From Data to Decision: Salton Sea Restoration Concept Evaluation

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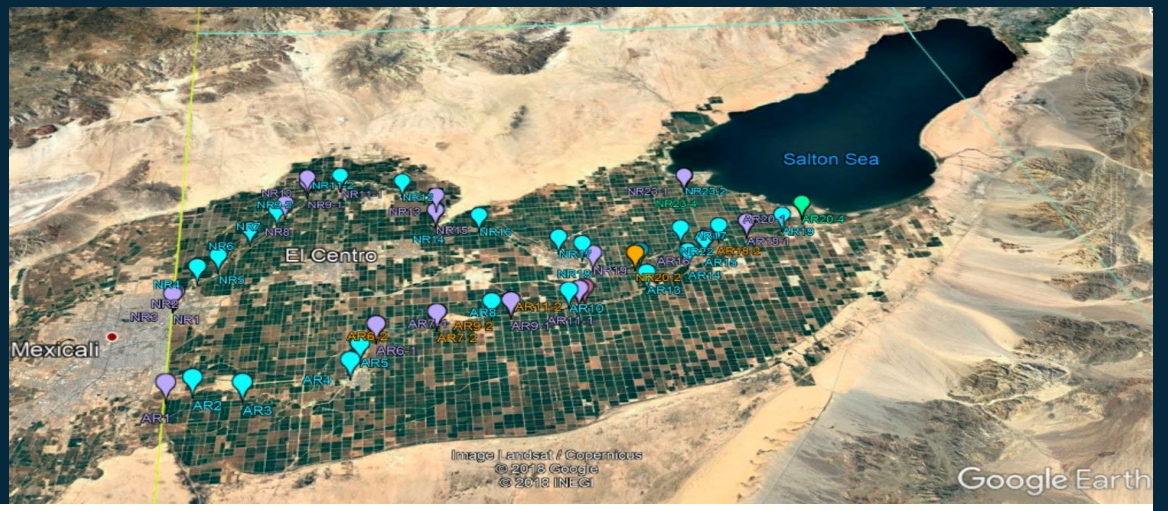
UCLA Previous works

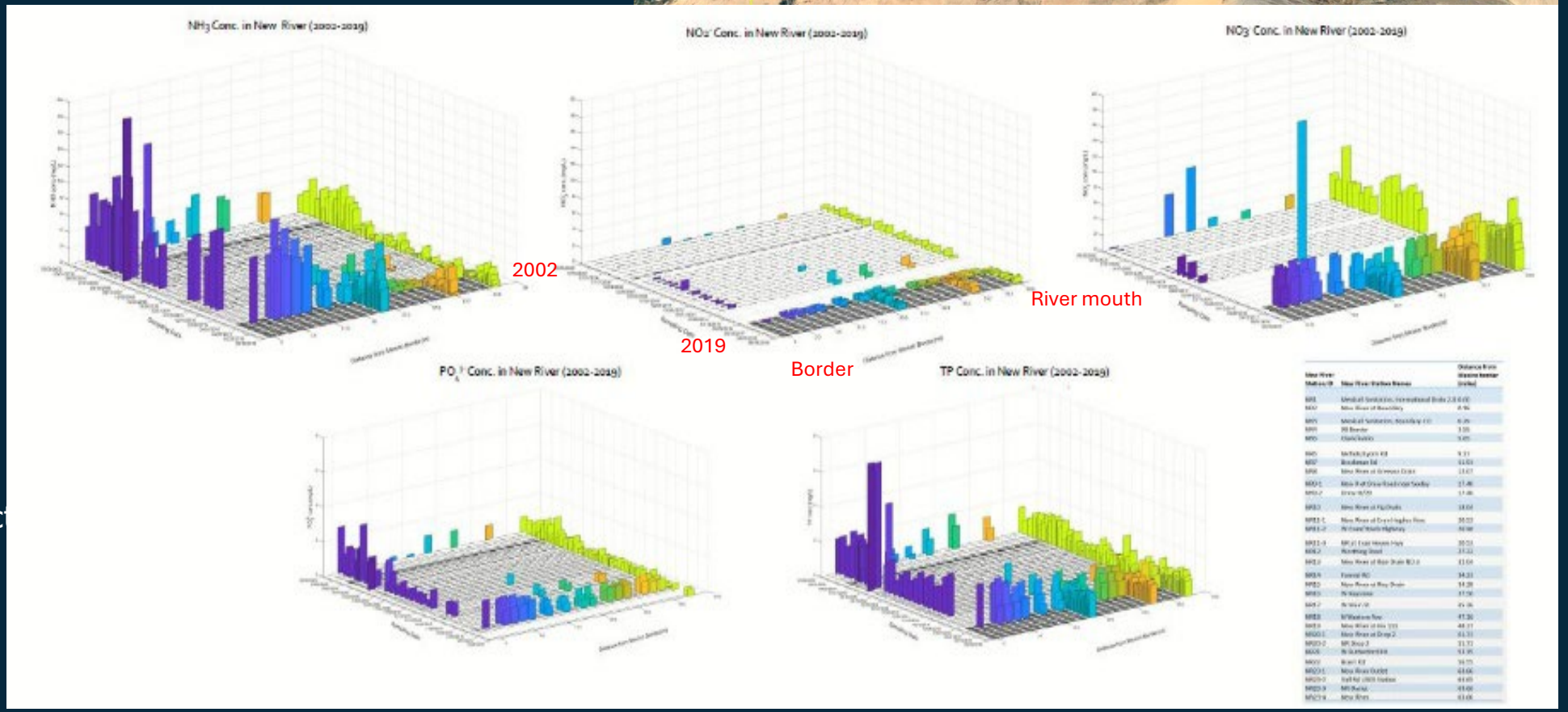
Pollutants of Interest:
- •Nutrients: **NH_3-N**, **NO_2^--N**, **NO_3^--N**, **PO_4^{3-}-P**, **TP**
- •Metal: Selenium

Station Numbers:
- •New River: 23
- •Alamo River: 20

Time Period: 2002-2019
- •Average sampling days/year: 6

Data Sources:
- •California Environmental Data Exchange Network(CEDEN)
- •Bureau of Reclamation
- •Imperial Irrigation Distric
- •Sandia National Lab
- •UCLA

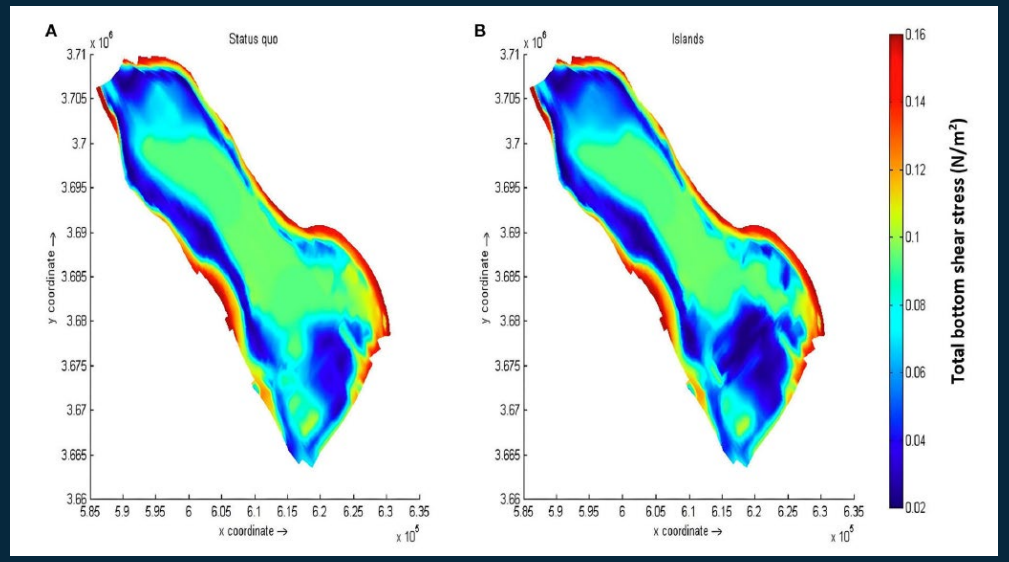


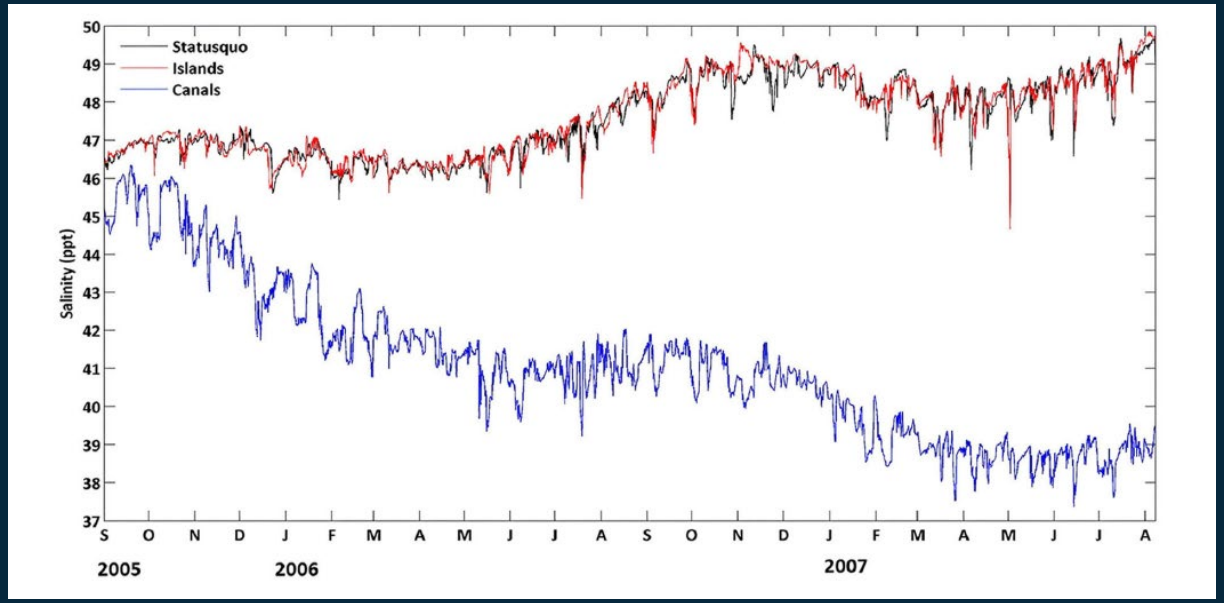


3D hydrodynamics/WQ Modeling

Modeling Approach

- Tool: Delft3D suite (FLOW · WAVE · WAQ)
- Focus: Nutrient transport & cycling under wind-driven sediment resuspension
- Framework: 3D hydrodynamic + water quality coupled model
- Objective: Evaluate long-term (2 years) salinity & water quality impacts of mitigation scenarios:
    - Nature-based: Emerged islands
    - Engineered: Seawater import/export
    - Hybrid: Seawater exchange + tributary nutrient removal





Lee M-C and Stenstrom MK (2023) Water quality mitigation strategy analysis of the Salton Sea, California, using the Delft-3D modeling suite. Front. Sustain. Resour. Manag. 2:1178038. doi: 10.3389/fsrma.2023.1178038

Long Range Plan Water Quality Criteria

At the current planning stage, all l evaluated concepts received the same water-quality score of 3.

Ability to Improve Water Quality

Restoration Concept	Score
Phase 1: 10-Year Plan	3
1. North/South Marine Sea	
1A With Saline Habitat Complex (SHC)	3
1B Without SHC	3
1C Without SHC, w Freshwater Reservoir	3
2. Divided Sea	
2A With Full 10-Yr Plan	3
2B Without Alamo River Project	3
2C Without Alamo/w 2 Perimeter Lake Cells	3
2D Without Alamo/w 2 Perimeter Lake Cells & Freshwater Reservoir	3
3. Updated Perimeter Lake	
3A Updated Perimeter Lake	3
3B Updated Perimeter Lake wo Alamo & 3 Cells/w Freshwater Reservoir	3
4. Pump Out	
4A With Dust Control	3
4B With Pipeline	3
4C With Dust Control + Pipeline	3
4D With Dust Control/Without Alamo/w FW Reservoir	3
5. Water Optimization (35,000 ac)	3
7. Water Recycling	3
11. IRP Water Importation	3
12. IRP Water Exchange	3
13. IRP Colorado River Water Transfer	3

Board questions the score cannot separate

Which concept reduces nutrients best?

Which concept manages selenium risk best?

Which concept avoids low oxygen best?

Which concept performs best during drought?

Which concept gives the best benefit per acre-foot?

Concept Categories

Concept family	Concepts included	Description	Main evaluation questions
Basin, Lake, and Water-Routing Concepts	Concepts 2, 3, and 5	These concepts **change how water is stored, divided, or moved** within the Salton Sea. They may create separate **basins, perimeter lakes**, **channels, gates, or causeways**.	How much water is needed? How does salinity change? How long does water remain in each area? Could stagnant or low-oxygen zones develop?
Treatment, Wetland, and Removal Concepts	Concepts 4, 6, and 7	These concepts improve water quality by removing salt, sediment, nutrients, selenium, or other pollutants through **pumping, wetlands, treatment, or recycling.**	How much pollution is removed? How reliable is the treatment? How much energy and maintenance are required? What waste or brine is produced?
Water Supply, Import, and Exchange Concepts	Concepts 11, 12, and 13	These concepts **add water** to the Sea, **exchange water** with another source, or increase existing inflows. Their success depends on the amount, quality, and long-term reliability of the water supply.	How much water can be delivered? Will the supply remain available during drought? How will added water affect salinity, lake level, exposed playa, and habitat?

Framework to Evaluate the Restoration Concepts

COMMON TEST FOR ALL CONCEPTS

- Same inflow, drought, heat, evaporation, and water quality conditions
- Same performance metrics and thresholds
- Same planning horizon

MODELS MATCHED TO HOW CONCEPTS WORK

- Basin, lake & routing concepts
- Treatment, wetland & removal concepts
- Water supply, import & exchange concepts
- Local habitat & community improvement concepts

SIDE-BY-SIDE EVALUATION

- Water demand (normal & drought)
- Salinity reliability
- Oxygen levels fish need to survive
- Nutrients & selenium *(a naturally occurring element that can build up in fish and birds)*
- Acres of exposed playa *(dust potential)*
- Habitat for fish & birds
- Recreation & community benefits
- Benefit per acre-foot, cost & energy
- Operational complexity

TEST DIFFICULT FUTURES

- Prolonged drought
- Hotter summers
- Storm events
- Reduced inflow
- Water quality shocks
- Infrastructure or treatment underperformance
- Different operating strategies

TARGETED DETAILED ANALYSIS

- Detailed three-dimensional modeling of how water moves and mixes
- Representative concepts from each family
- High-uncertainty or high-consequence concepts
- Finalist concepts

BOARD DECISION PACKAGE

- One-page scorecards for all concepts
- Side-by-side dashboard for easy comparison
- Maps and visual summaries
- Recommended finalists and next steps

SUPPORTING INPUTS

Species Conservation Habitat (SCH) Monitoring & Operations
- Real-time observations
- Gates, blending, flow & water quality

SCH MACHINE-LEARNING FORECAST
Forecasts the amount and quality of water leaving SCH under different weather and operating conditions.

Used only for concepts physically connected to SCH.

New & Alamo River Data, Climate & Evaporation, Water Quality Loads, Infrastructure & Operations

PHASED SCHEDULE

SETUP & ALIGNMENT
Months 1–4
Data, assumptions, scenarios, metrics, and thresholds

GATE 1 — Approve scenarios & metrics

SCREEN ALL 10 CONCEPTS
Months 5–10
Apply matched models and create initial scorecards

GATE 2 — Select concepts for deeper analysis

TEST RESILIENCE & UNCERTAINTY
Months 11–16
Stress test, evaluate uncertainty, and identify key information gaps

GATE 3 — Select finalists for detailed study

TARGETED DETAILED MODELING
Months 17–22
High-value and high-uncertainty concepts; refine results

GATE 4 — Board decision on investments

BOARD REPORT & RECOMMENDATIONS
Months 23–24
Scorecards, dashboards, maps, and recommendations

Example Dashboard

Concept	Main benefit	Water need	Drought resilience	Playa & habitat benefit	Main risk	Confidence	Recommended action
2 — Divided Sea	Large managed habitat area	High	Moderate	High	Circulation, causeway operation, low oxygen	Medium	**Advance with conditions**
3 — Perimeter Lake	Habitat and shoreline benefits with moderate water use	Medium	High	High	Stagnation in some lake cells	Medium	**Advance**
4 — Pump-Out	Removes salt and poor-quality water	Low–Medium	High	Low	Disposal cost and long-term pumping	Medium	**Use as supporting strategy**
5 — Water Optimization	Directs limited water to priority areas	Medium	Moderate	Medium	Operating rules remain uncertain	Low–Medium	**Advance with conditions**
6 — Wetland Treatment	Removes pollutants and creates local habitat	Low	Moderate	Medium locally	Maintenance and full-scale reliability	Medium	**Use as supporting strategy**
7 — Recycling / Desalination	Treats water and may recover usable supply	Medium	Moderate	Medium	Cost, energy, and brine disposal	Low	**Hold pending feasibility**
11 — Water Importation	Major Sea-wide habitat and playa benefit	Very High	Low if supply fails	Very High	Water-source reliability, permitting, cost	Low	**Advance only after supply verification**
12 — Water Exchange	Improves lake level, dilution, and salinity	High	Moderate	Very High	Legal, supply, and conveyance uncertainty	Low	**Advance only after feasibility review**
13 — Additional Inflow	Improves elevation, salinity, and habitat	High	Moderate	High	Dry-year water availability	Medium	**Advance with conditions**

*This table shows hypothetical results

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