Progress in WQSTM Climate Change Analyses

Richard Tian and CBPO modeling team

Modeling Quarterly Review
04/02/2019
Annapolis

Outline

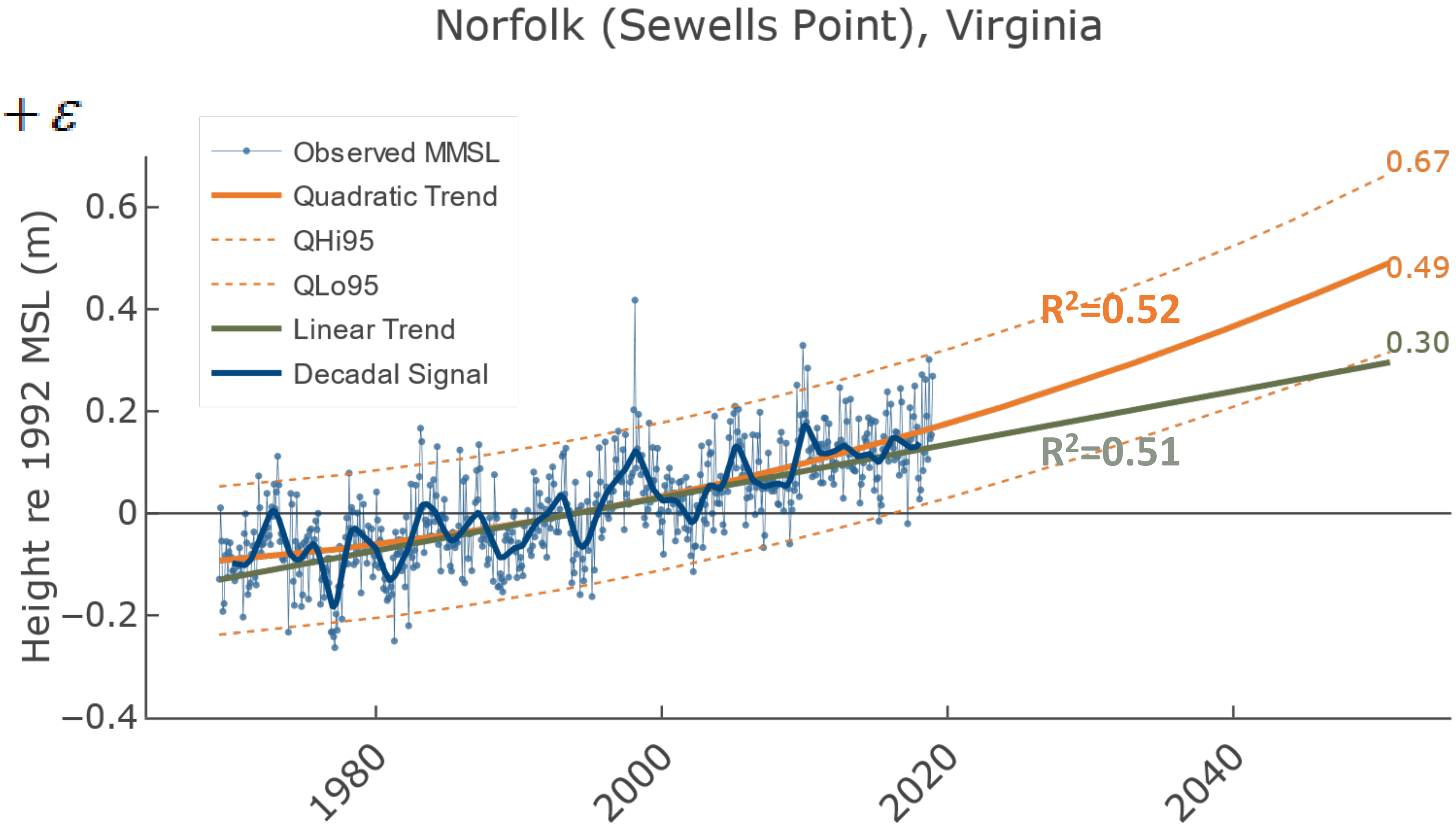
- Sea level rise
- Heat flux
- Temperature parameter values
- Nutrient loading
- Preliminary results for 2025

Quadratic function projection, Norfolk

$$h = \beta_0 + \beta_1 t + \tfrac{1}{2}\beta_2 t^2 + \varepsilon$$

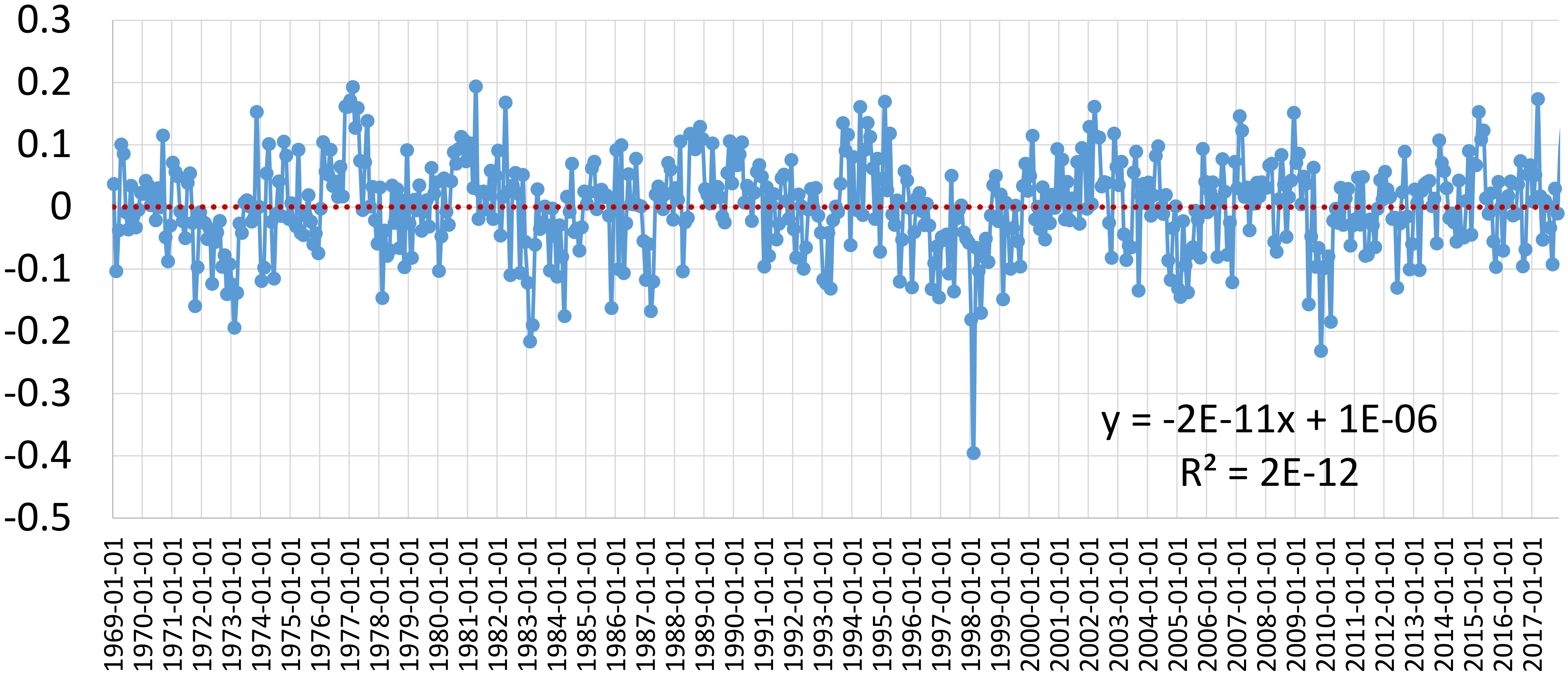
$\beta_1 = 5.203$ mm/yr
$\beta_2 = 0.12$ mm/yr^2

(with 2018 data.
Boon, Mitchel and others)



https://www.vims.edu/research/products/slrc/localities/norfolkva/index.php

Residual of Quadratic Projection-Sewells Point



Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites (Kopp et al. 2014)

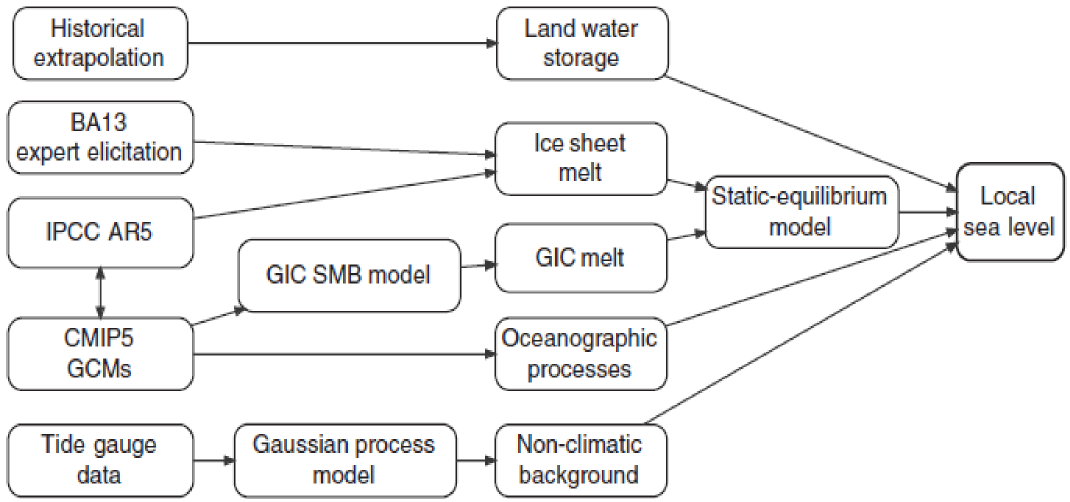
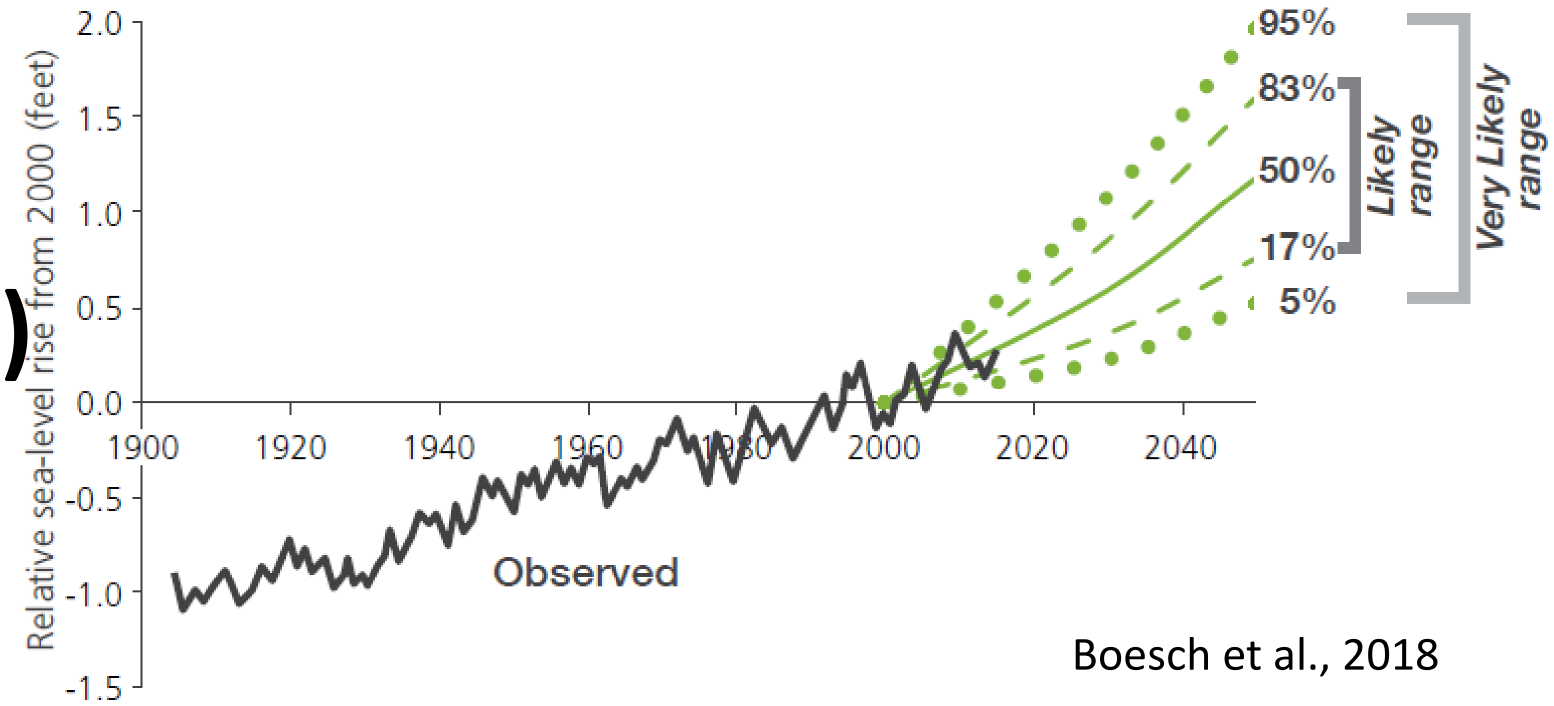


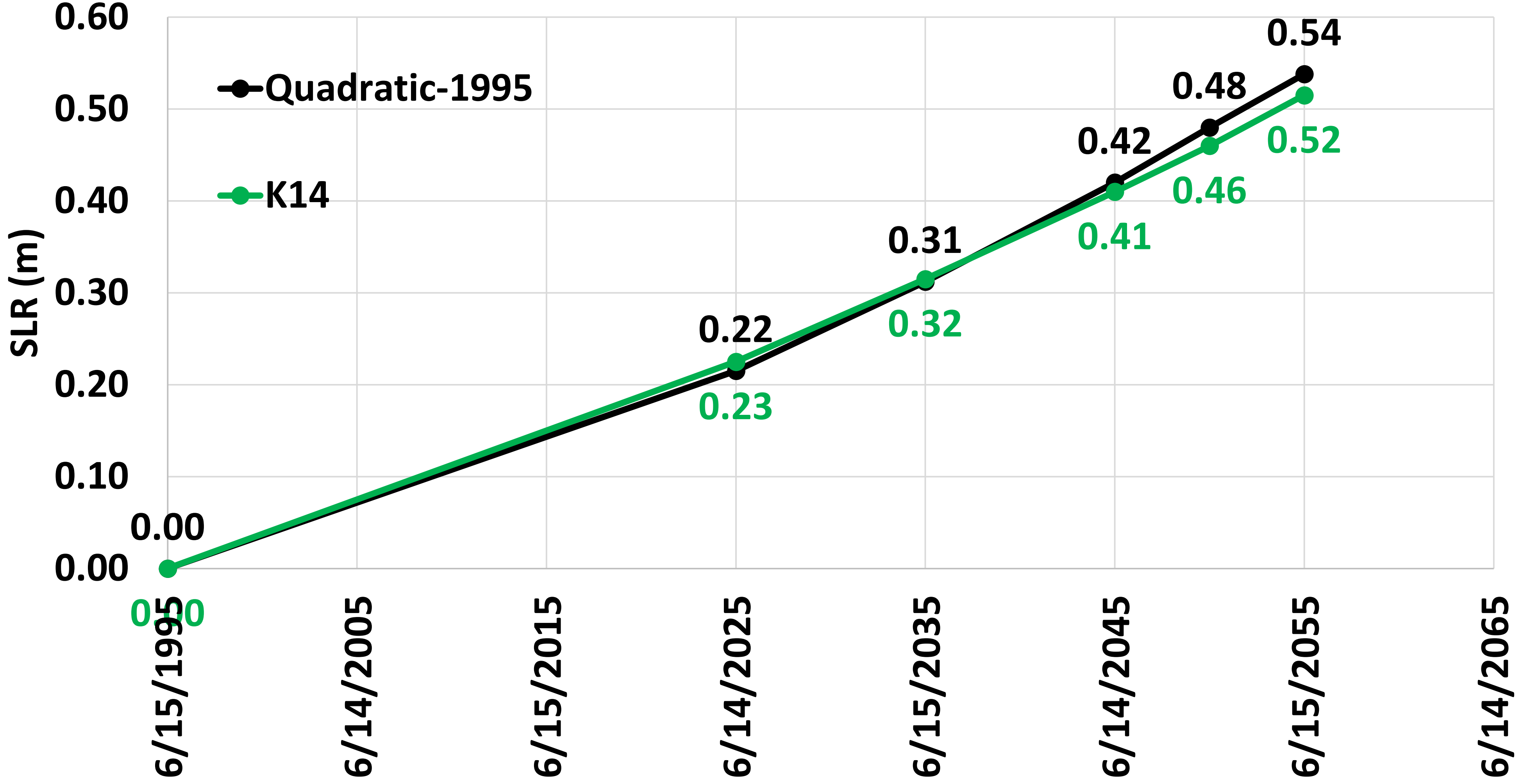
Figure 1. Logical flow of sources of information used in local sea-level projections. GCMs, global climate models; GIC, glaciers and ice caps; SMB: surface mass balance.



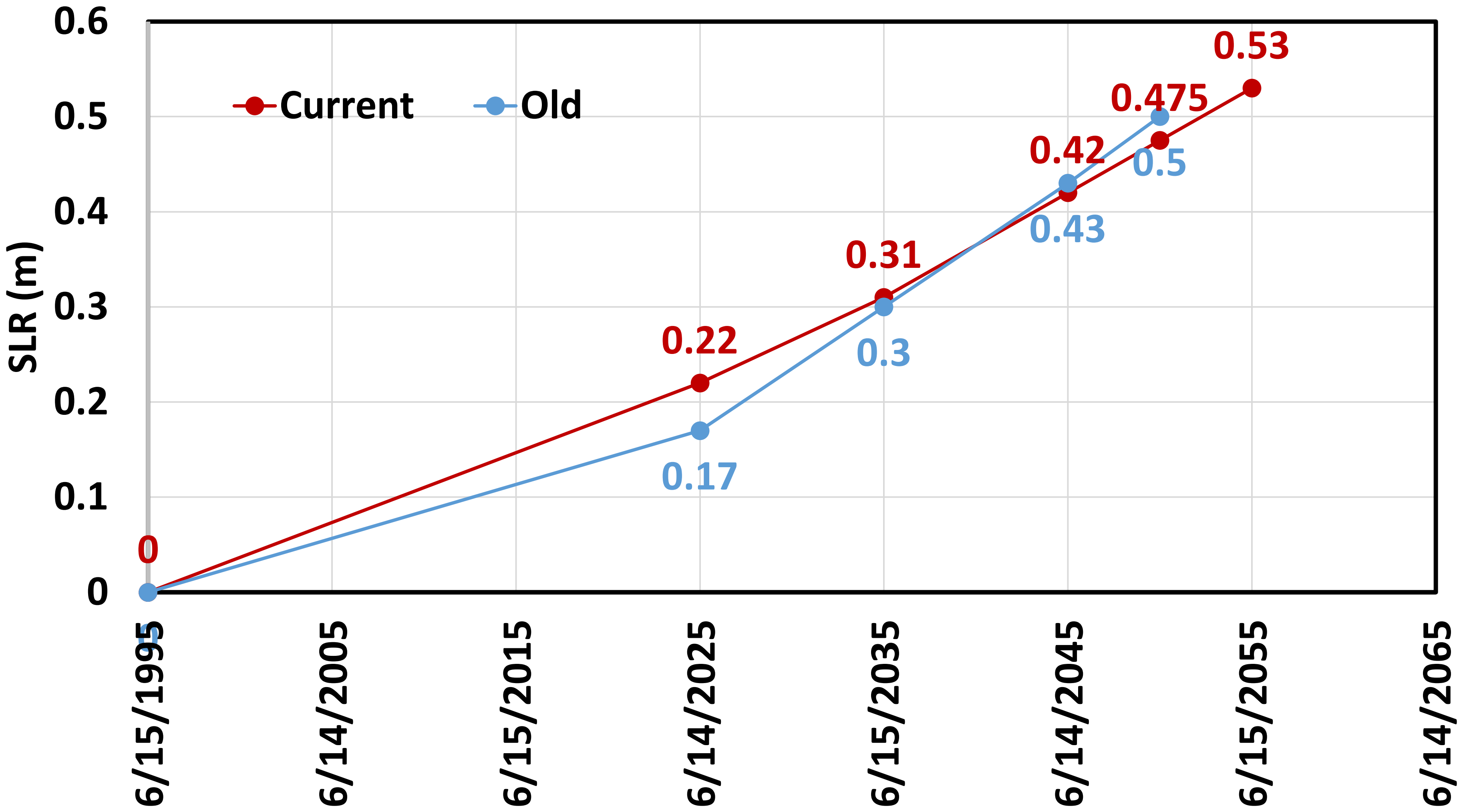
BA13: *Bamber and Aspinall* [2013].
GIC: glacier and ice cap.
SMB: surface mass balance.

Boesch et al., 2018

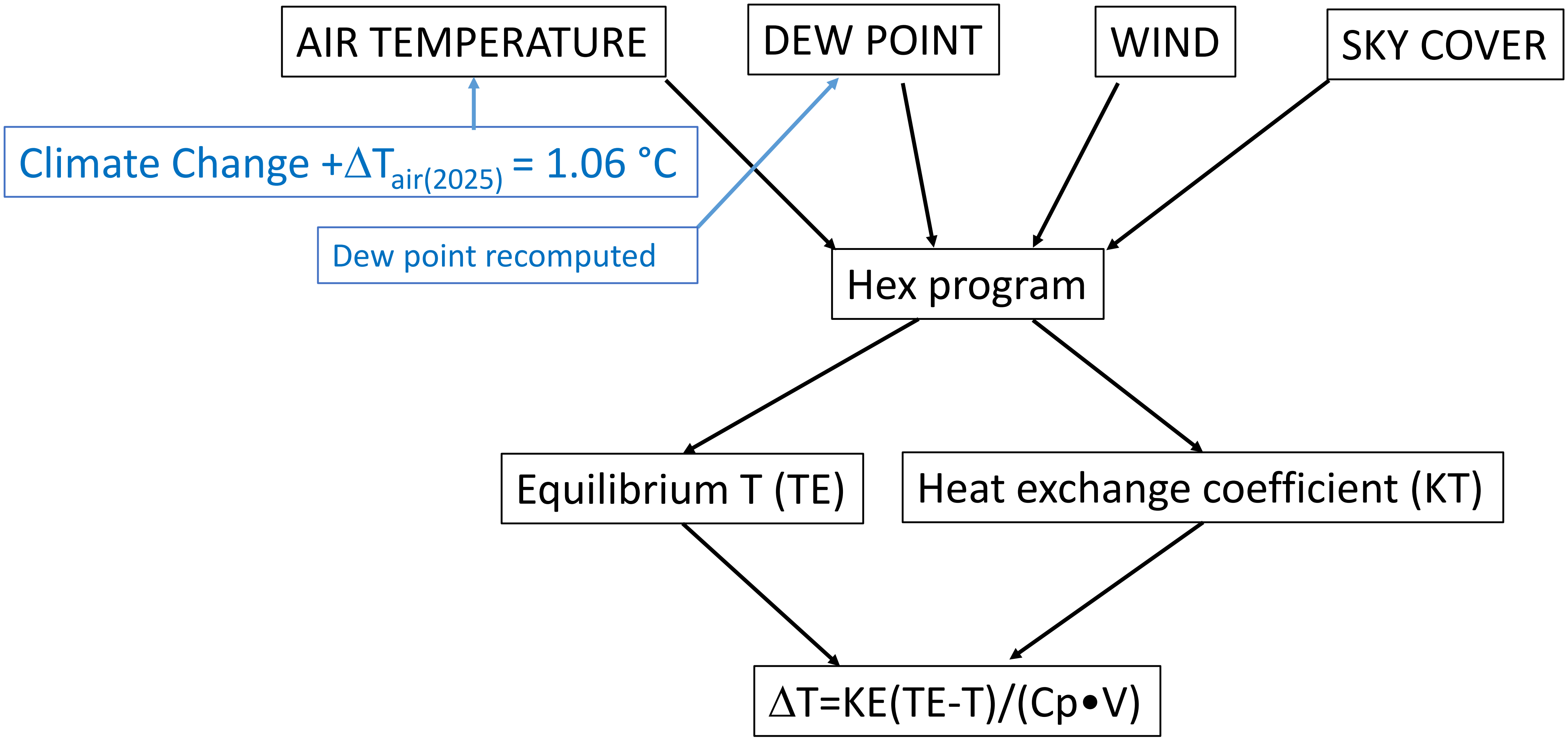
SLR future projection-Sewells Point



SLR future projection-Sewells Point (Climate Resiliency Group)

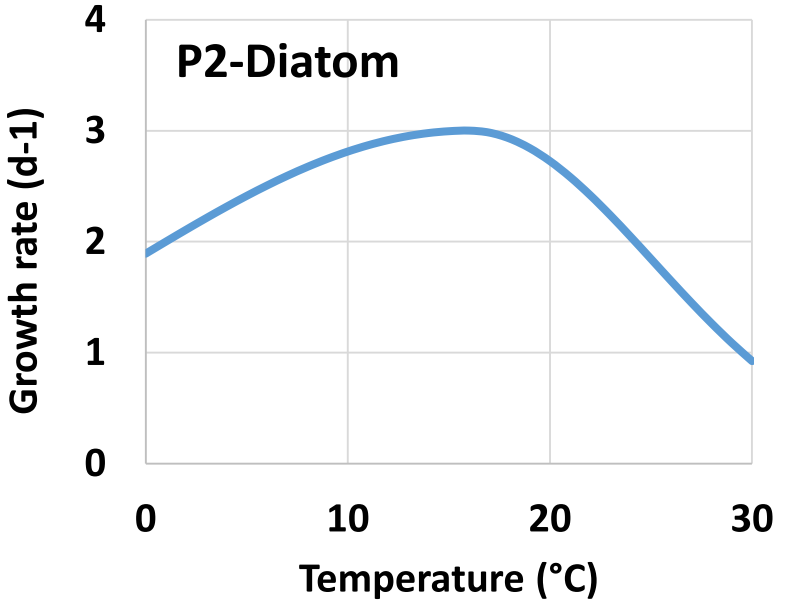


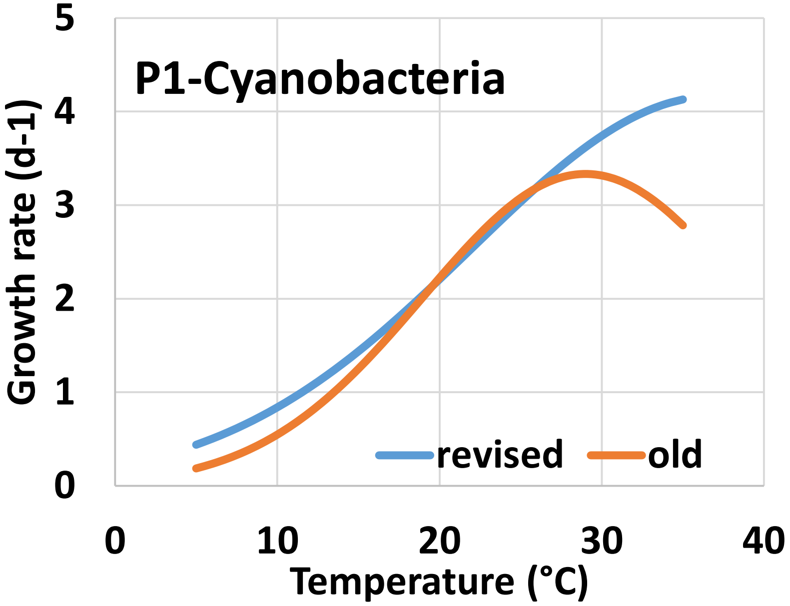
ICM Meteorological Forcing for Heat Transfer From Air to the Tidal Waters

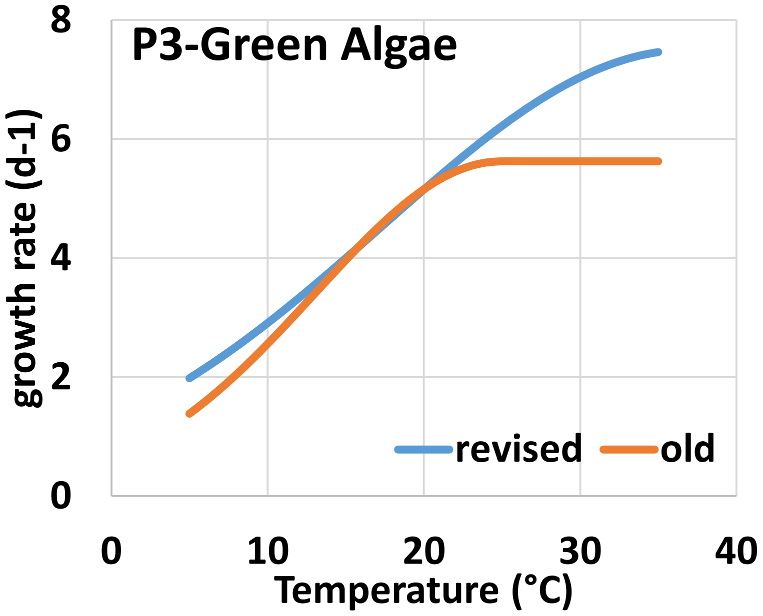


Revised temperature control on phytoplankton growth rate

$$f(T)=\begin{cases} e^{-k1(T-Topt)^2}, T \le T_{opt} \\ e^{-k2(T-Topt)^2}, T > T_{opt} \end{cases}$$







SATC recommendation

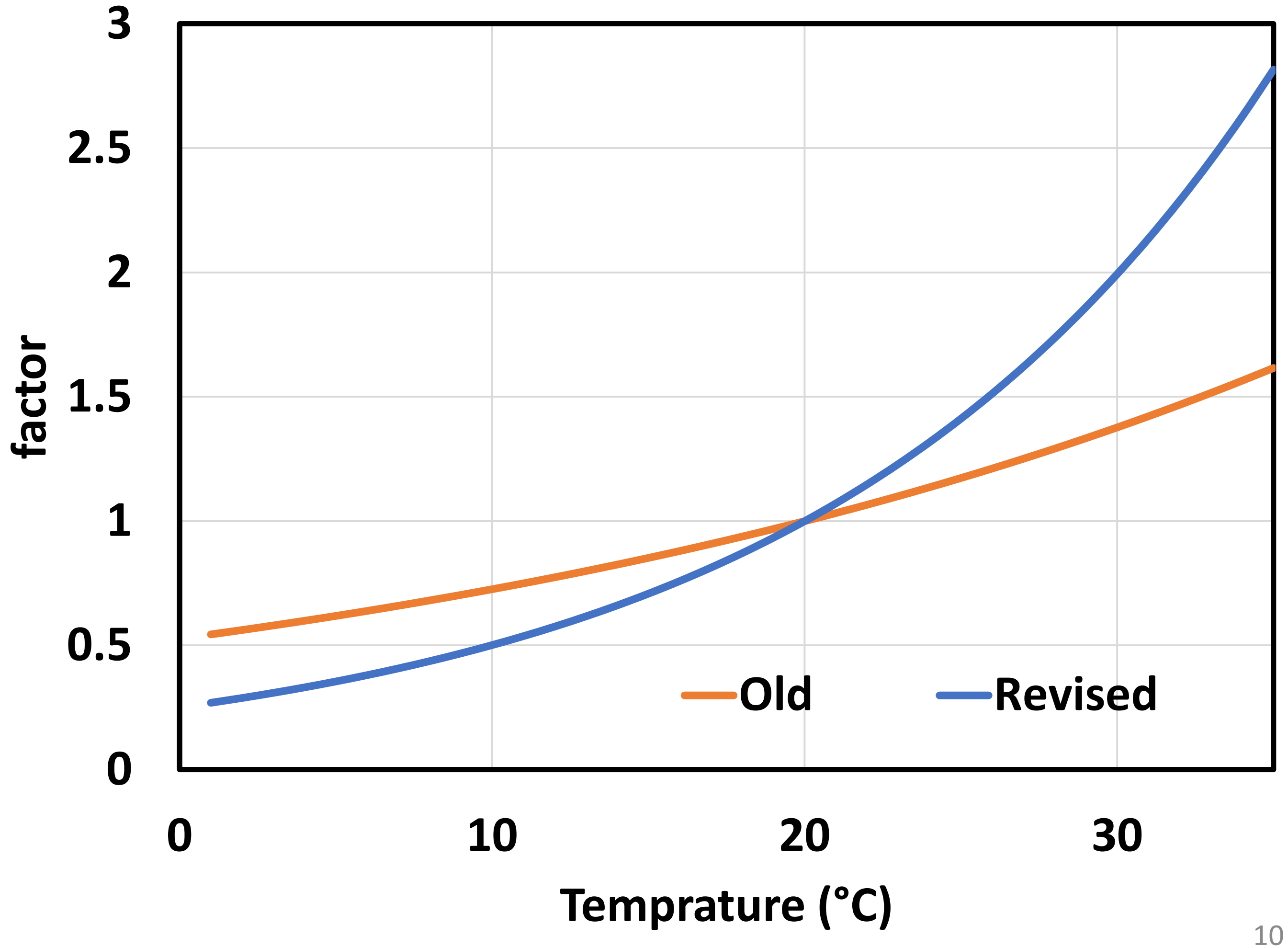
From Carl Cerco

Revised temperature control on phytoplankton repiration

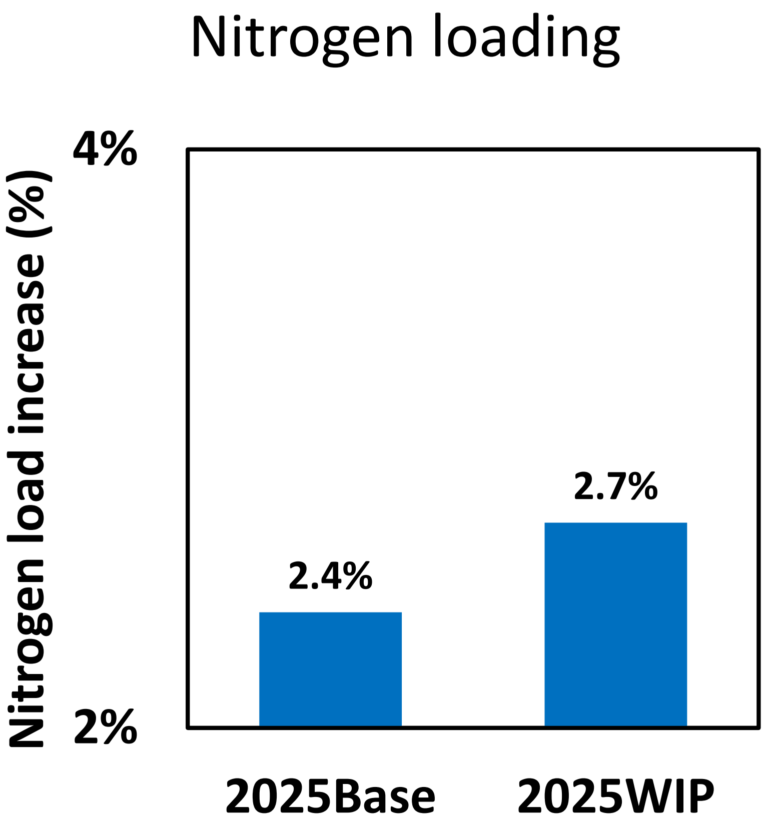
$$a_{res} = \alpha_r B e^{kr(T - To)}$$

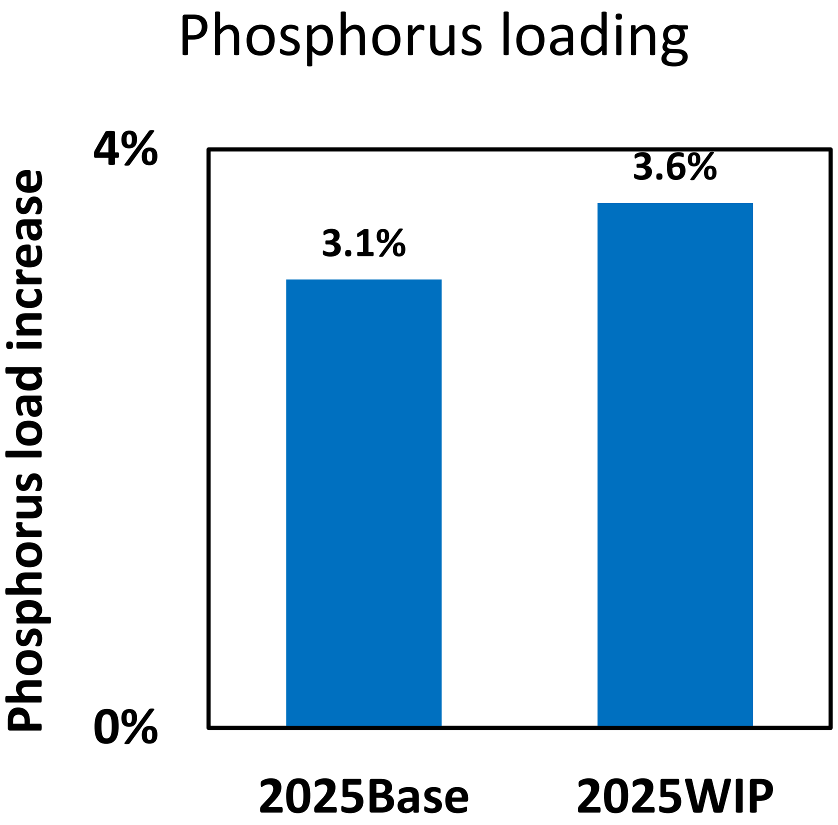
Old: kr=0.0322
Revised: kr = 0.069

SATC recommendation



Changes in nutrient loading in the 2025



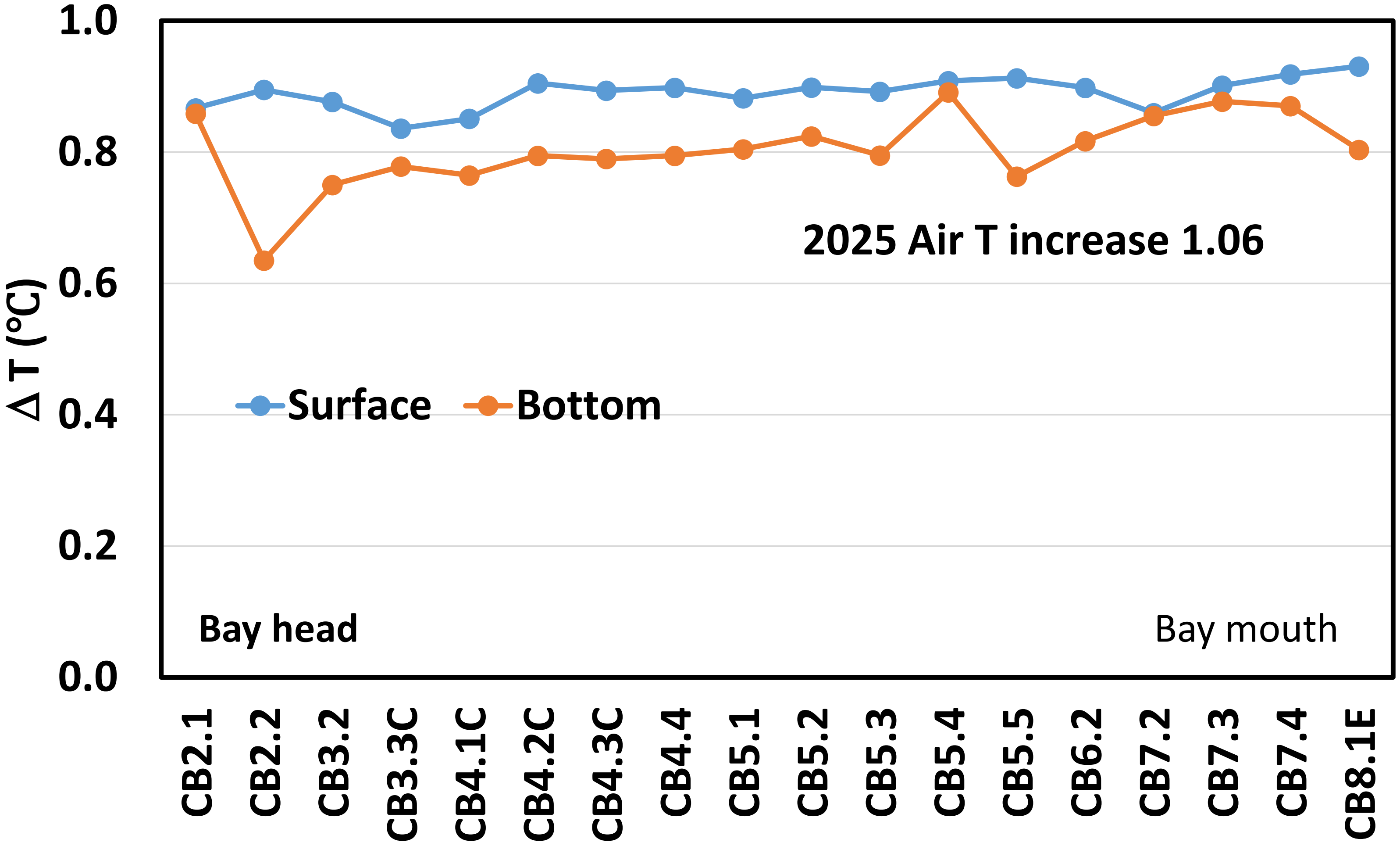


From Gopal Bhatt

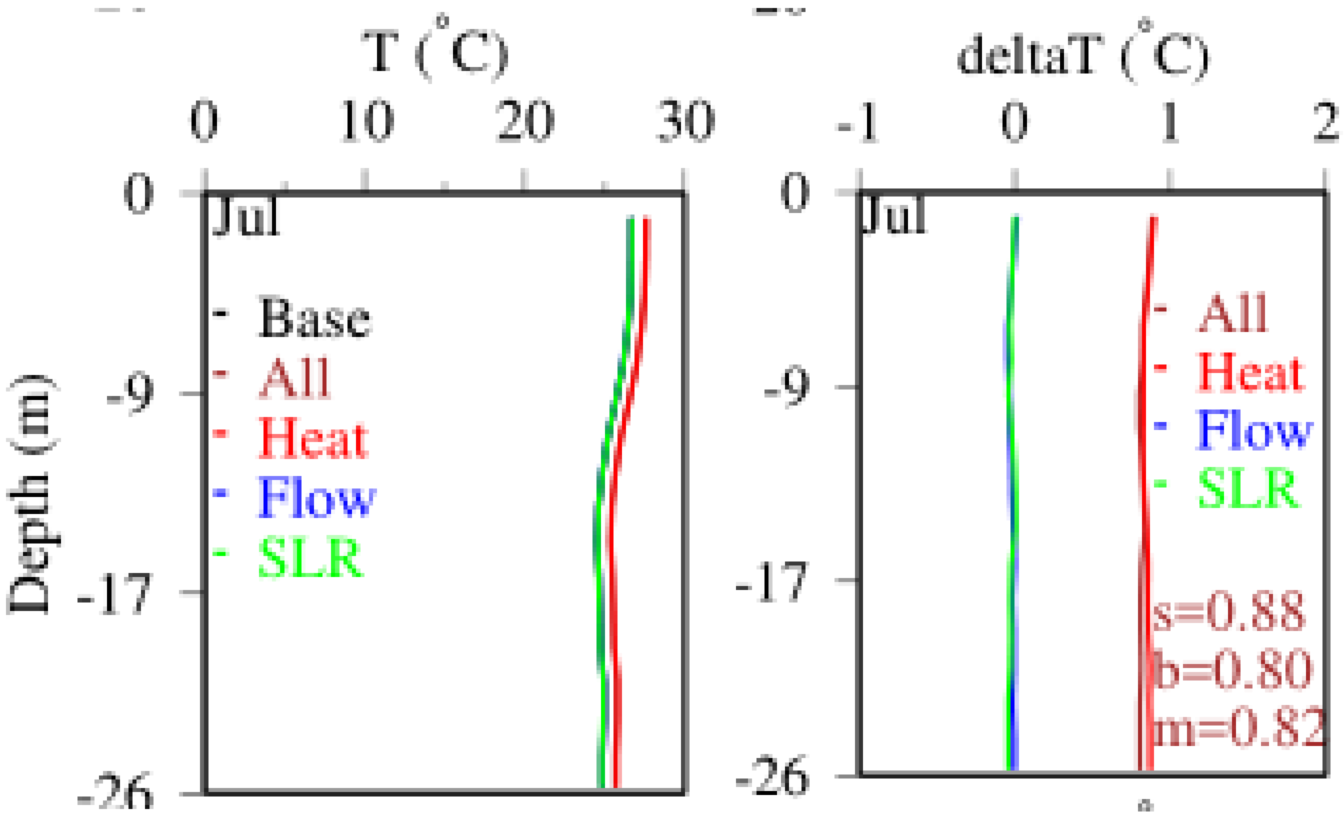
Summer surface water T change under 2025 CC (average 1993-1995)

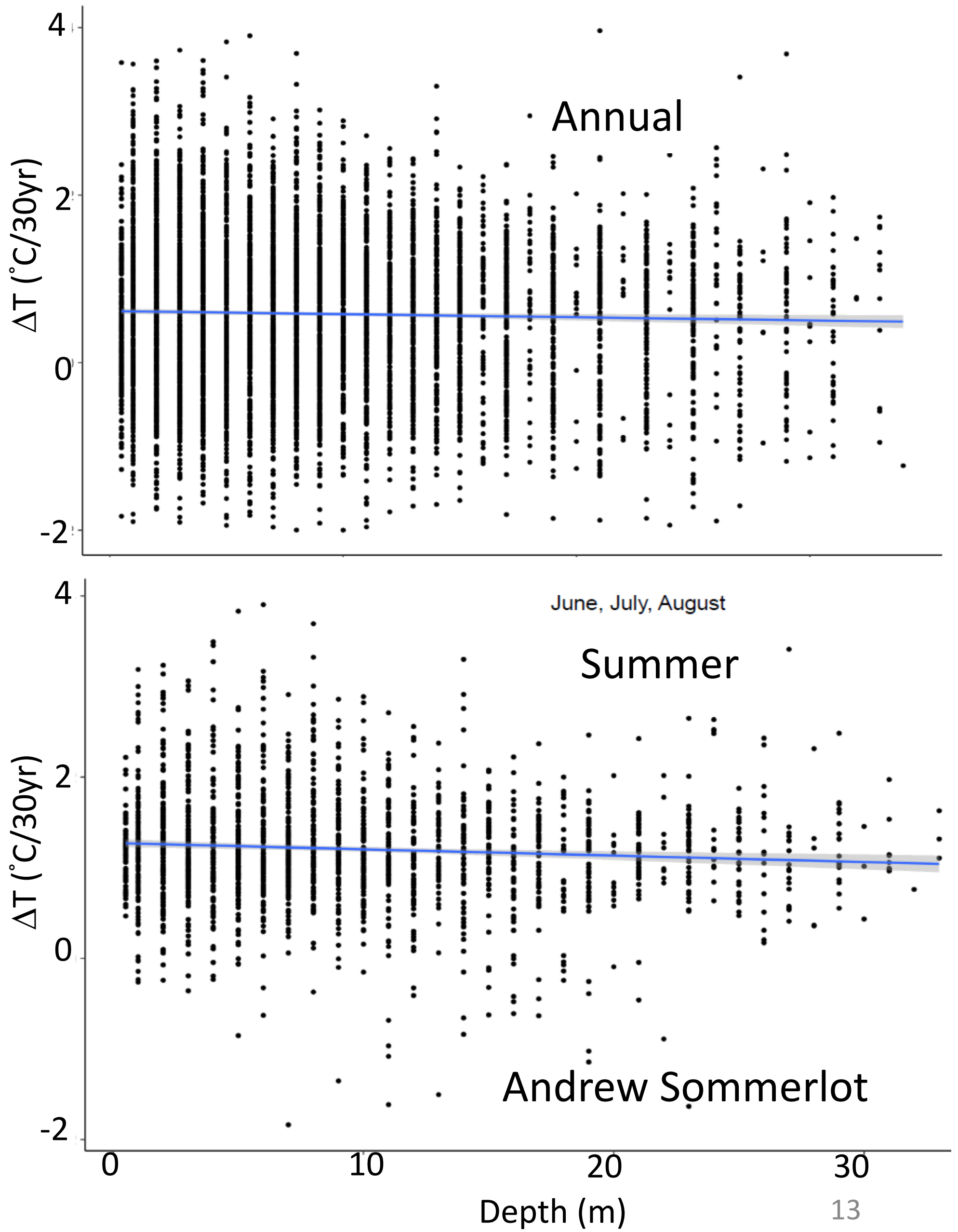
Thomas et al 2017: data 1982-2014, 0.3 °C per decade;

Preston 2004: Data 1949-2002: 0.185 °C per decade;



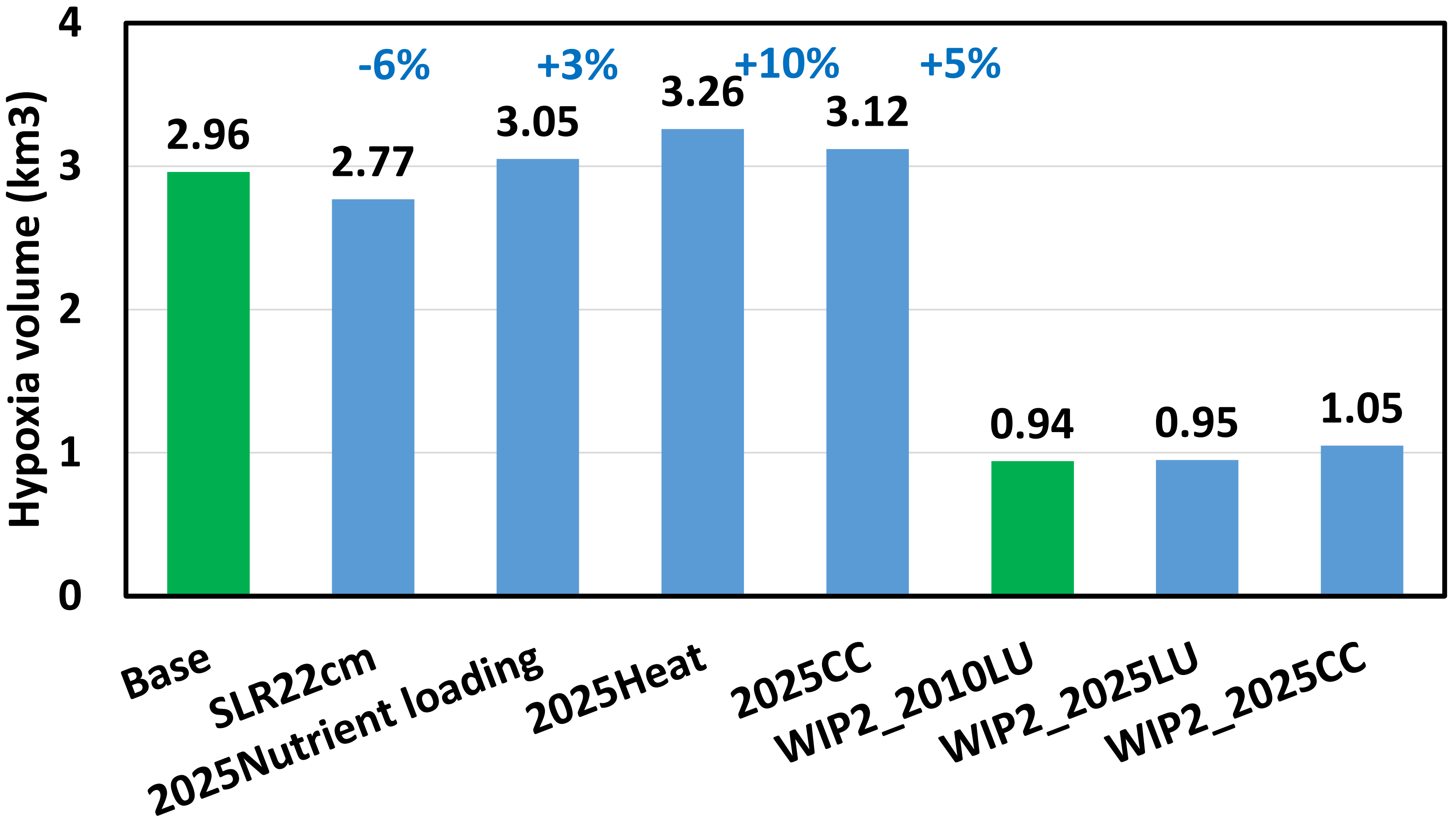
T and ΔT profile at CB4.3C under 2025 CCC





S: surface; b: bottom; m: vertical average over 10 years.

Hypoxia volume (<1 mg/l) in summer (Jun-Sep) 1991-2000 in Whole Bay



2025CC includes all climate change factors (SLR, Heat Flux and Nutrient loading)

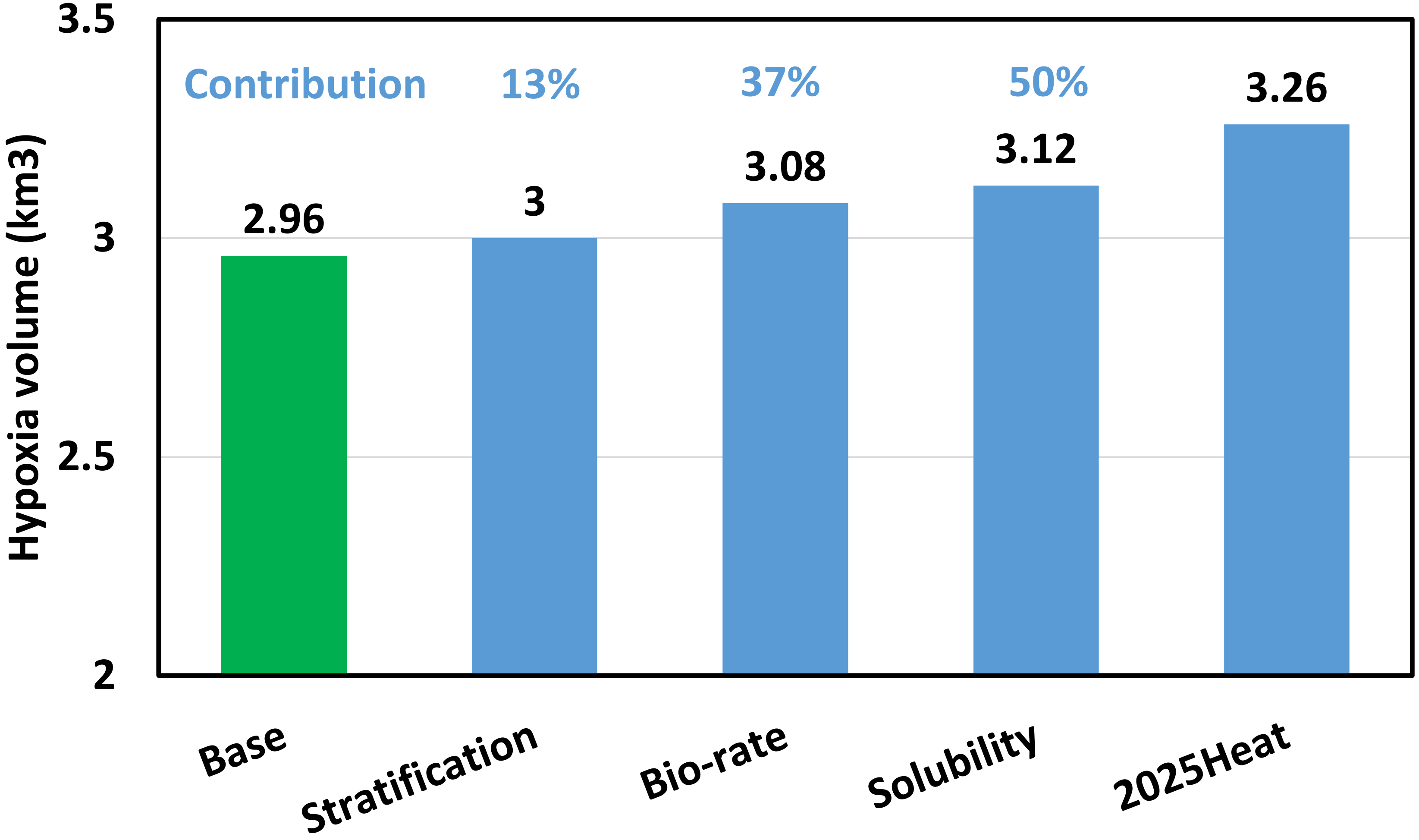
Temperature effects

- **Solubility: 0.9 °C increase decreases solubility by 0.13 mg/l, or 1.7%.**

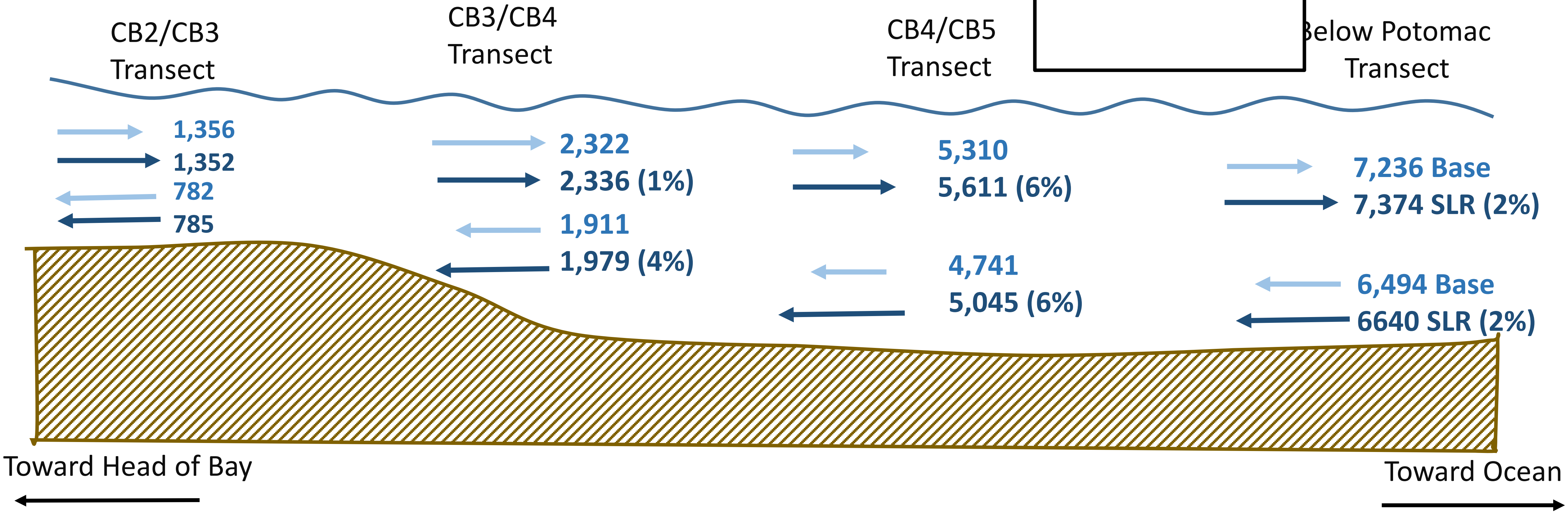
- **Biological rates: increase 6% over 0.9 °C (Q_{10}=2)**

- **Stratification (physics)**

Impact of T modified DO-solubility (DOS), biological rate and stratification (physics) on hypoxia volume in CB4MH (DO<1 mg/l summer 1990-2000)



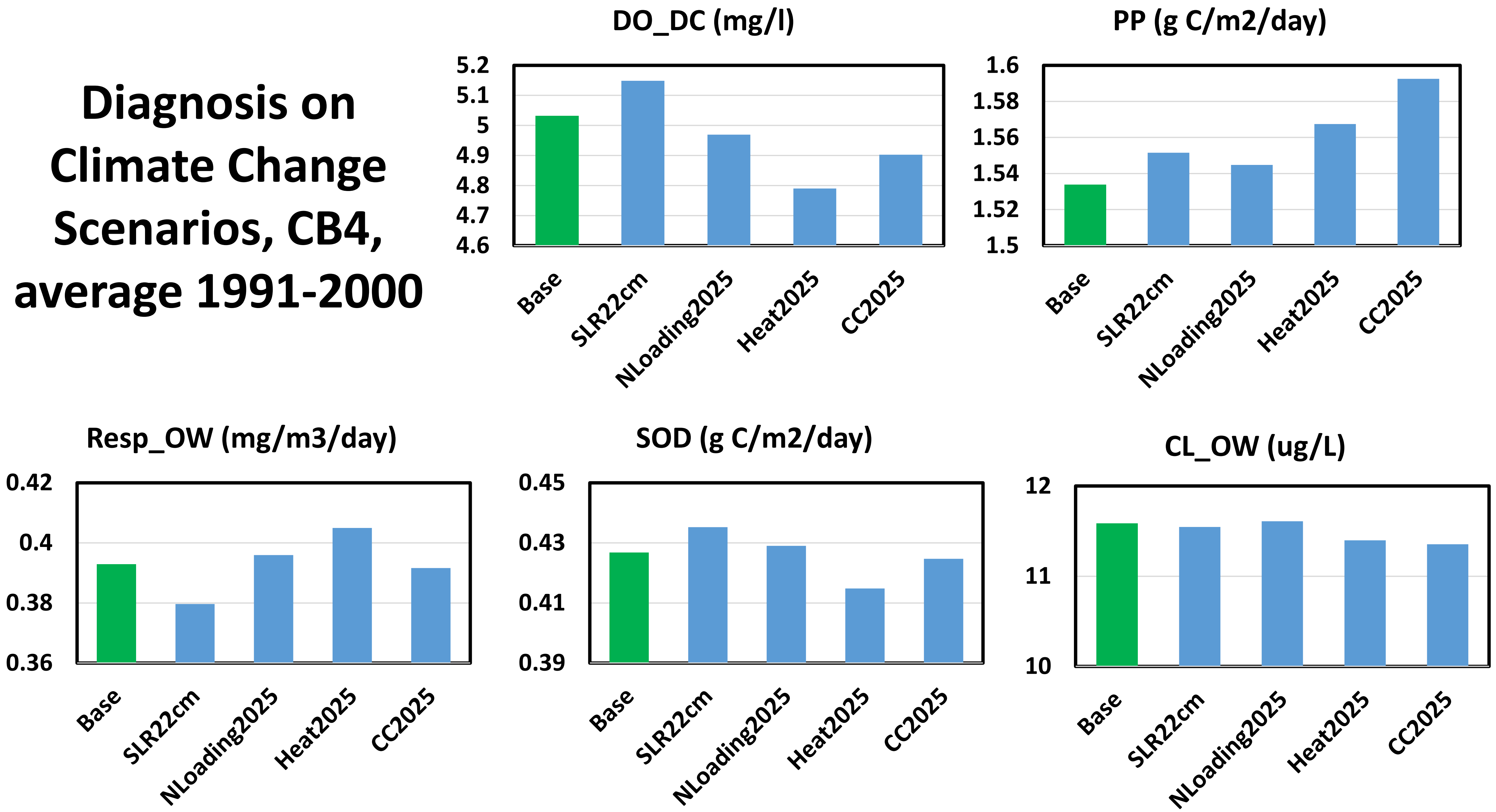
Cross-transect water mass fluxes
Base case versus sea level rise (SLR)
Summer 1993-1995



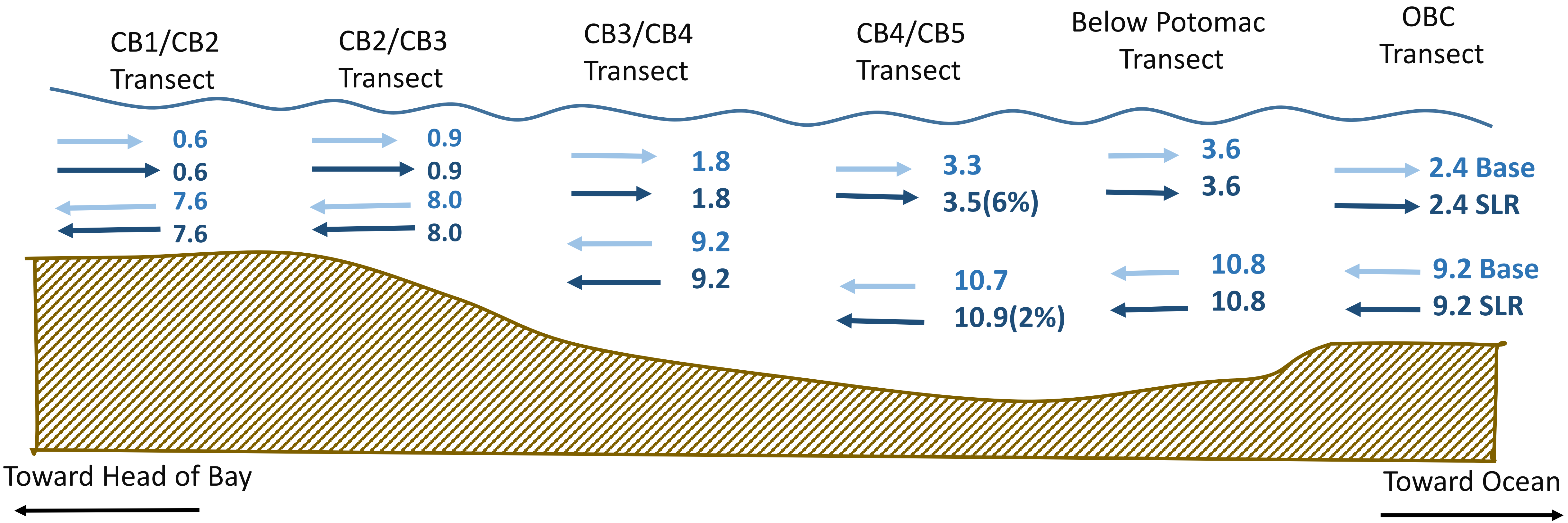
Base = Beta 2 Calibration. SLR = 0.22m Sea Level Rise Scenario representing relative Chesapeake sea level riser from 1995 to 2050. Units in mean cubic meters per second (m^3/s) for summer 1993 to 1995 hydrodynamics.

17

Diagnosis on Climate Change Scenarios, CB4, average 1991-2000

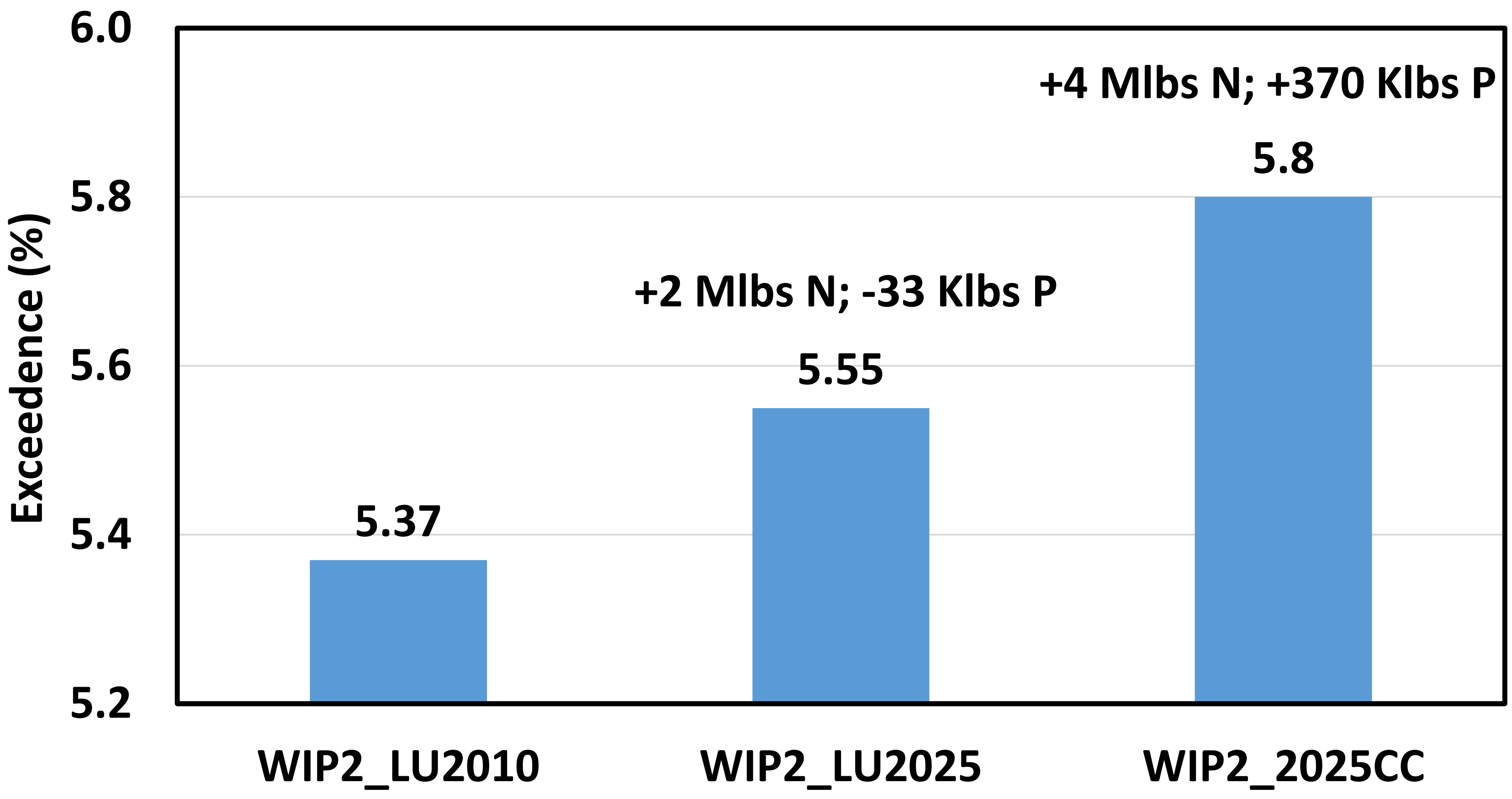


Cross-transect TN fluxes: Base case versus sea level rise (SLR), summer 1993-1995



Base = Beta 2 Calibration. SLR = 0.22m Sea Level Rise Scenario representing relative Chesapeake sea level rise from 1995 to 2025. Units in mean gram per second (g/s) averaged over June-Sep 1993-1995.

Estimate on water quality attainment in the Deep Channel CB4MH Under the WIP condition



2025CC includes all climate change factors (SLR, Heat Flux and Nutrient loading)

Messages

- **Temperature is the most sensitive variable in controlling DO under climate change conditions, followed by sea level rise and nutrient loading.**
- **Solubility contribute 50% to temperature effect.**
- **Temperature deteriorates water quality whereas sea level rise improves DO in the deep channel, with combined effect of 0.4% degradation of attainment under the WIP condition.**
- **Working on projection for 2035, 2045 and 2055.**