Progress in WQSTM Climate Change Analyses and Plans in Response to STAC recommendations

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Outline

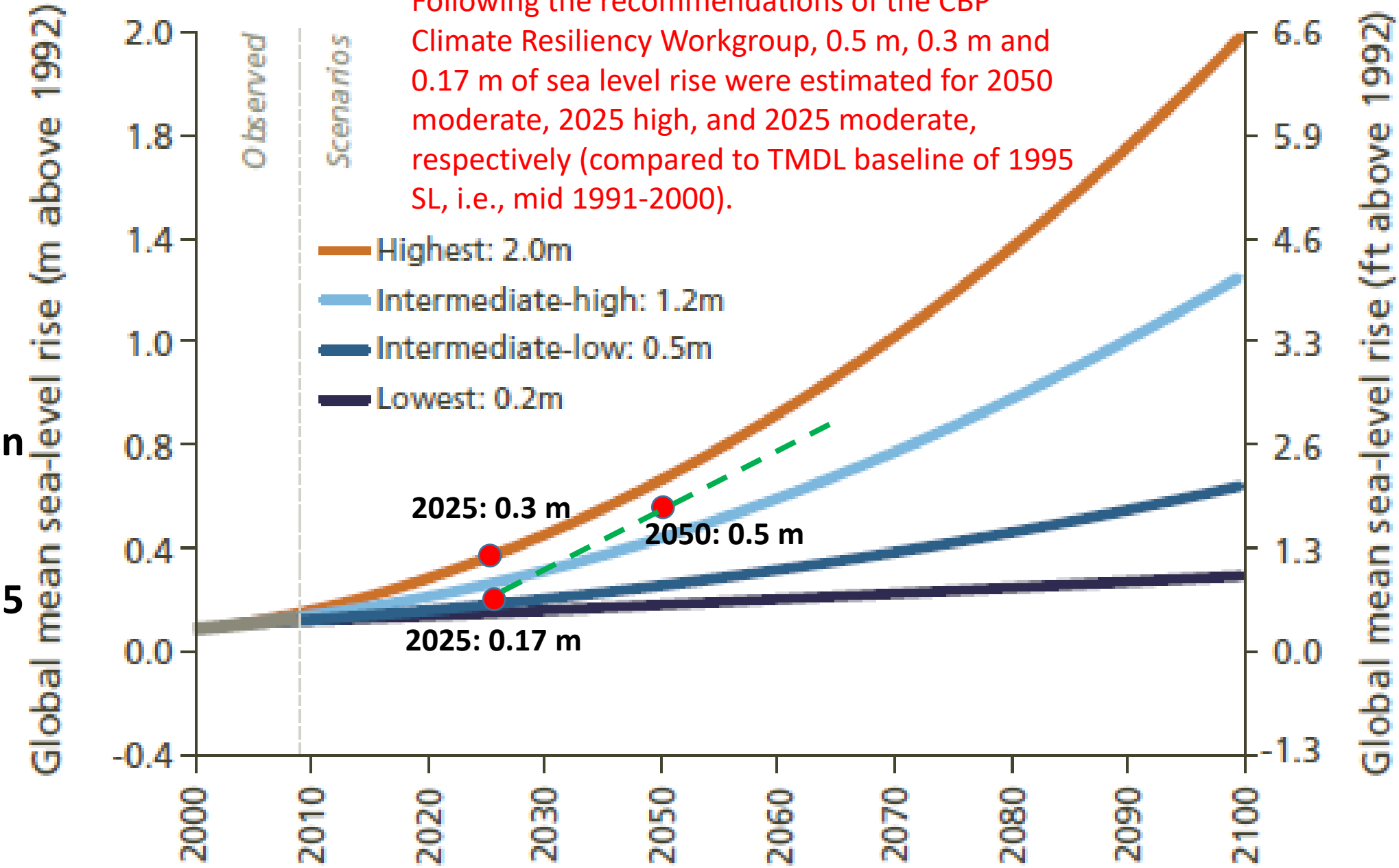
- **What we have done.**
- **Plan in response to the STAC recommendation.**
- **Preliminary analysis.**

Sea level rise numbers

Following the recommendations of the CBP Climate Resiliency Workgroup, 0.5 m, 0.3 m and 0.17 m of sea level rise were estimated for 2050 moderate, 2025 high, and 2025 moderate, respectively (compared to TMDL baseline of 1995 SL, i.e., mid 1991-2000).

Linear interpolation and extrapolation for 2035 (0.3 m), 2045 (0.43 m), 2055 (0.57 m) and 2065 (0.7 m).

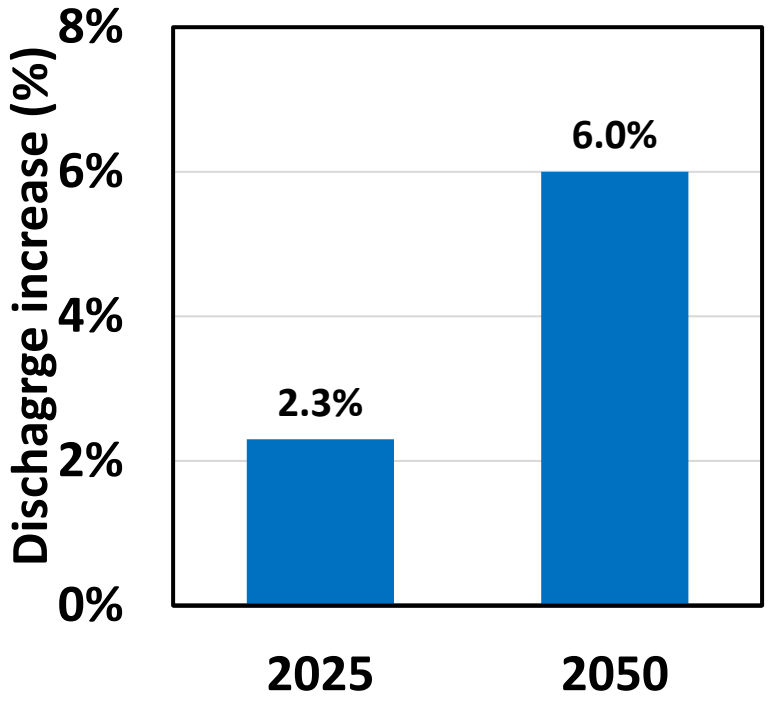
Climate resiliency group will revise these numbers



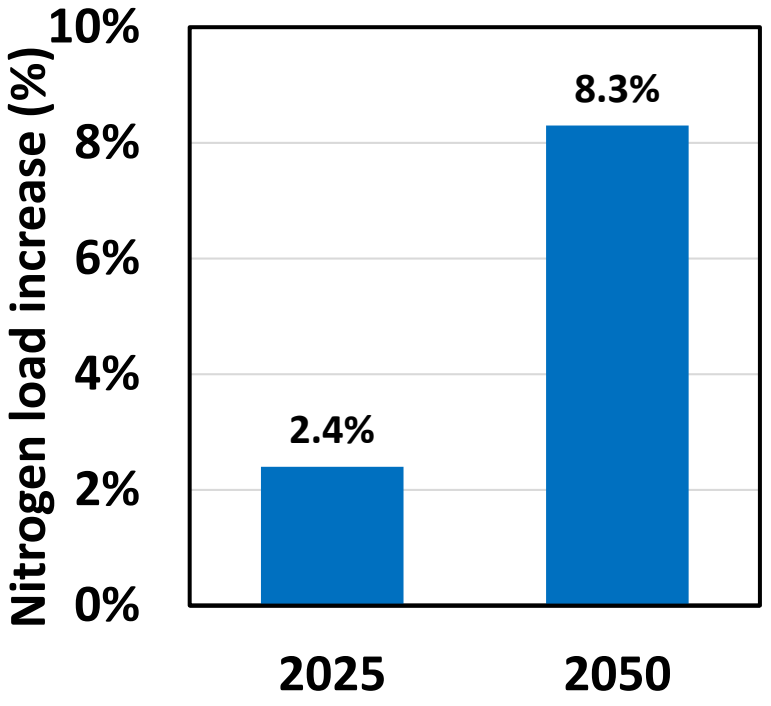
From Parris et al. (2012). *Global Sea Level Rise Scenarios for the United States National Climate Assessment. NOAA Technical Report OAR CPO-1. (1992 used as the starting year)*

Changes in river discharge and nutrient loading in the 2025 and 2050 climate change scenarios

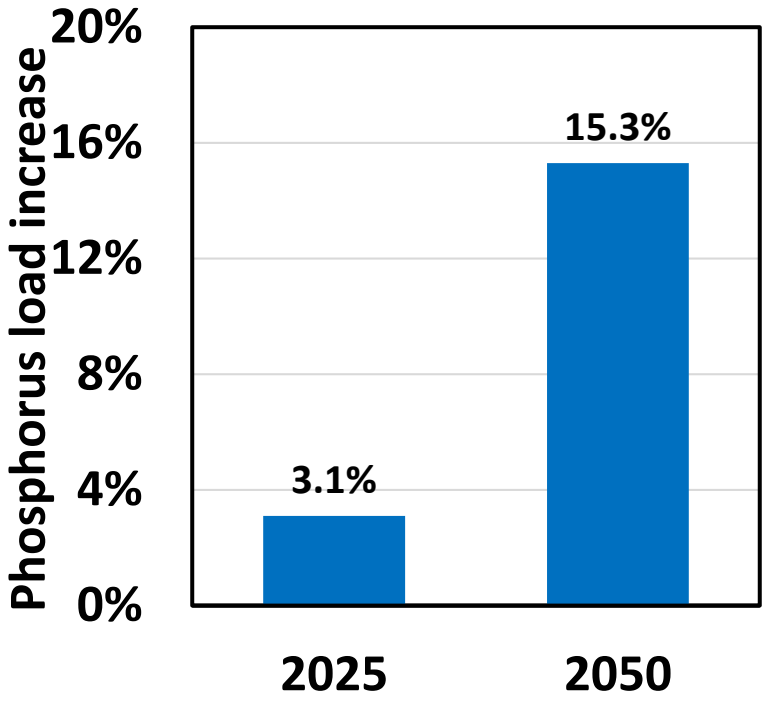
River discharge



Nitrogen loading

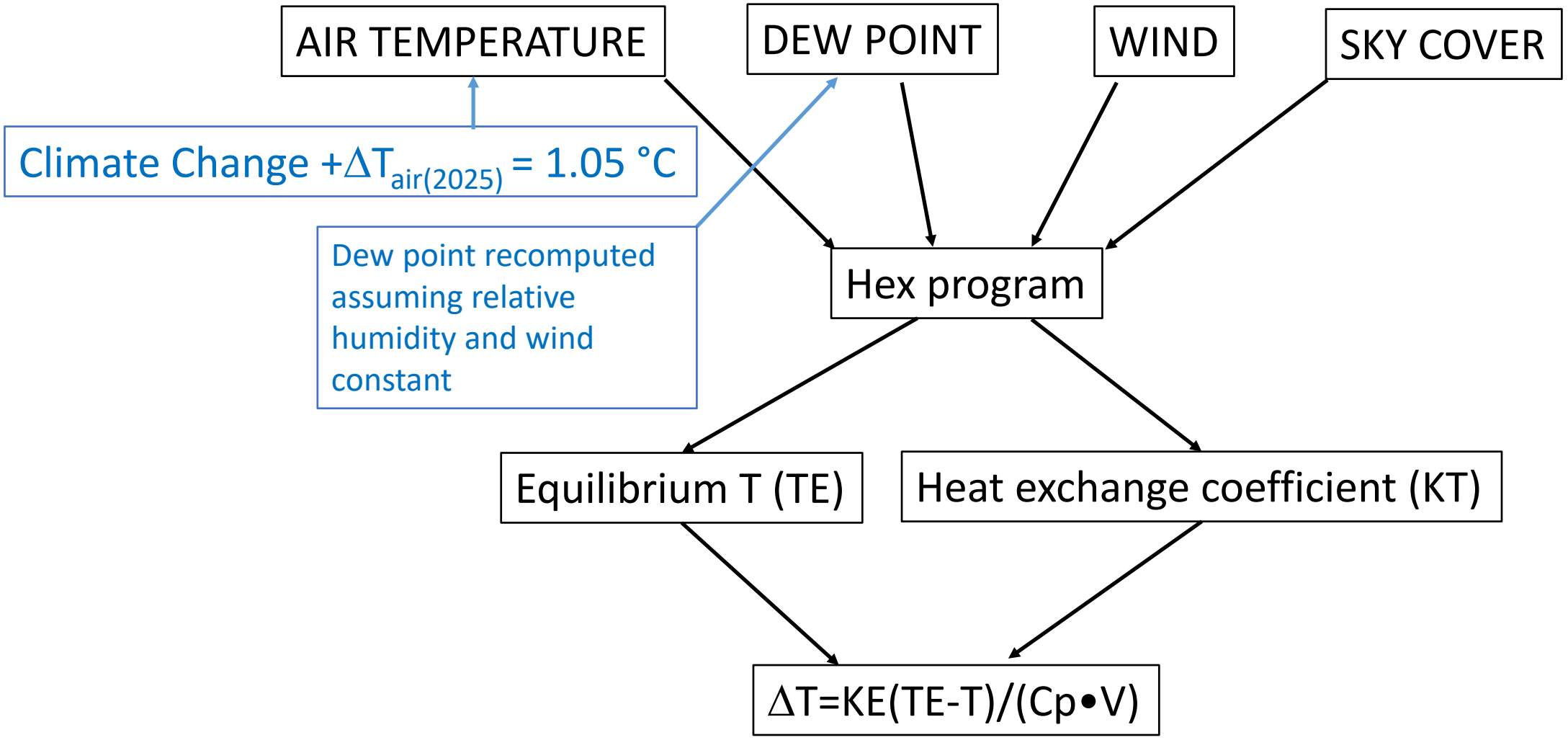


Phosphorus loading



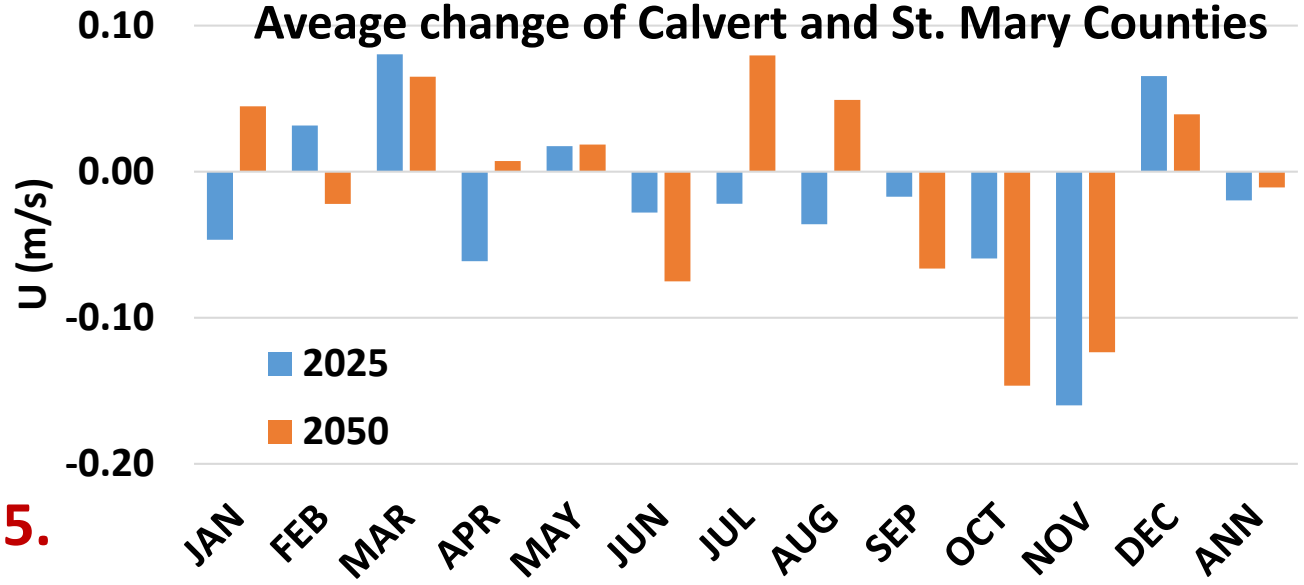
From Gopal Bhatt

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



Changes in wind projected for 2025 and 2050

From Gopal Bhatt, MACA downscale analysis, 20 CMIP5 GCMs ensemble, RCP8.5.

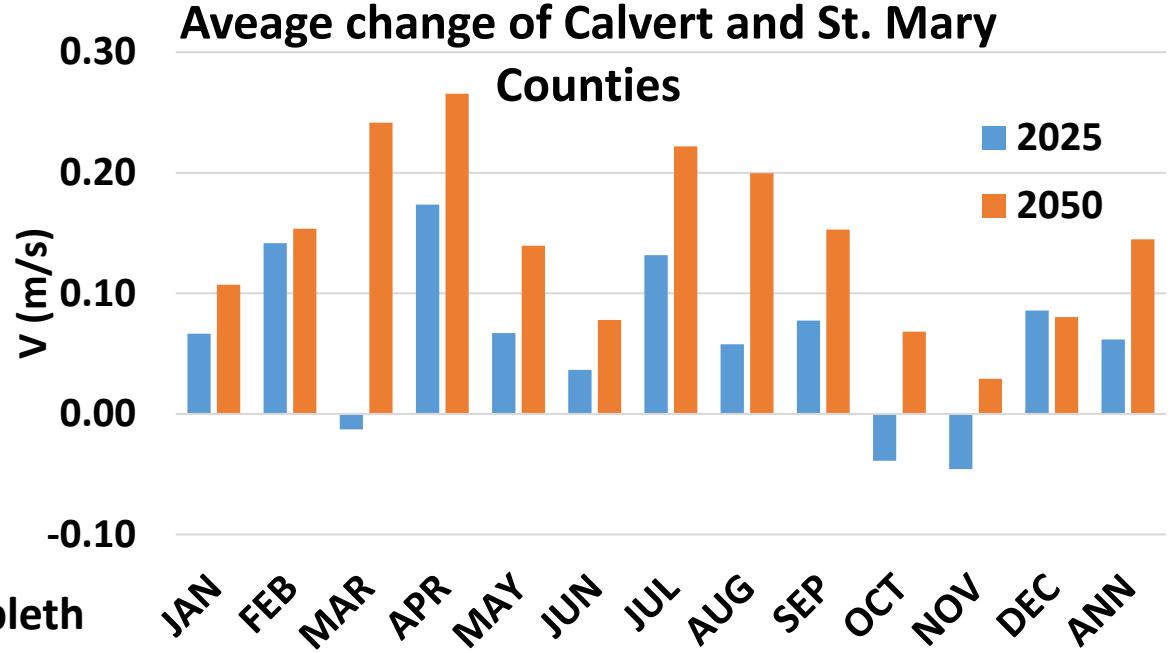


Scully, 2010

Table 1. Correlations with Hypoxic Volume

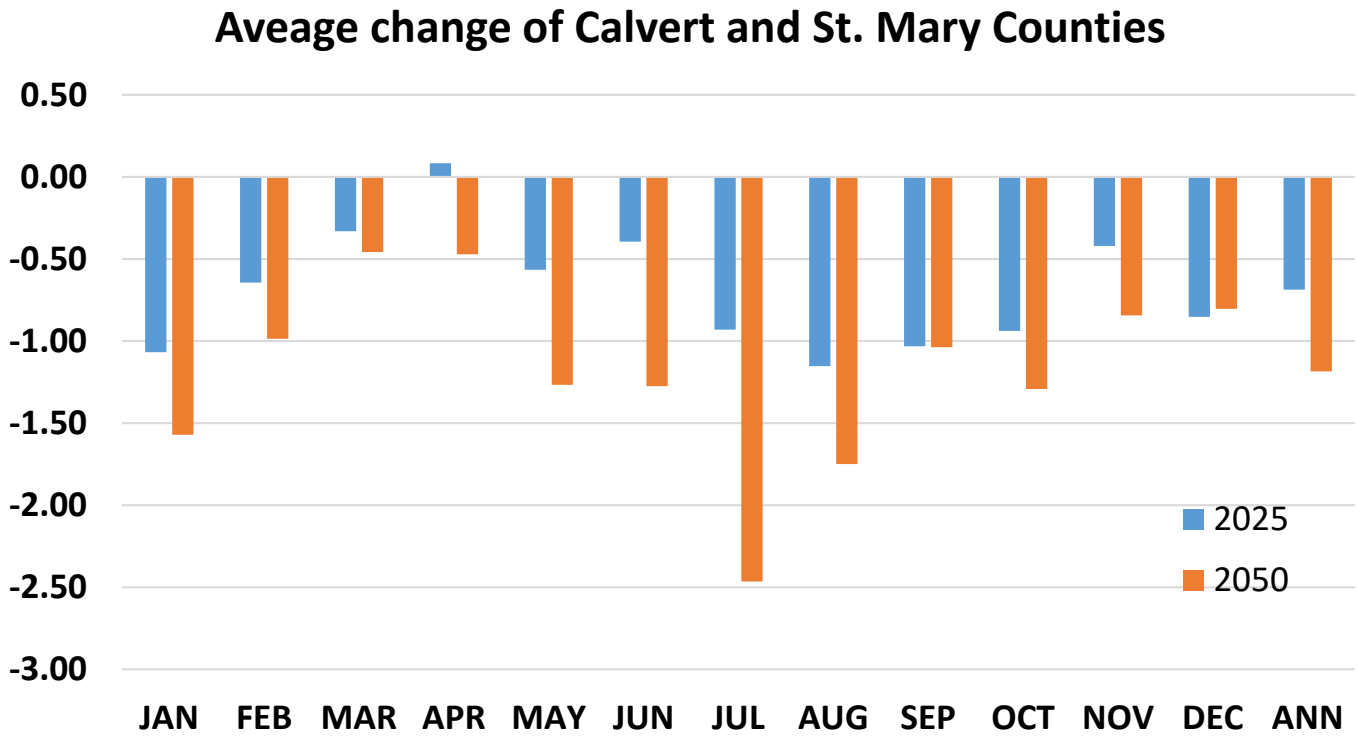
Hypoxic Volume	Duration of Summer Wind							
	N	NE	E	SE	S	SW	W	NW
< 2 mg/L	0.00	0.08	0.18	-0.49*	-0.37*	0.04	0.69*	0.32*
< 1mg/L	-0.02	0.04	0.15	-0.48*	-0.34*	0.03	0.71*	0.36*
< 0.2 mg/L	-0.11	-0.08	0.05	-0.42*	-0.17	-0.10	0.55*	0.30

* indicates significance at 95% confidence interval.



Ping Wang: 2m/s during 1 hour did not change the 0 isopleth

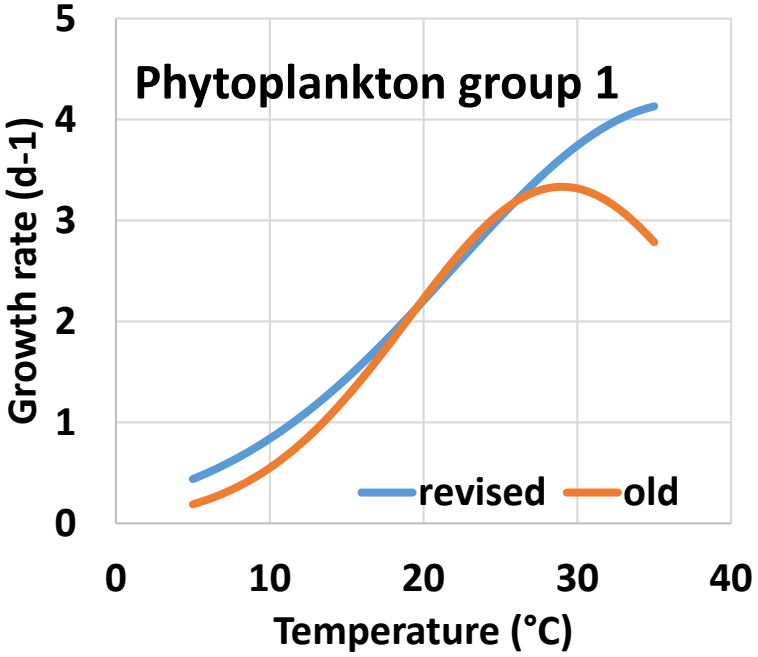
Changes in relative humidity projected for 2025 and 2050

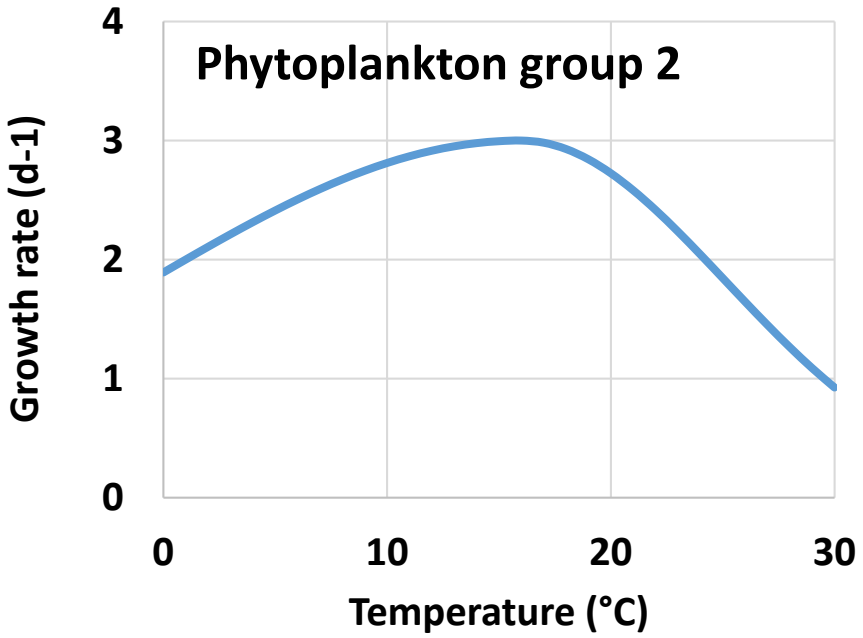


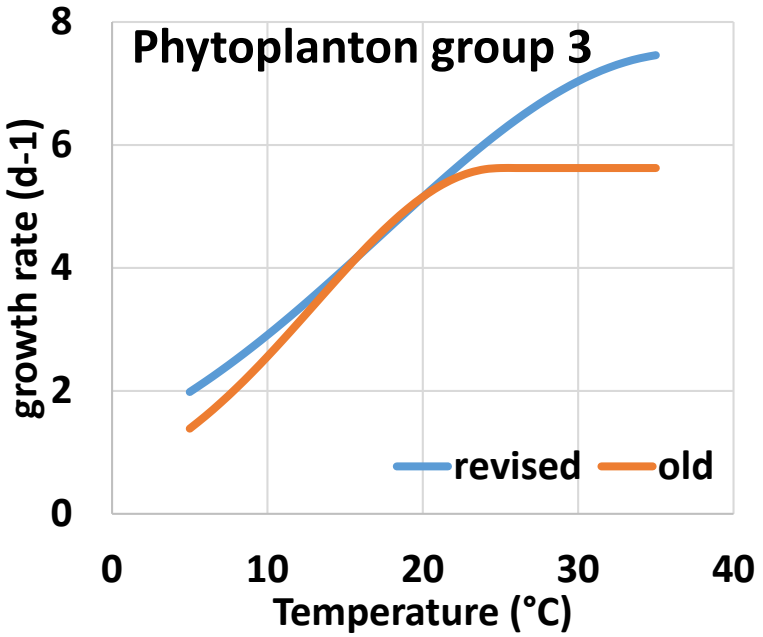
From Gopal Bhatt, MACA downscale analysis, 20 CMIP5 GCMs ensemble, RCP8.5.

Temperature effect of phytoplankton growth rate

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





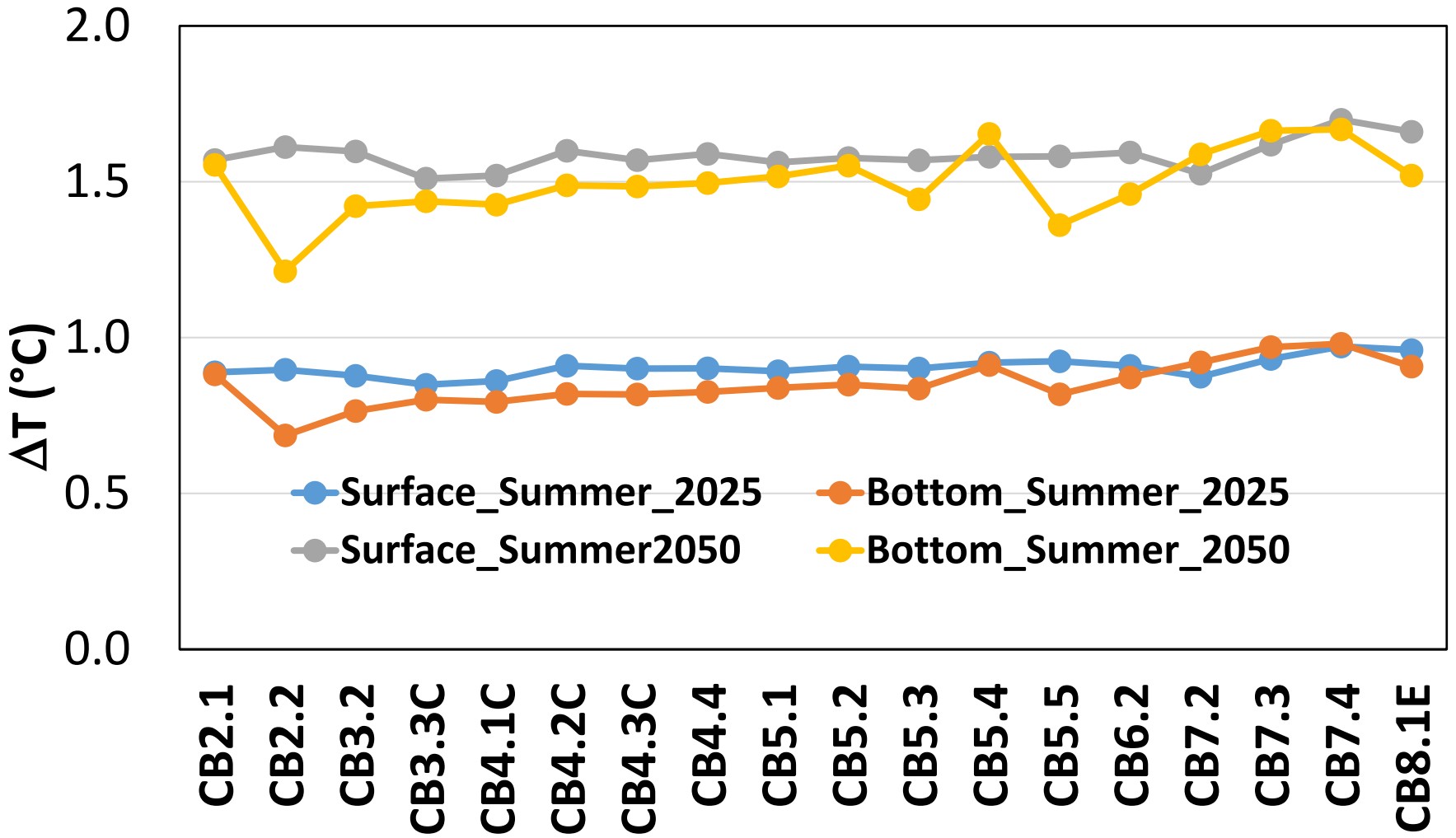


From Carl Cerco

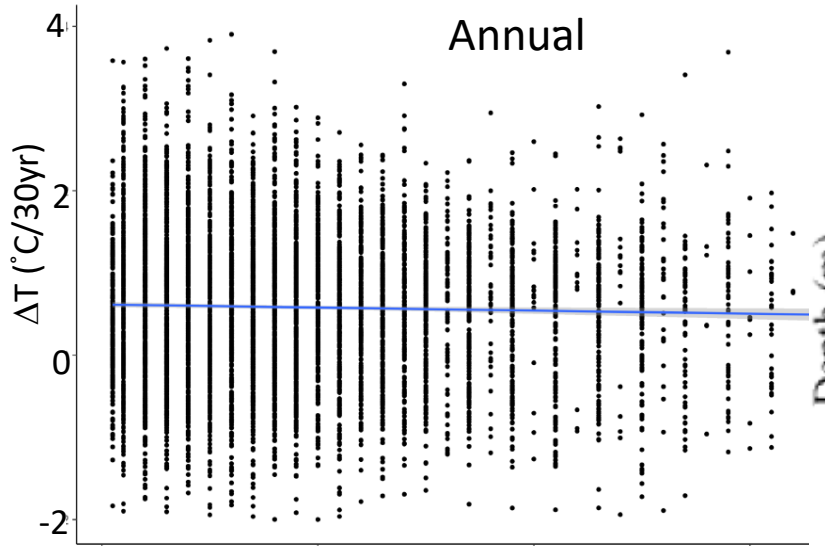
Water temperature change under 2025 and 2050 CC

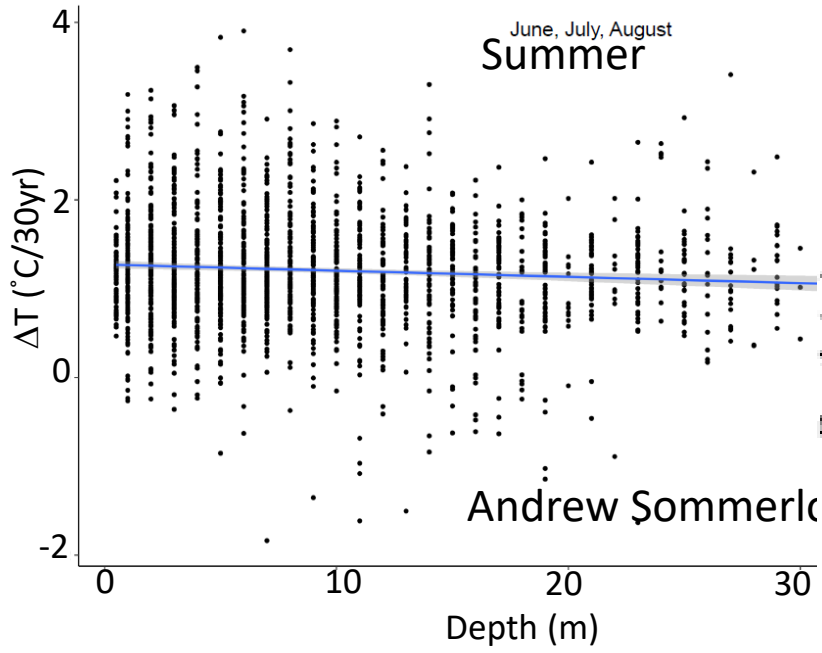
Thomas et al 2017: data 1982-2014, 0.3 °C per decade;

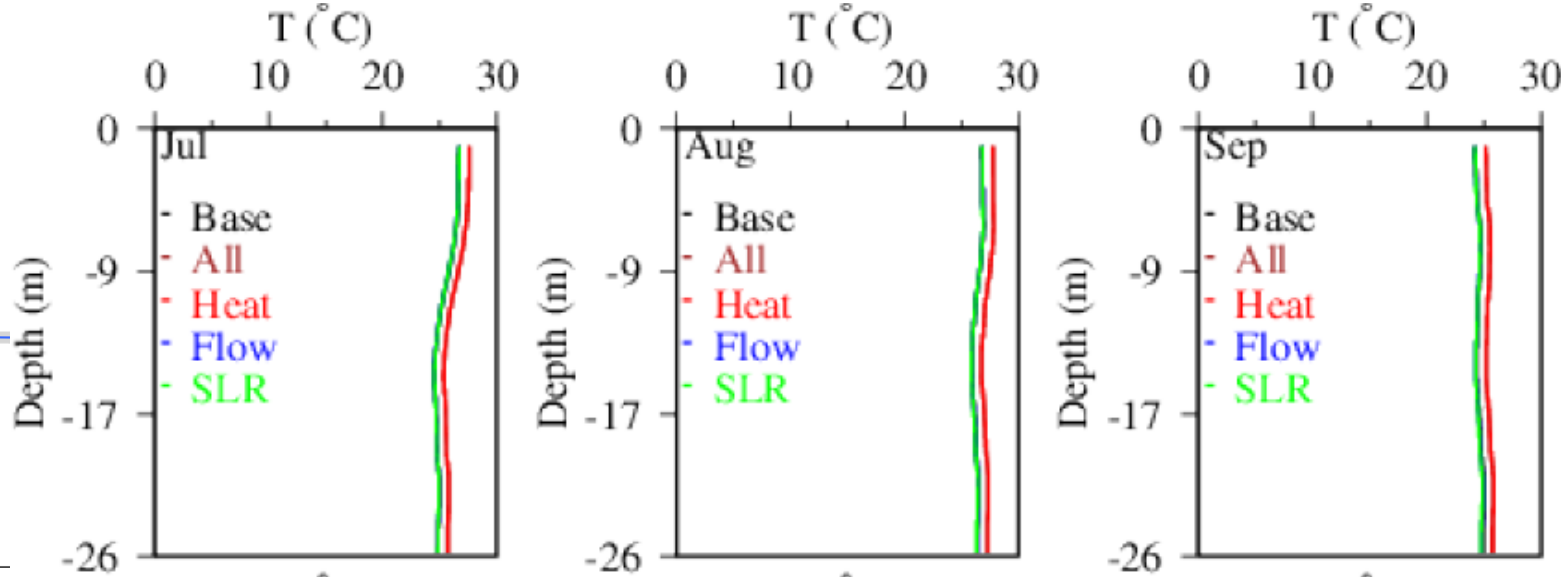
Irby et al., 2018: 1.75 °C for 2050.

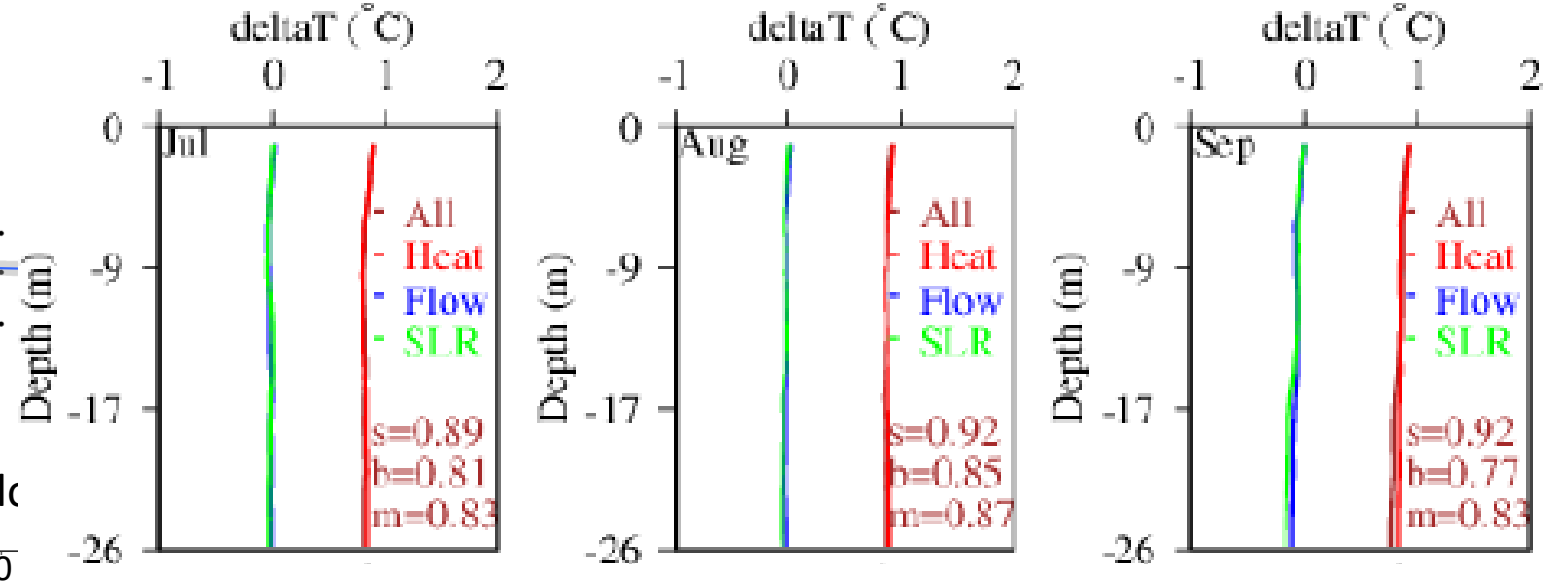


T and ΔT profile at CB4.3C under 2025 CCC NT F0.9



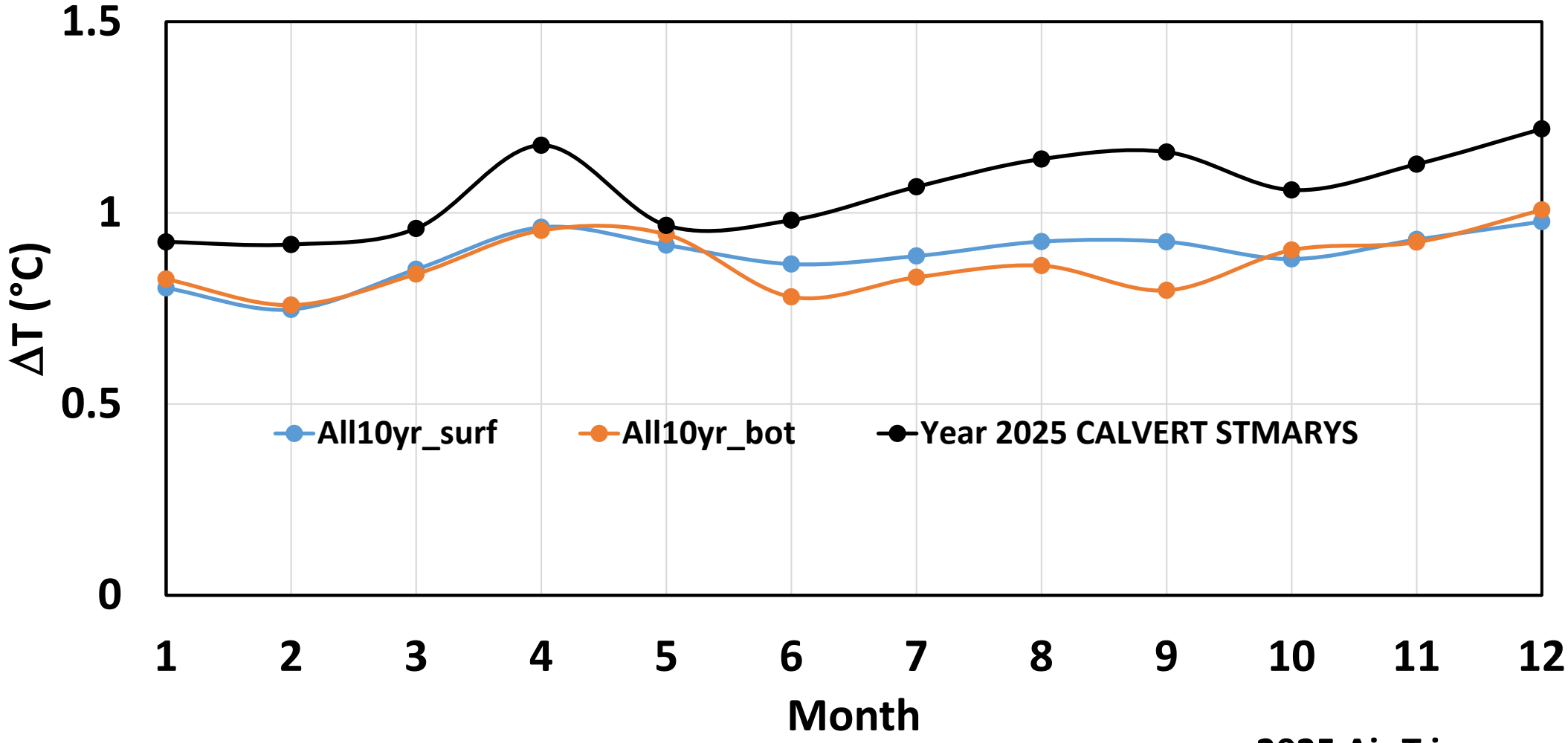






S: surface; b: bottom; m: vertical average over 10 years.

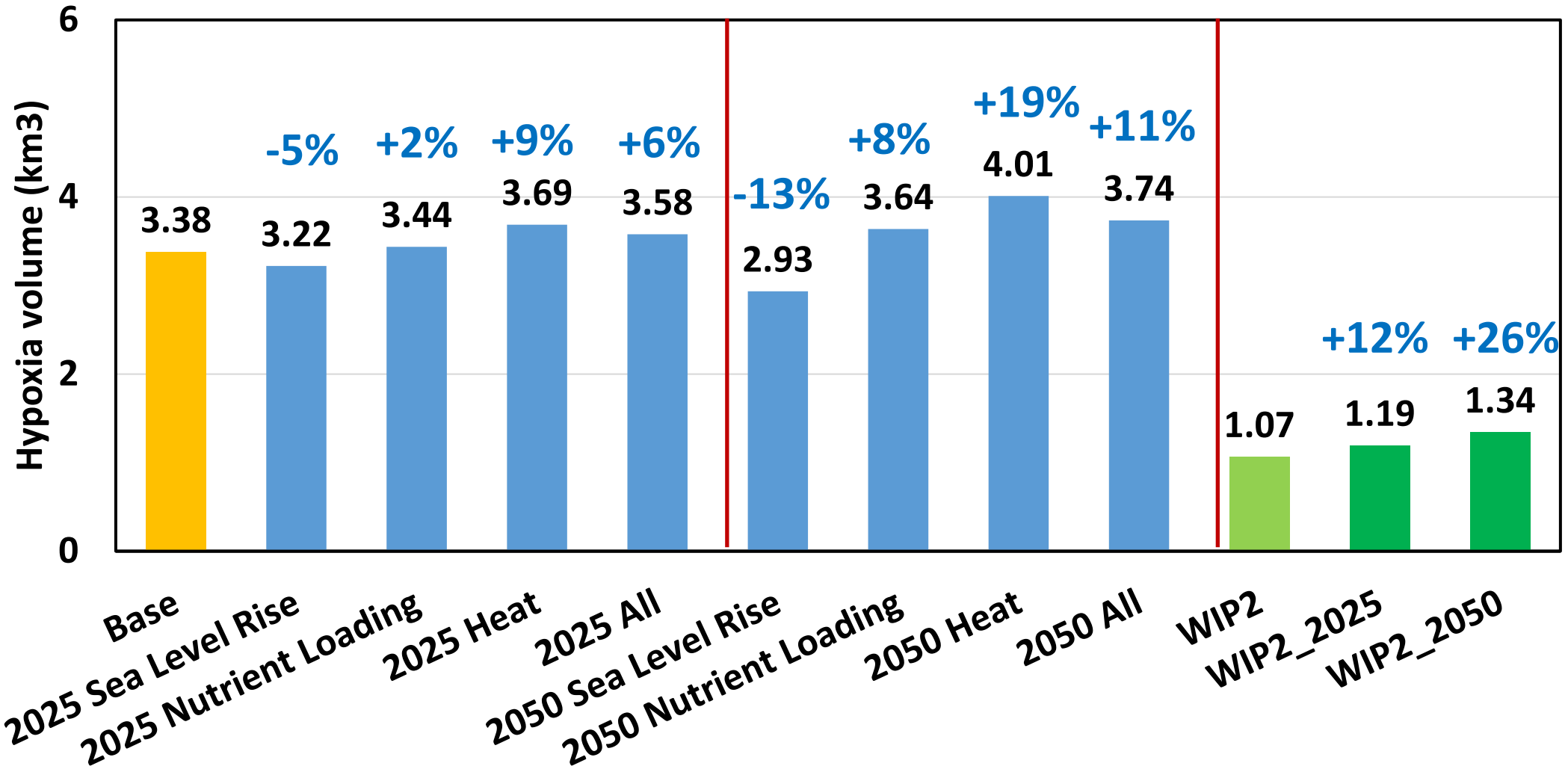
Monthly air T change and surface T simulation at CB4.3C



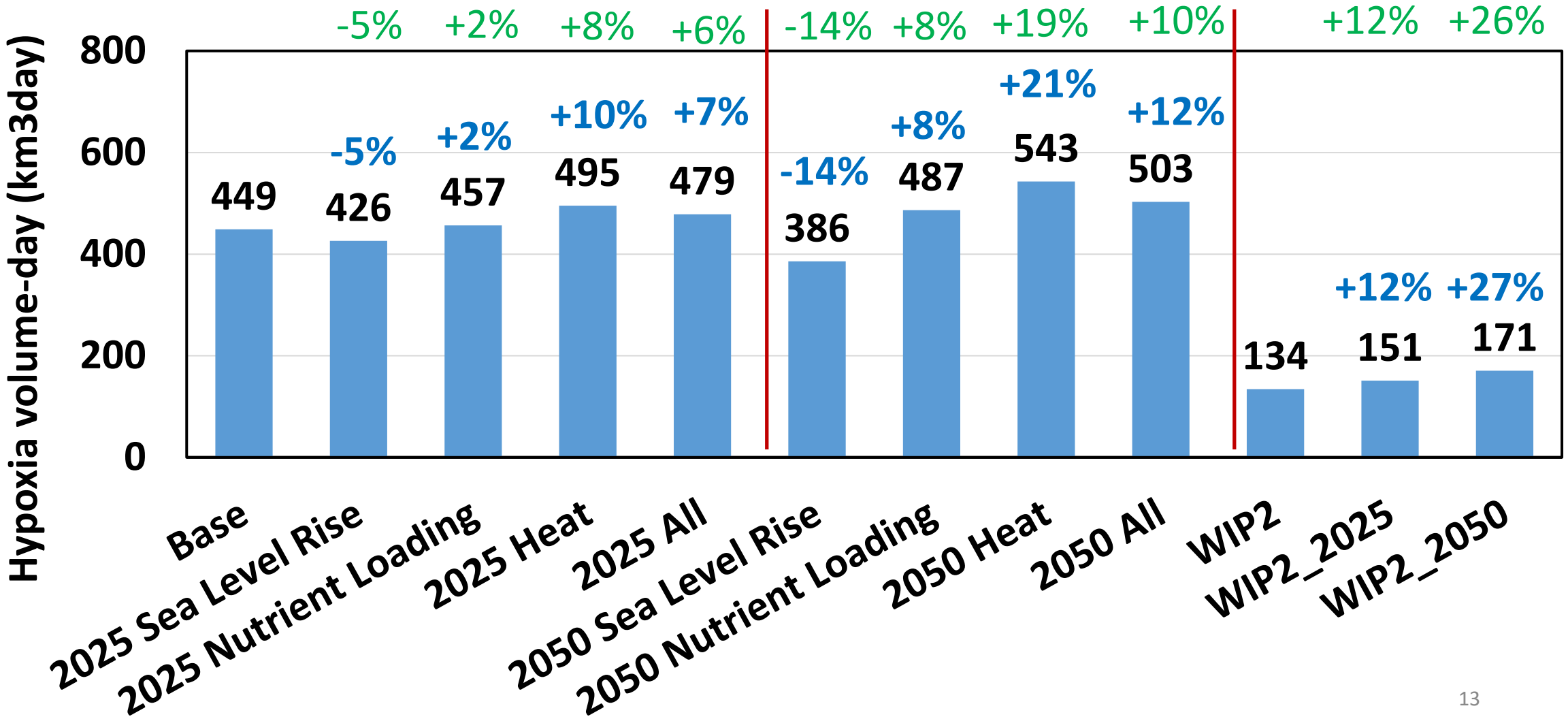
2025 Air T increase 1.05

2050 Air T increase 1.85

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



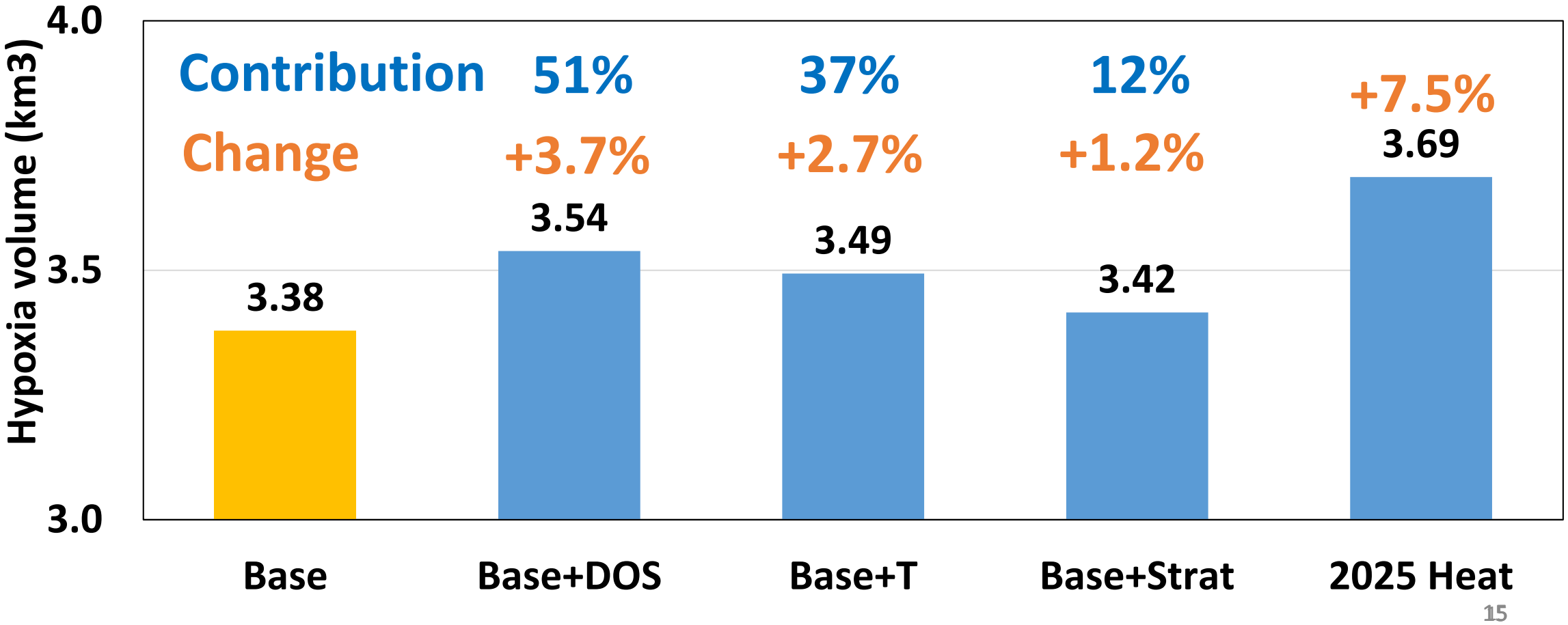
Hypoxia volume-day (<1 mg/l) 1991-2000 in the Whole Bay



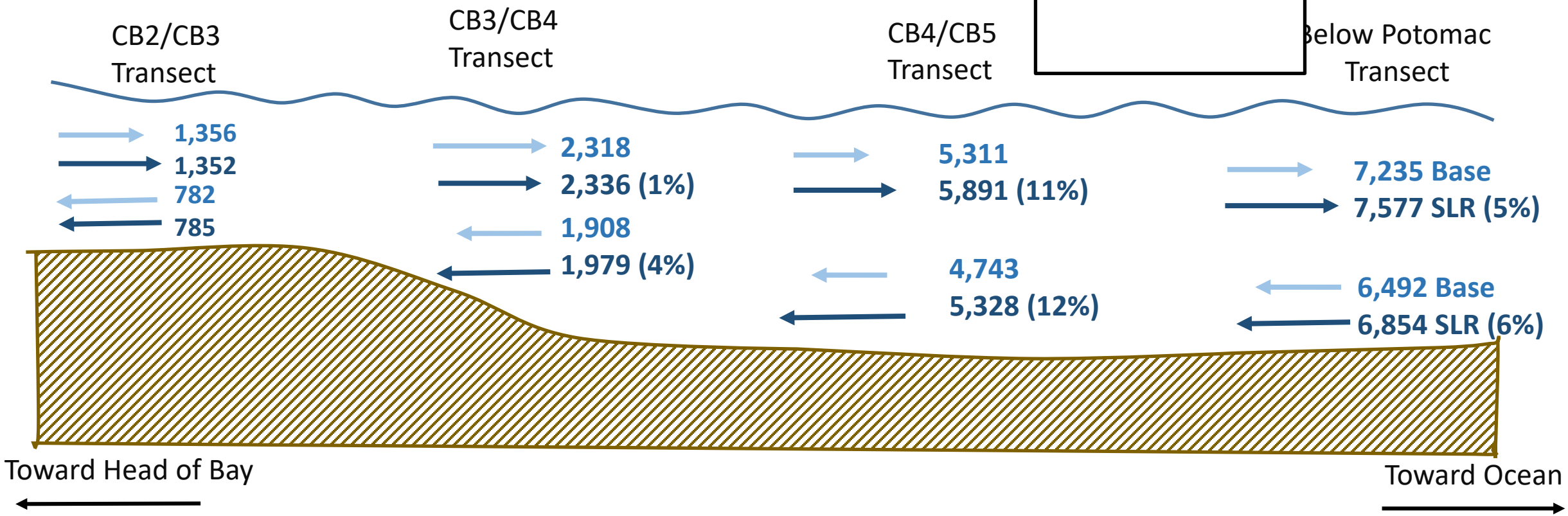
Temperature effects

- **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)**

Sensitivity analysis of T modified DO-solubility (DOS), biological rate and stratification (physics) on water quality, whole Bay



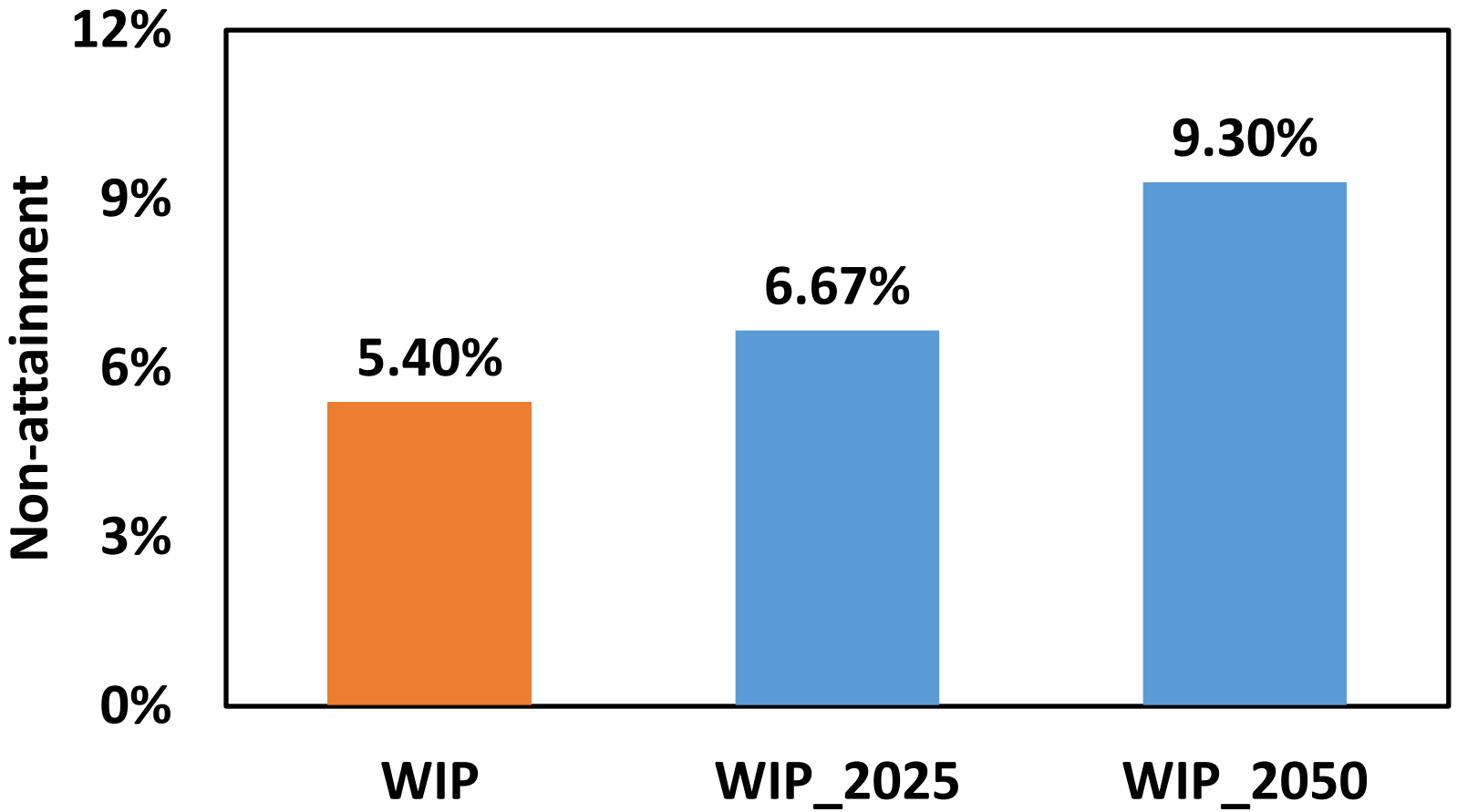
Cross-transect water mass fluxes
Base case versus sea level rise (SLR)
Summer 1993-1995



Base = Beta 2 Calibration. SLR = 0.5m 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.

16

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



Messages

- **Temperature is the most sensitive variable in controlling DO under climate change conditions, followed by sea level rise and nutrient loading.**
- **Solubility contribute 51% to temperature effect.**
- **Temperature deteriorates water quality whereas sea level rise improves DO in the deep channel, with combined effect of 1.3% degradation of attainment under the WIP condition by 2025 and 3.9% by 2050.**
- **Future runs in progress: changes in wind and relative humidity.**
- **Projection for 2035 and 2045.**

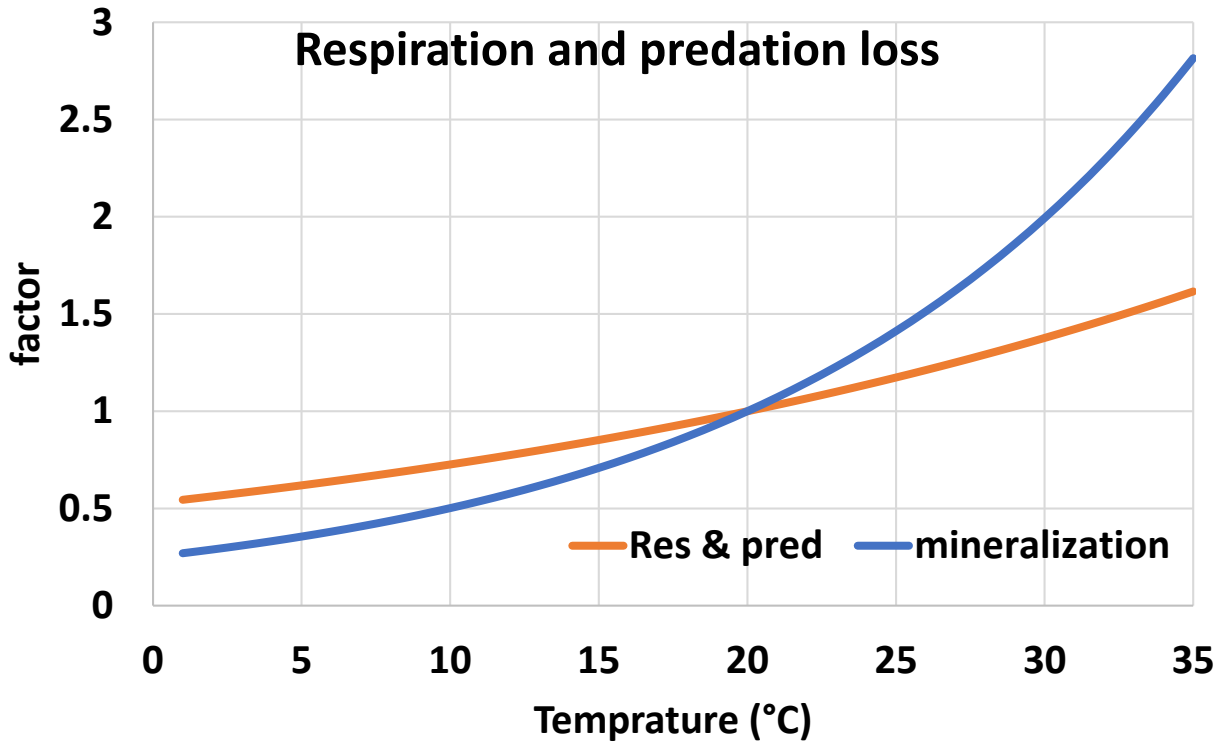
Temperature effect on remineralization and phytoplankton respiration and predation loss

$$a_{mnl} = \alpha_m DOC e^{km(T - Tm)}$$

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

$$a_{pr} = \alpha_p B^2 e^{kp\,(T - Tp)}$$

Km = 0.069
kr, kp = 0.032
Tr, Tp, Tm = 20



19