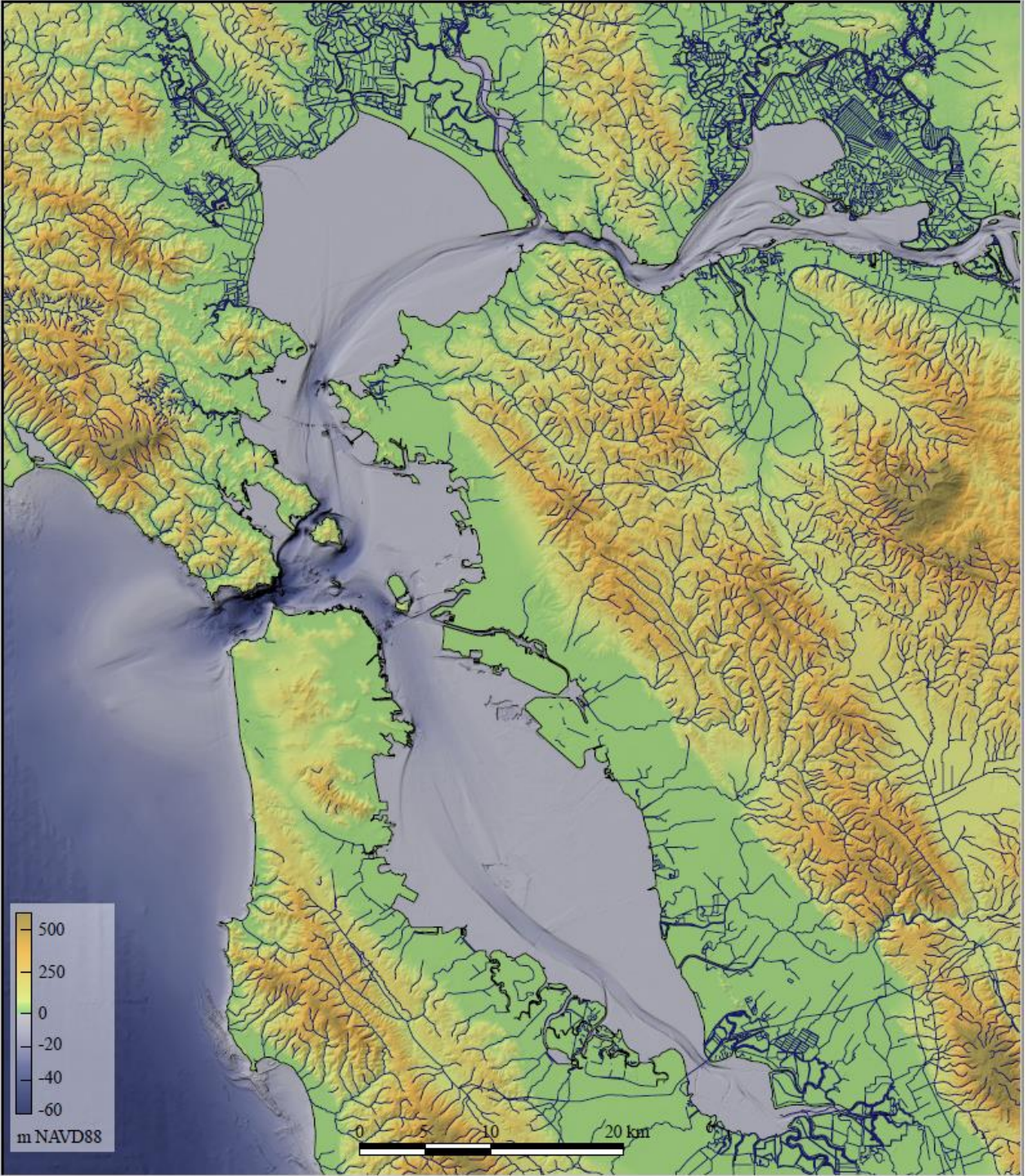
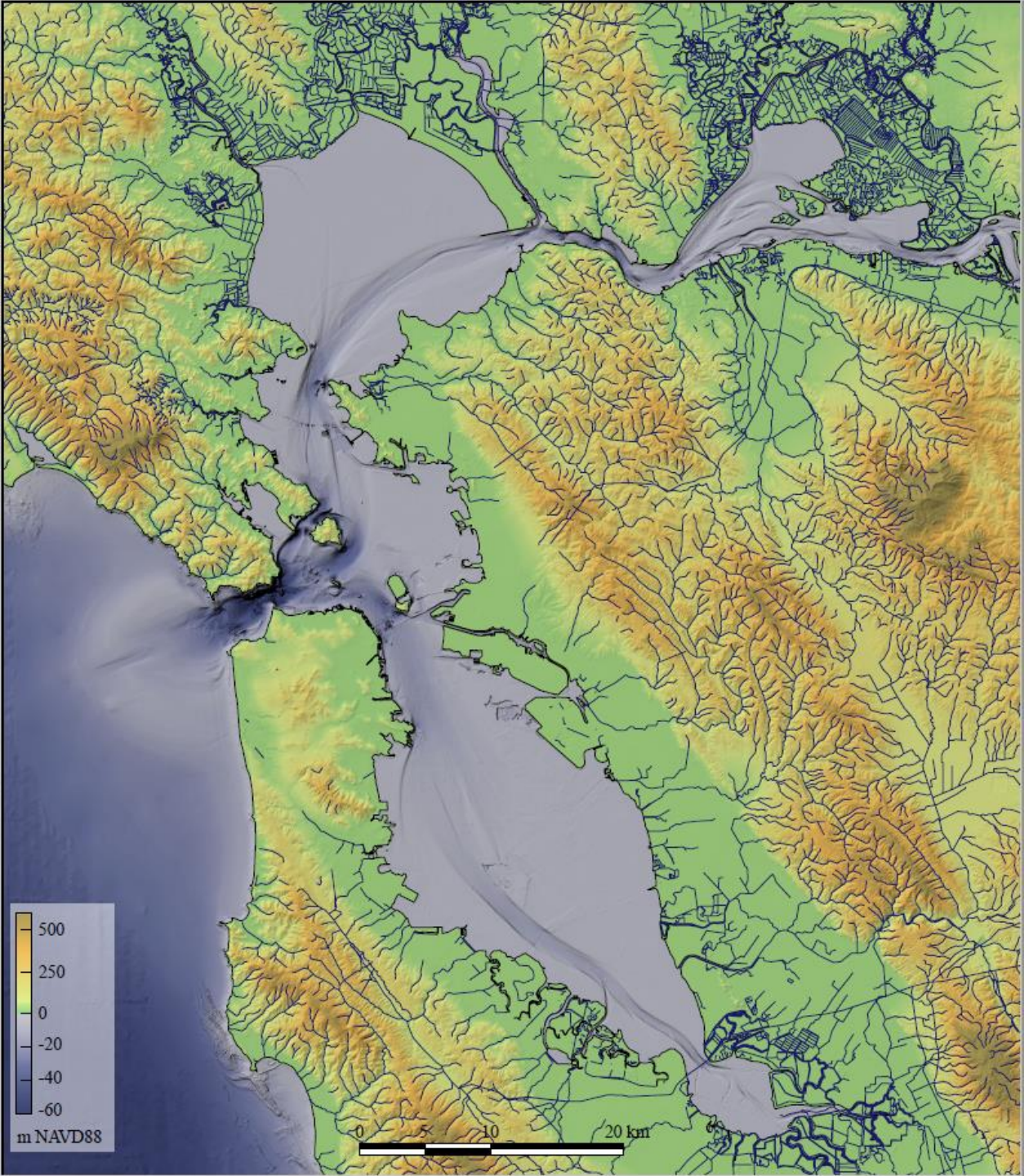


Source Apportionment Method Development:

Quantifying Point Source Contributions to Nutrient Concentrations throughout San Francisco Bay

12/18/2020



- Goals / Background
- POTW Zones of Influence: areal extent, magnitude
- Source Apportionment: Relative Contributions to Regions of SFB
- Major Take-Homes to Date
- Discussion

Science Plan and Modeling Workplan

Inform decisions related to subdividing SFB into 'Management Units[1]' by identifying contiguous regions that can be considered biogeochemically-similar from a management standpoint.

Multiple Considerations:

- regulatory/management priorities
- physical and biogeochemical realities, e.g.,
  - similar nutrient source signatures;
  - comparable responses in terms of nutrient-related indicators
- enough MUs to inform effective management strategies, but not more than necessary.
- Phased Approach:
  - provisional estimates early using the best available calibration
  - refined thereafter after major model refinements (FY22, final FY24).

Task 3.1 Nutrient Source Attribution, Management Unit Delineation:

Task 3.1 Nutrient Source Attribution, Management Unit Delineation: In this task, biogeochemical simulations will be interpreted to: i) Quantify the contributions of individual POTWs to nutrient delivery (mass fluxes to a region) and nutrient concentrations within specific regions or habitats; and ii) Inform decisions related to subdividing SFB into 'Management Units1' by identifying contiguous regions that can be considered biogeochemically-similar from a management standpoint.The identification of Management Units (MUs) will depend on multiple factors, including regulatory/management priorities and physical and biogeochemical considerations (e.g., similar nutrient source signatures; comparable responses in terms of nutrient-related management indicators). The aim is to subdivide SFB into a practical yet scientifically defensible number of regions – enough MUs to inform effective management strategies, but not more than necessary. Multiple water years and seasons will be explored as part of identifying appropriate Management Unit designations. Work will proceed in phases, obtaining provisional estimates early using the best available calibration (end of FY20), and refined thereafter, as needed, after major model refinements (FY22, final FY24).

Link to Modeling Workplan

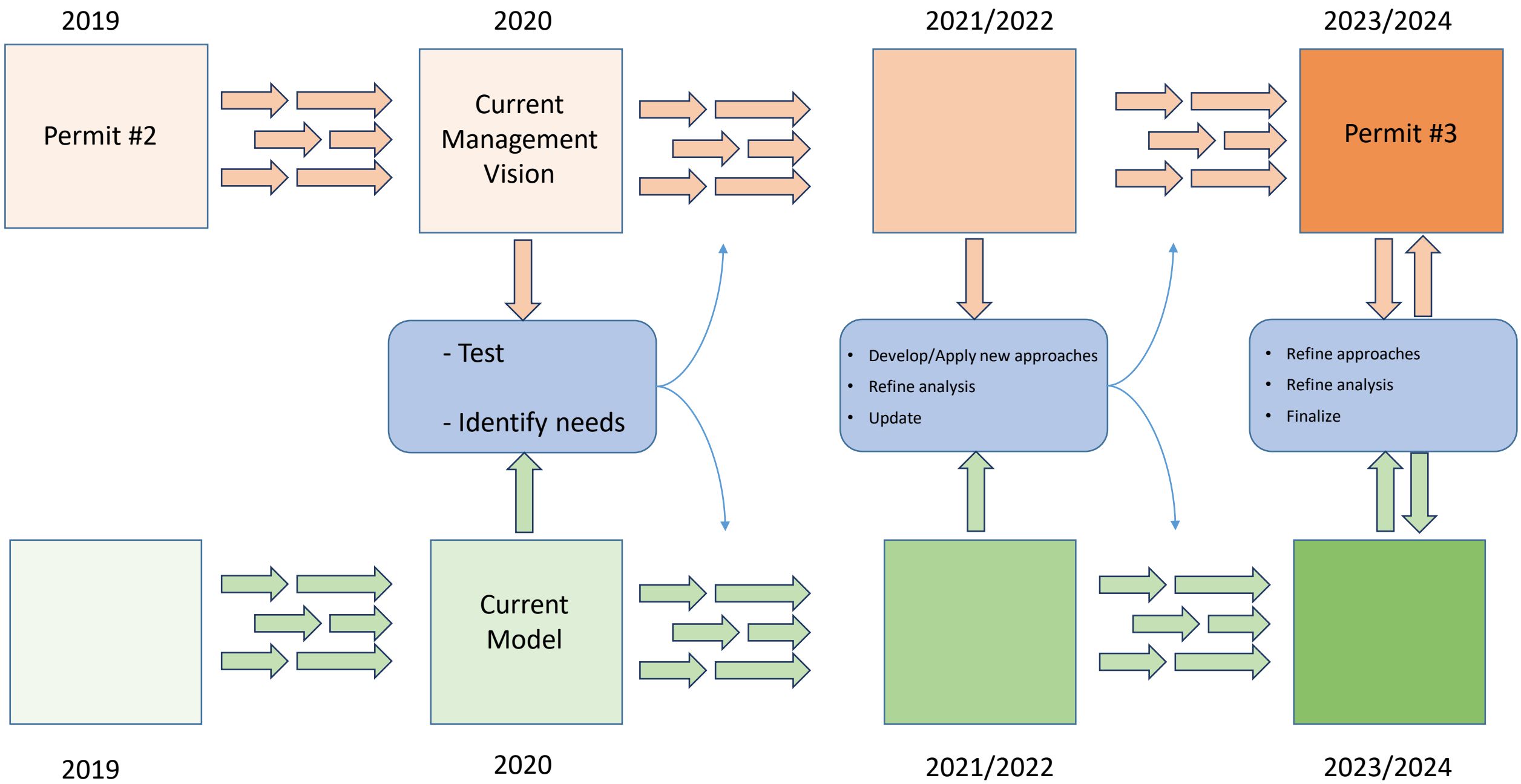
1 Management Units are essentially the same as 'subembayments'. Since there are multiple (formal and informal) subembayment designations for SFB, the term Management Units was used to avoid confusion, since the exact Management Unit boundaries are currently undetermined

‘Management Units’ | Source Apportionment | Zone of Influence

Goals for this Project:

- Develop approach(es) for quantitative source apportionment
- Explore
  - Zones of Influence (ZOI) for each POTW
  - Source Apportionment / Source Fingerprints (space, time)
- Management Units:
  - Explore sensitivity/uncertainty
  - Identify important considerations to inform planning/decisions
- Identify priority improvements and refined approach*

*This project is first of several planned, iterative steps. See Tables 4 and 5 in Modeling Workplan.


Regulatory/Management Decisions
2019
2020
2021/2022
2023/2024
Permit #2
Current Management Vision
Permit #3
- Test
- Identify needs
• Develop/Apply new approaches
• Refine analysis
• Update
• Refine approaches
• Refine analysis
• Finalize
Current Model
2019
2020
2021/2022
2023/2024

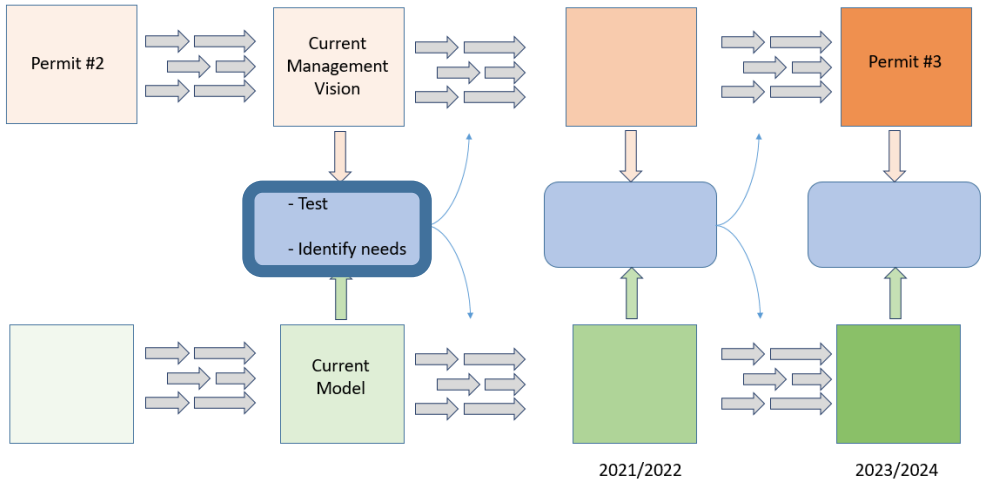
1. Test / validate high-res & low-res models
   - Compared high-res and low-res simulations
   - Low-res (fast) model performed reasonably well predicting concentrations/responses
   - Sufficient for ‘proof-of-concept’

2. Individual tracer studies, transport+rxns
   - 40 tracer simulations (one for each source)
   - Tracer: reduce load by 25%
   - Track changes in [DIN] (and responses)

3. Characterize each source’s Zone of Influence

4. Source Apportionment
   - relative contribution of individual sources
   - “Default”

5. Examine sensitivity relative to “Default”



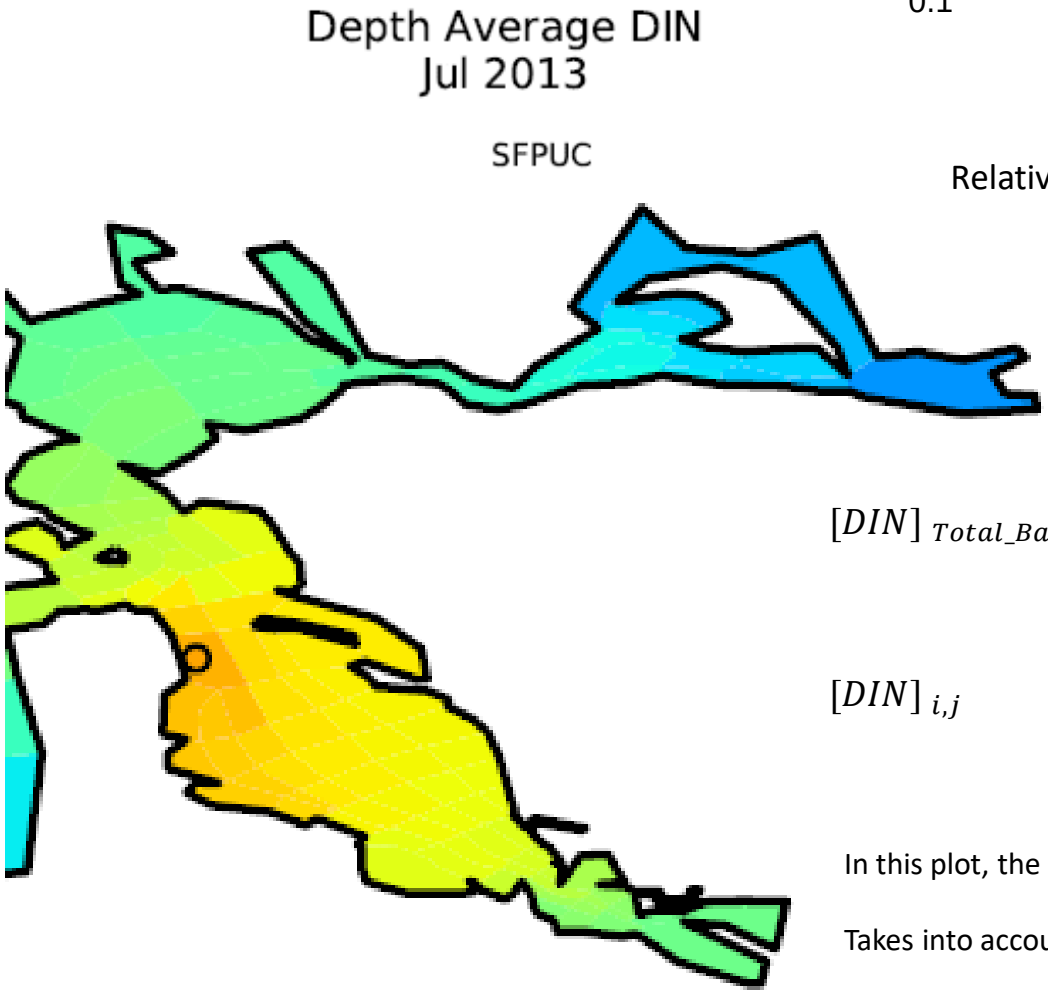
A key aim of this project: To inform discussions with regulators and stakeholders to identify next steps and priorities over next…
-- 1-3 months
-- 1yr
-- 2-3yr

Quantitatively-Characterizing Zone of Influence

Relative Contribution to “total [DIN]”

Depth-averaged concentration

Based on aggregated model results



$$\text{Relative Contribution} = \frac{[DIN]_{i,j}}{[DIN]_{Total\_Base,j}}$$

$[DIN]_{Total\_Base,j}$ — Predicted total DIN concentration predicted in the base simulation, in grid-cell or region ‘j’.

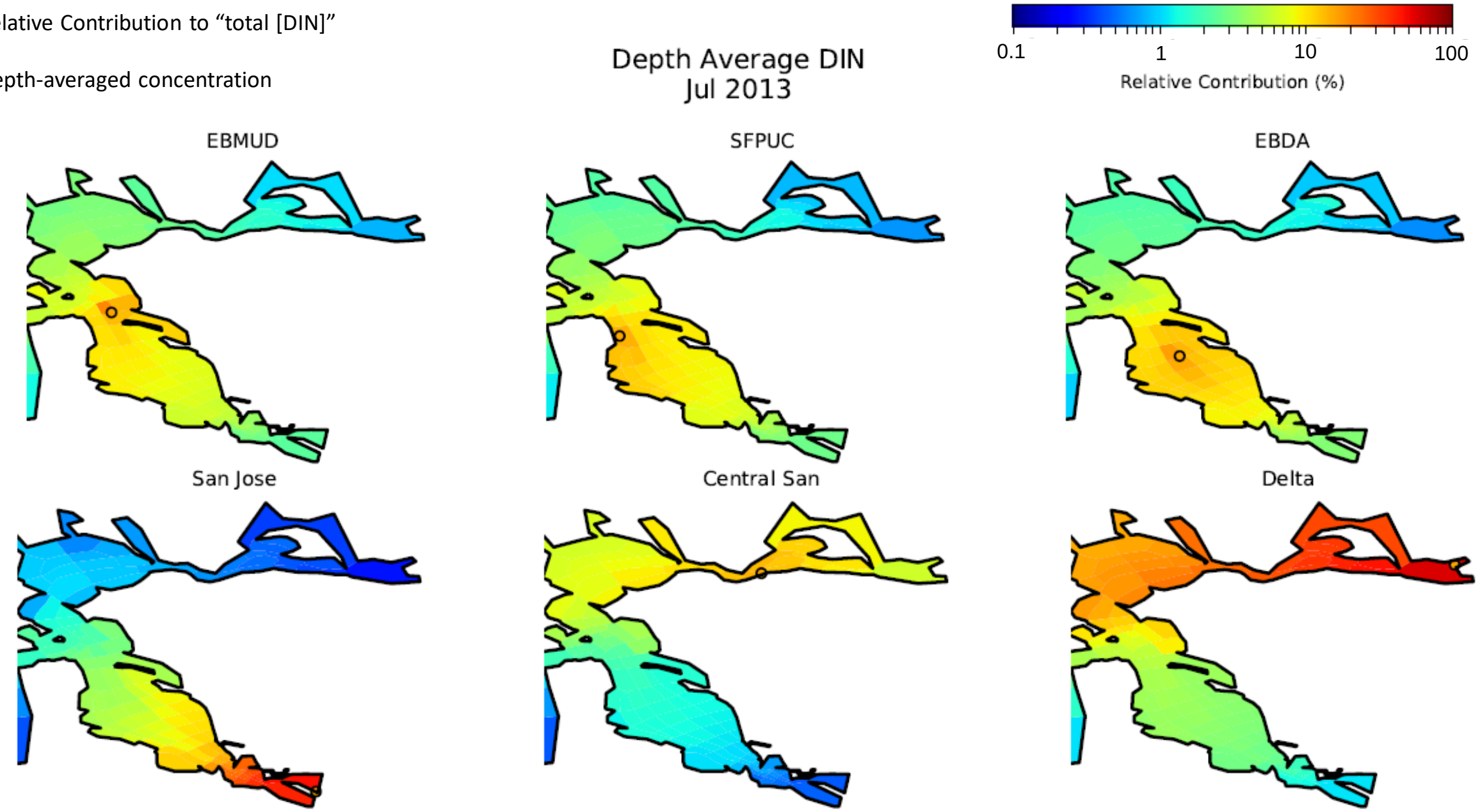
$[DIN]_{i,j}$ — Predicted contribution to DIN from POTW ‘ i ‘ in grid-cell or region ‘j’, estimated from tracer run.

In this plot, the %Contribution is averaged over the month of Jul 2013

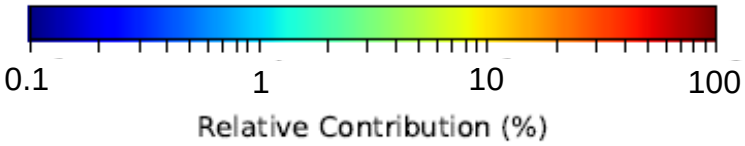
Takes into account both transport and transformations.

Relative Contribution to “total [DIN]”

Depth-averaged concentration

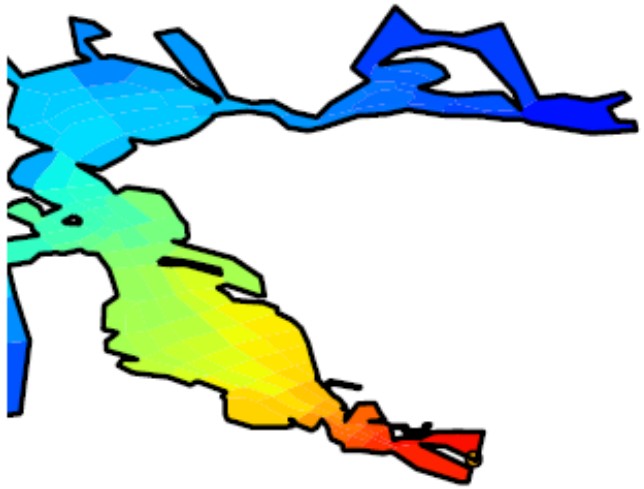


Seasonal Variability?



July 2013

San Jose

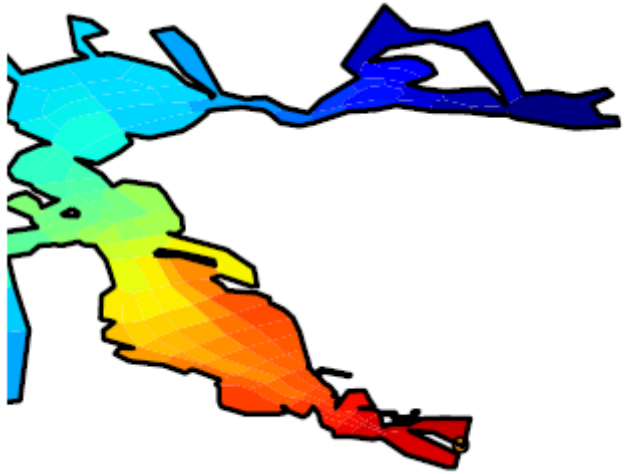


July 2013

Delta

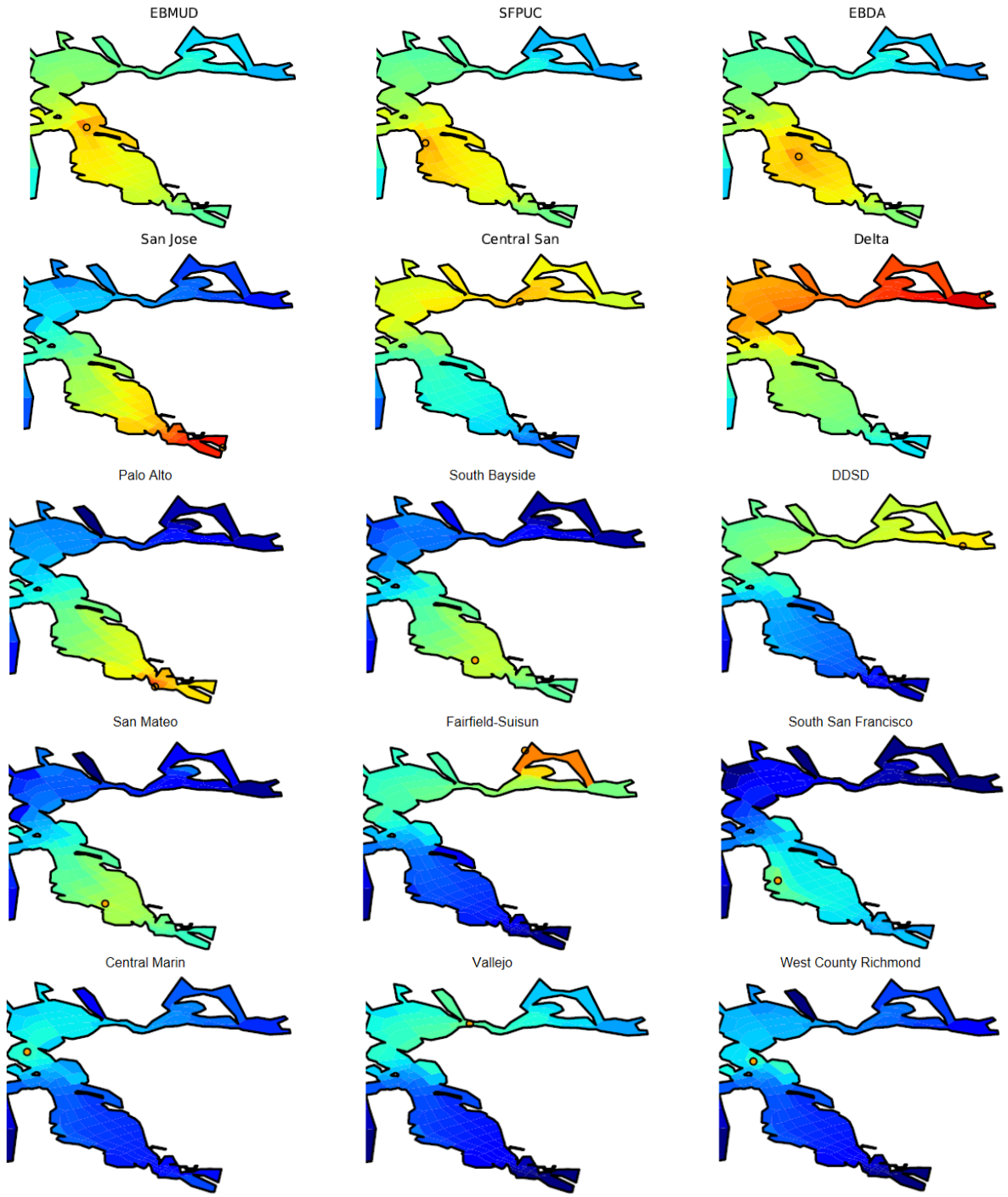
February 2013

San Jose



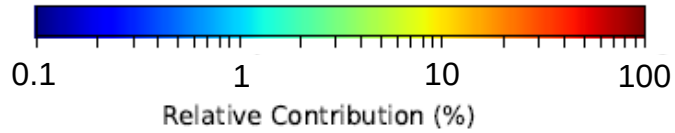
February 2013

Delta



What are the relative contributions of individual sources to DIN in ‘regions’ or

…potential Management Units?



1. ✓ Test / validate high-res & low-res models
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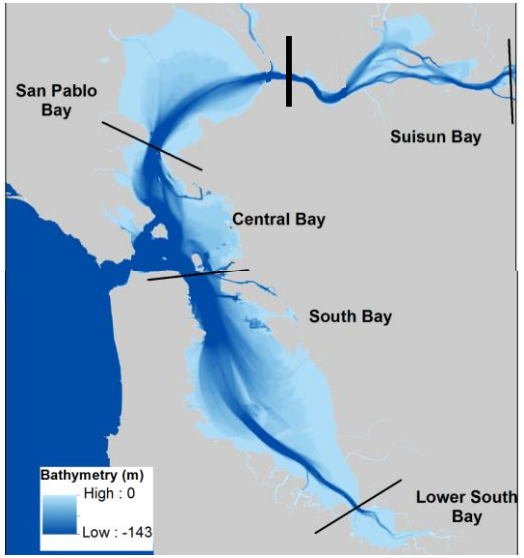
   - Sufficient for 'proof-of-concept'

2. ✓ Individual tracer studies, transport+rxns
   - 40 tracer simulations (one for each source)
   - Tracer: reduce load by 25%
   - Track changes in [DIN] (and responses)

3. ✓ Characterize each source's Zone of Influence

4. Source Apportionment
   - ✓ relative contribution of individual sources
   - ✓ "Default"*

5. Examine sensitivity relative to "Default"



Default*
- WB boundaries
- Summer (Jul 2013)
- Depth Avg concentration

*The "Default" was selected as a starting place or jumping off point, to facilitate comparisons for evaluating sensitivity about assumptions related to boundary definitions, timing/conditions, and approach. The Default defined here was the most logical/straightforward starting place for analysis and comparison purposes. The Default is not intended as a recommendation.

Explore and Quantitatively-Characterize Sensitivity to…

- ❑ Timing:
  - ✓ ❑ Season or Month
  - ❑ Interannual
- ❑ Boundary locations (i.e., definition of management unit)
  - ✓ ❑ South Bay / Central Bay (WB vs. RMP)
  - ✓ ❑ Subdividing South Bay (shoal, channel)
  - ❑ Other boundaries, other subdivisions
- ❑ Approach to determining %contribution:
  - ✓ ❑ [DIN] concentration vs. DIN mass
  - ❑ Other response variables (chl-a, GPP, DO, etc.)
- ❑ Other sensitivity: (model uncertainties, ocean & sediment fluxes)

✓ Topics addressed in current report

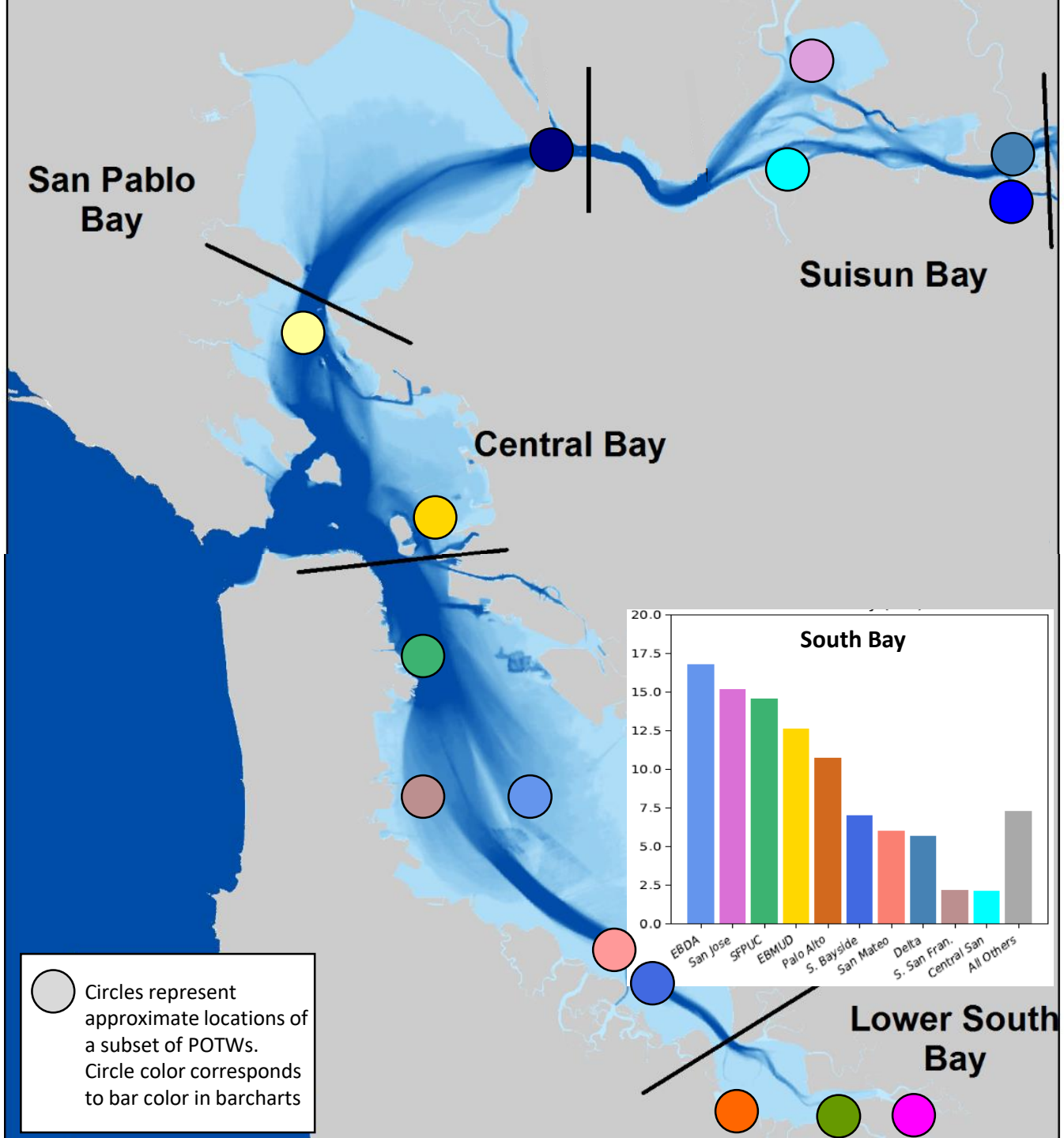
Source Apportionment: Default / Jumping off Point

- Water Board Boundaries

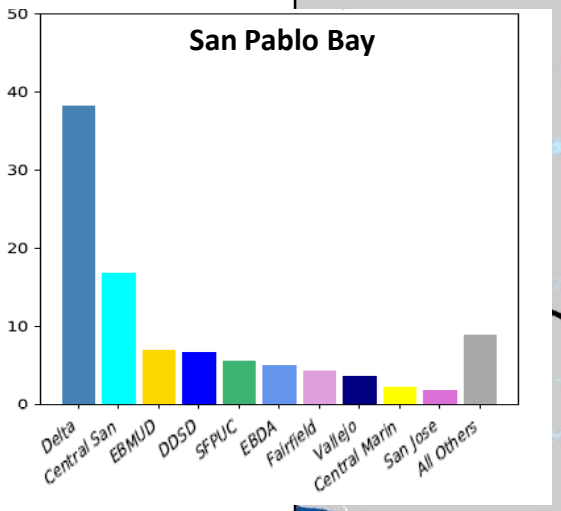
- Jul 2013

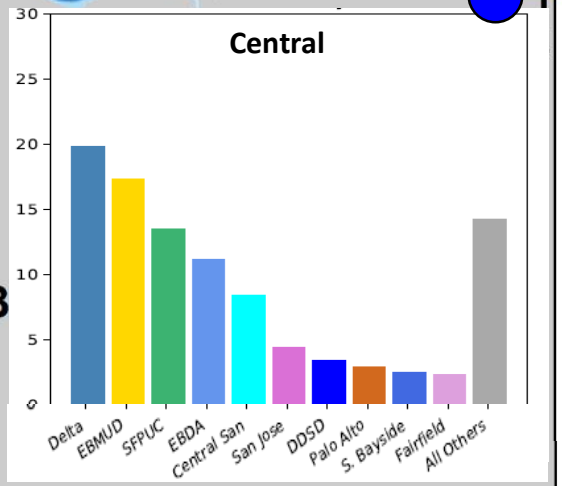
- Calculation Approach: Mean of depth-average concentration for all grid cells within boundaries

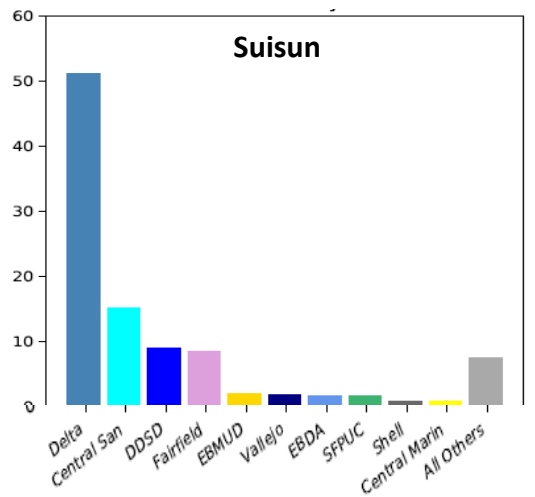
%contribution to [DIN] from **all POINT SOURCES** **

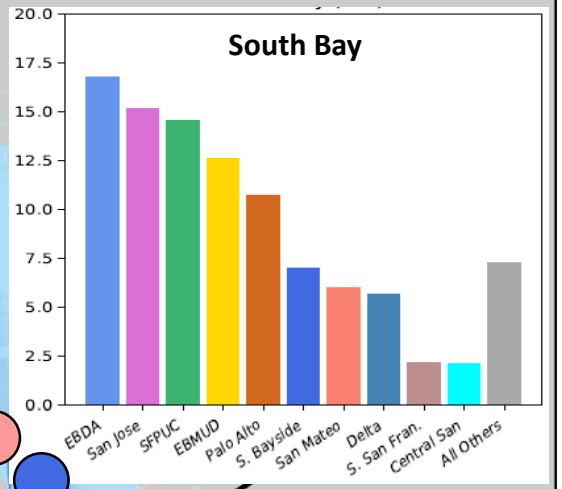


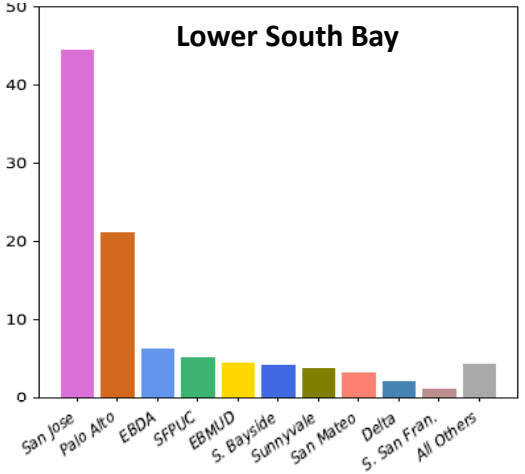
**For the current work, the % contribution was determined based on total from all point sources (including Delta). DIN sources not included in the total: sediment fluxes, influx from coastal ocean. These will be included in follow-up work











Central B

Lower South Bay

Source Apportionment: Default / Jumping off Point

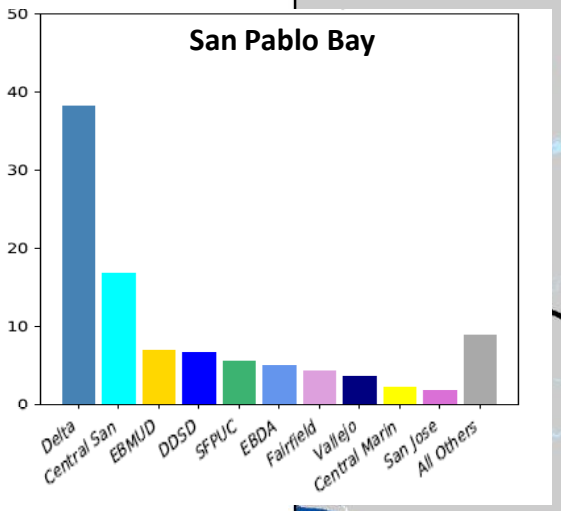
- Water Board Boundaries

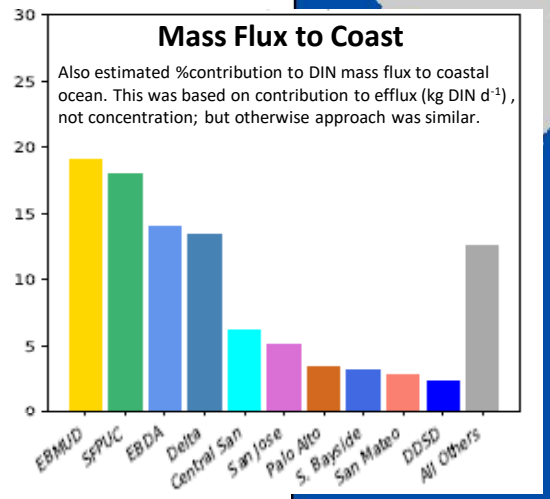
- Jul 2013

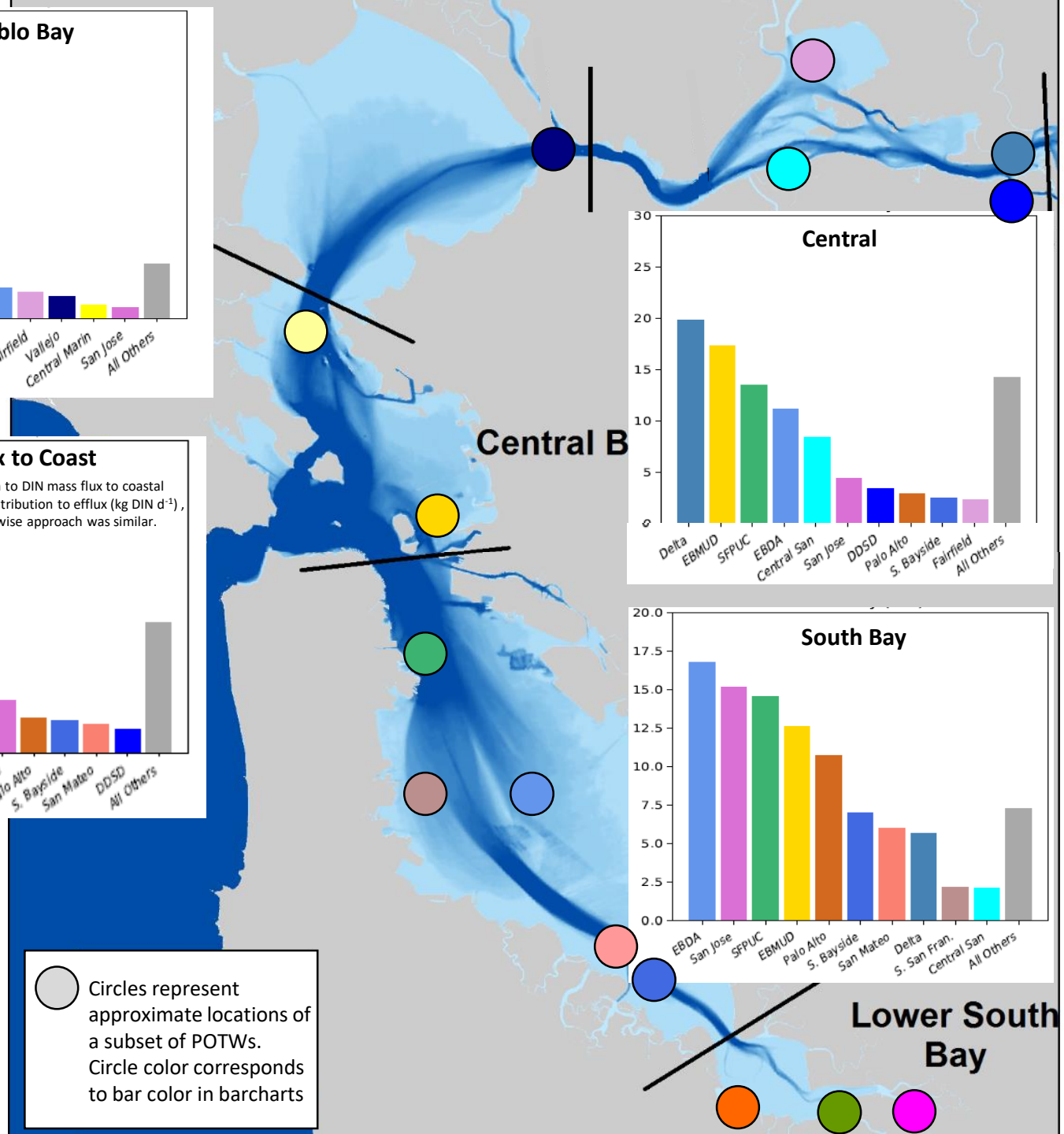
- Calculation Approach: Mean of depth-average concentration for all grid cells within boundaries

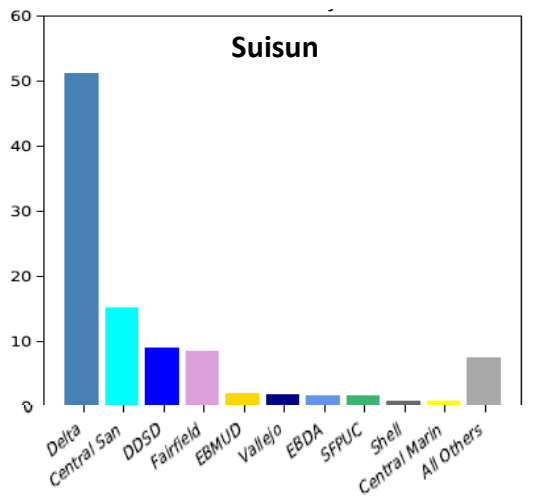
%contribution to [DIN] from **all POINT SOURCES** **

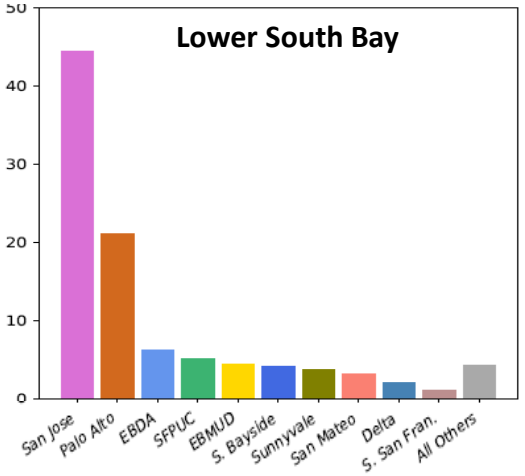
Circles represent approximate locations of a subset of POTWs. Circle color corresponds to bar color in barcharts







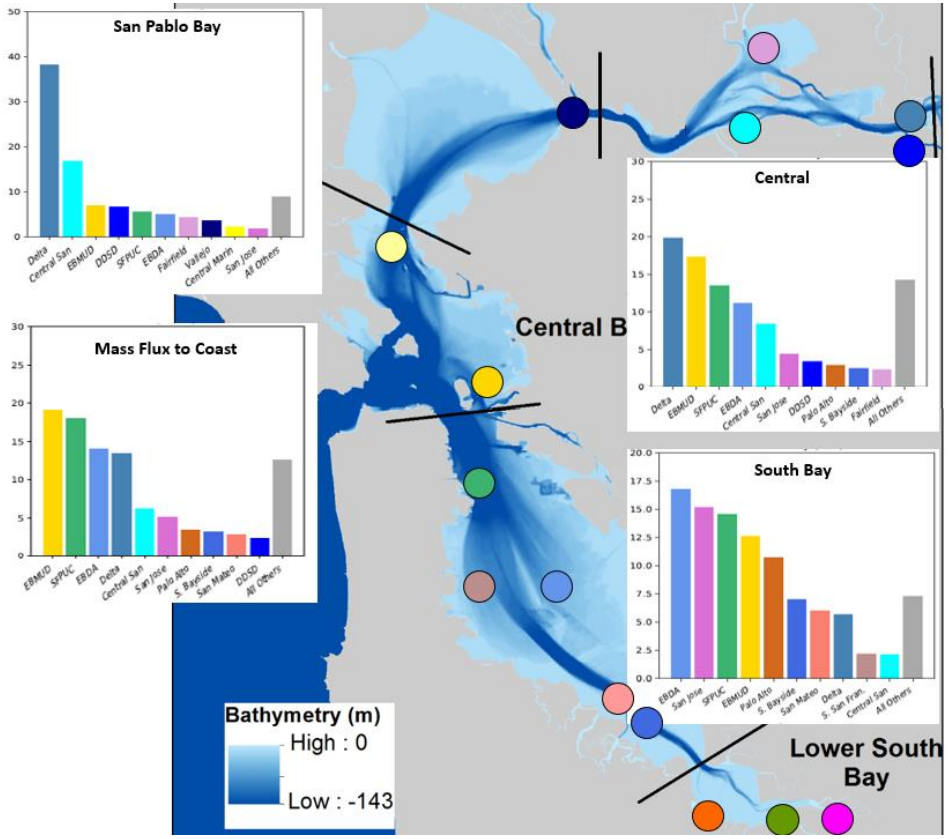


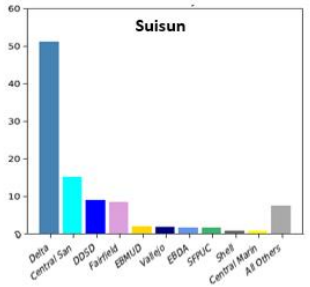


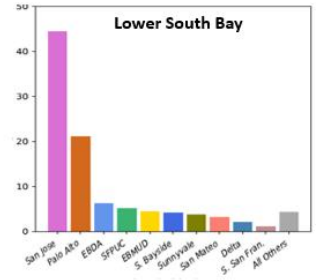
%contribution to [DIN] from **all POINT SOURCES** **

Circles represent approximate locations of a subset of POTWs. Circle color corresponds to bar color in barcharts

Compare relative to base case…







Explore and Quantitatively-Characterize Sensitivity to…

- ❑ Timing:
  - ❑ Season or Month
  - ❑ Interannual
- ❑ Boundary locations (i.e., definition of management unit)
  - ❑ South Bay / Central Bay (WB vs. RMP)
  - ❑ Subdividing South Bay (shoal, channel)
  - ❑ Other boundaries, other subdivisions
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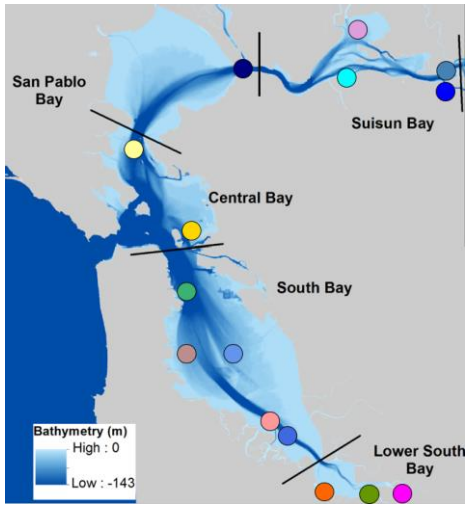
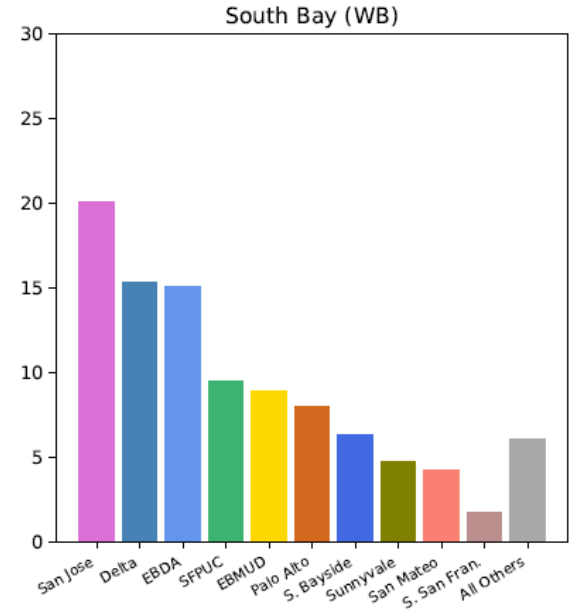
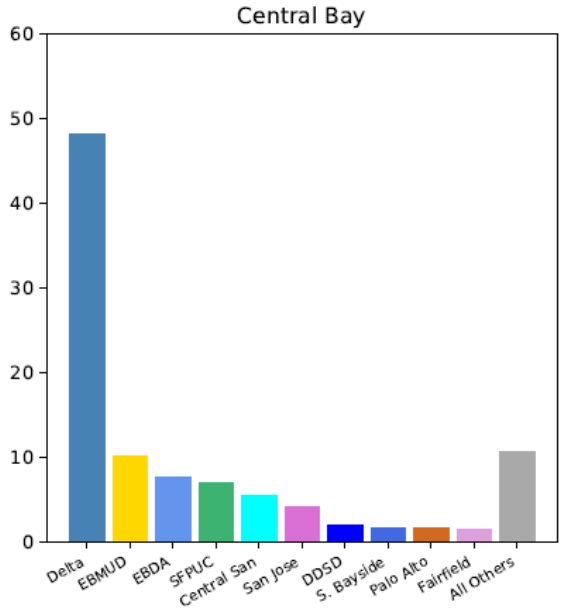
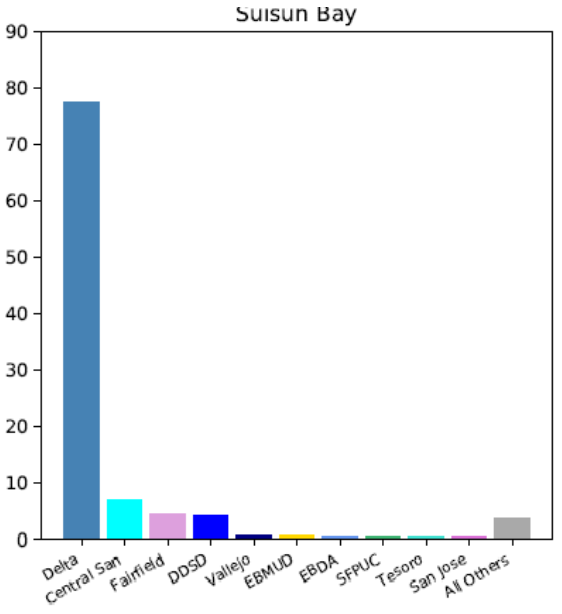


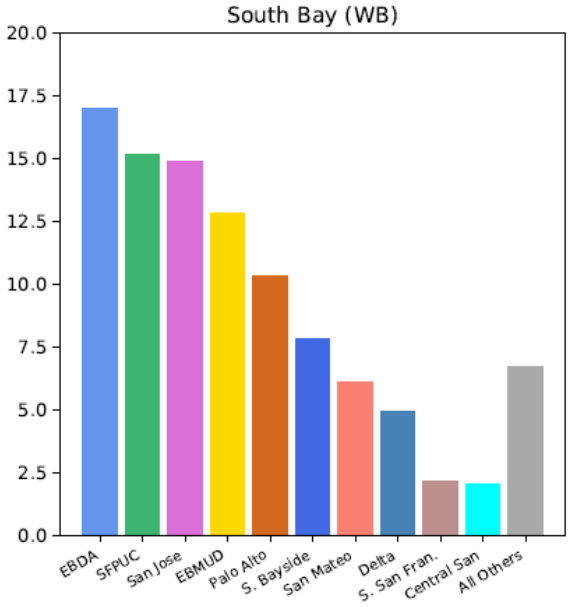
Winter (Jan-Mar 2013)

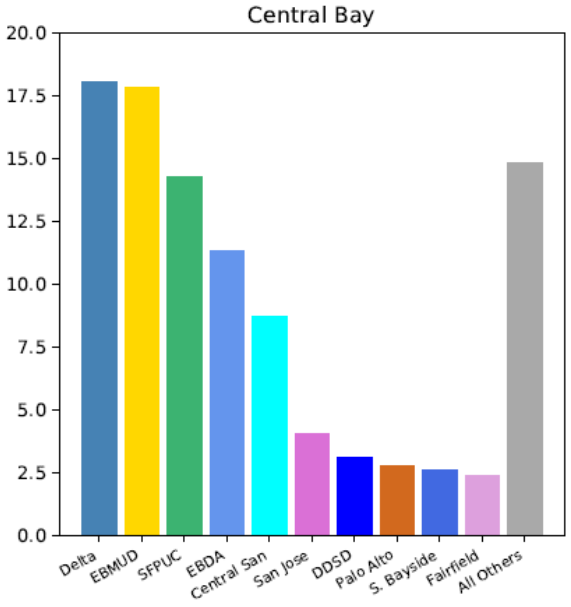


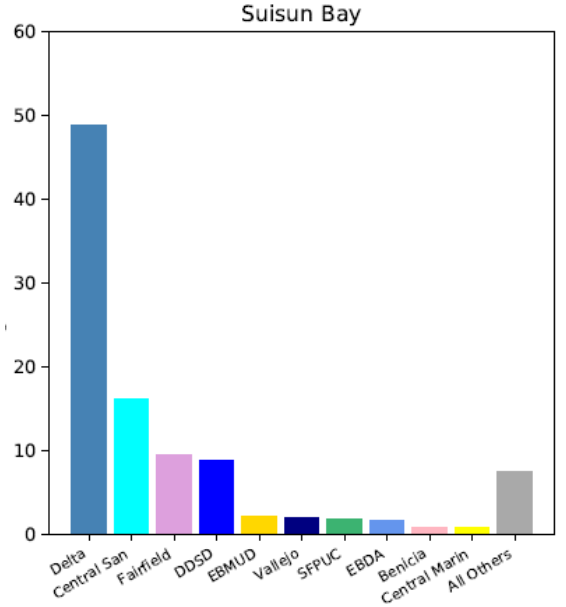




Summer (Jul-Sep 2013)





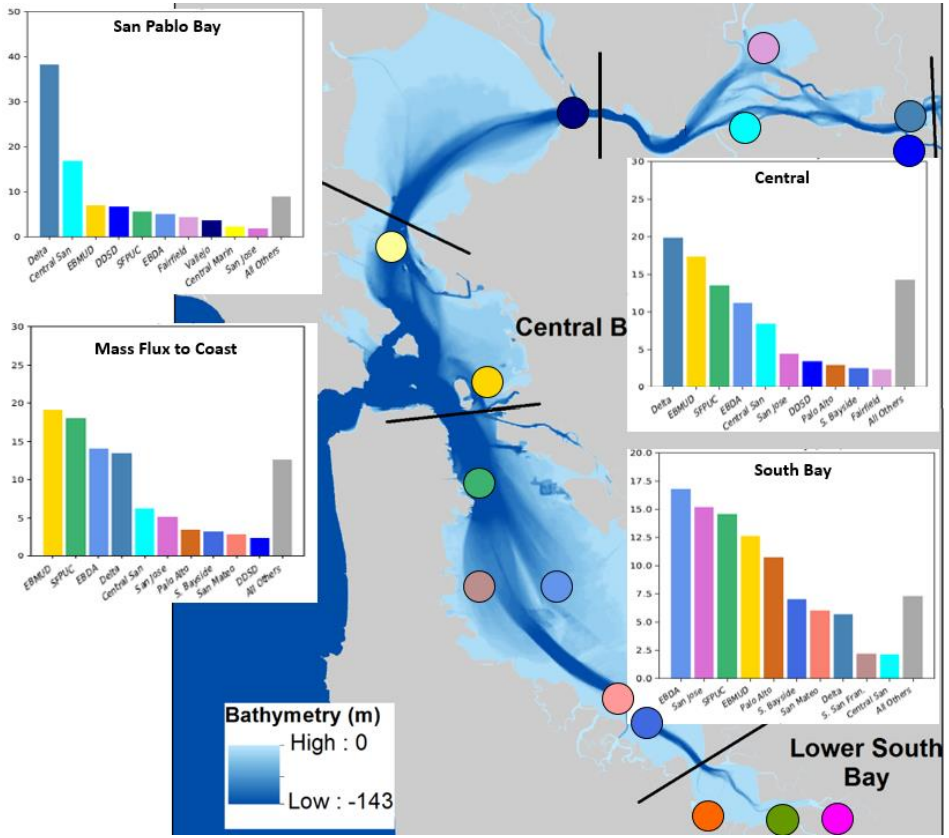


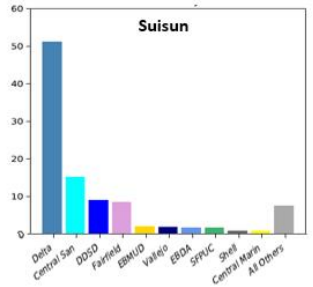
Does source apportionment differ substantially by season?

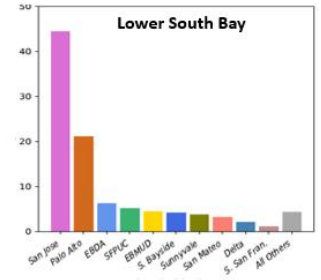
(examples: South, Central Suisun)

- Yes
- Largest differences are related to Delta contribution (relatively large contribution in all three subembayments in winter)
- Other modest changes in %-contribution and sequence (largest to smallest)
  - South Bay: San Jose shifts from 3rd largest summer source (~15%) to 1st largest winter source (~20%)
  - Central Bay: SFPUC and EBDA swap places

Note: The actual 'Default' is July 2013, and bottom row of barcharts is Jul-Sep. For comparison with the 3-month Winter season, we used Summer season (Jul-Sep).
There were only slight differences between Jul (p. 13) and Jul-Sep.







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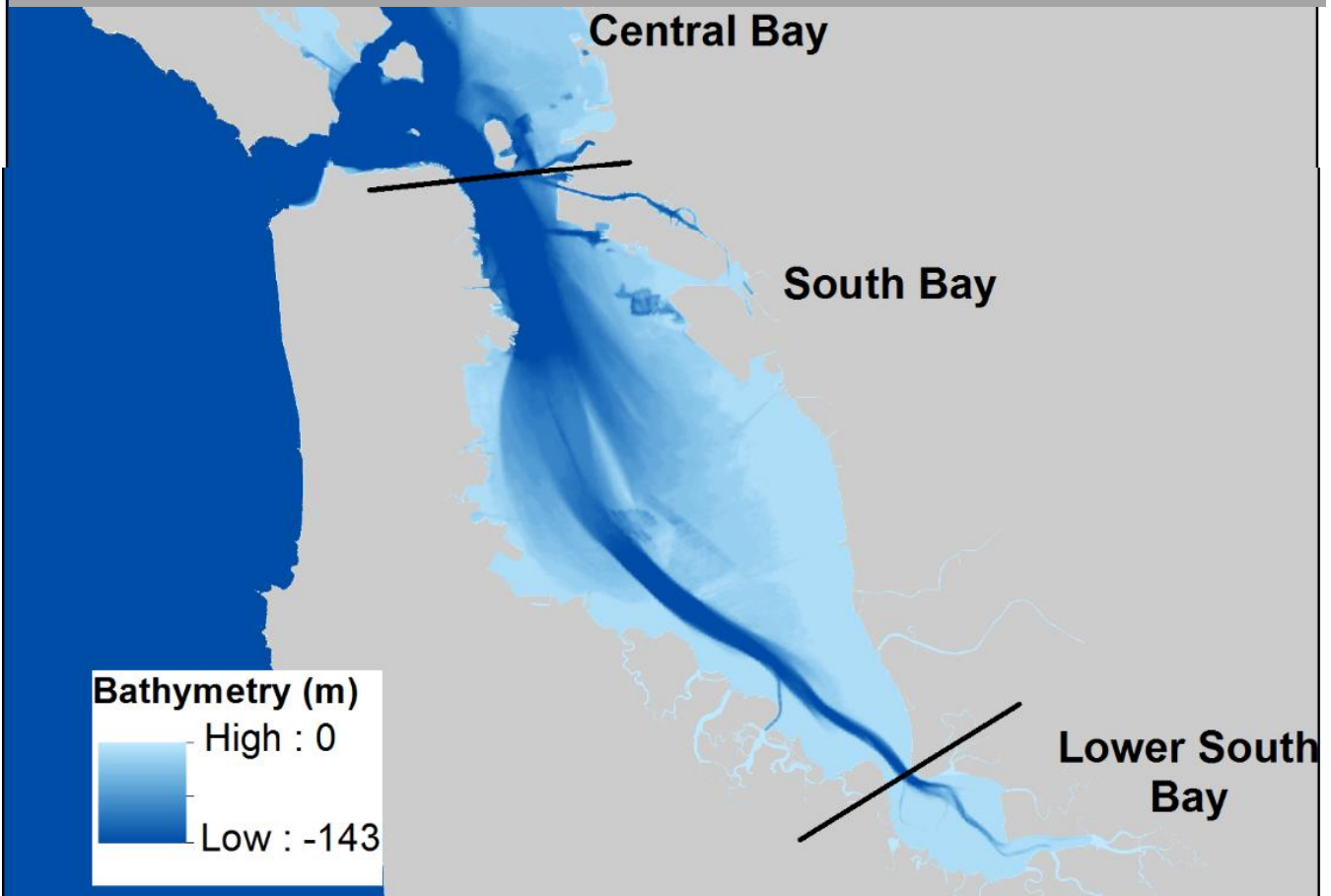
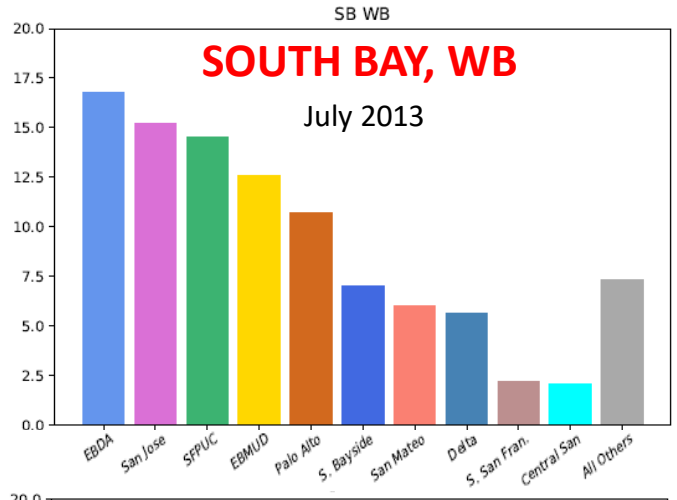
- ❑ Other sensitivity: (model uncertainties, ocean & sediment fluxes)

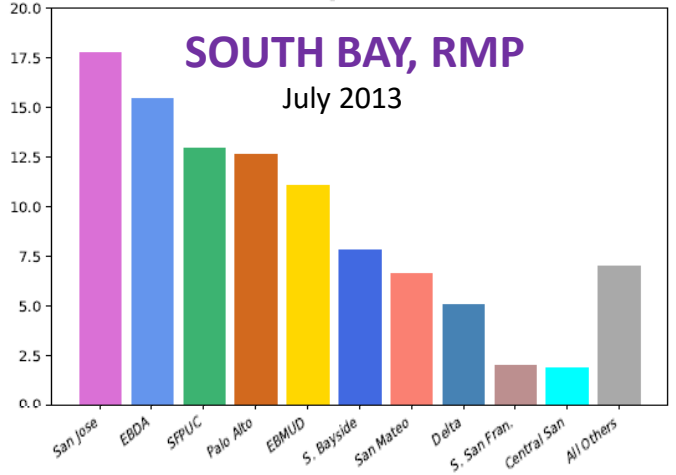
South Bay as an Example

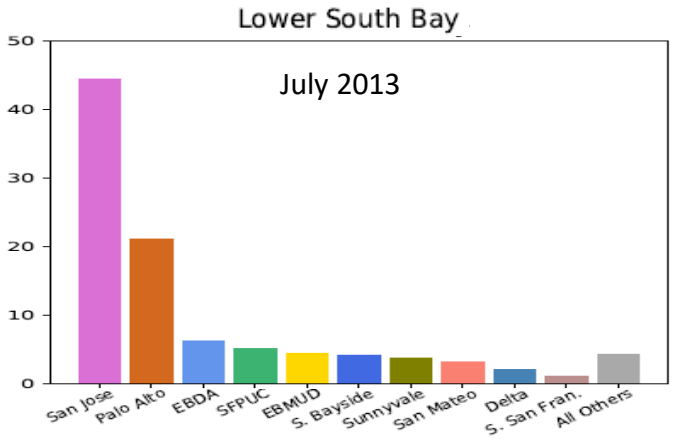
- Sensitive to exact location of boundaries?
- Same, or different, contributions if subembayment is further subdivided (shoal, channel)?

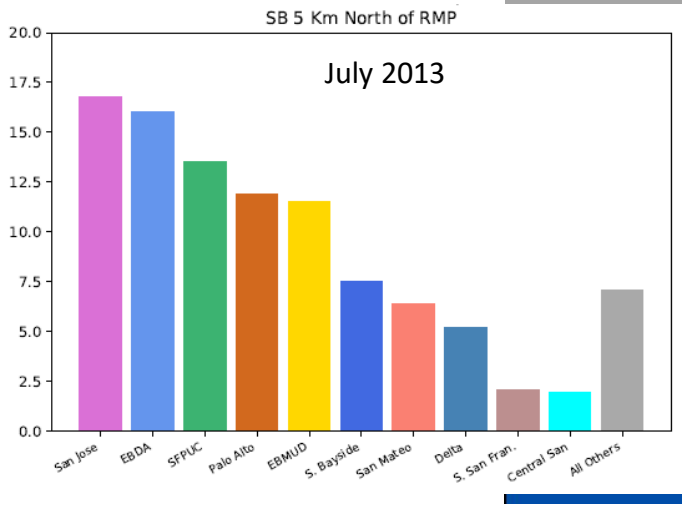


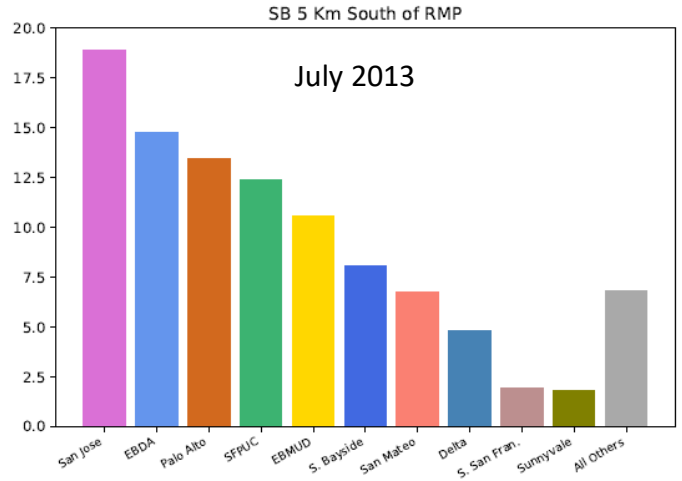


Default





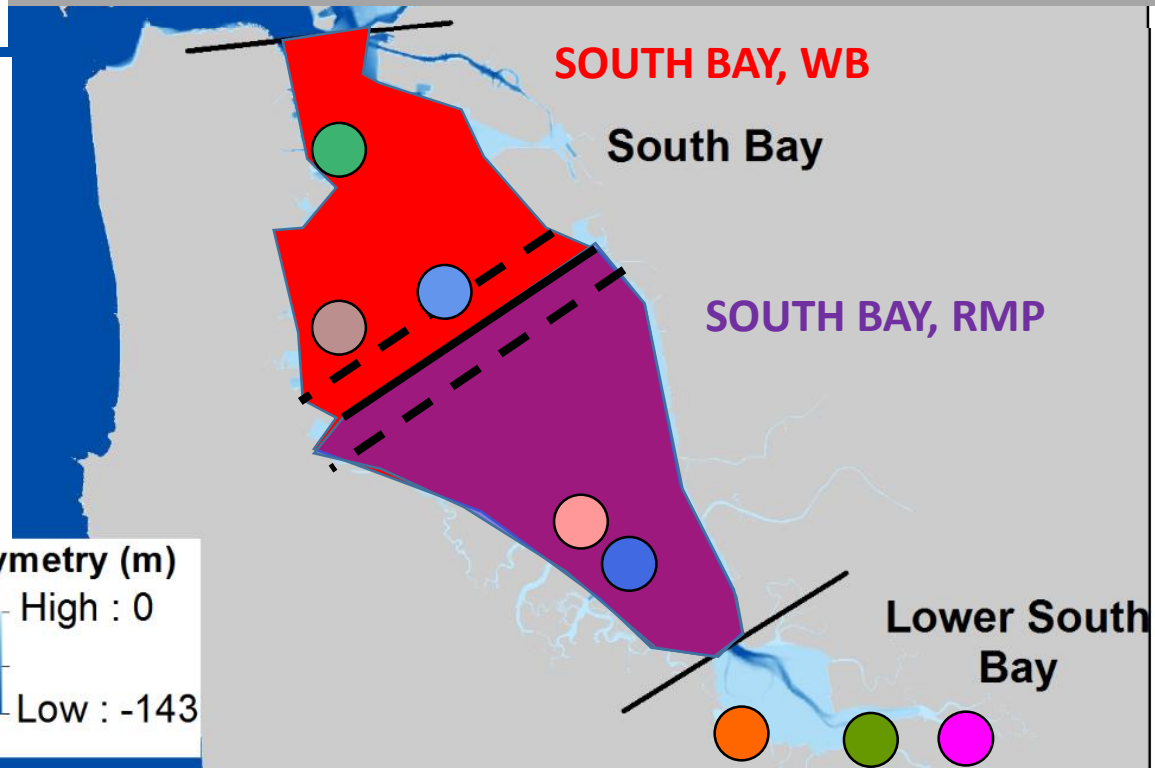


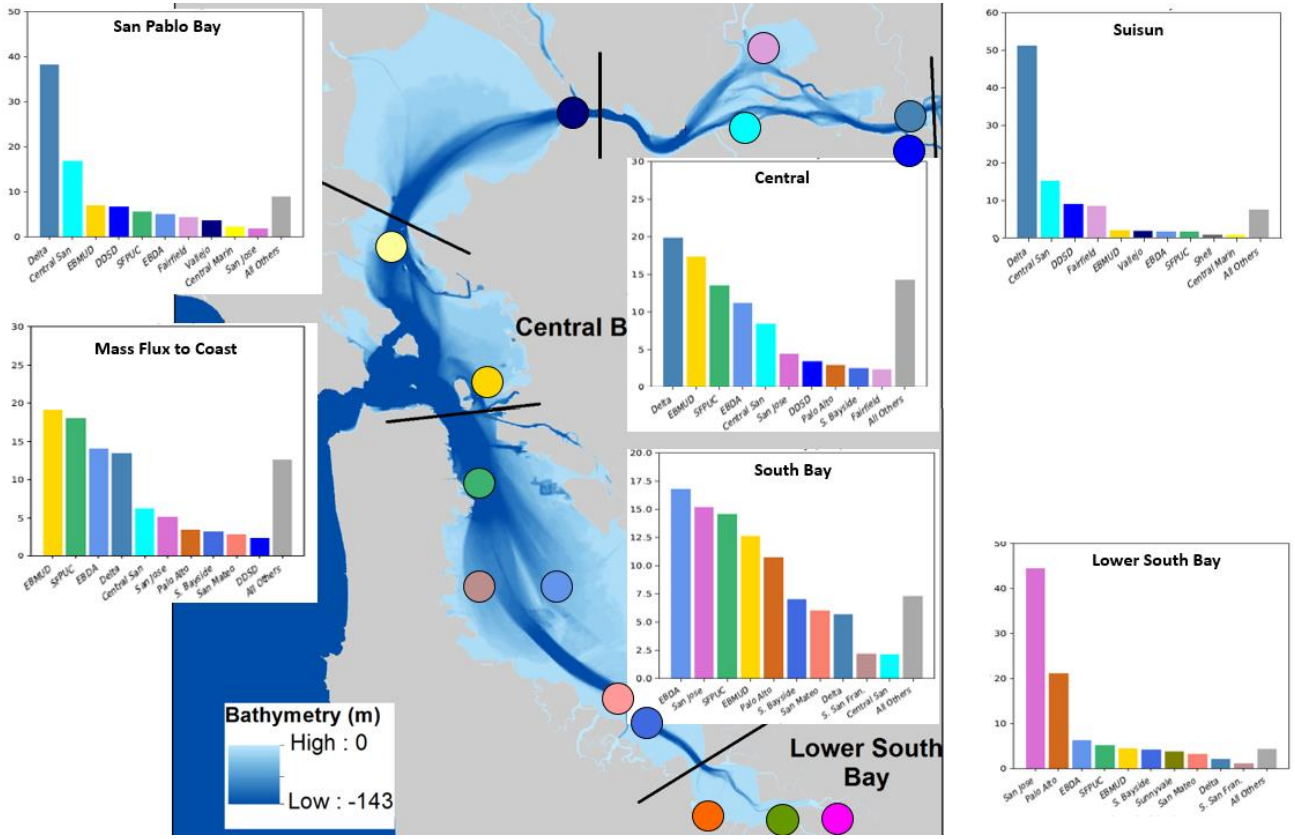


Does source apportionment vary depending on boundary location(s)?

(example: South Bay)

- Yes
- Largest difference: EBDA and San Jose shift positions (1st, 2nd) when northern boundary moved from WB to RMP. But relatively modest changes in % contribution
- Minor changes related to moving boundary north-south by +/- 5km (relatively to RMP boundary).



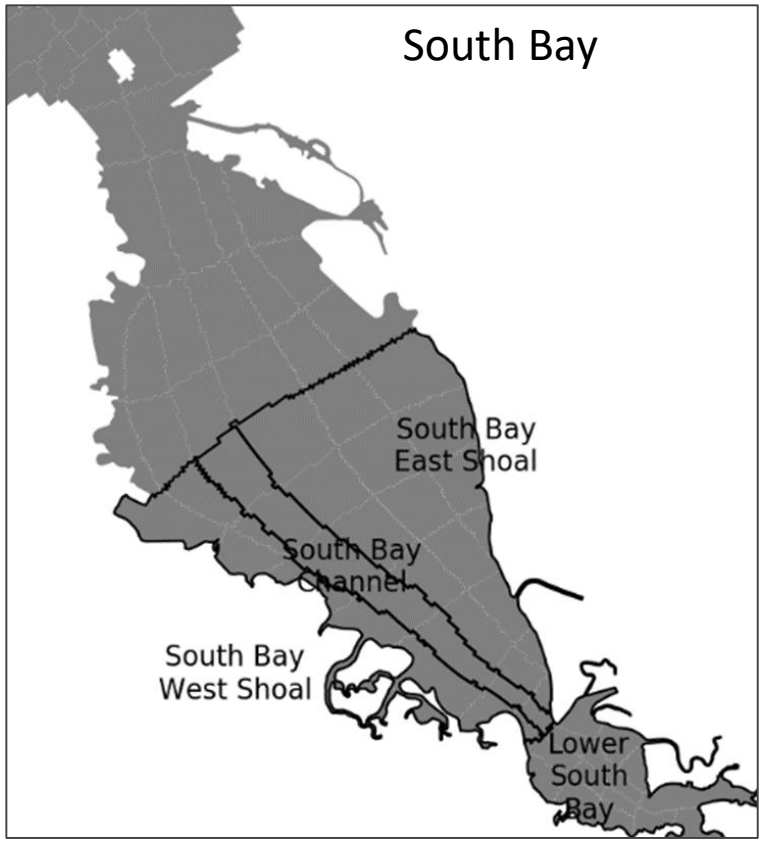


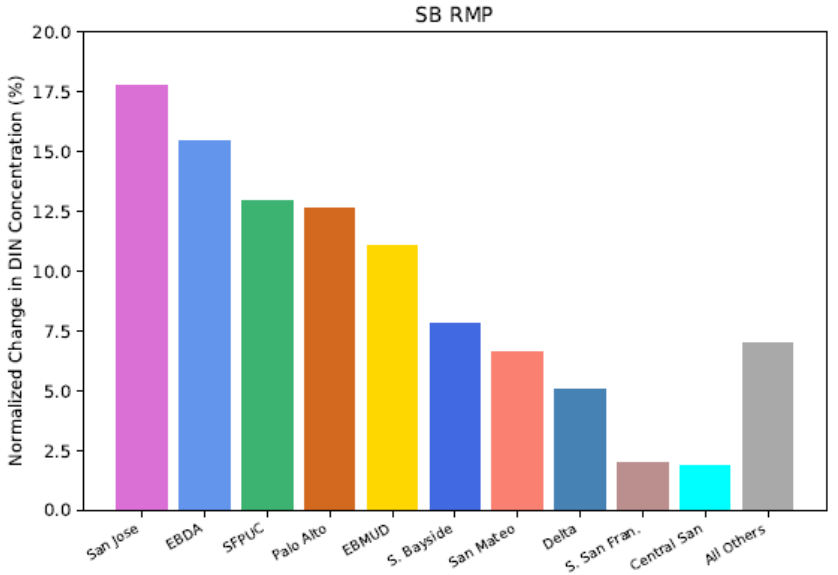
Explore and Quantitatively-Characterize Sensitivity to…

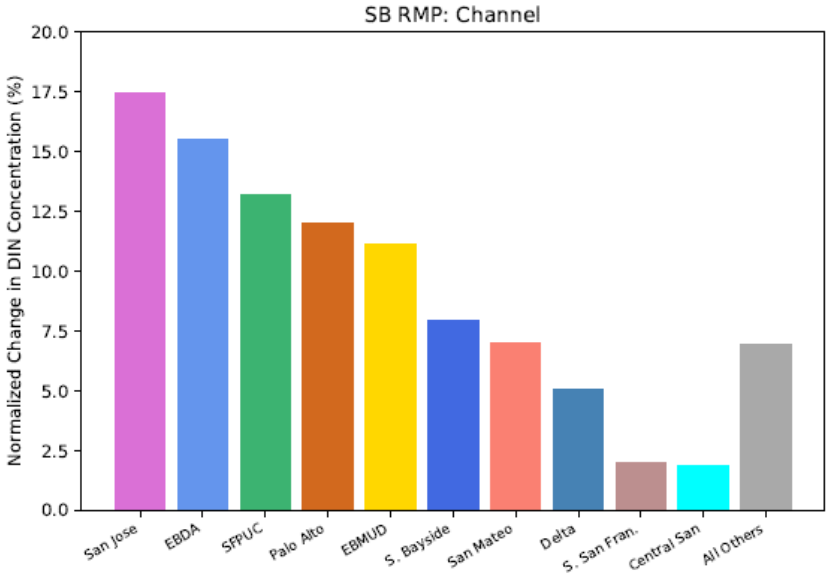
- ❑ Timing:
  - ❑ Season or Month
  - ❑ Interannual
- ❑ Boundary locations (i.e., definition of management unit)
  - ❑ South Bay / Central Bay (WB vs. RMP)
  - ❑ Subdividing South Bay (shoal, channel)
  - ❑ Other boundaries, other subdivisions
- ❑ Approach to determining %contribution:
  - ❑ [DIN] concentration vs. DIN mass
  - ❑ Other response variables (chl-a, GPP, DO, etc.)
- ❑ Other sensitivity: (model uncertainties, ocean & sediment fluxes)

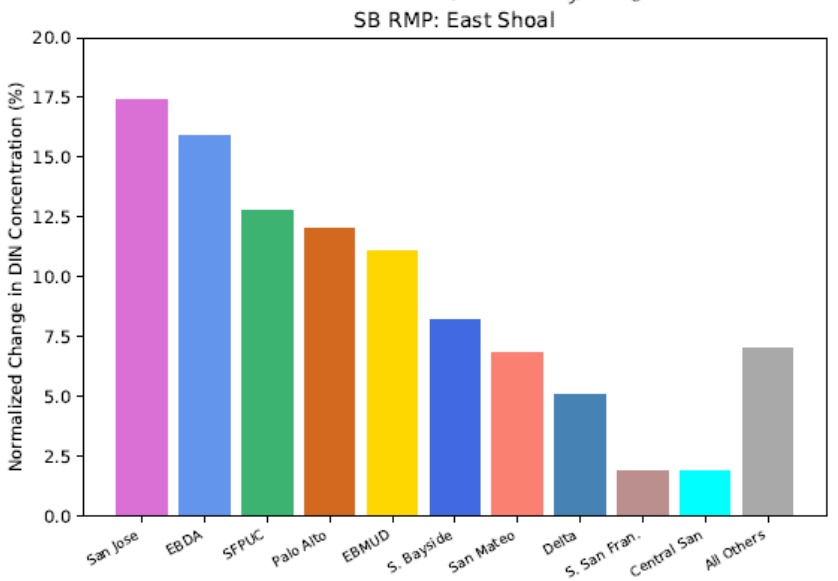
sub-South-Bay-RMP shoal and channel.

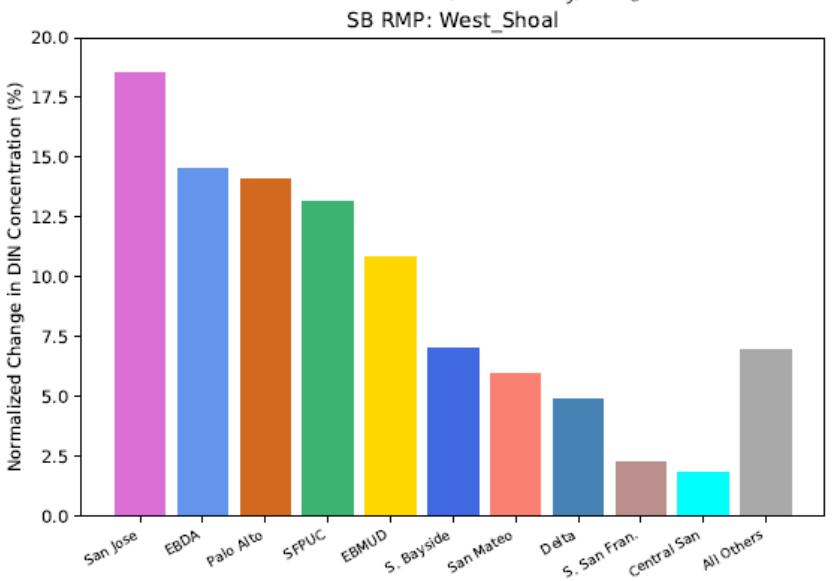
Time: July, 2013. Analysis: Depth-Avg Concentration



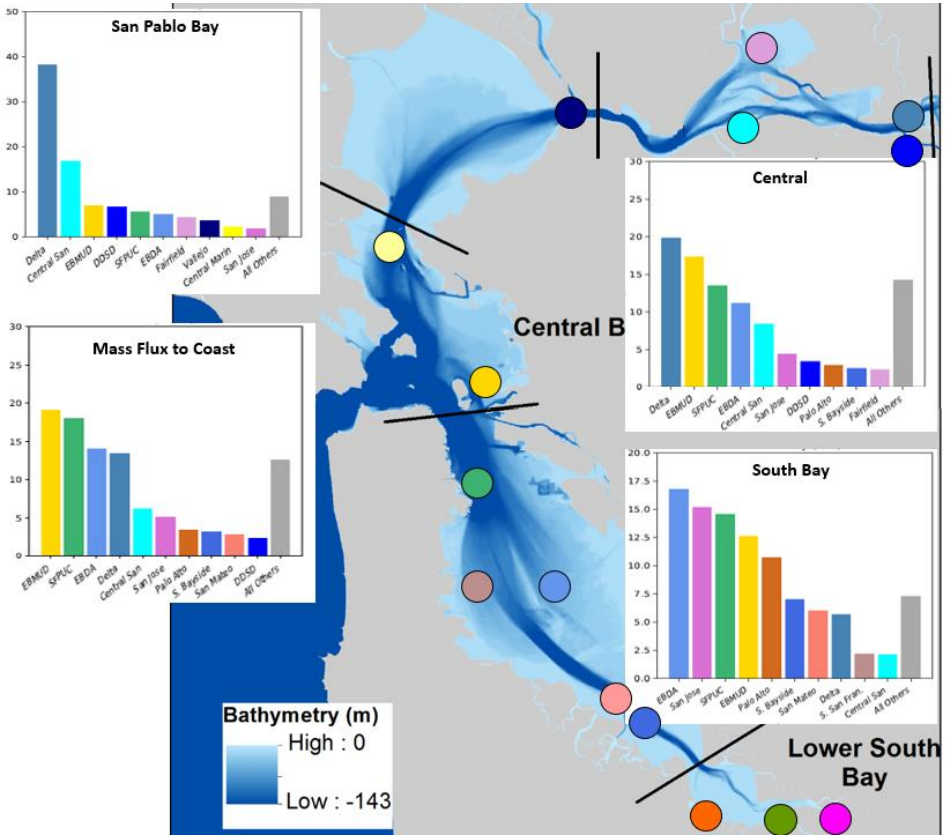


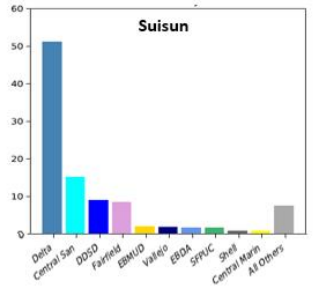


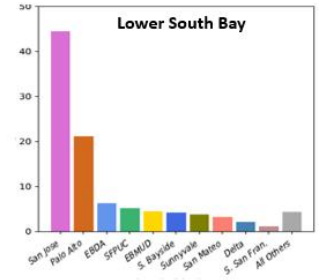




Small/Modest differences when South Bay (RMP) is further subdivided into shoal/channel regions.







Explore and Quantitatively-Characterize Sensitivity to…

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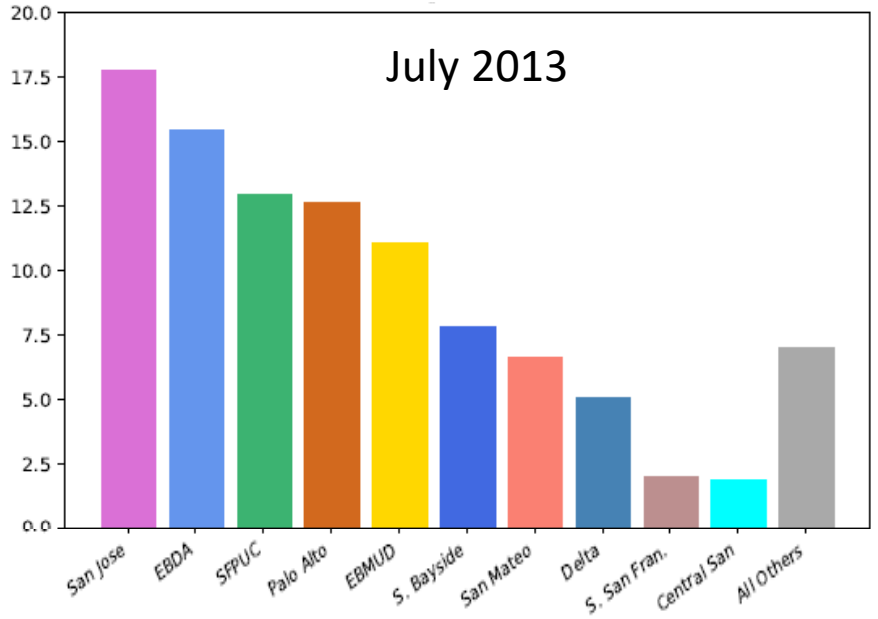
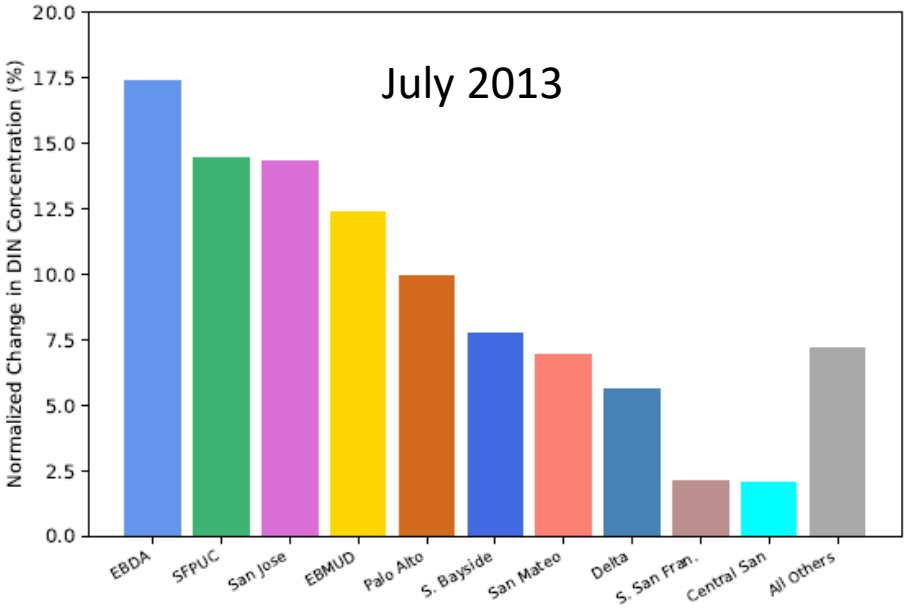
SOUTH BAY, RMP -- Depth-Avg Concentration



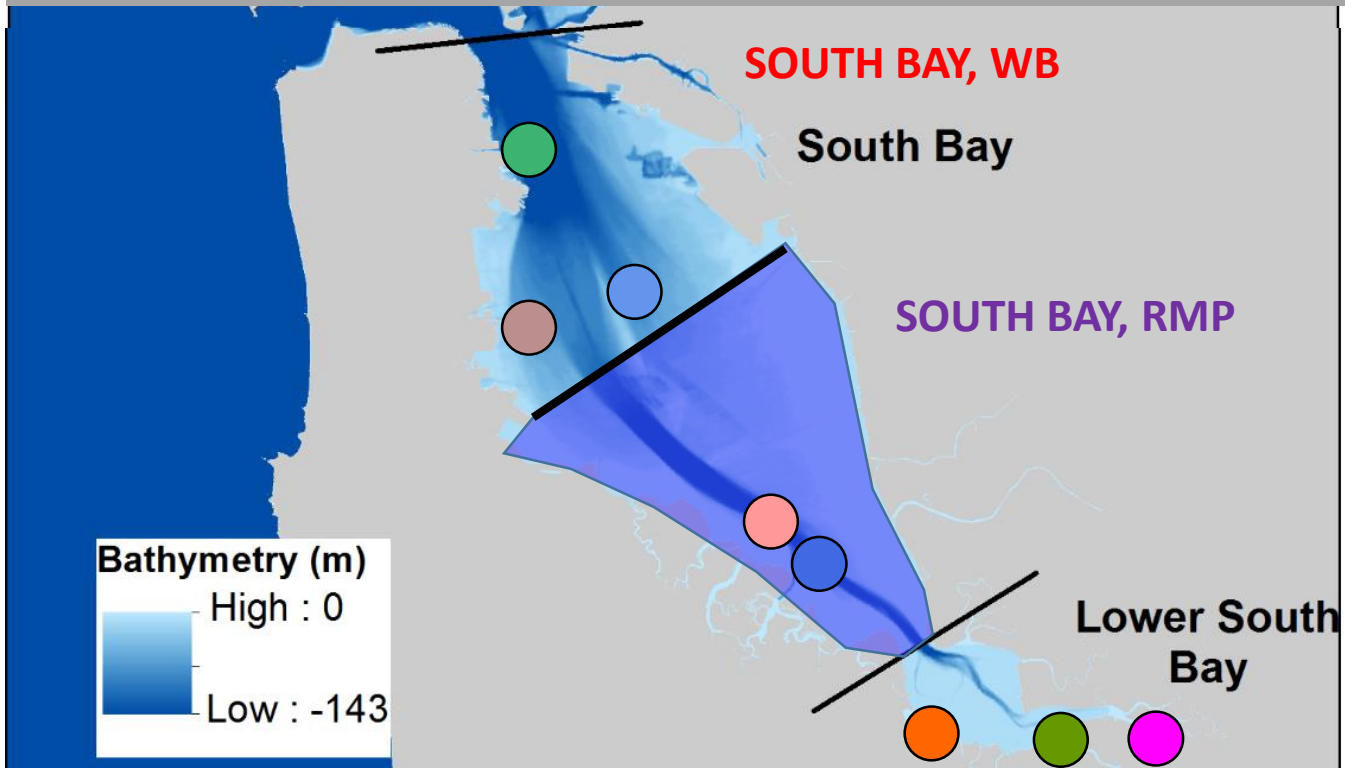
SOUTH BAY, RMP -- Volume-Weighted Concentration (i.e., mass)



Does averaging/calculation approach influence source apportionment?

(example: South Bay)

- Yes
- Largest difference: San Jose shifts positions (1st to 3nd), depth-avg concentration vs. volume-weighted (mass)
- % contributions are still comparable (few % changes)



Major Take-Homes To-Date

1. There are major regional differences in %-contribution
2. Also substantial seasonal influence on %-contribution
   - Zones of Influence (ZOI) for each POTW
   - Source Apportionment / Source Fingerprints (space, time)
3. Initial (limited) analysis suggests that further subdividing subembayments may not have major influence on %contribution
   - More work needed, in particular related to response variables (chl-a, DO)

Major Take-Homes To-Date (cont'd)

4. Individual POTWs do not fit neatly into single subembayments.
    - This is particularly true for major sources, in terms of having non-trivial contributions to DIN levels in multiple subembayments (similar story for smaller POTWs, but proportionally smaller)
5. For a given subemayment…in general, multiple POTWs contribute non-trivially to DIN concentrations.
    - e.g. , in Central Bay and South Bay, 50% of summer DIN levels come from the summed contributions of the largest 3-4 sources

Limitations of Current Approach

- Delta = point source + POTW
- Addressing ‘other’ nutrient sources: sediments, coastal ocean
- Necessary on-going model improvements (e.g., denitrification in LSB)
- Reanalyze through the lens of response variables (chl-a, DO?)
- Method
  - Potential aggregated grid influence on some results…
    - More compact ZOIs?
    - Influence on Management Unit source apportionment?
  - Confirm / test tracer approach (e.g., Delta)

Input on Potential Directions ?

- Focus next round of method development /refinement focused on subset
  - Largest
  - A few medium and small
- Explore load cap scenarios (load forecasts)
- Formally include ‘other sources’…coast, sediment flux
- Response variables
- Test high-res vs. low res model