BUREAU OF RECLAMATION

Evaluation of Summer-Fall Smelt Habitat in Bay-Delta under various LTO alternatives

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Study Goal

- To evaluate how LTO management alternatives will impact summer-fall habitat in Bay-Delta for Smelt
  - Four alternatives (Exp 1, Exp2, NAA, Alt2)
  - 2022 median climate
  - Sea level rise
  - Three-dimensional forecast with Bay-Delta SCHISM
  - Representative water years
  - Habitat suitability index for Bay-Delta

Alternatives

	Alternative	Description
1	Run-of-the-river (EXP1)	Exploratory alternative with hydrologic conditions in the absence of the operation of projects
2	Non-discretionary obligations (EXP3)	Exploratory alternative in which Reclamation and DWR make releases from reservoir storage to meet D1641, senior water rights and Level 2 Refuges
3	No action (NAA)	Current regulatory environment
4	Multi-Agency Consensus version 1 (Alt2 without VAs, without TUCP)	Represents actions and tradeoffs made to reach consensus with DWR, USFWS, CDFW, and NMFS: Without voluntary agreements and without TUCP actions.
5	Multi-Agency Consensus version 1 (Alt2 without VAs, with TUCP)	Same as #4 above but with TUCP actions.
6	Multi-Agency Consensus version 1 (Alt2 with Delta VAs, without TUCP)	Same as #4 above but with Delta VA.
7	Multi-Agency Consensus version 1 (Alt2 with All VAs, without TUCP)	Same as #4 above but with All VAs

Representative Years Simulated

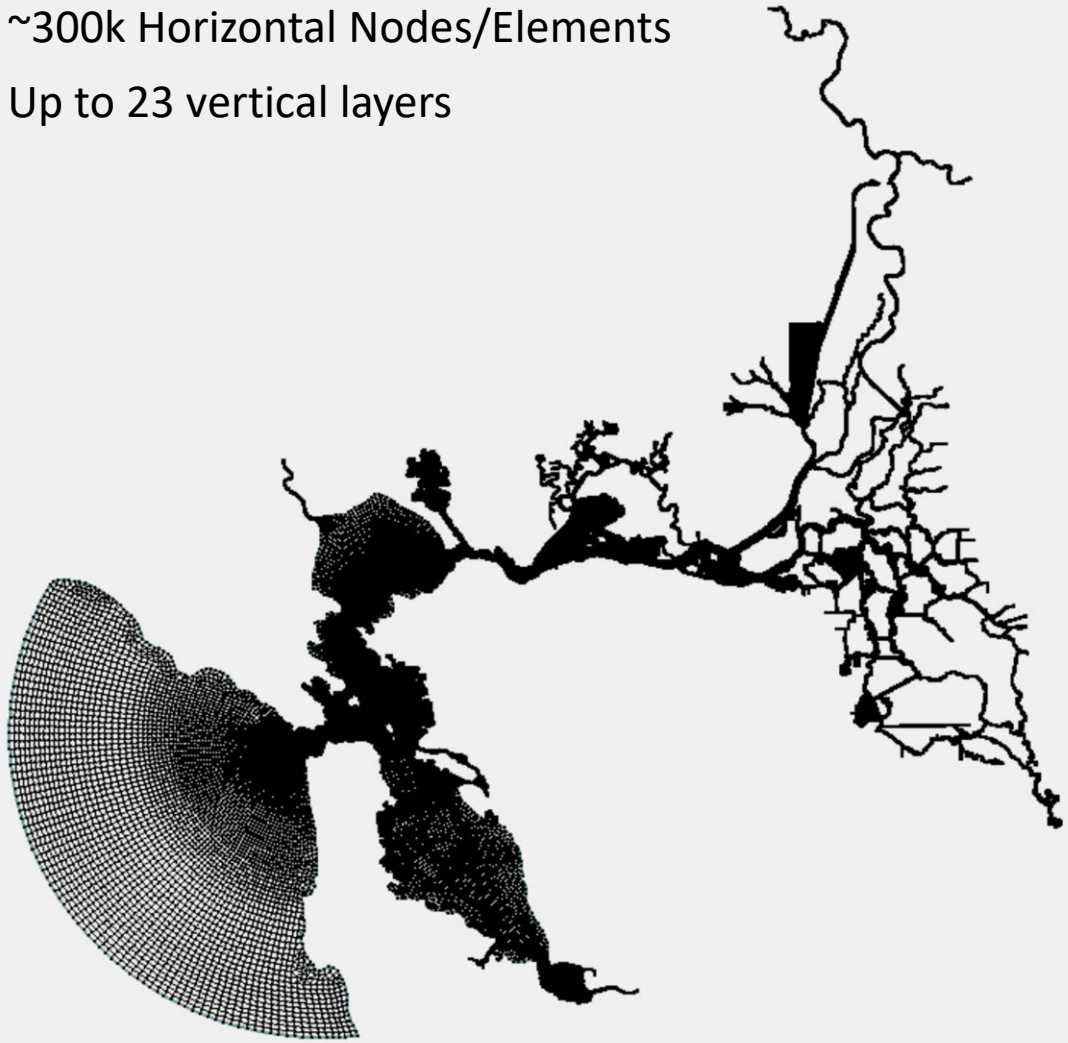
- Based on readily available data
  - Atmospheric and Instream Considerations
  - 1979 - 2021
  - 2022 median climate
- Utilized SAC river index
  - Median for each WY

	Water Year Type	CALSIM Year	SAC River Index (MAF)
1	Wet	1997	10.8
2	Above Normal	1993	8.5
3	Below Normal	2012	6.5
4	Dry	2009	5.7
5	Critical	2015	4.0

SCHISM Model Mesh and Habitat Regions

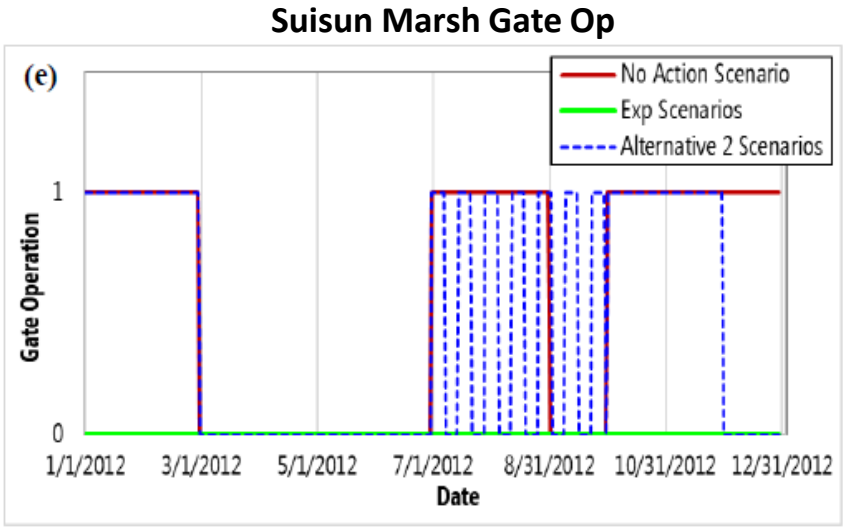
~300k Horizontal Nodes/Elements

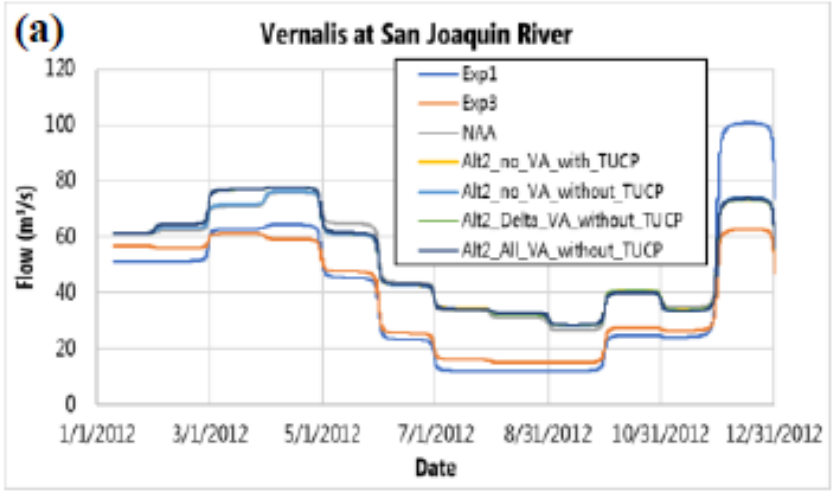
Up to 23 vertical layers

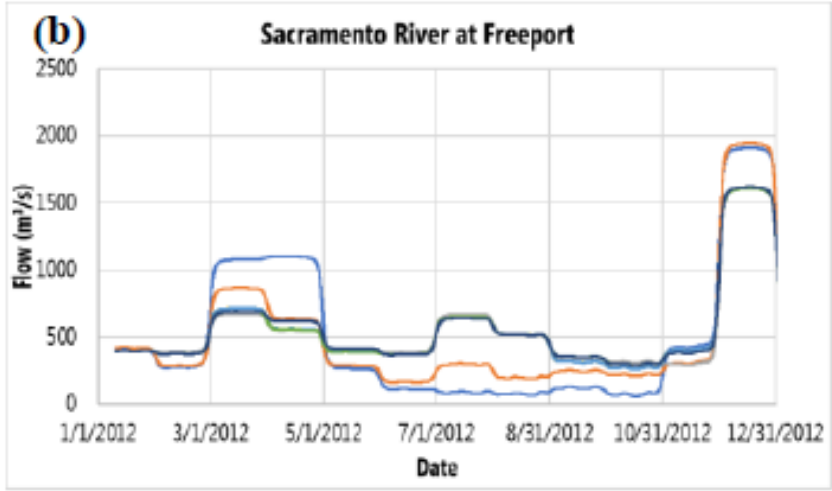


Data Sources

- Flow & Gate Operation Data Sources
  - CalSim 3 & DSM2 (8.2.2)
  - Ported flow using DWR tool (GitHub - dwr-rhoang/schism_boundary_porter: Porter tool to port files of various formats to SCHISM boundary inputs)
  - Gate Ops manually transferred







Data Sources

- Atmospheric Forcing (Historic)
  - North American Regional Reanalysis
  - DWR
- Perturbation (Jacobs)
  - Quantile Mapping
  - 2022 Median Climate

	1993 (AN)	1997 (W)	2009 (D)	2012 (BN)	2015 (C)
Precipitation rate ($kg/m^2/s$)	0.5272 – 1.2128	0.5765 – 1.8588	0.6140 – 1.1872	0.6562 – 1.2230	0.4259 – 1.7226
Air temperature (K)	1.0015 – 1.0054	1.0018 – 1.0054	1.0009 – 1.0047	1.0007 – 1.0047	1.0011 – 1.0044
Long wave radiation (W/m^2)	1.0096 – 1.0282	1.0096 – 1.0290	1.0098 – 1.0238	1.0074 – 1.0242	1.0058 – 1.0220
Short wave radiation (W/m^2)	0.9590 – 1.0066	0.9602 – 1.0242	0.9670 – 1.0116	0.9582 – 1.0218	0.9704 – 1.0194
Pressure at mean sea level (Pa)	1.0006 – 1.1146	0.9887 – 1.1134	1.0220 – 1.1143	0.9974 – 1.0924	0.9739 – 1.1119
Specific humidity (-)	0.9982 – 1.1172	0.9882 – 1.1319	1.0231 – 1.1135	0.9974 – 1.0956	0.9713 – 1.1132

Data Sources

- Stream temperature data source (SJR @ vernalis & SAC @ Freeport)
  - Artificial Neural Networks
    - Air Temperature
    - Solar Radiation
    - Flow-related vars
- Salinity data source
  - DSM2
- Ocean boundary
  - NOAA
  - 15 cm Sea Level Rise

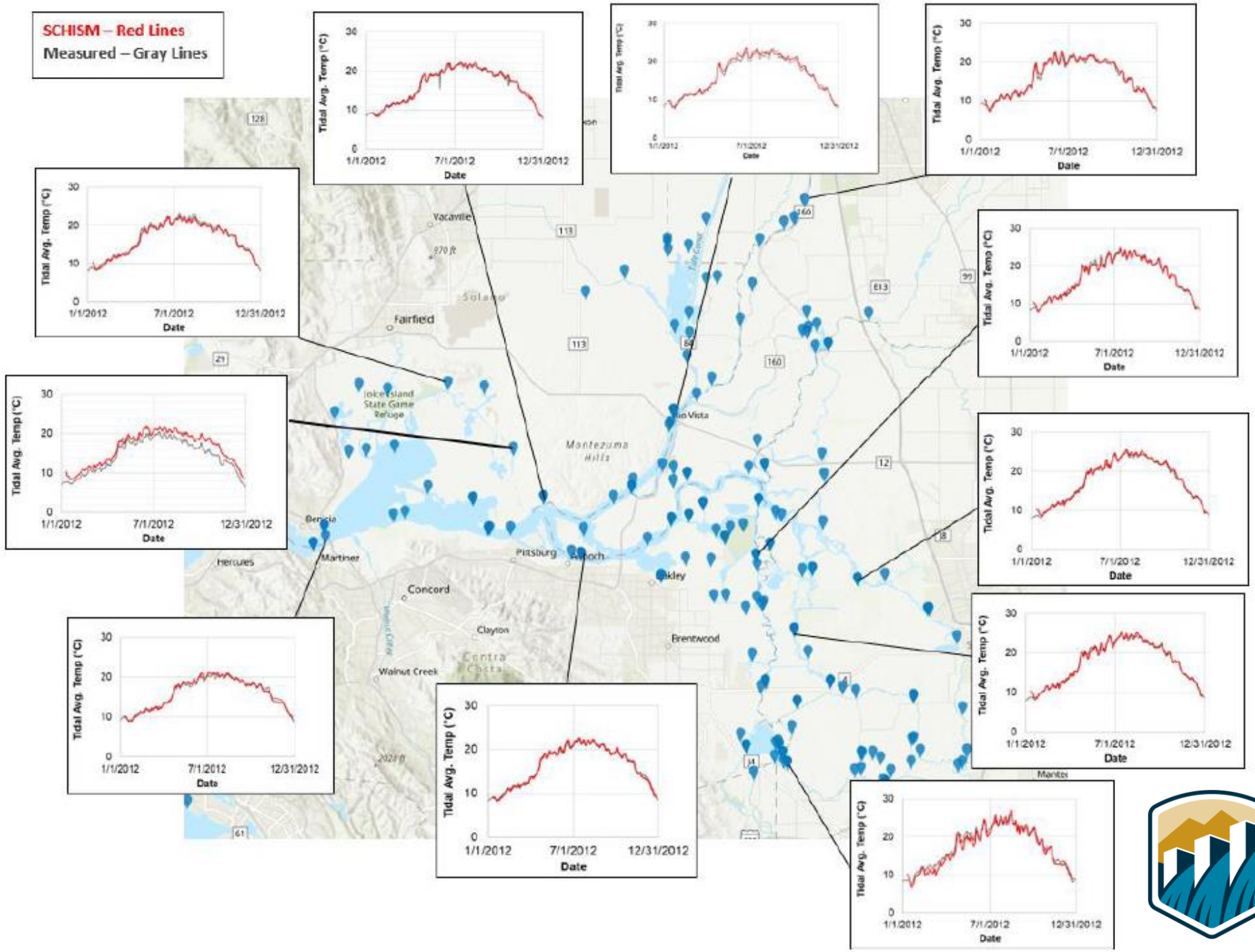
Model verification

- Historical years with ample data and close SAC Indices

	Validation Year	CALSIM SAC River Index (MAF)	Historical SAC River Index (MAF)
1	2012	6.5	6.9
2	2009	5.7	5.8
3	2015	4.0	4.0

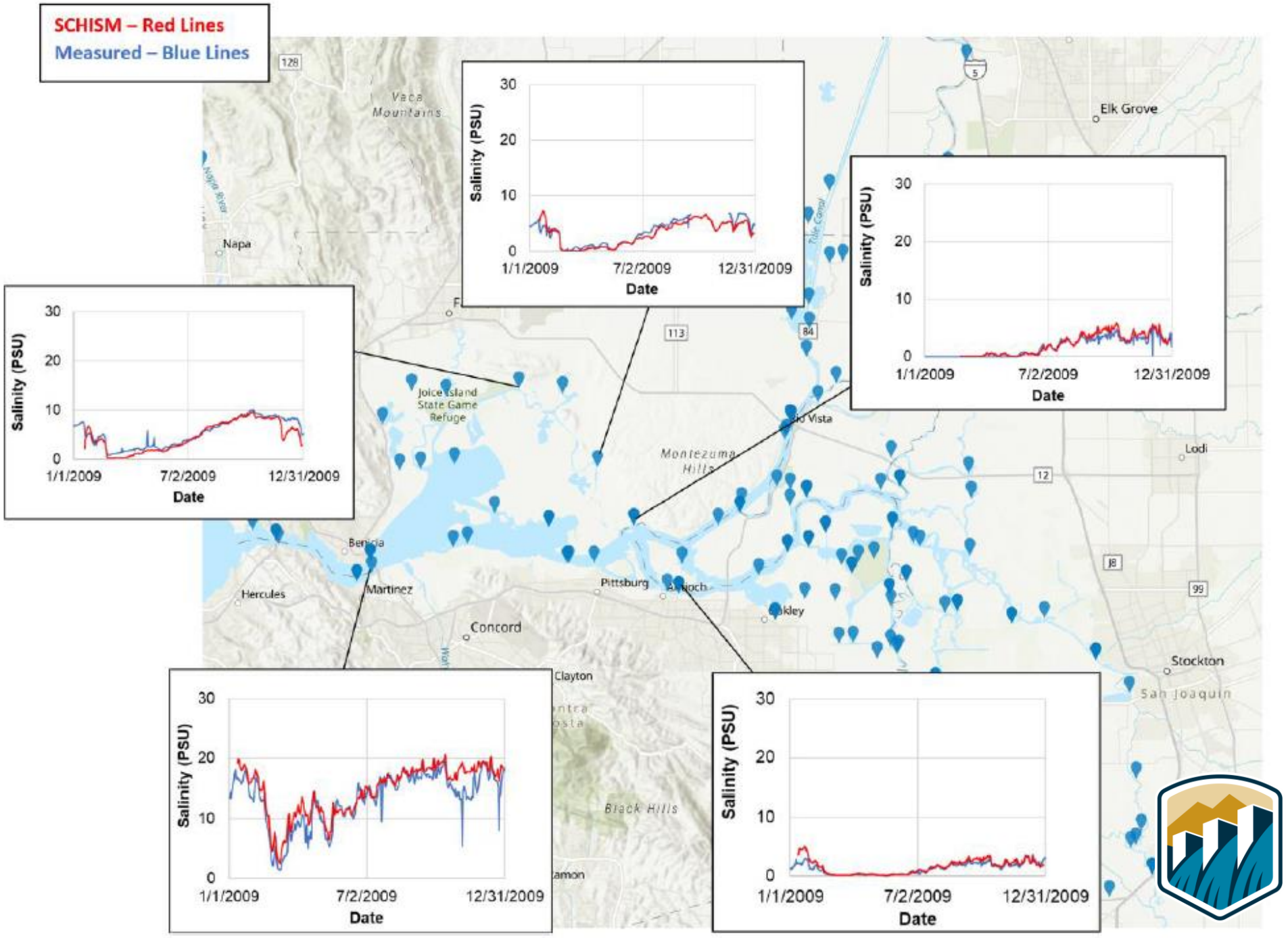
Model validation

- Temperature



Model validation

- Salinity



Habitat Suitability Index (HSI)

- **Bever et al. (2016) approach**

  $S_i = 0.67S + 0.33V$, turbidity > 12 NTU

  $S_i = (0.67S + 0.33V) \times 0.42$, turbidity < 12 NTU

  where S is based on the fraction of time salinity < 6 PSU (computed with SCHISM)

  V is based on the maximum current speed (computed with SCHISM)

- **Turbidity**
  - **We used historical quantiles for each day**

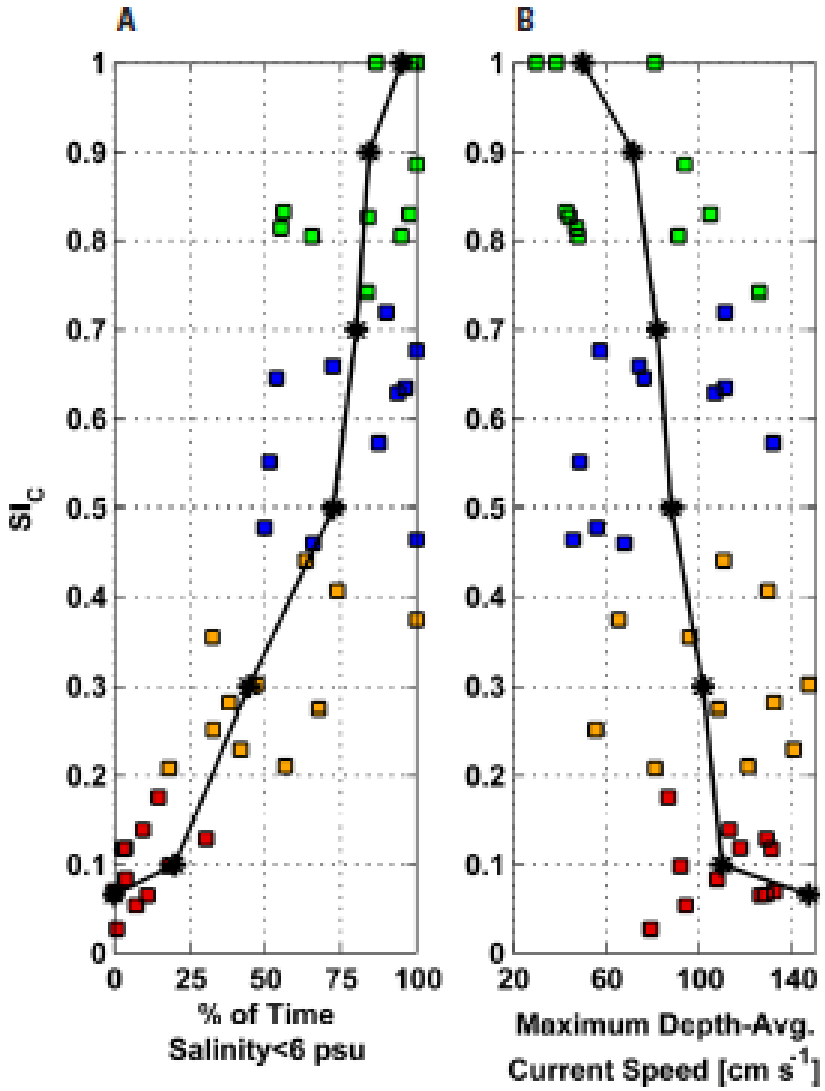
    For example, if the 75% quantile was 12 NTU, the suitability index was calculated as:

    $S_i = 0.75 \times [\ (0.67S + 0.33V) \times 0.42\ ] + 0.25 \times [0.67S + 0.33V]$

- **Temperature (RMA)**

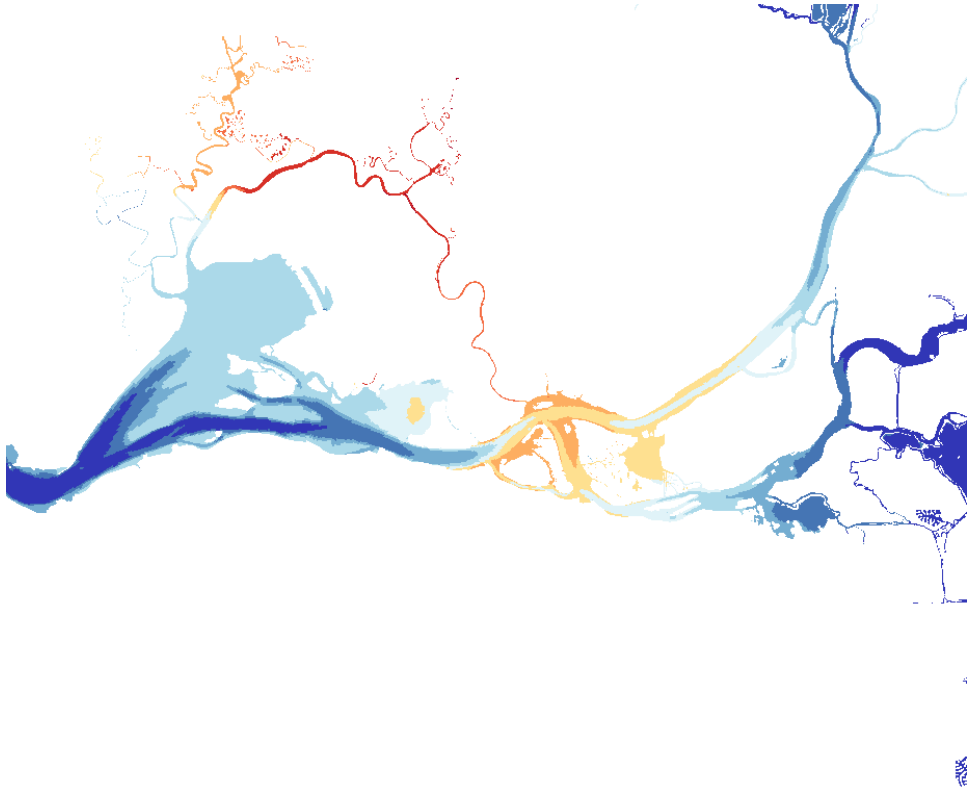
  $HSI = S_i \times T$

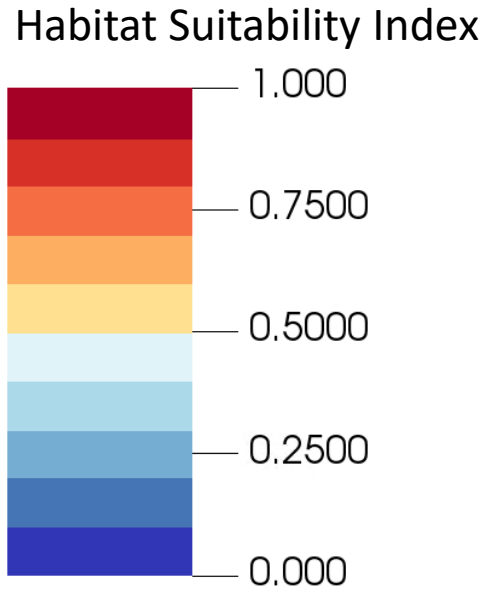
  where T is based on the fraction of time temperature < 22°C



Results – General Trend

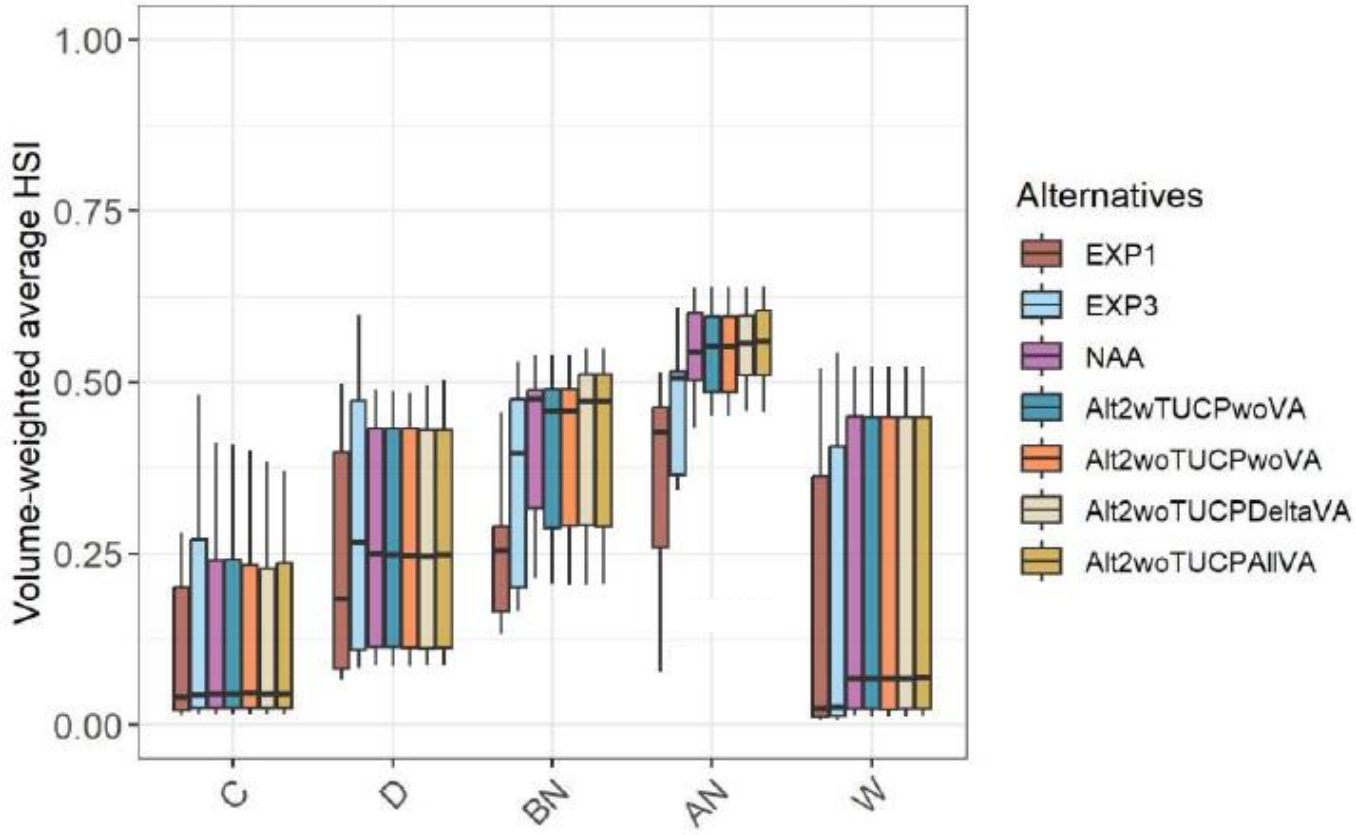
HSI for AN Year 08-12-1993 to 08-26-1993





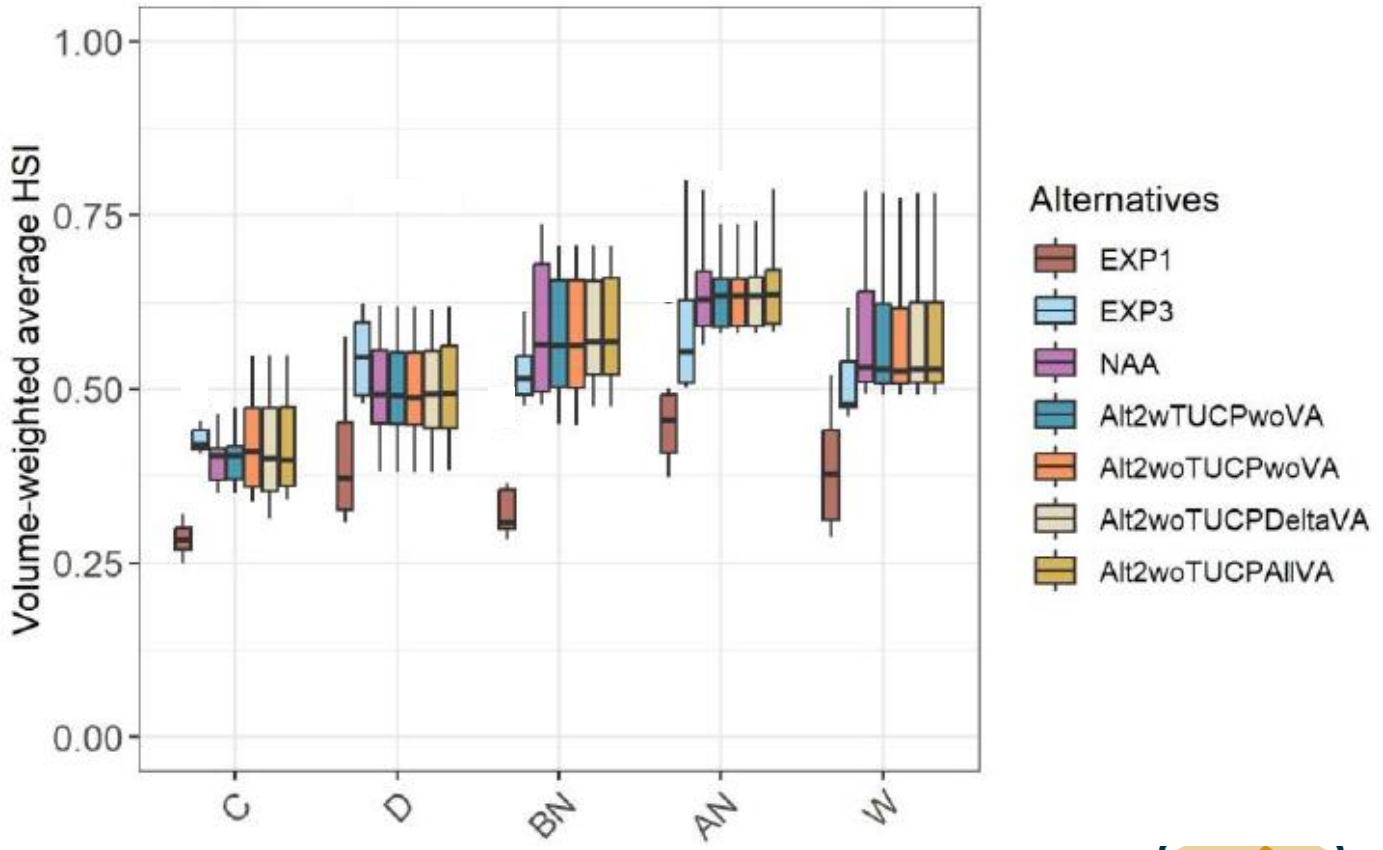
Results – Averaged HSI over Habitat Arc

- Main difference EXP1 & EXP3
  - Generally lower than other alternatives
- Not much difference in NAA & Alt2 scenarios
- Why wet year HSI low?



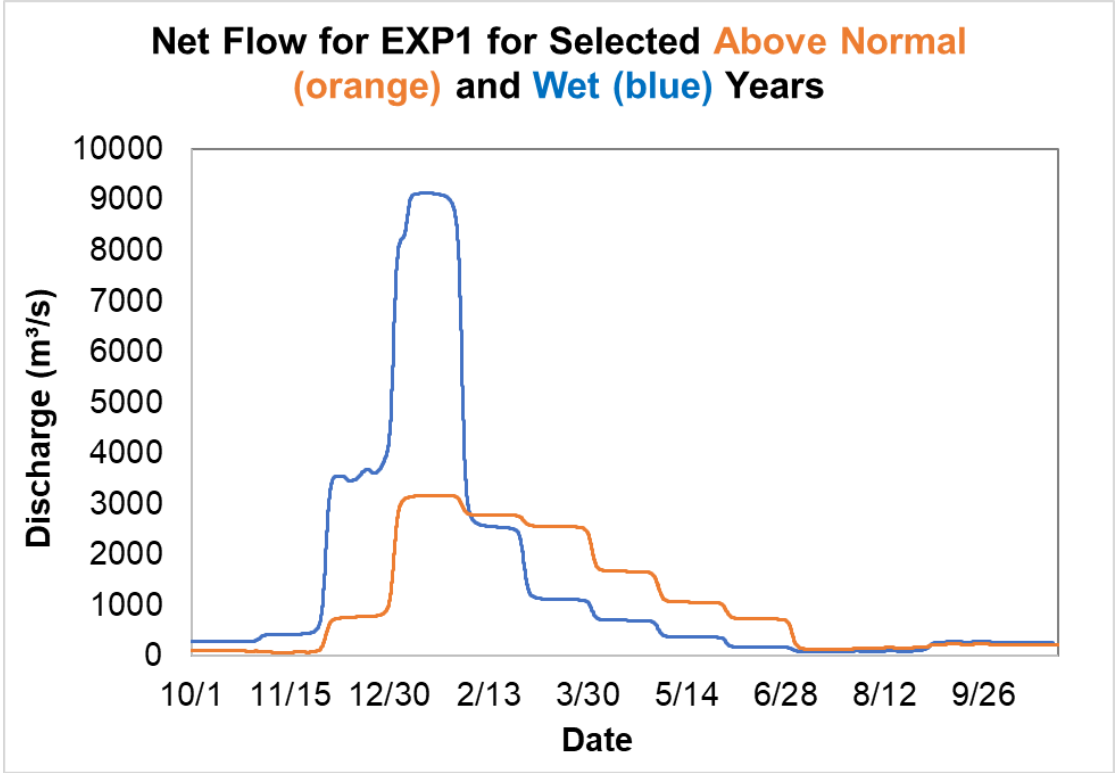
Results – Averaged HSI over Habitat Arc

- Original Bever (no temperature effects)
- Better but why is wet year HSI lower than Above Normal and Below Normal?



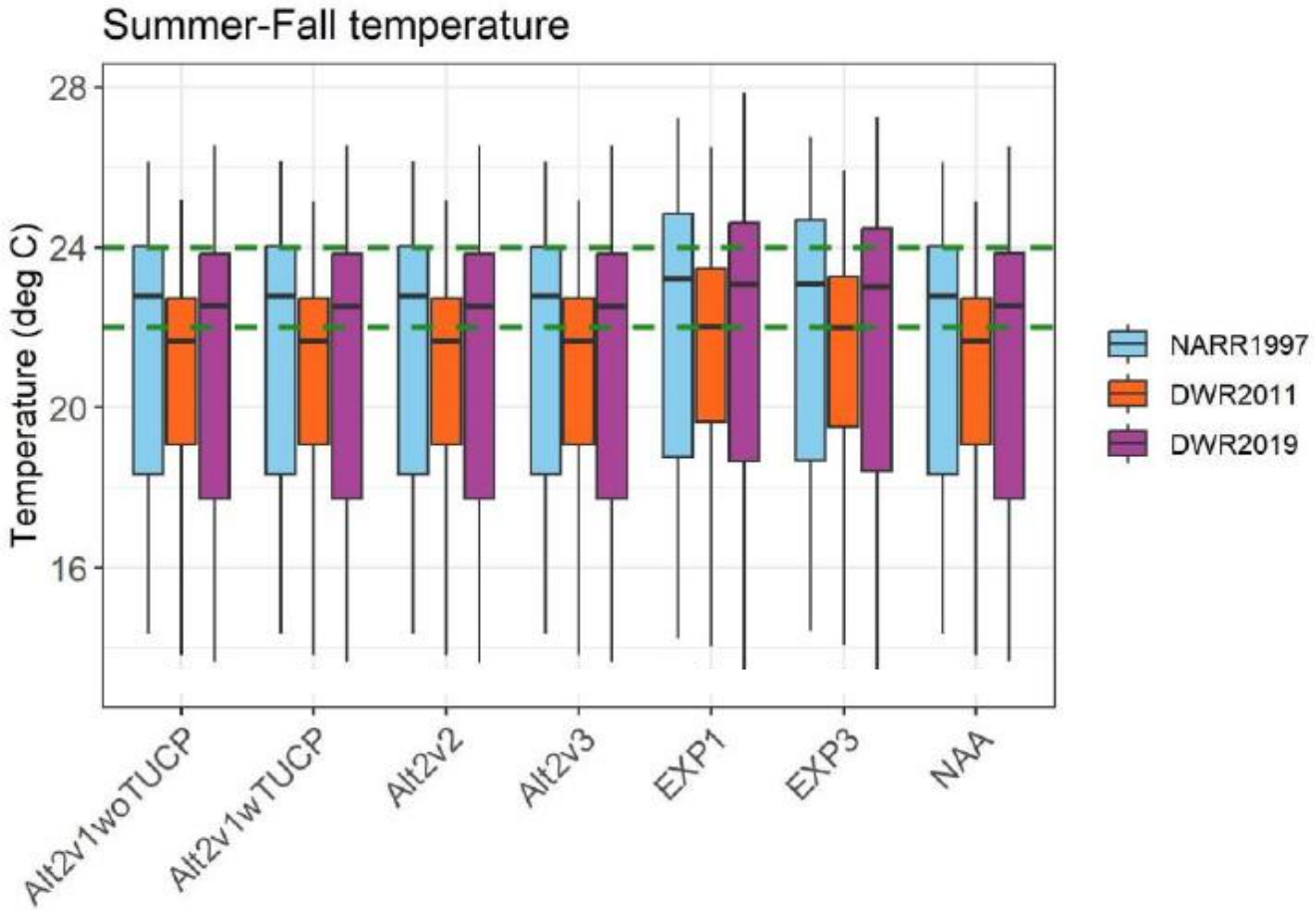
Results

- Flow distribution throughout the year.
  - More flow earlier on in water year
  - But less flow heading into summer-fall period of interest resulting in higher salinities
  - Takes time for salinity to improve



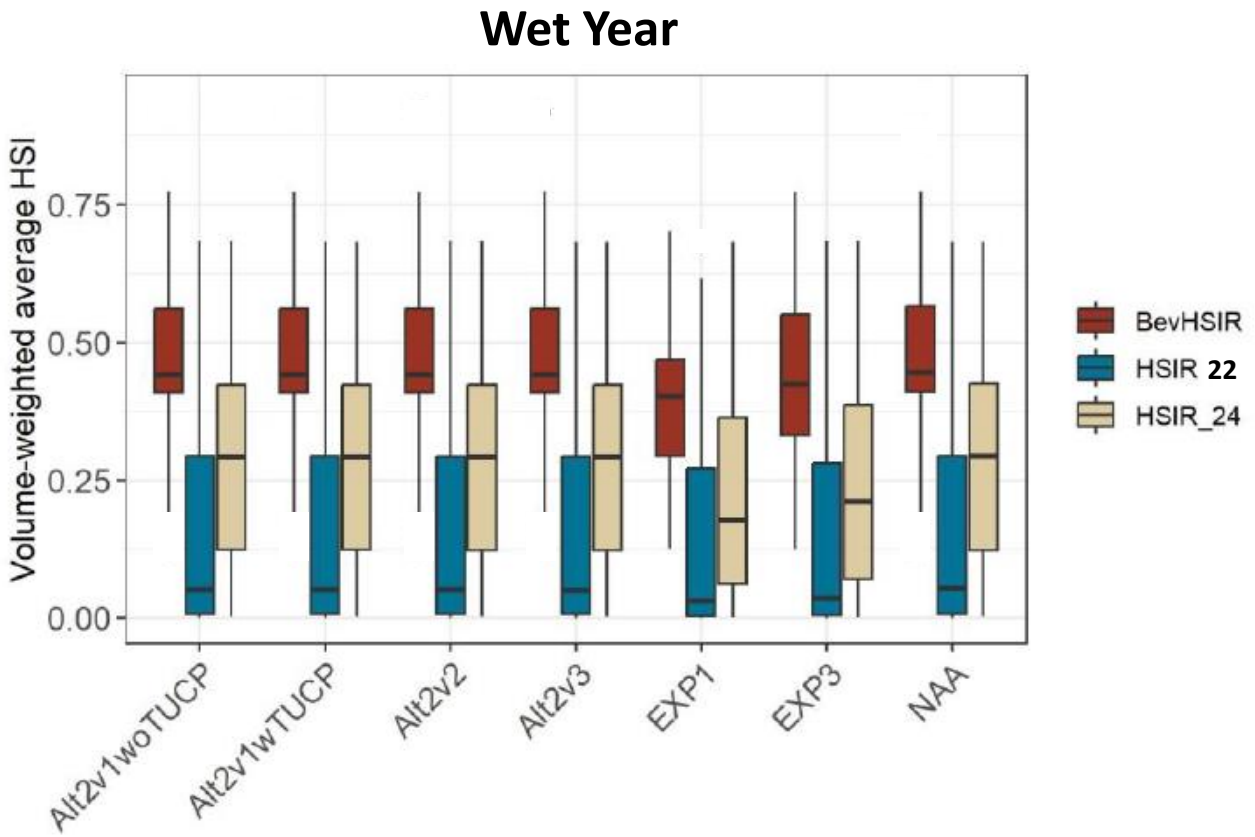
Results in Delta

- Temperature effects very important
  - Temperatures in summer hover around threshold
  - Temperatures can be warmer regardless of water year type



Results in Delta

- HSI forecasts are sensitive to temperature threshold



Summary

- All Alt2 scenarios impact on HSI similar to NAA. Exp1 and Exp3 generally more negative impact on HSI
- The above normal year had best habitat suitability out of the years examined
- Regardless of water year type, temperature can be controlling
- How flow is distributed through the water year has important implications for salinity and habitat suitability during summer-fall period.
- HSI is sensitive to the temperature threshold

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2	Non-discretionary obligations (EXP3)	Exploratory alternative in which Reclamation and DWR make releases from reservoir storage to meet D1641, senior water rights and Level 2 Refuges
3	No action (NAA)	Current regulatory environment
4	Water Quality Control Plan (Alt 1)	Operates to D-1641 and tributary specific water right requirements and agreements (including authorizing legislation, water rights, contracts, and agreements like WQCP and COA).
5	Multi-Agency Consensus version 1 (Alt2 without VAs, without TUCP)	Represents actions and tradeoffs made to reach consensus with DWR, USFWS, CDFW, and NMFS: Without voluntary agreements and without TUCP actions.

Alternative		Description
6	Multi-Agency Consensus version 1 (Alt2 without VAs, with TUCP)	Same as #5 above but with TUCP actions.
7	Multi-Agency Consensus version 1 (Alt2 with Delta VAs, without TUCP)	Same as #5 above but with Delta VA.
8	Multi-Agency Consensus version 1 (Alt2 with All VAs, without TUCP)	Same as #5 above but with All VAs
9	Modified Natural Hydrograph (Alt 3)	Combines additional Delta outflow with measures to improve drought protection and temperature management through increased reservoir carryover storage (informed by discussions with NGOs).
10	Risk Informed Operations (Alt 4)	Provides alternative criteria for Shasta and incorporates improved real-time analytics using real-time information to support Delta water deliveries while minimizing impacts to listed species.

Results – Averaged HSI over Habitat Arc