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Futurecasting effects of sea level rise, climate change, and restoration on individual species

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Hydrodynamic/Climate Models

- Abundance of futurecast data from hydrology/climate models becoming available.
- Huge data volume creates opportunity and data analysis problem.
- Need to incorporate futurecast data into biological models.
- Long temporal scale and large spatial extent dictate use of simple biological models.

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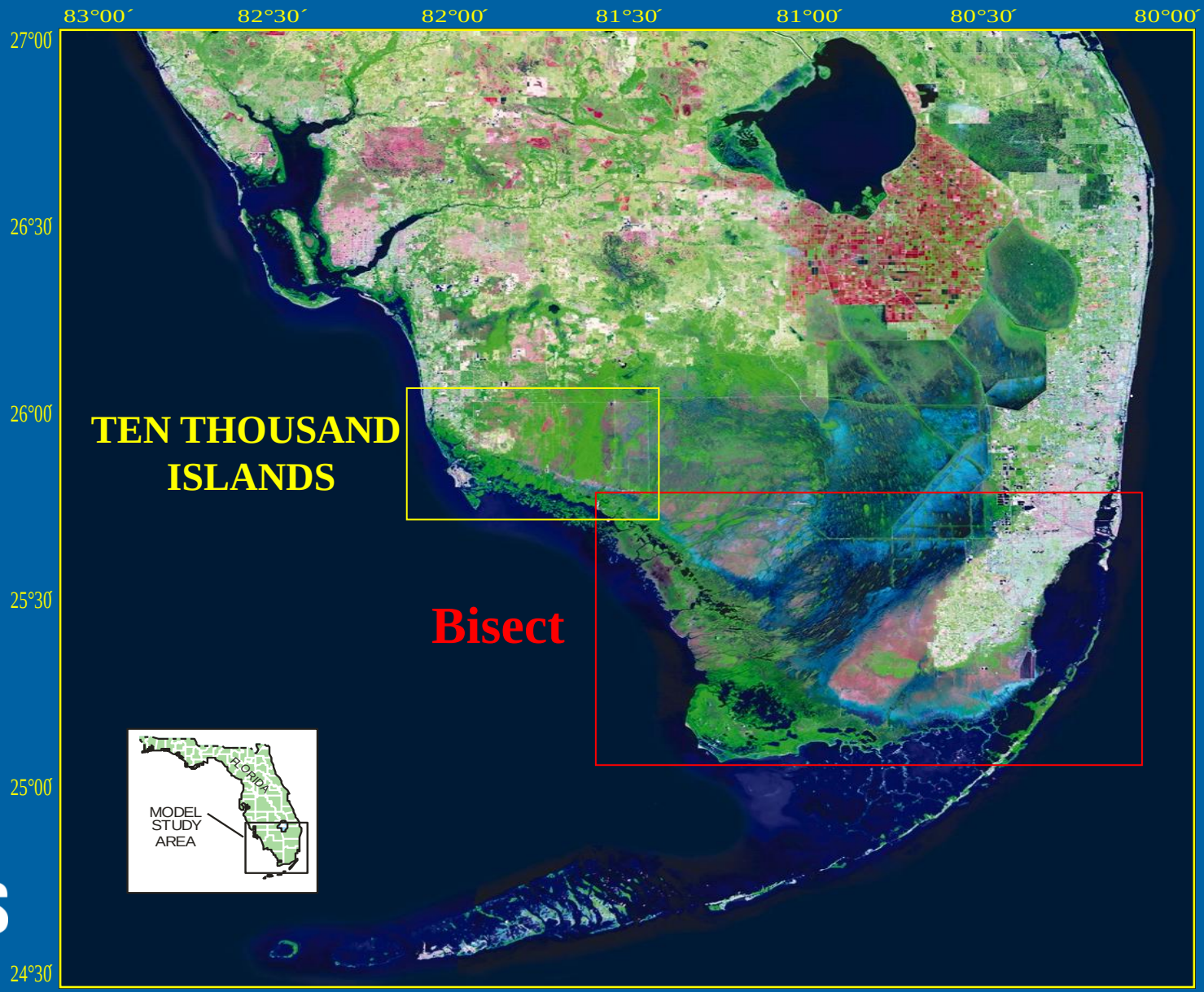
S. Florida Hydrodynamic Models



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Hydrology Model Output

- Salinity
- Temperature
- Stage/depth

Resolution

- 15 minute time step
- 500 meter grid cell

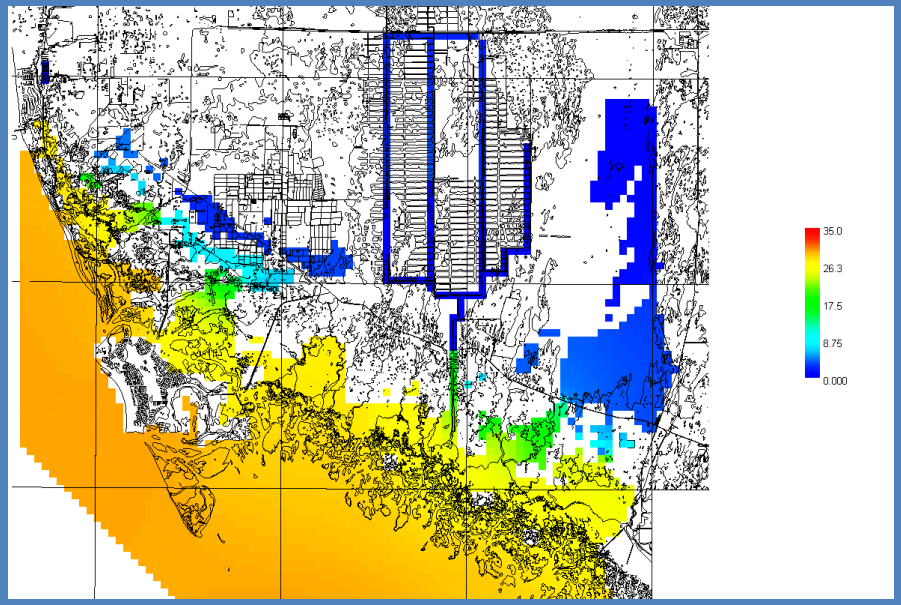
Scenarios

- CERP restorations
- Sea Level Rise

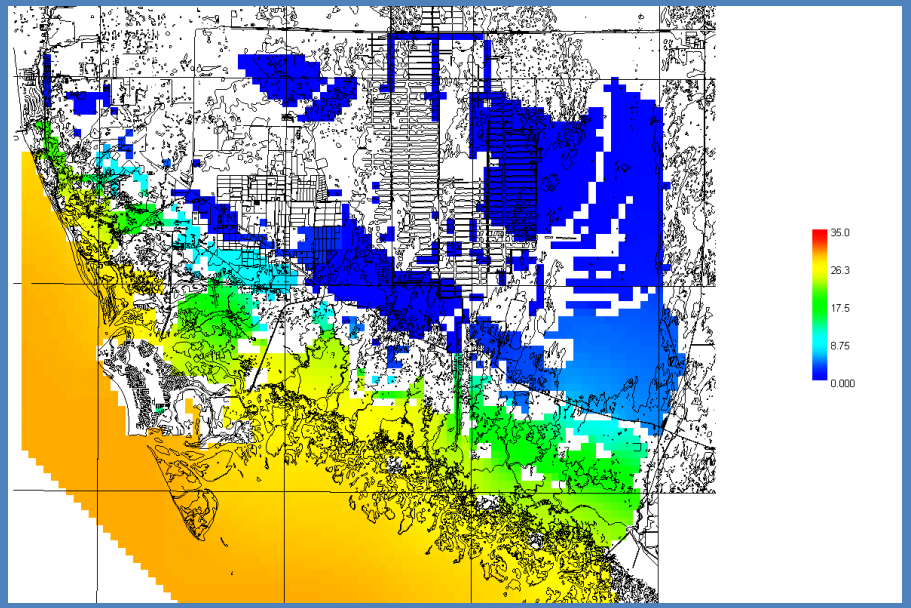
Sample output (Figures)

Ten-Thousand Islands salinity before and after Picayune Strand Restoration

Snapshot: 01 Oct. 2003



Before Picayune Strand Restoration Project



After Picayune Strand Restoration Project

Biological Models

- Need a simple approach to compare biological implications of different scenarios of restoration, sea level rise, and climate change
- Habitat Suitability Index (HSI) and Spatially Explicit Species Index (SESI) models
  - do not require extensive biological datasets
  - incorporate spatial and temporal variation
  - allow relative comparisons of different scenarios
  - model potential habitat suitability, not predicting occurrence

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Biological Research Focus

- **Submerged Aquatic Vegetation (SAV)**
  - ***Vallisneria americana*** **(Tape grass) – freshwater species**
  - ***Halodule wrightii*** **(Shoal grass) – salt-tolerant species**
- **Florida Manatee**

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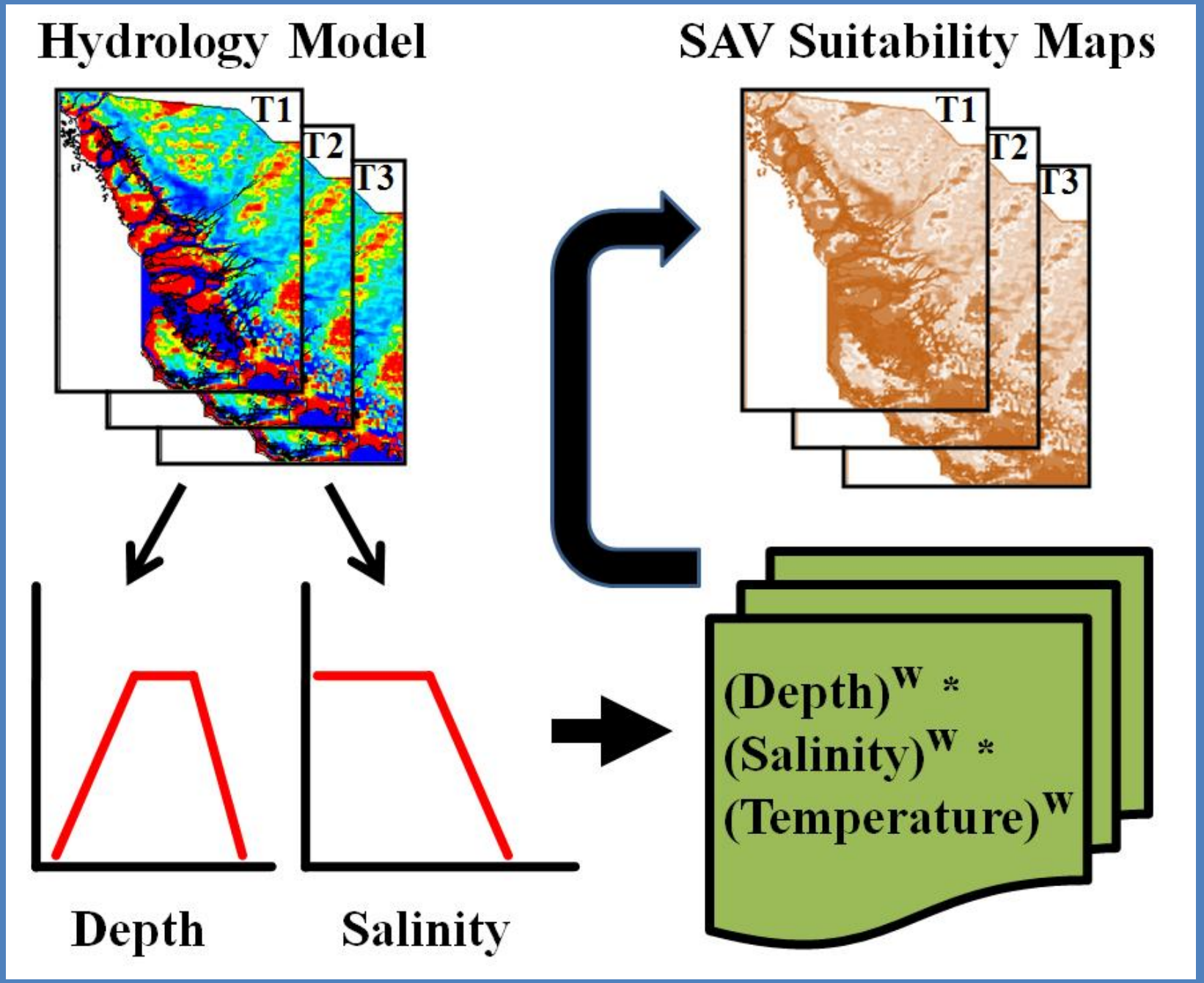

Hydrology Model
SAV Suitability Maps
T1
T2
T3
T1
T2
T3
(Depth)^W *
(Salinity)^W *
(Temperature)^W
Depth
Salinity

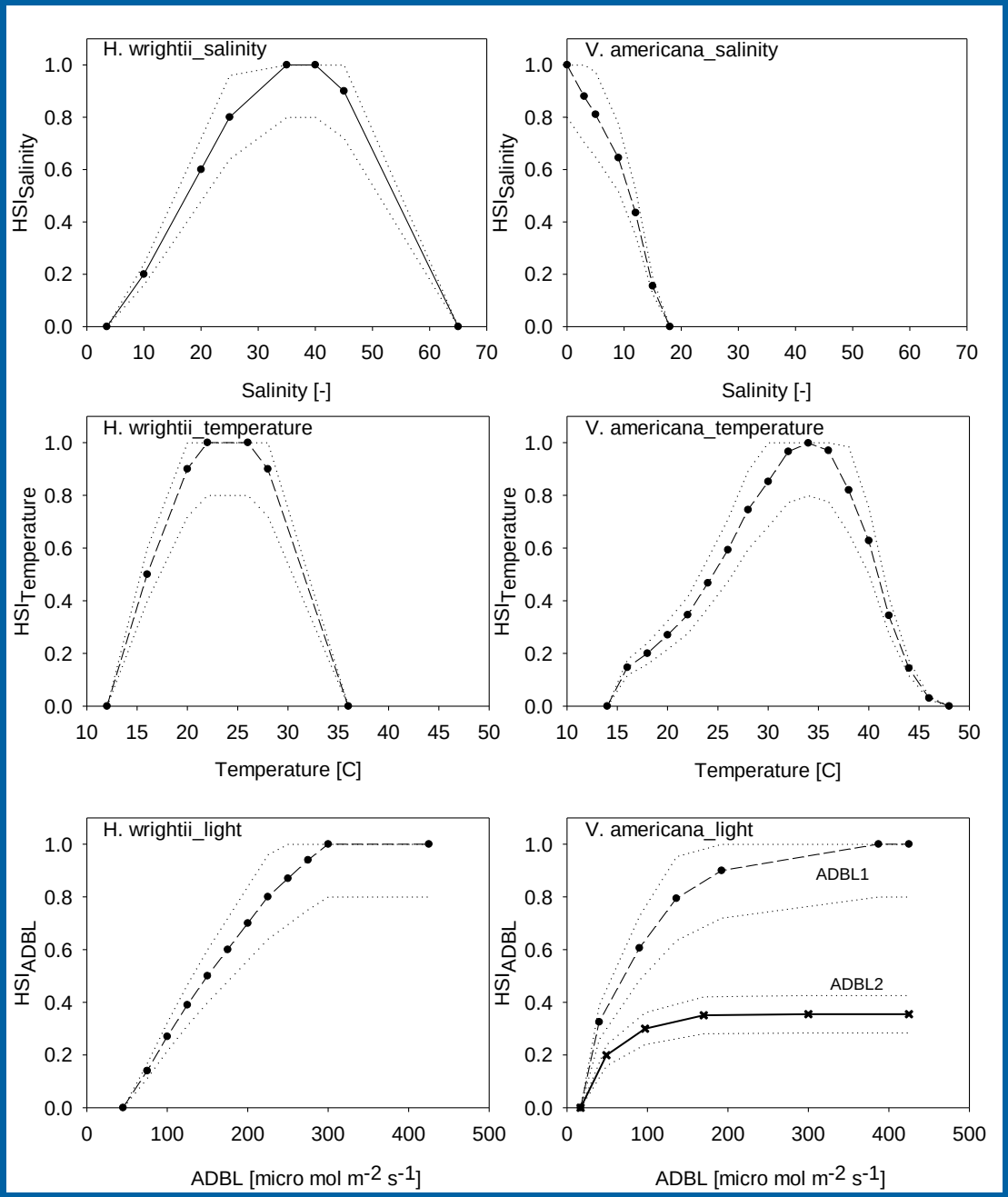
HSI Model

Halodule wrightii *Vallisneria americana*

Salinity

Temperature

Light/depth



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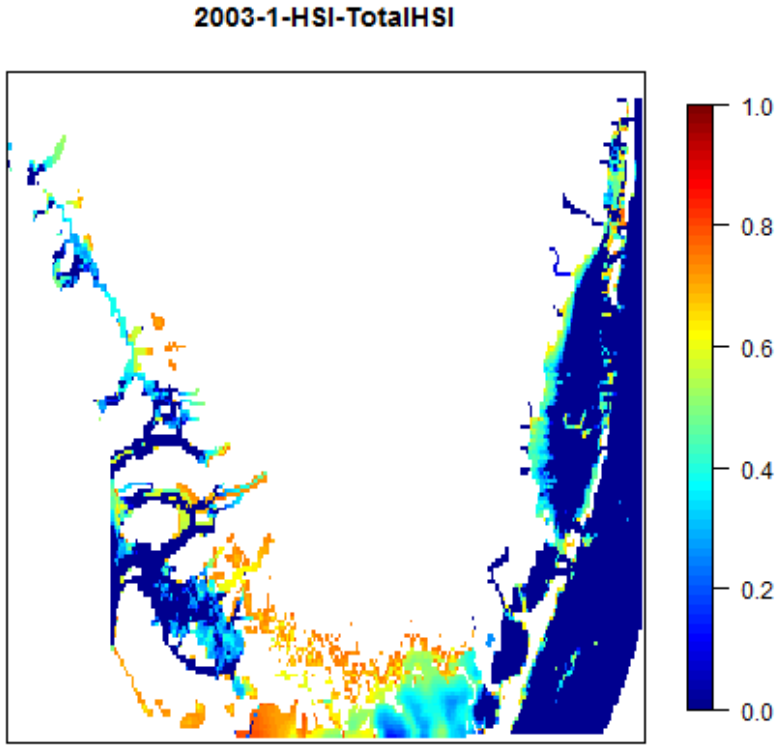
Habitat Suitability Indices (HSIs)

$$HSI_{Total} = \sqrt[3]{HSI_{Salinity} \times HSI_{Temperature} \times HSI_{ADBL}}$$

- Calculated for each grid cell and every time step
- HSI_{Total} for a cell depends only on environmental variables in each cell (i.e. is independent from neighboring cell values).



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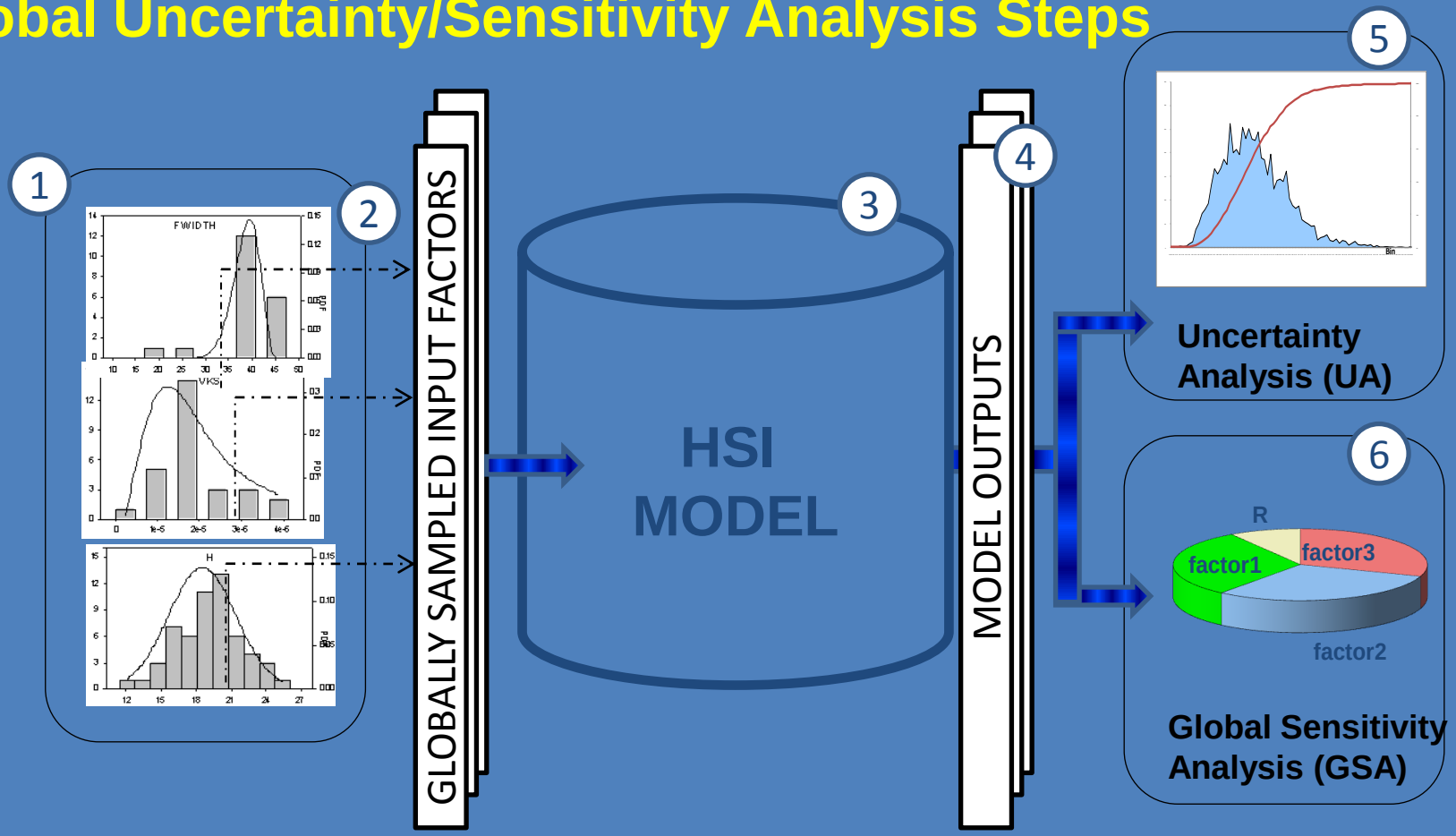
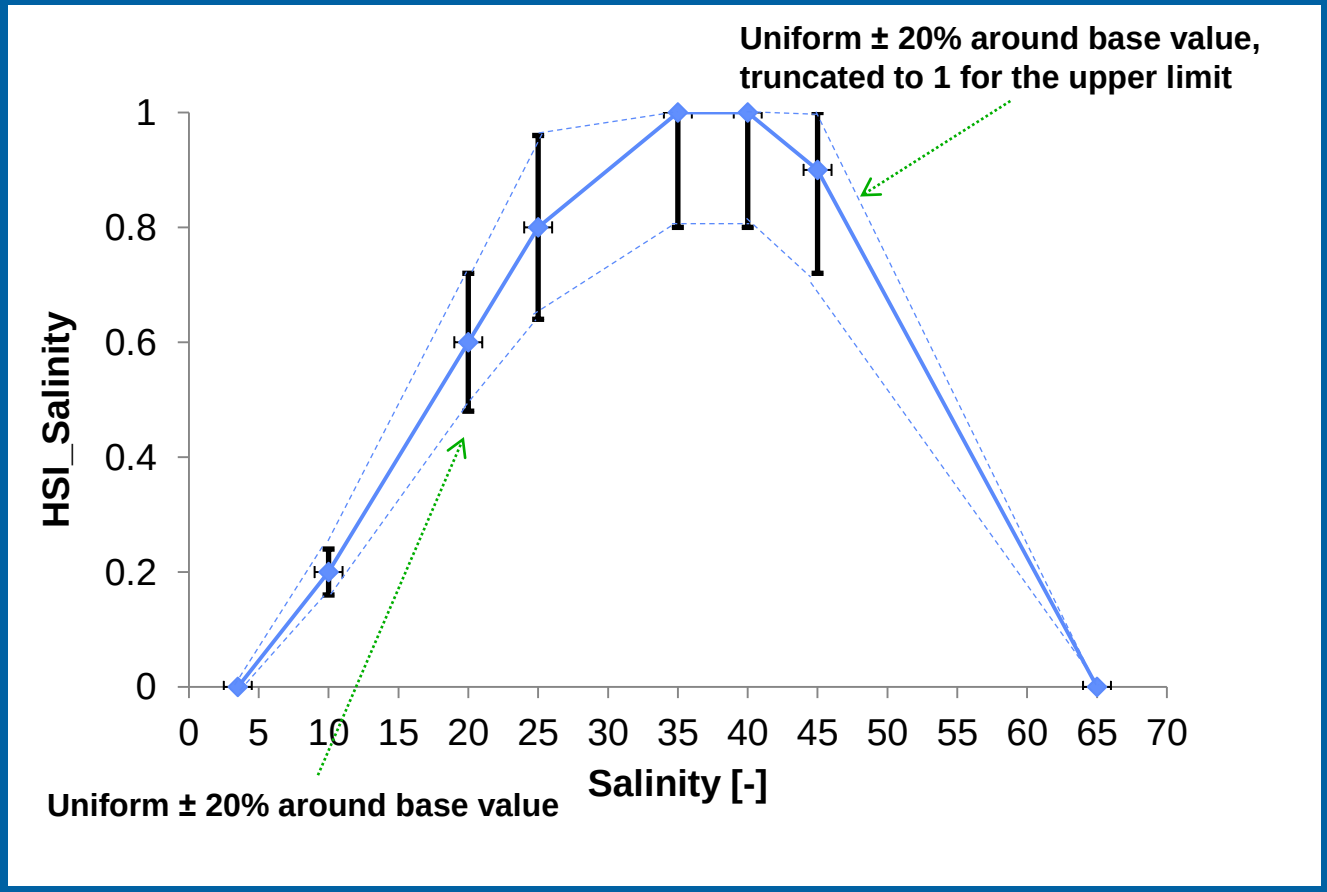
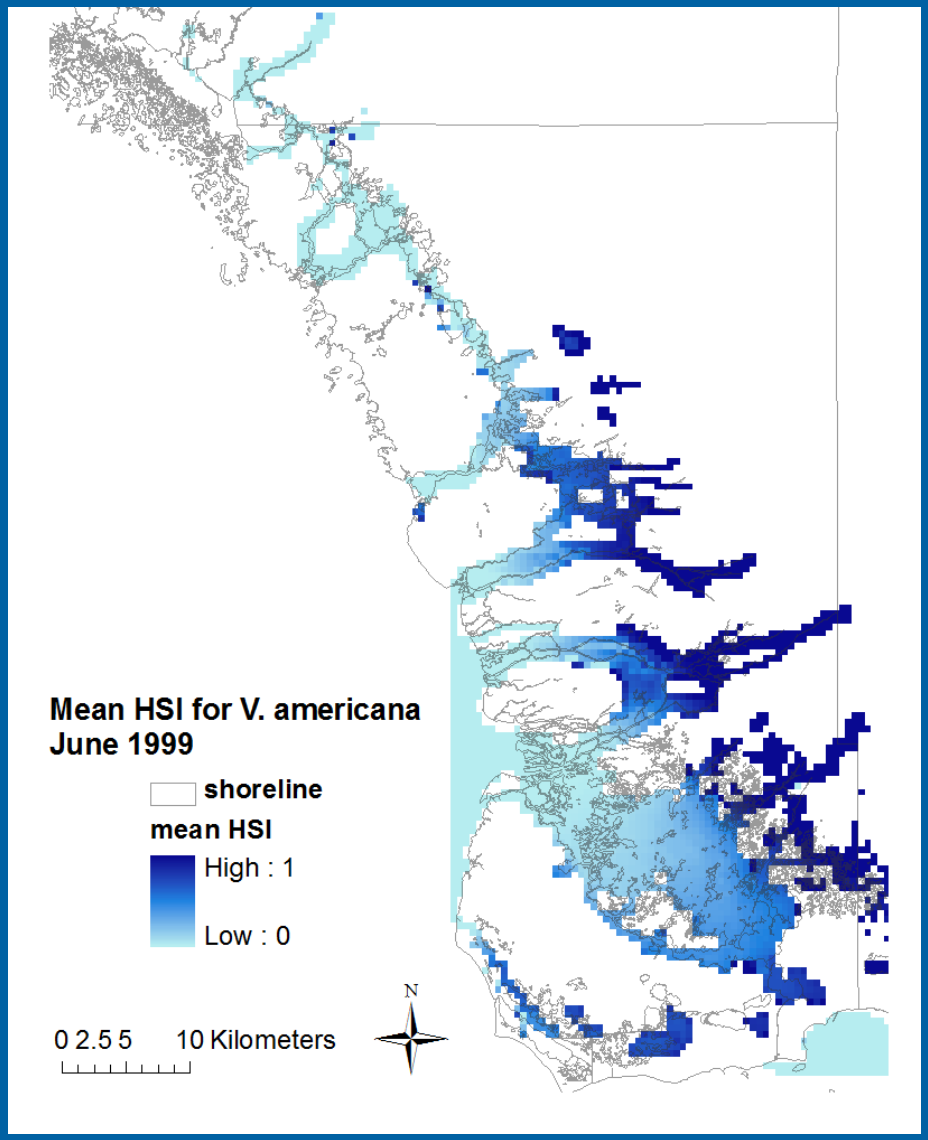
Global Uncertainty/Sensitivity Analysis Steps

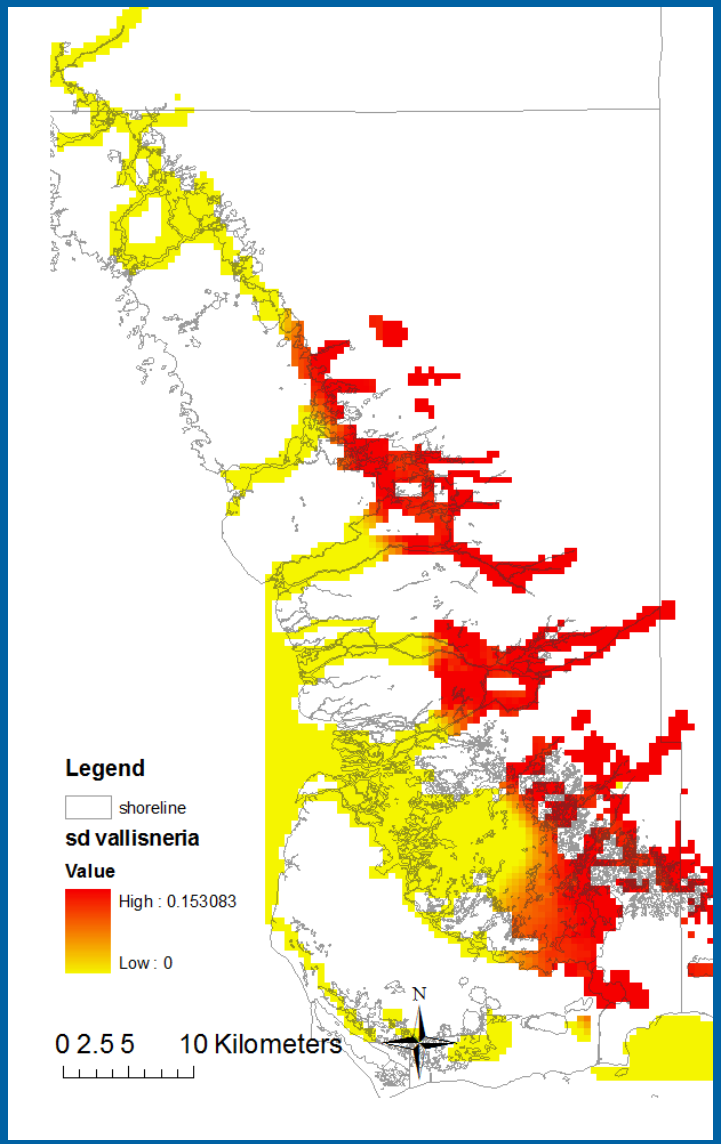


1. Identify uncertain spatially distributed inputs and define uncertainty models (PDFs).
2. Generate input values pseudo randomly from assigned PDFs using Sobol method.
3. Run the model for multiple alternative input sample (Monte Carlo).
4. Construct PDF for the model output (from N output values).
5. Perform SA using SIMLAB.

Specification of uncertainty for look-up tables, using $HSI_{salinity}$ vs. salinity lookup table as an example variable







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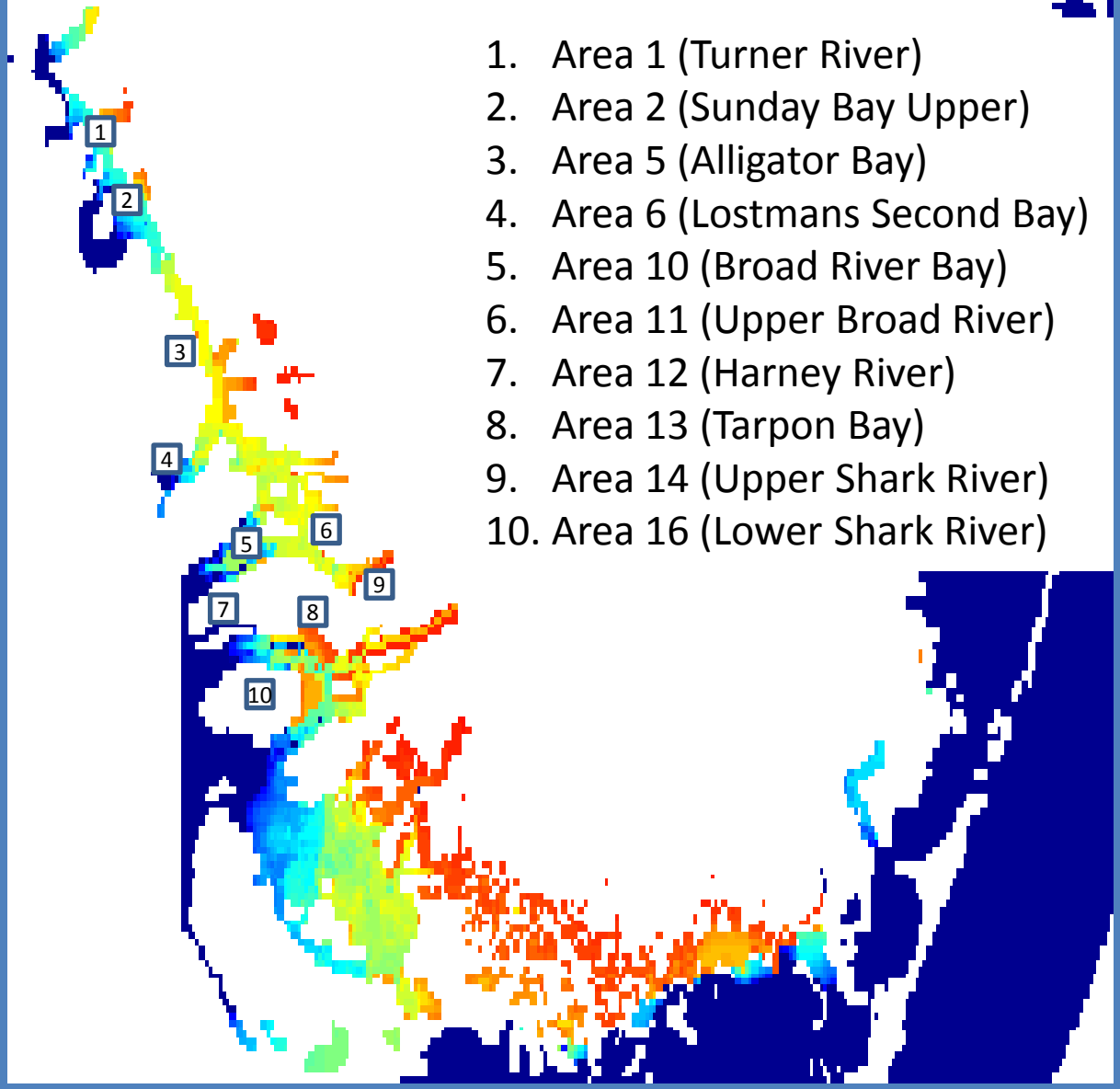
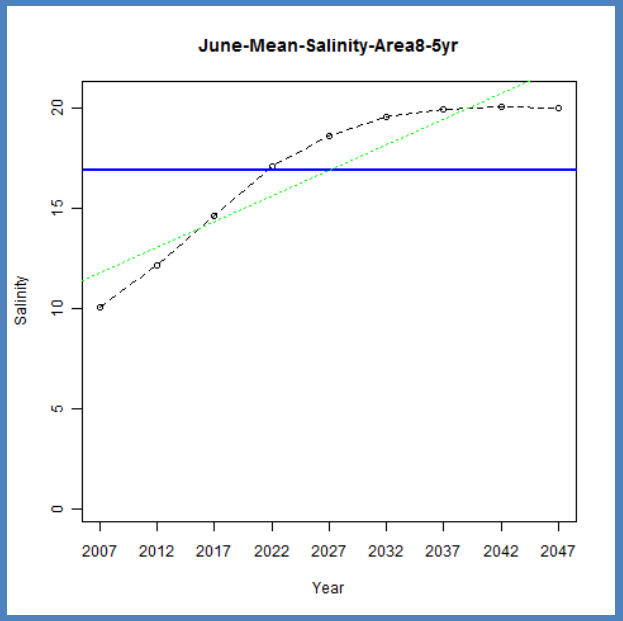
Mean HSI (left) and Uncertainty/SD (right) for *Vallisneria americana*.

Benchmark Cells for Sensitivity Analysis

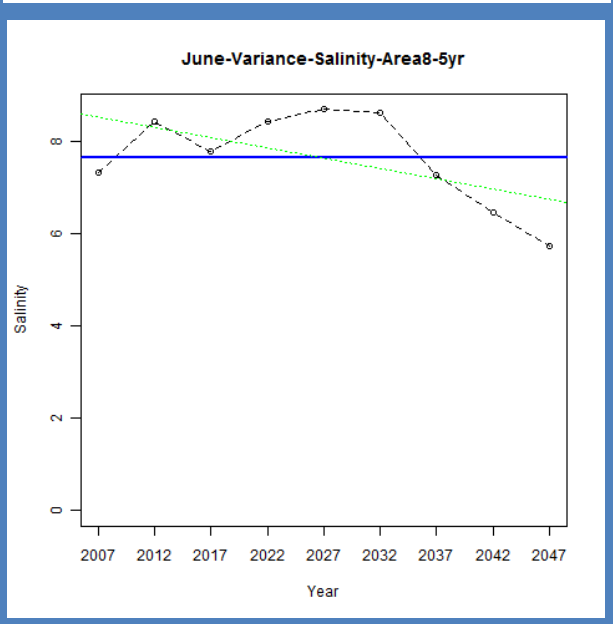


1. Area 1 (Turner River)
2. Area 2 (Sunday Bay Upper)
3. Area 5 (Alligator Bay)
4. Area 6 (Lostmans Second Bay)
5. Area 10 (Broad River Bay)
6. Area 11 (Upper Broad River)
7. Area 12 (Harney River)
8. Area 13 (Tarpon Bay)
9. Area 14 (Upper Shark River)
10. Area 16 (Lower Shark River)

Dry Season Salinity Trends



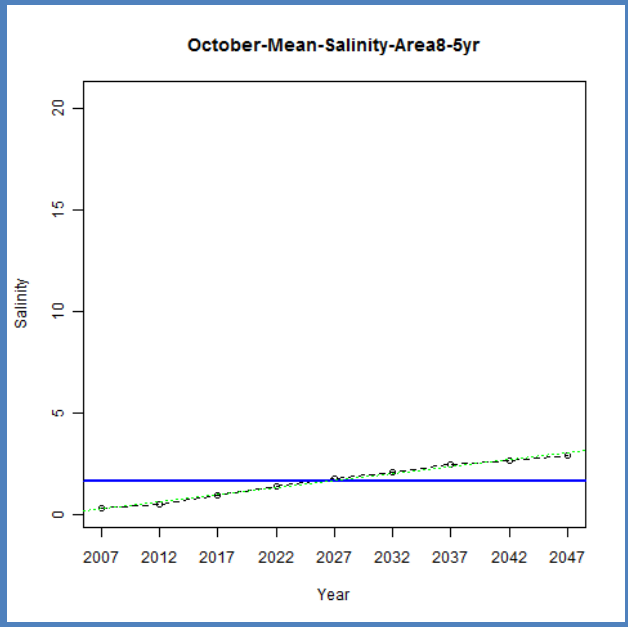
Mean Salinity
(5-year mean)

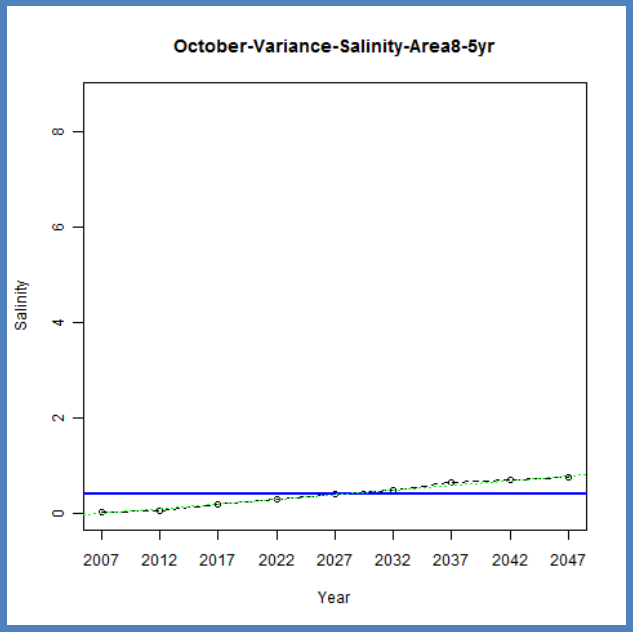


Salinity Variance

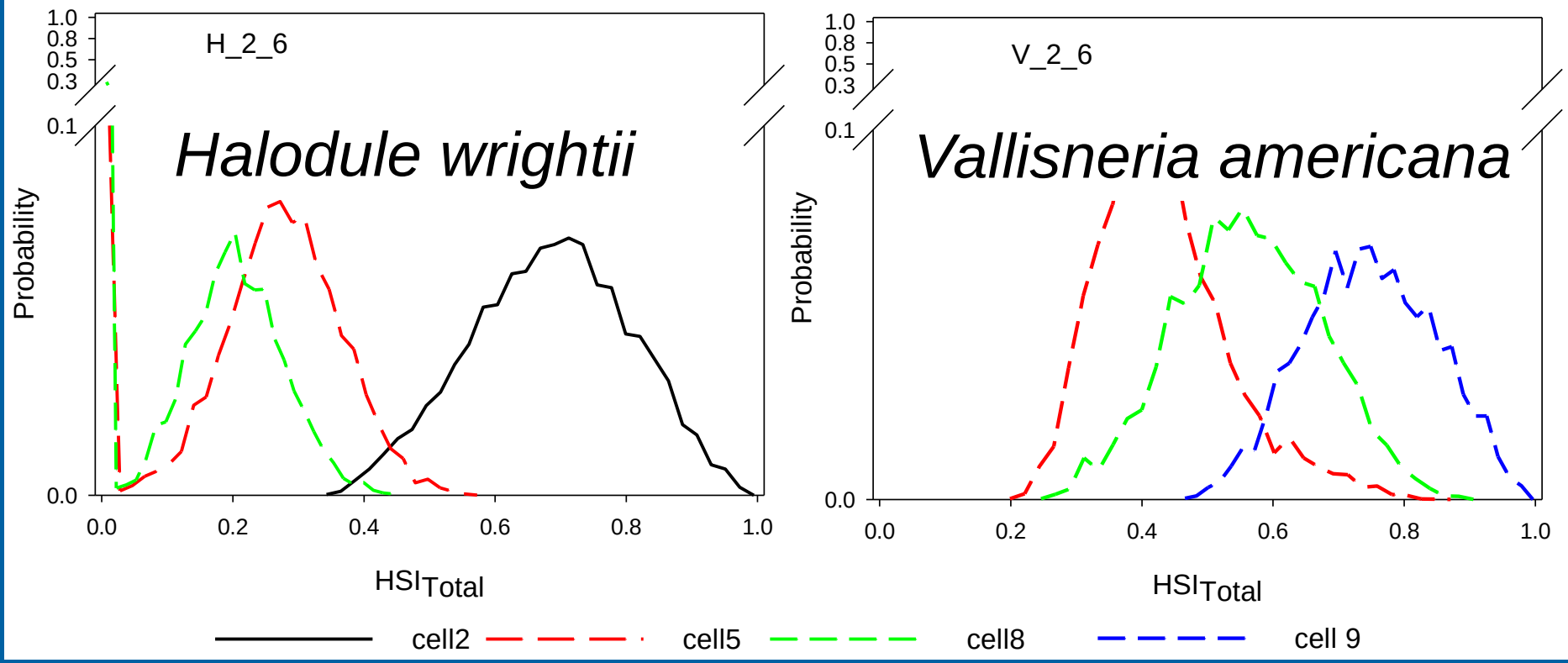
Shark River

Wet Season Salinity Trends





PDFs of HSI values – 4 ENP sites



Habitat suitability PDFs reflect uncertainty, but show high and low suitabilities for the 2 SAV species that differ among sites

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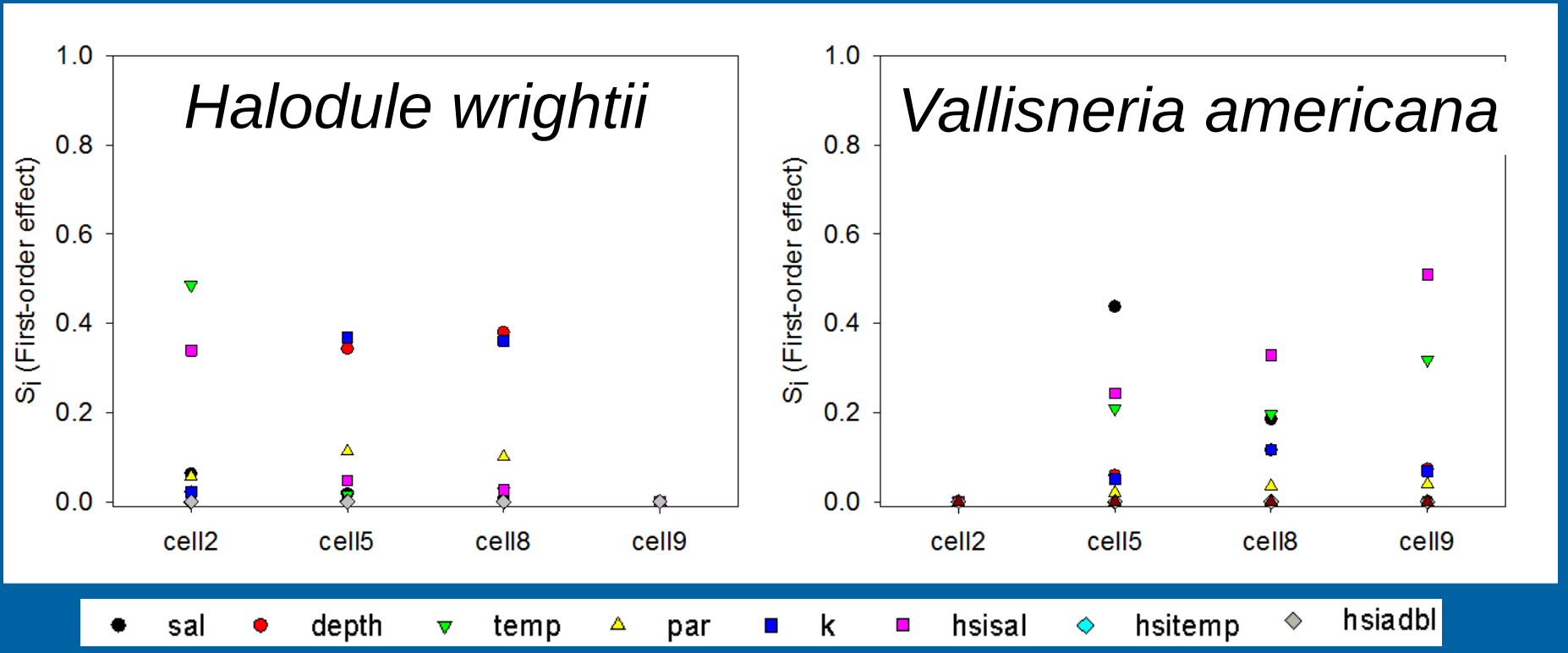
Sensitivity Indices – 4 ENP sites



Halodule model shows more sensitivity to light,
Vallisneria model shows more sensitivity to salinity

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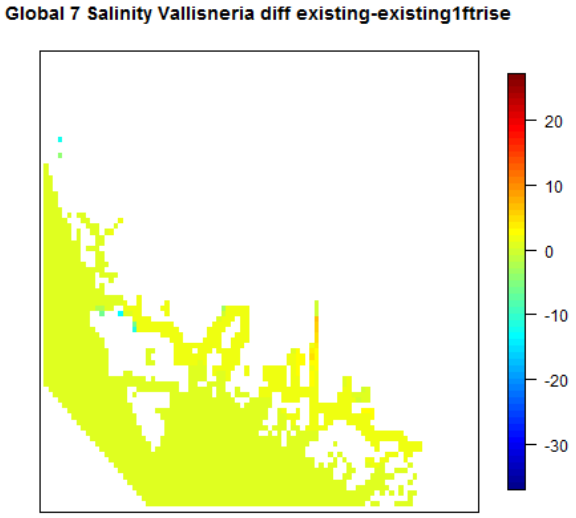
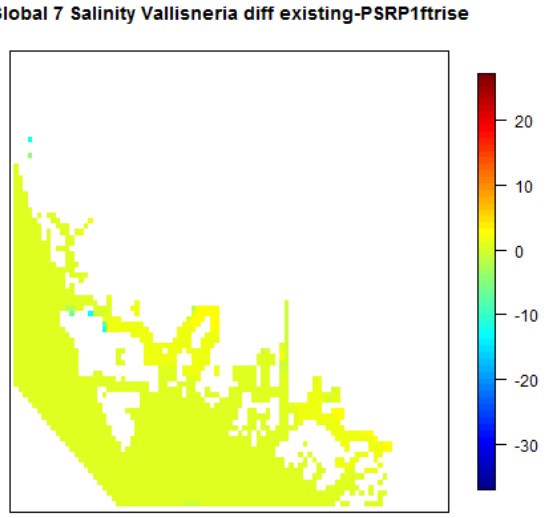
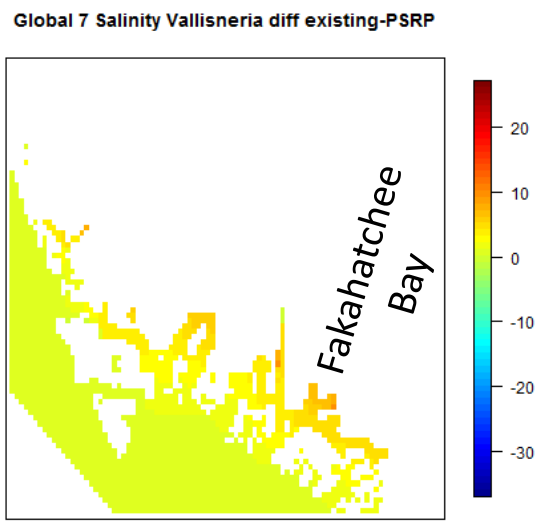
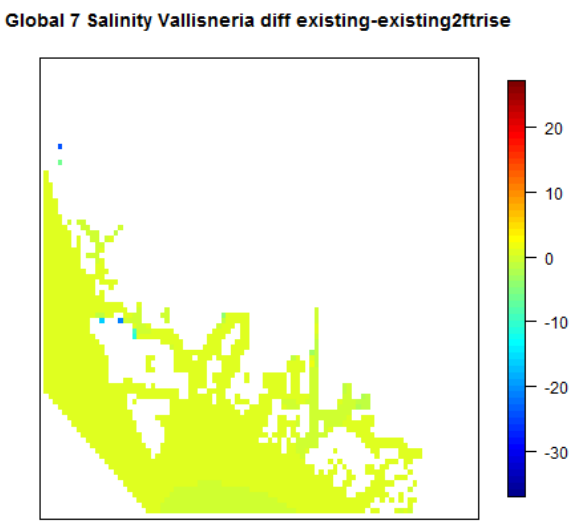
TTI Salinity Difference Maps

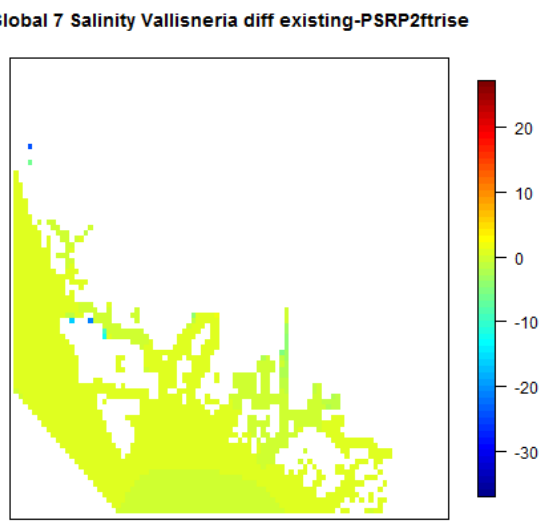
Picayune Strand Restoration (lower left map) shows reduced bay salinities, but differences absent with sea level rise (July 1998-2008 mean)





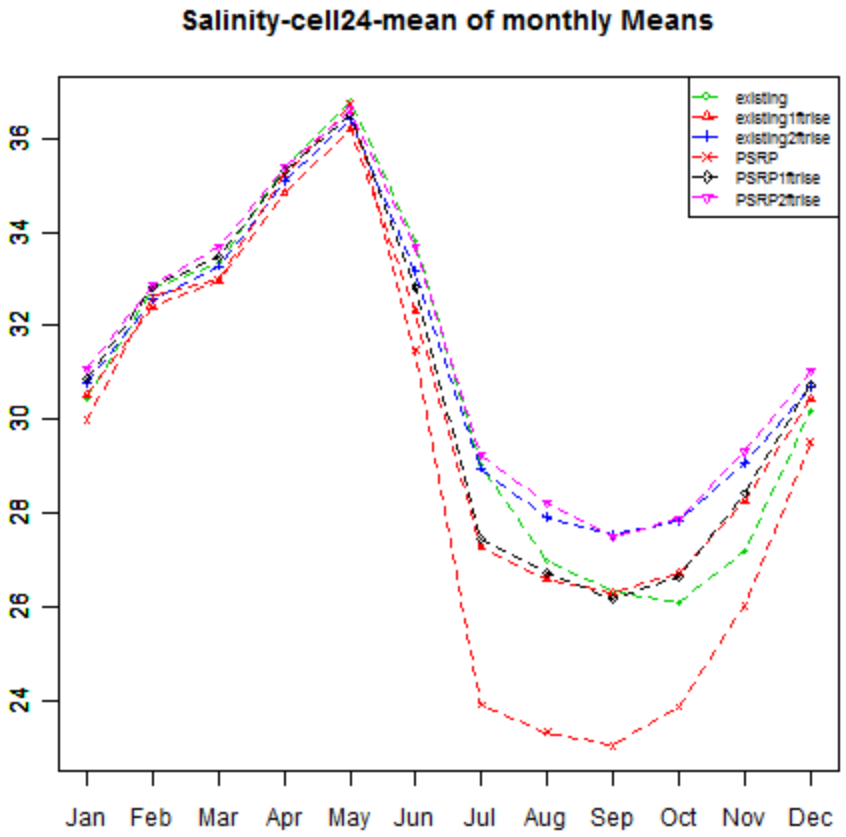




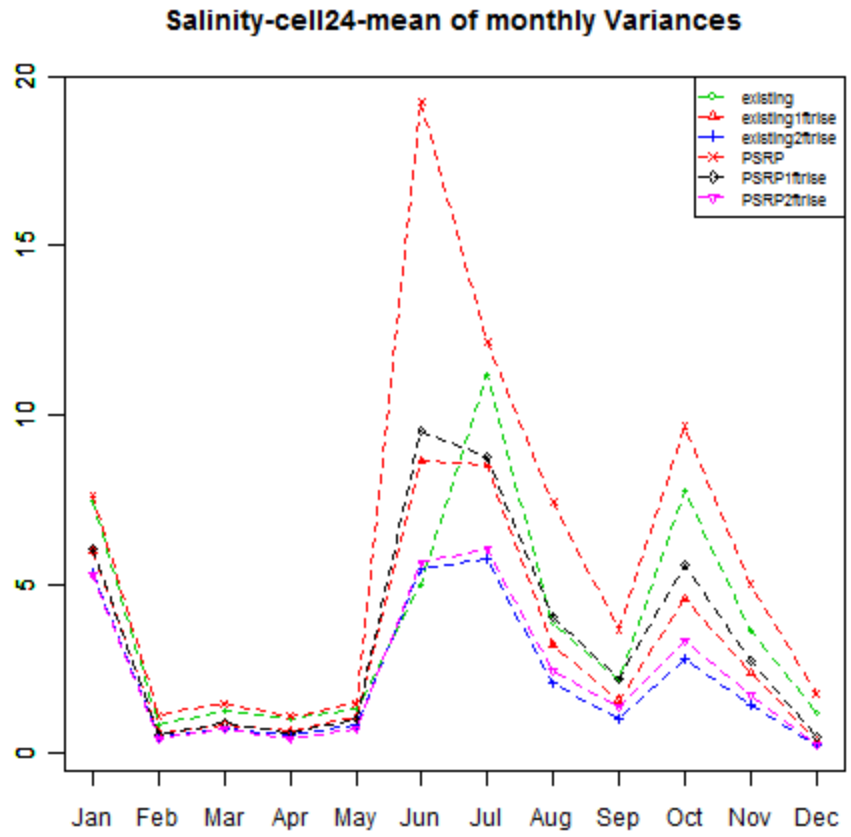


Fakahatchee Bay salinity differences for 6 scenarios

Salinity (mean)



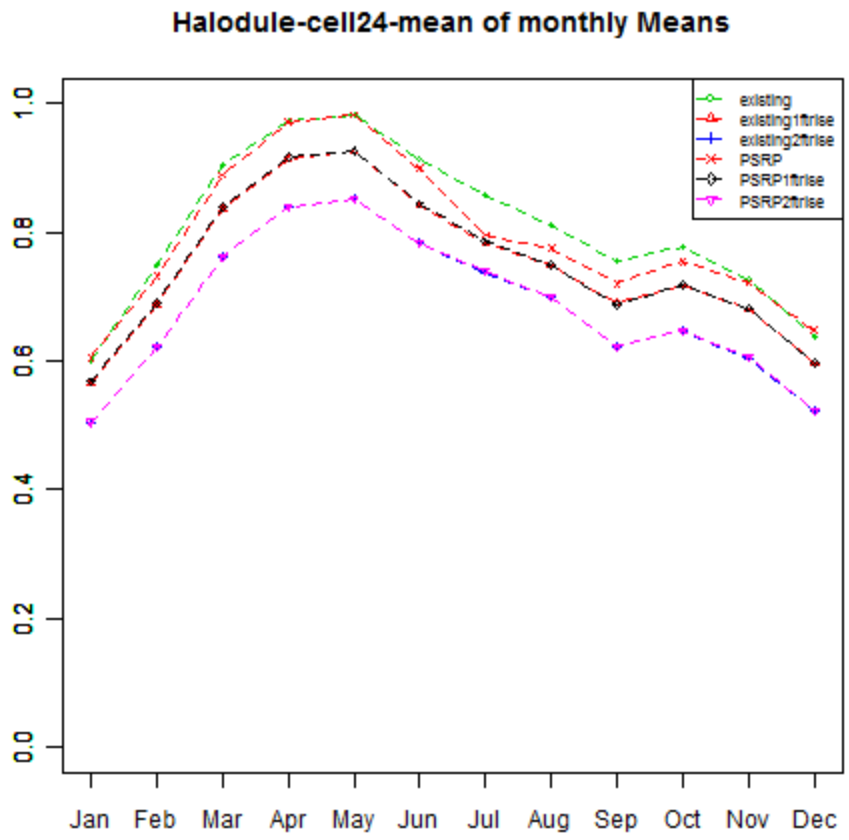
Variance



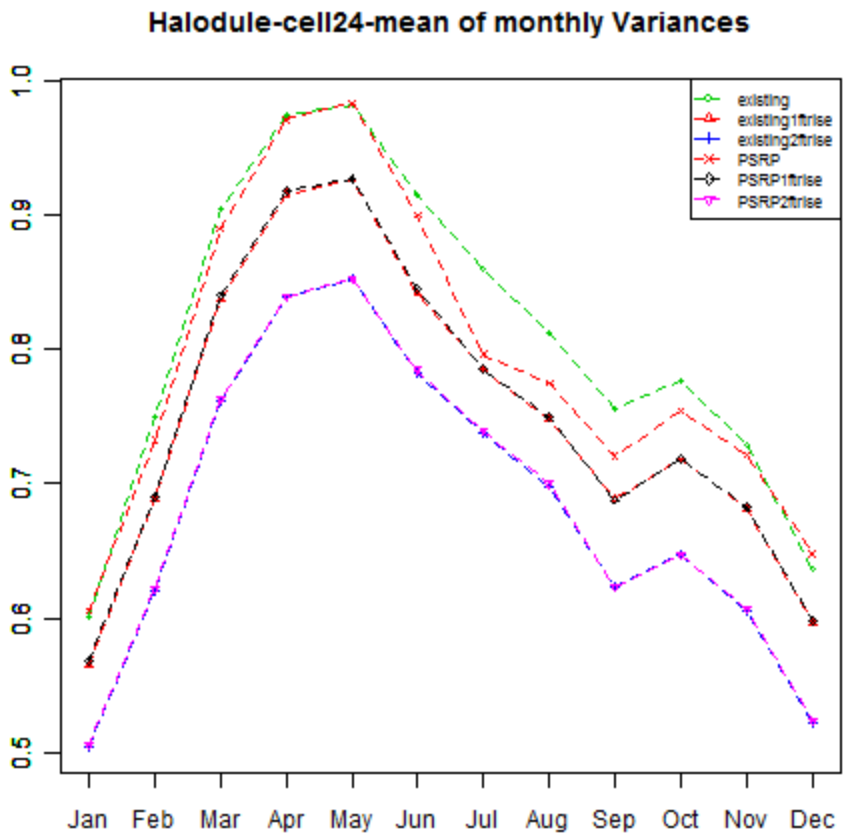
Picayune Strand Restoration shows reduced salinities compared to sea level rise and existing condition scenarios. Variance peaks during beginning and end of wet season.

Fakahatchee Bay *Halodule* HSI differences for 6 scenarios

HSI (mean)



HSI Uncertainty



Habitat suitability for *Halodule* is lower for sea level rise scenarios at this site. Variance is high, especially at dry-wet season transition.

Summary

- **HSI/SESI approach provides a simple modeling framework to analyze and compare biological implications of large futurecast datasets and alternative restoration scenarios**

- **Uncertainty and Sensitivity Analysis shows which model parameters produce the greatest variation and provide estimates of model uncertainty in space and time**
  - **can help direct monitoring resources to measure parameters and sites with greatest uncertainty and sensitivity**
  - **uncertainty maps can help managers evaluate model results**

- **Difference maps and graphs of changes in habitat suitability can reveal trends and relative differences associated with restoration and sea level rise.**

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Acknowledgements

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