Climate Change Modeling of Lake Mead: Extrapolating Model Results to Biological Change

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Acknowledgement

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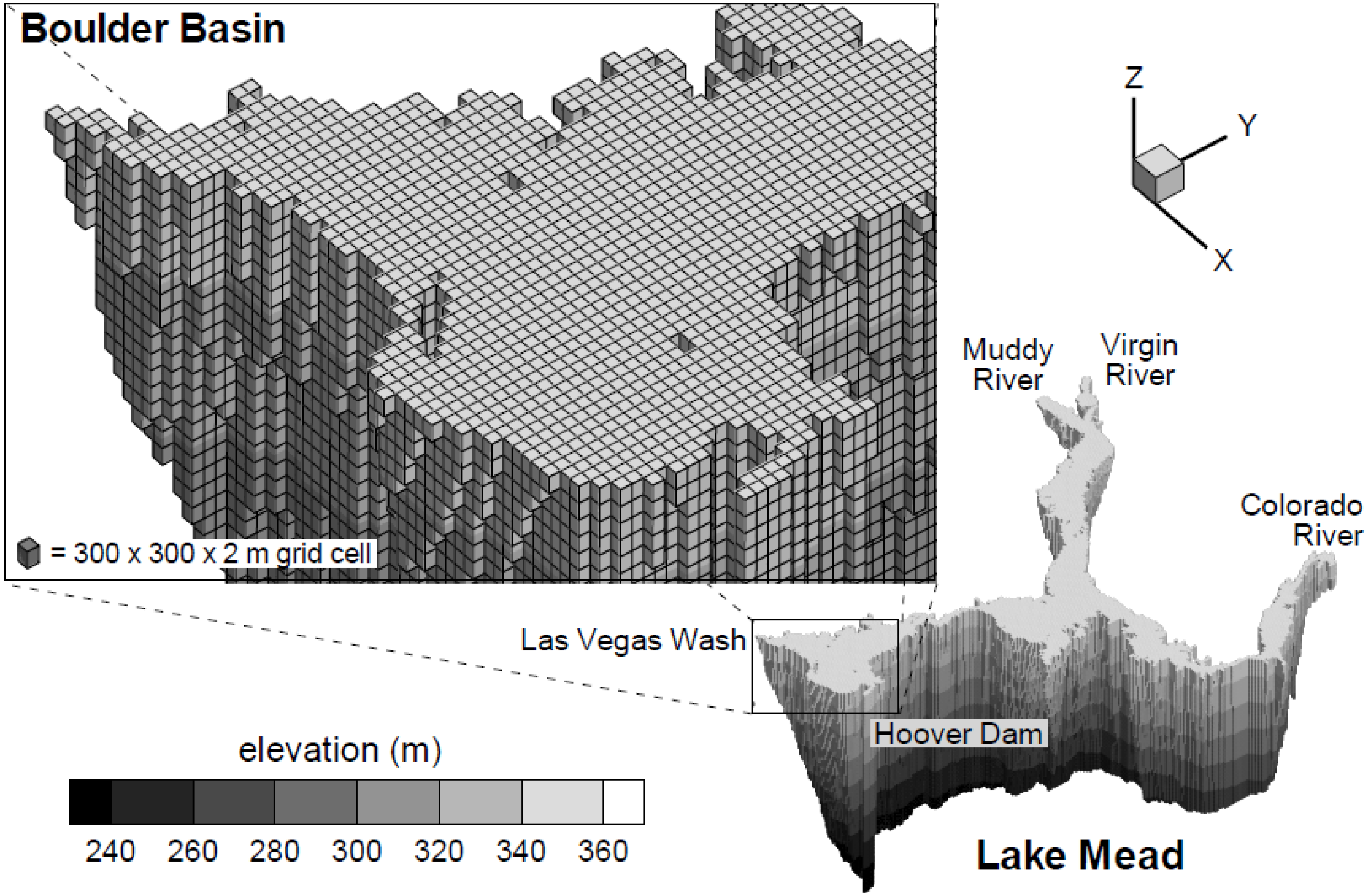
Lake Mead Model

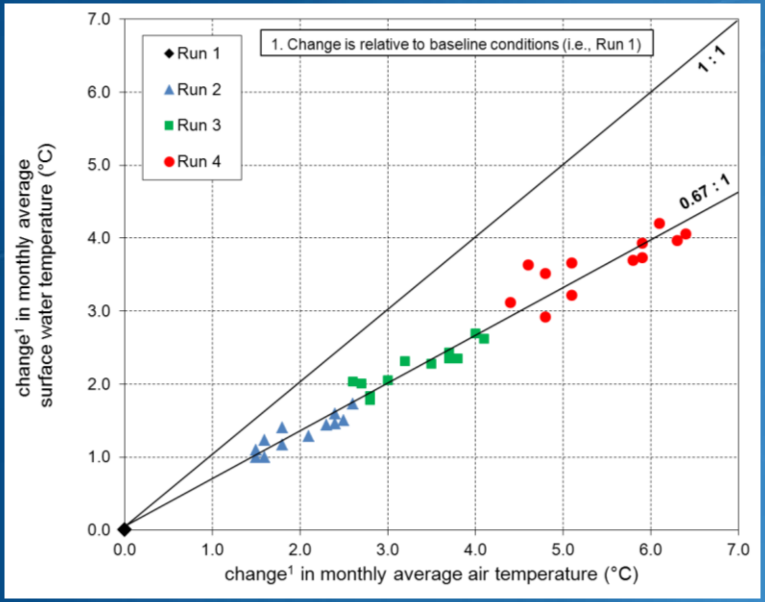
- A linked hydrodynamic, biological, and chemical numerical simulation model for Lake Mead has been developed over the past decade
- ELCOM: Estuary and Lake Computer Model
  - 3D Hydrodynamic model
- CAEDYM: Computational Aquatic Ecosystem Dynamics
  - Aquatic Ecology model coupled to the ELCOM model
- The performance of the model(s) has been evaluated and enhanced throughout its life

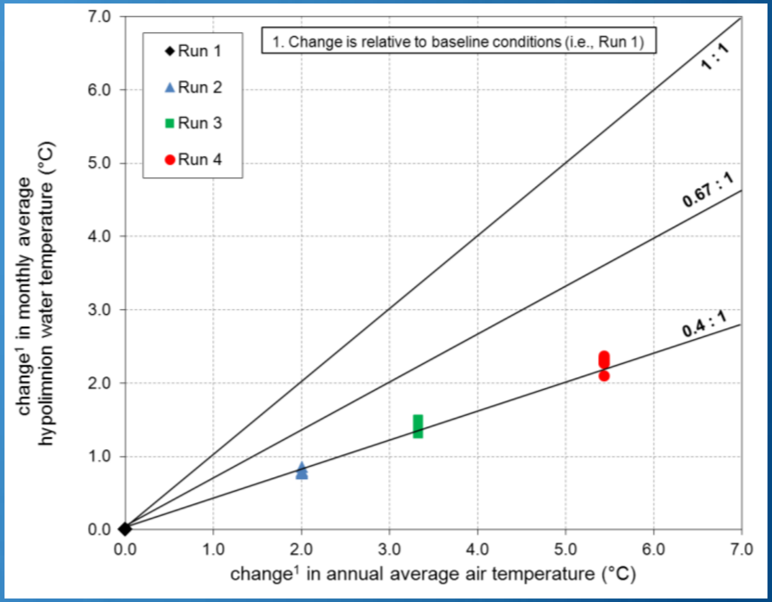
Computation Grid for Whole Lake Model



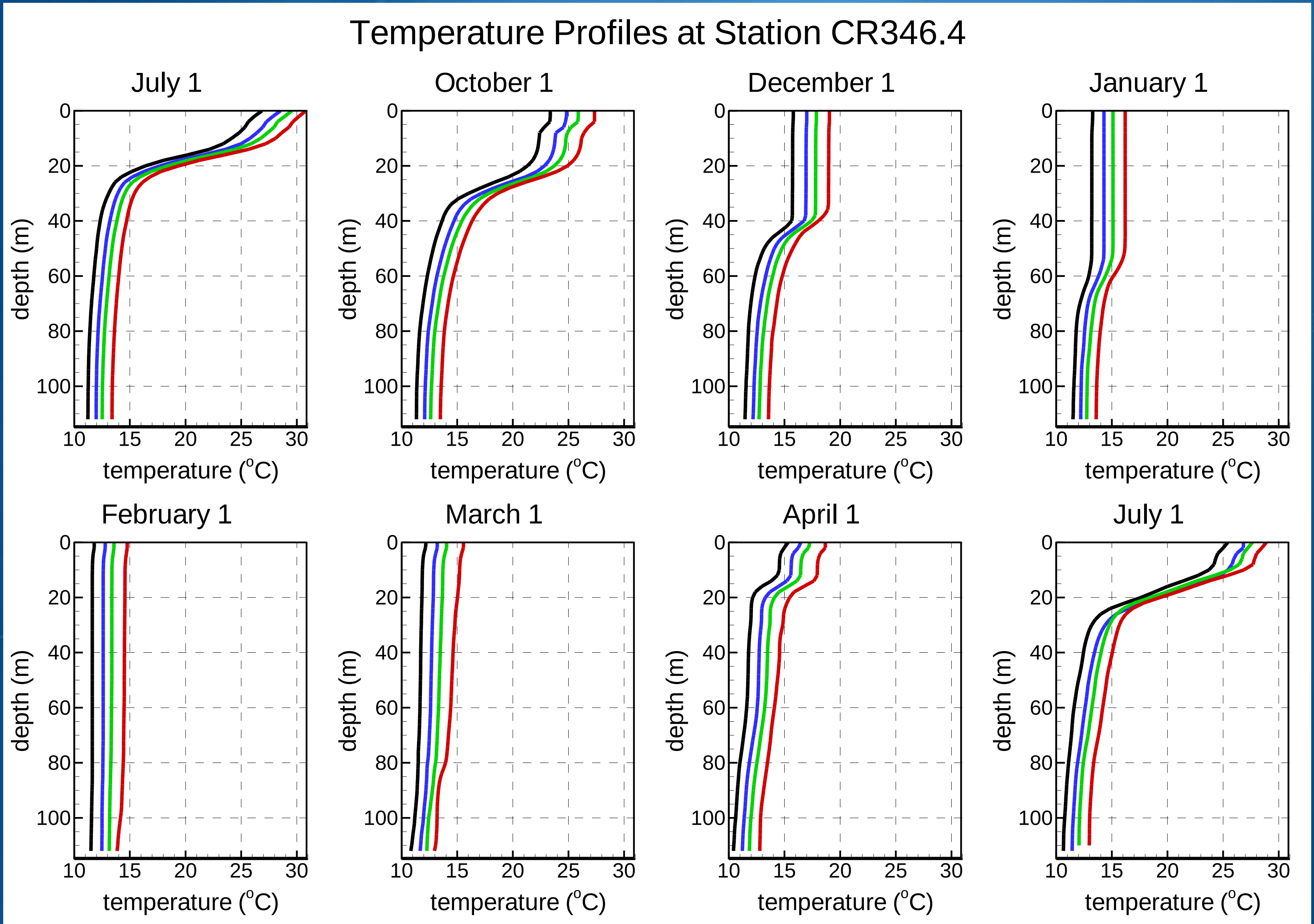
Initial Model Runs: Average Temperature Increases

- 2050 median: +2.0 °C Air Temperature
- 2090 median: +3.2 °C Air Temperature
- 2090 90th percentile: +5.4 °C Air Temperature
  - CMIP3 projections
- Based on initial model runs and literature review water temperatures were adjusted to 67 % of these values in the surface and inflow and 40 % of these values for the lower water column

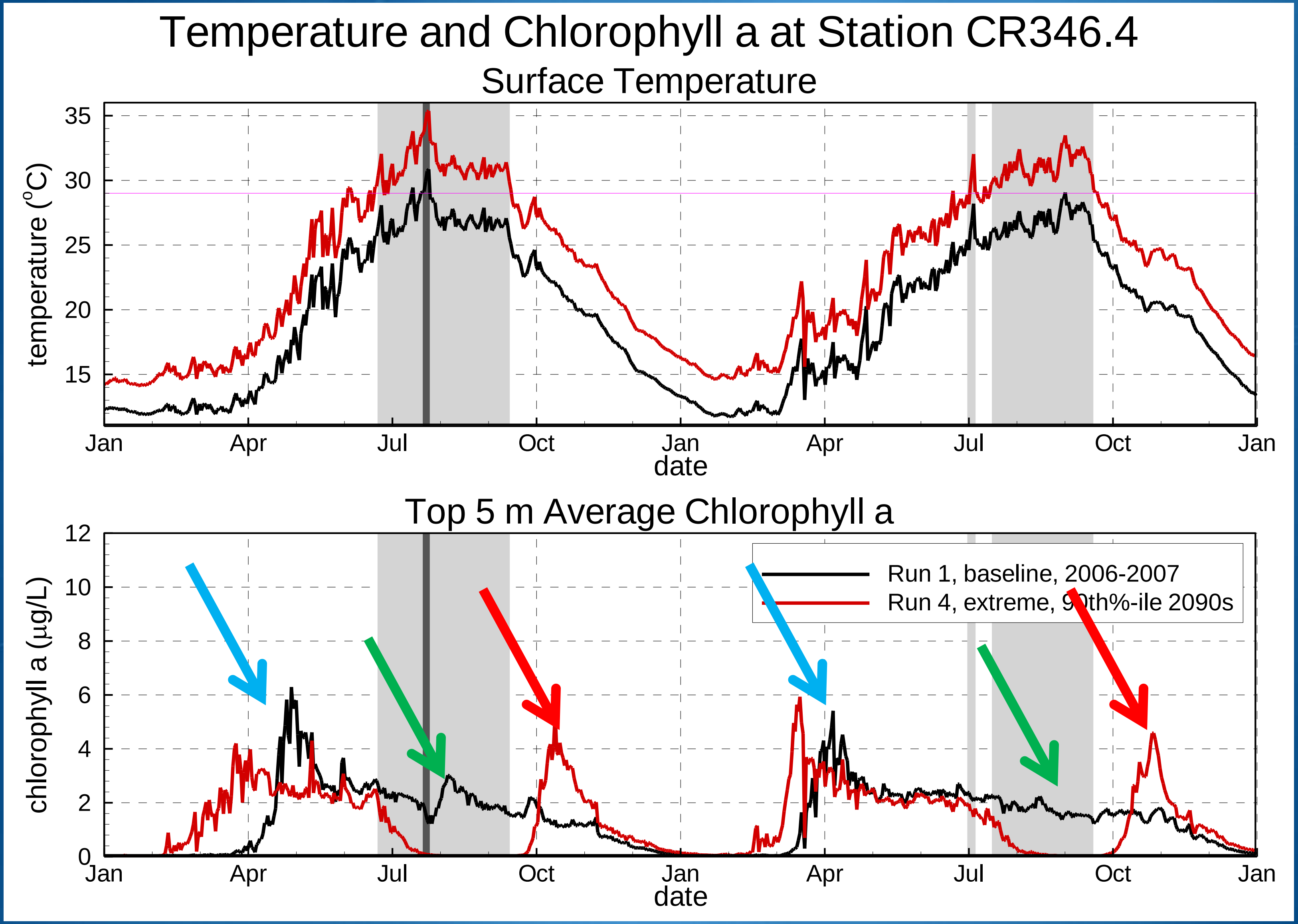




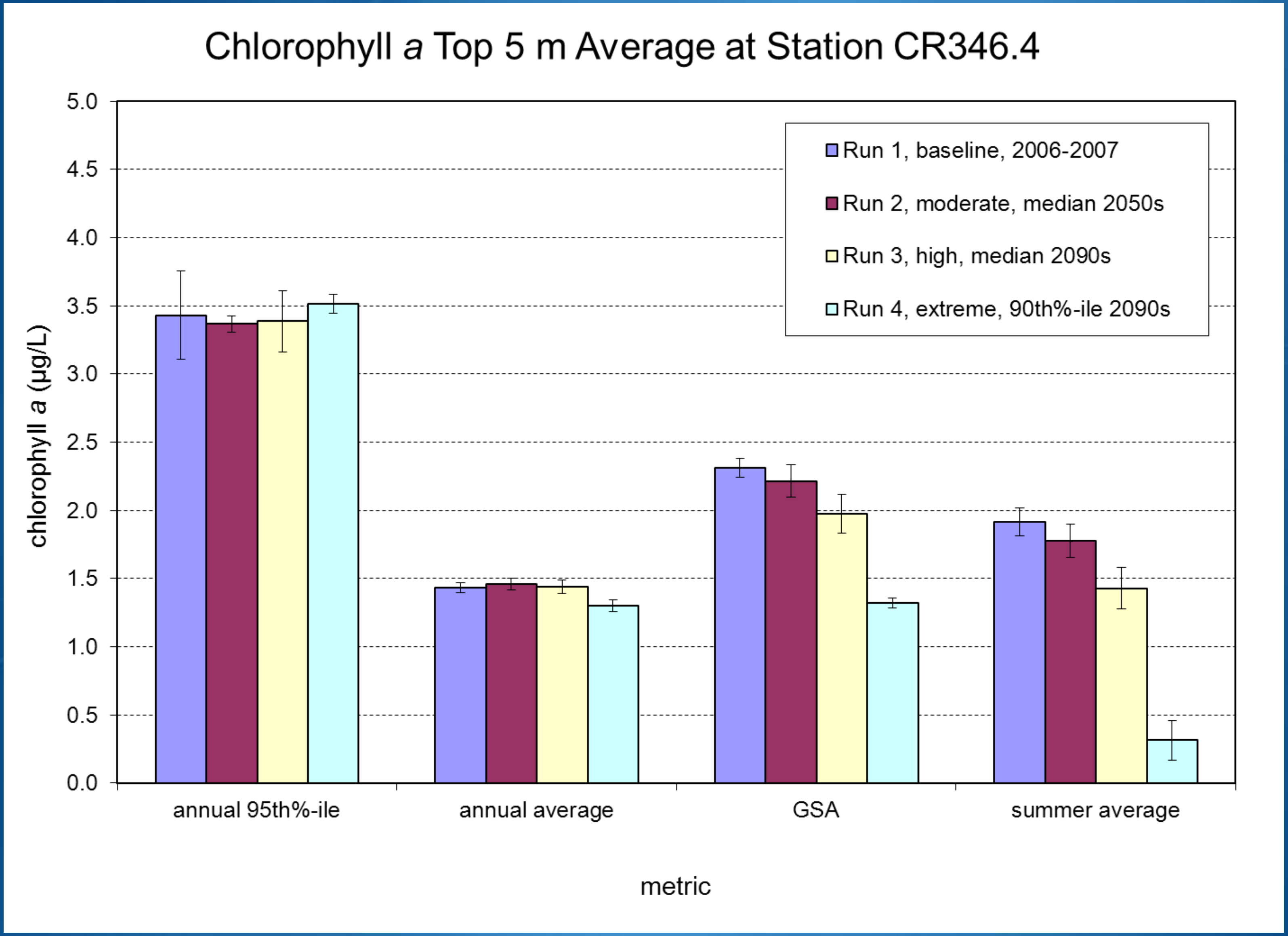
Temperature Profiles



Chlorophyll a Concentrations



Chlorophyll a impacts



Chlorophyll, Temperature and Nutrients

- With warmer temperatures there is a pronounced decrease in summer Chlorophyll a concentrations
- There is a second significant chlorophyll peak in the early autumn after temperatures fall back below 30 °C
- There was little difference in average concentrations
  - Depending on how average is calculated

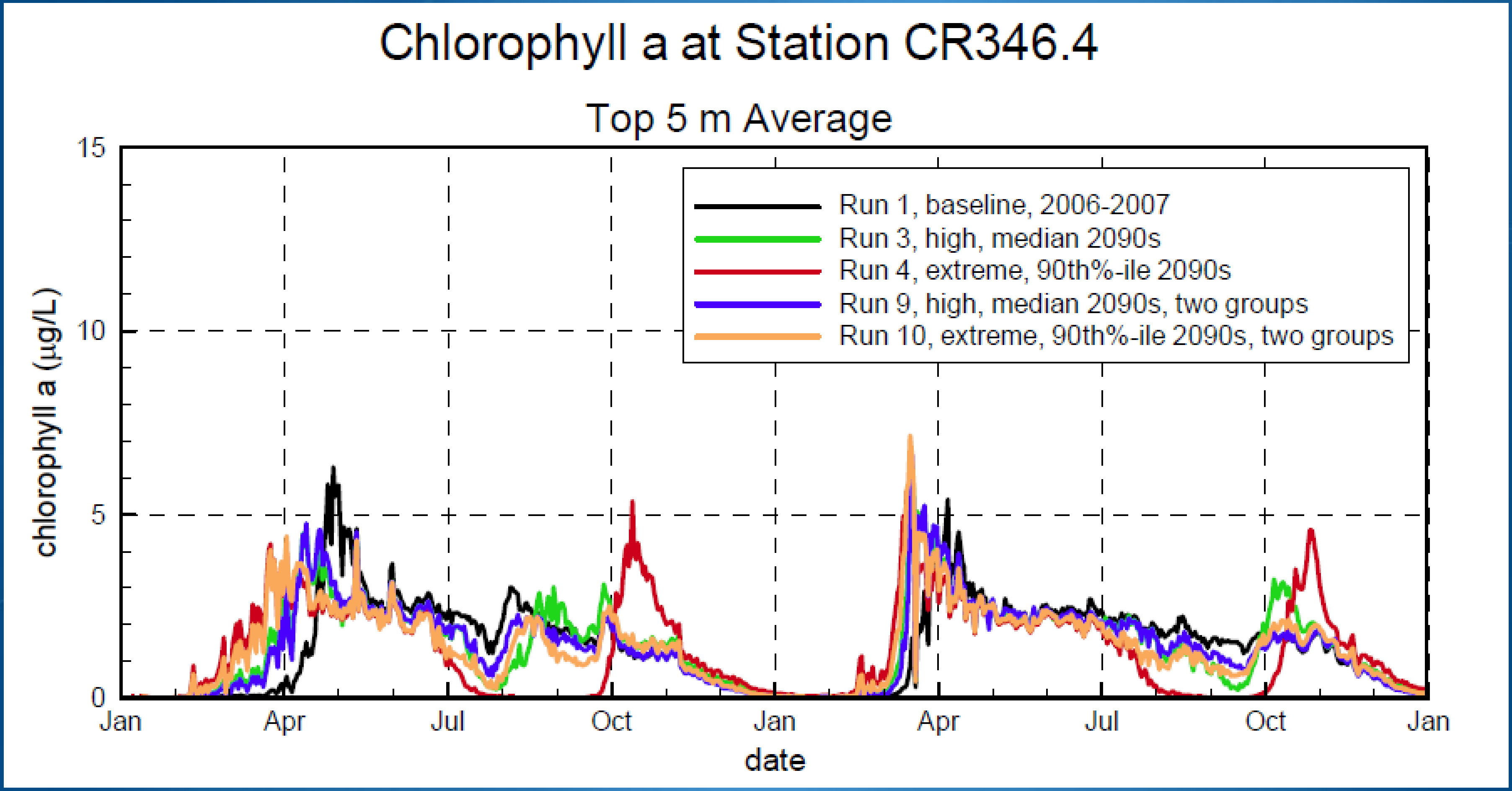
Chlorophyll, Temperature and Nutrients

- A key part of this cycle is the accumulation of nutrients during the summer
  - There is extensive data indicating that algae in Lake Mead is phosphorus limited
    - The Las Vegas Wash contributes a large proportion of the available phosphorus to the lake
    - During the summer months the majority of the Las Vegas Wash water enters the lake as an interflow, adding phosphorus to the surface/middle waters of the lake
- When temperatures are too high for the current algal community, phosphorus accumulates, allowing for the development of an Autumn chlorophyll peak

Can we modify the community?

- There is no reason to believe that the community present today would be the same following ~70 years of gradual warming
  - There are algal species that can thrive at > 30 °C
- Within the model this is accomplished by adding a second "generic" algal group with slightly higher thermal tolerance
- The pattern returned to "normal"

Chlorophyll a Impacts: Modified Community



Accommodating Higher Temperatures

- If we know that the model is limited by the current state of knowledge and…
- We know that we can modify the model slightly and obtain believable results
  - Slight modifications in the sense that they are biologically likely, but not explicitly quantitatively derived
- So what can we predict, biologically, in light of these model changes
  - i.e. what changes will we see in the algal community to meet the need to accommodate a 3 – 5 °C peak temperature increase

Likely Algal Changes

- From the literature it has been demonstrated that higher temperatures typically lead to some fairly predictable changes
  - Smaller celled species tend to dominate over larger celled species
  - Cyanobacterial species tend to become more dominant

Smaller Celled Species

- In general terms smaller celled species have metabolic advantages during periods of stress
  - Generally explained as an advantage derived from changes in relative surface area to volume ratios
    - Smaller cells have a large surface area and smaller
      - Facilitates capture of light for photosynthesis and nutrient acquisition
- The Lake Mead algal community is already dominated (numerically) by small celled species
  - Low nutrient concentrations
  - Grazing losses
  - Temperature

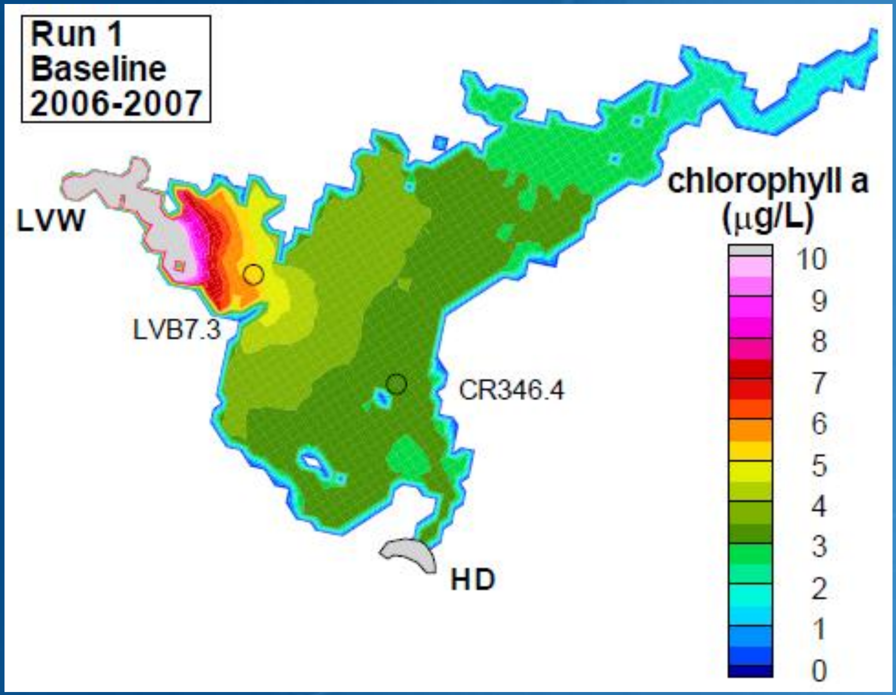
Cyanobacteria

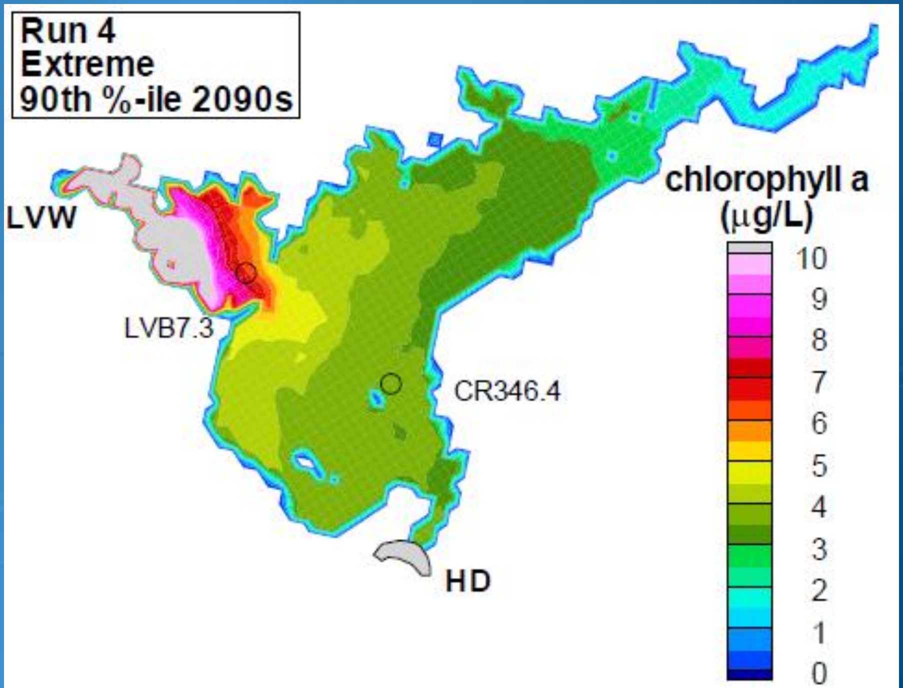
- Cyanobacteria tend to outcompete other algal groups at higher temperatures
  - 2 theories
    - Better physiological adaptation at higher temps
    - More capable of moving in the water column, preventing settling and maintaining favorable position
- It doesn’t really matter why they are advantaged
- Cyanobacteria pose 2 threats
  - Bloom forming species
  - Toxin producing species

Cyanobacterial Threats

- Bloom forming species
  - Cyanobacteria frequently produce significant blooms as they are able to use available nutrients very efficiently
    - As long as phosphorus remains the limiting nutrient, and loading is maintained at current levels these blooms should be infrequent
- Toxin producing species
  - As one strategy for competition with other algal species **some** cyanobacteria produce toxins
  - SNWA currently monitors for toxin producing species and some toxins
    - Potentially toxin producing species are present
    - Toxins have never been detected

What is the (potential) End Result





Slight increases in chlorophyll concentrations

Potential shifts in species composition

Not addressed, other ecosystem shifts

Food quality, changes in location of productivity

If the Worst Happens, How to Respond?

- Decreases in the size of the algal cells
  - Drinking Water: Maintenance of filtration capacity
  - Ecosystem: Changes in the availability of food to the rest of foodweb is unclear
    - Species shifts
- Increased possibility of blooms
  - The management of nutrient loading from the Las Vegas Valley has kept algal blooms in check for 13 years.
- Increased possibility of algal toxins
  - Drinking Water: Ozonation destroys toxins
  - Ecosystem: Potentially harmful
  - Recreation: Potential risk

Questions?

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