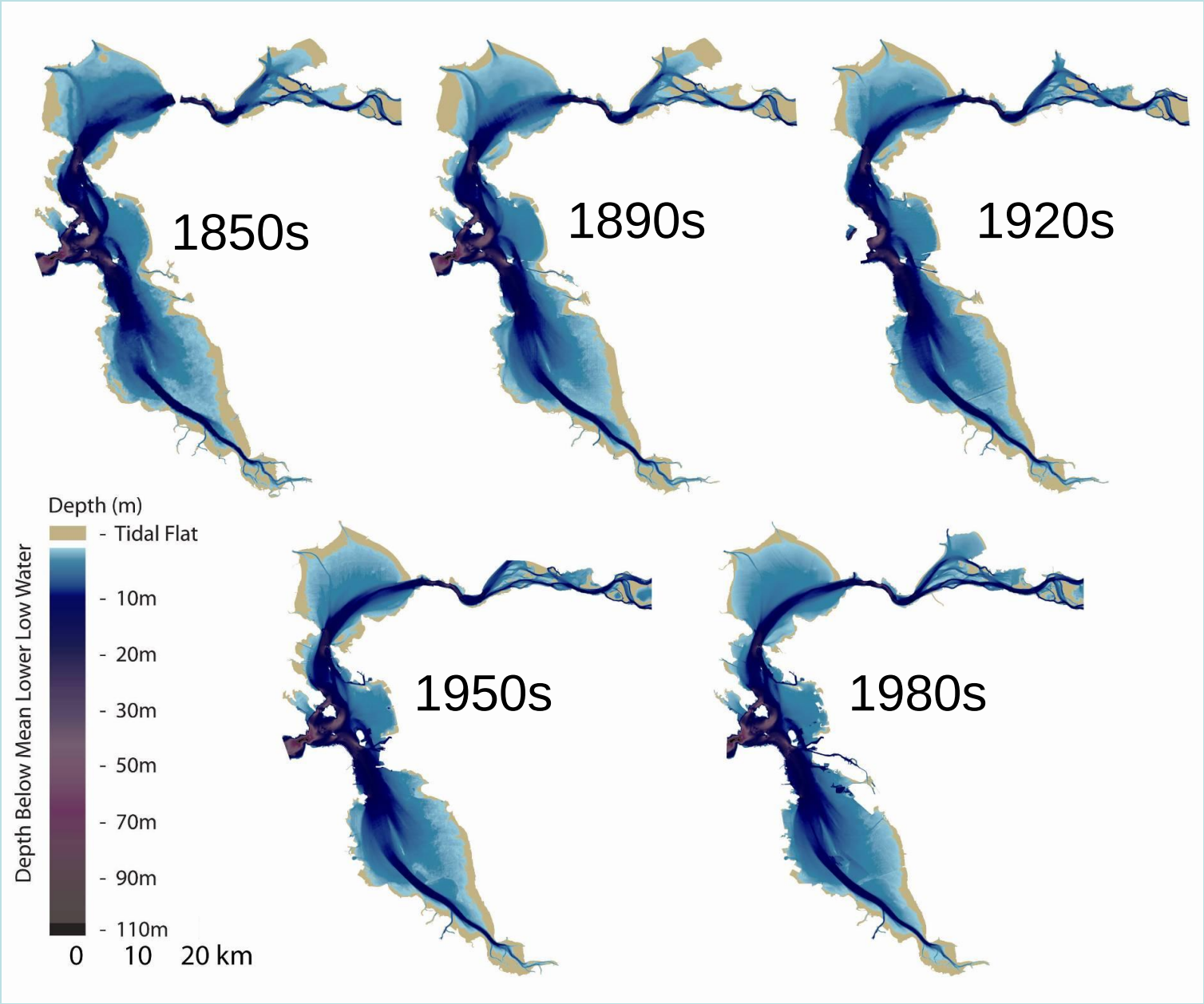
- **Remote techniques**
  - **Bedform asymmetry**
  - **Numerical modeling**



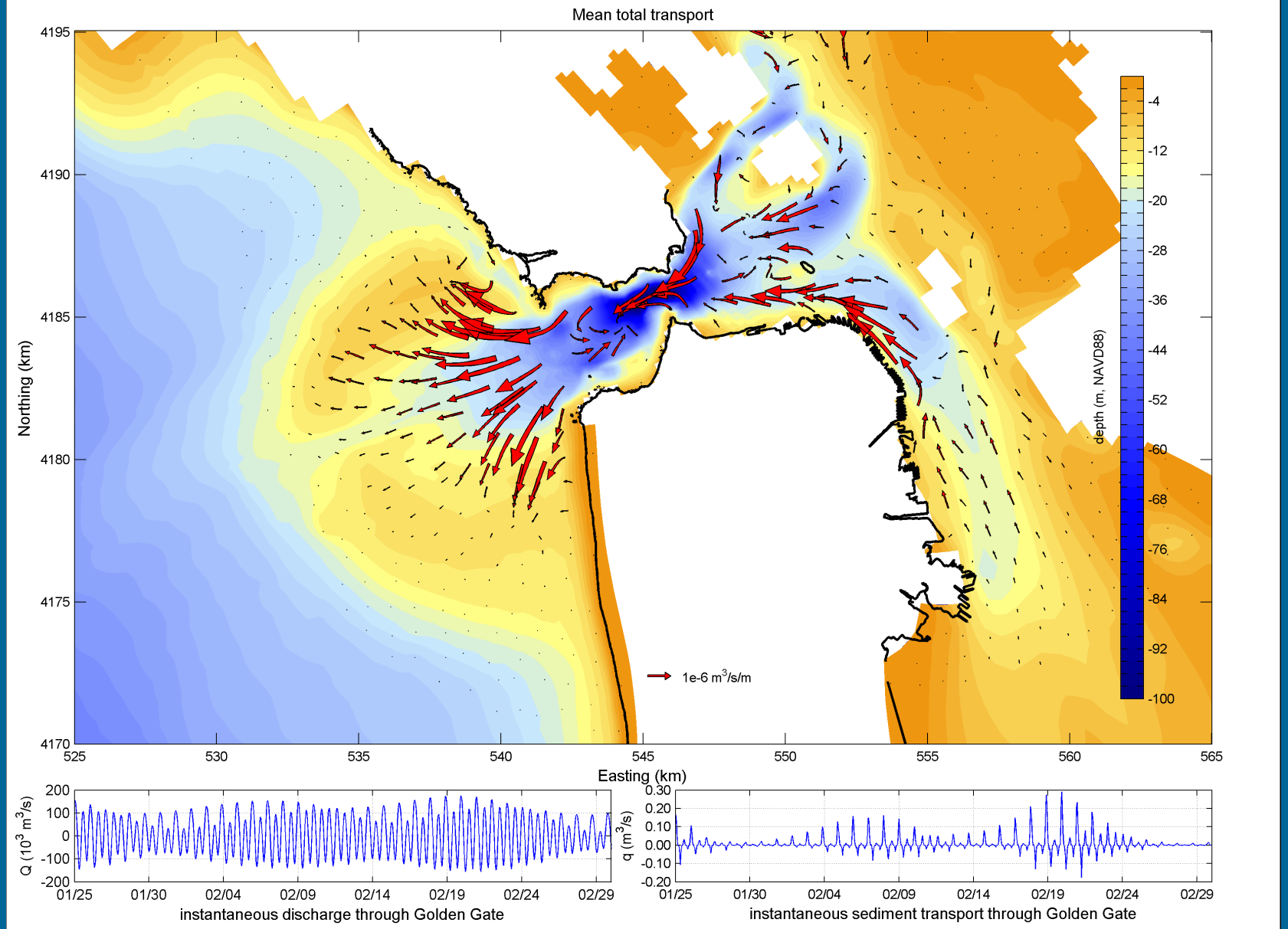
- **Direct sampling and physical characteristics**
  - **Morphometric analyses (grain size, shape, sorting, etc)**
  - **Foraminiferal analysis (McGann)**

- **Geochemical analysis**
  - **Isotopes, $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$ (Hein)**
  - **X-ray diffraction (Hein)**
  - **Heavy minerals (Woodrow and Wong)**
  - **Rare earth elements (Rosenbauer)**

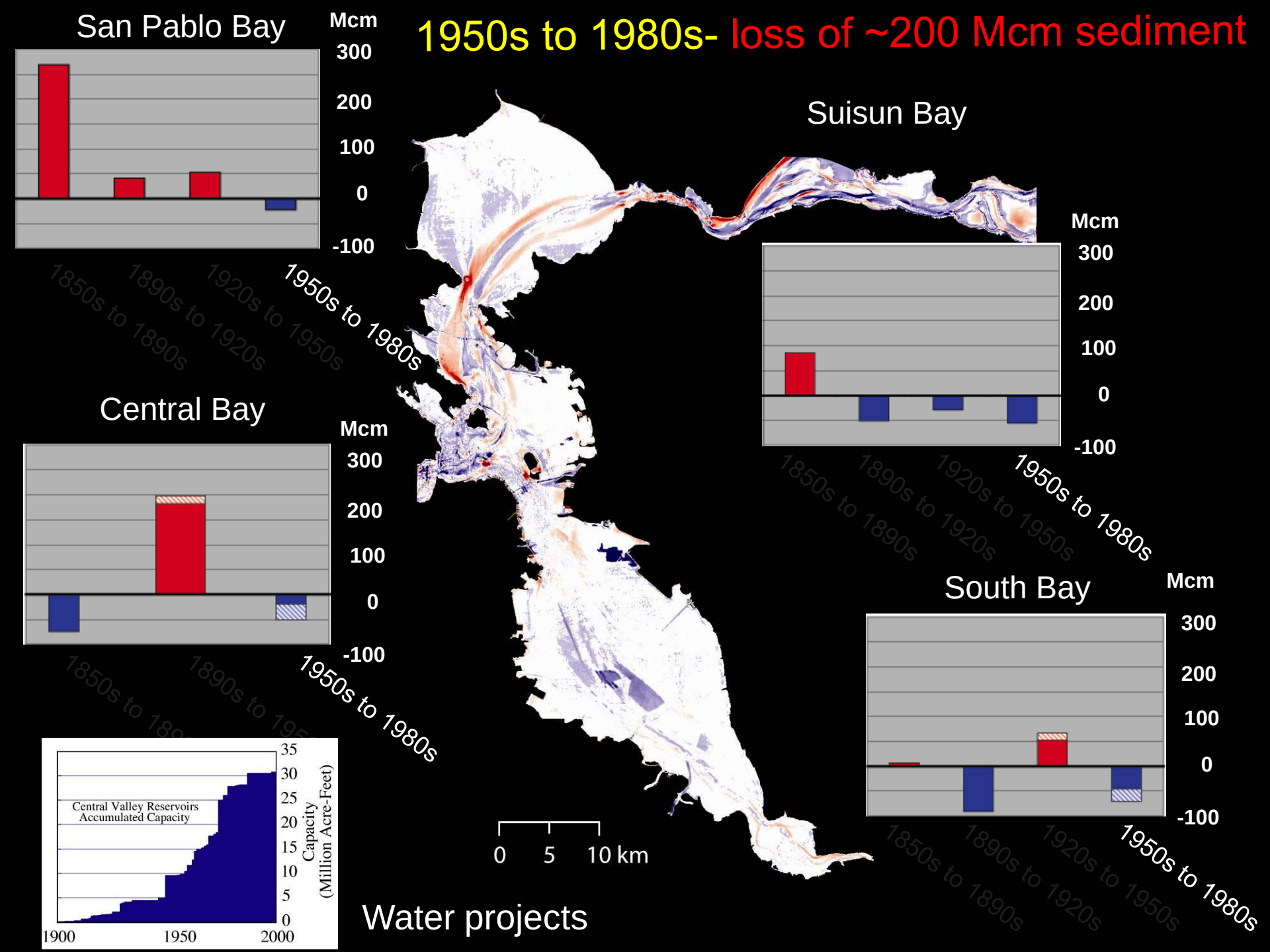
Historical Sedimentation in San Francisco Bay



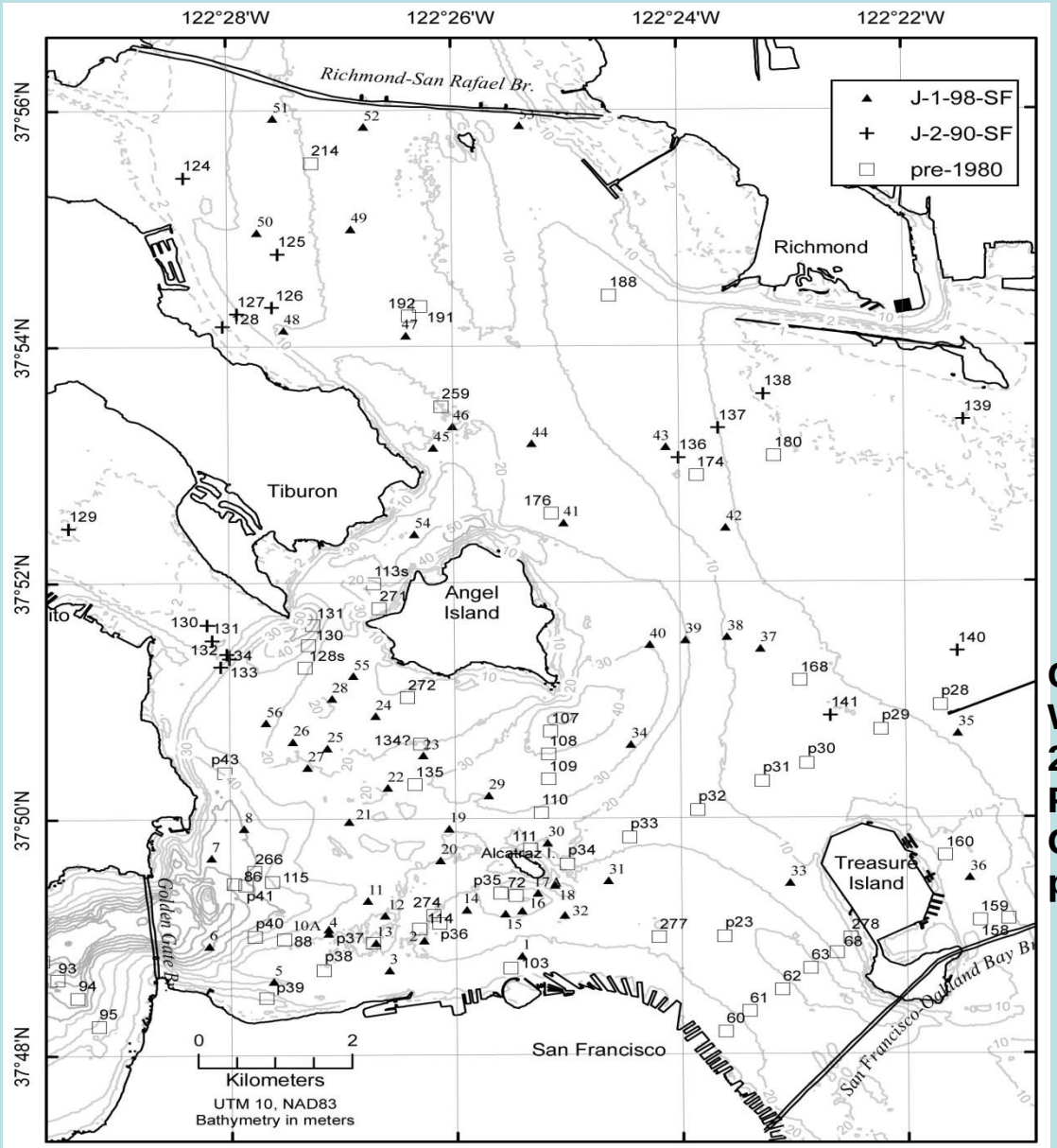
Predicted sediment transport - ‘hydrodynamic tide’



L. Erikson


1950s to 1980s- loss of ~200 Mcm sediment
San Pablo Bay
Mcm
300
200
100
0
-100
1850s to 1890s
1890s to 1920s
1920s to 1950s
1950s to 1980s
Suisun Bay
Mcm
300
200
100
0
-100
1850s to 1890s
1890s to 1920s
1920s to 1950s
1950s to 1980s
Central Bay
Mcm
300
200
100
0
-100
1850s to 1890s
1890s to 1920s
1950s to 1980s
South Bay
Mcm
300
200
100
0
-100
1850s to 1890s
1890s to 1920s
1920s to 1950s
1950s to 1980s
0 5 10 km
Central Valley Reservoirs
Accumulated Capacity
Capacity
(Million Acre-Feet)
35
30
25
20
15
10
5
0
1900
1950
2000
Water projects

Sediment Characteristics -- Samples



Chin, J. L., Woodrow, D. L., McGann, M., Wong, F. L.,Fregoso, T., and Jaffe, B. E., 2010. Sedimentation in central San Francisco Bay, California: U.S. Geological Survey Open-File Report (in press).

Location map. 1990 gravity cores: +. Grain-size samples: boxes - pre-1980 ; triangles – 1998.