BaySys Team 4

- Produced the first comprehensive estimate for CO_2 exchange budget for Hudson Bay. The space-time variation in fluxes requires an understanding of moderating factors associated with the Bay's physical, biological and biochemical systems, **linking ALL BaySys Teams**.

- Produced the first comprehensive examination of OA state, and assessment of OA risk. As OA is linked to pCO_{2sw} (and pH), current and future assessments are tied to processes associated with a **ALL BaySys Teams**.

- BaySys research has shown the influence of rivers on carbon dynamics of the downstream marine system depends on the quality and quantity of delivered C (inorganic and organic) which varies regionally around the bay. While affects are reflected in proximity to river plumes, the integrated impact of rivers and river carbon is small if not negligible on the Bay's source/sink status.

- pCO_{2sw} reflects the net response of several processes, some acting to push pCO_{2sw} in opposite directions. While locally, or short term, pCO_{2sw} can be dominated by remineralization of OC_{terr} delivered by rivers & OC_{mar}, and/or primary production, areally-weighted pCO_{2sw} across the bay appears overwhelming determined by thermodynamics (sea ice, T and salinity) through their impact on carbonate equilibria and gas exchange. Questions on the net influence moderating factors across seasons remain, requiring a more thorough assessment of modelled fields and the addition of seasonally-balance observations.

Specific examples ->

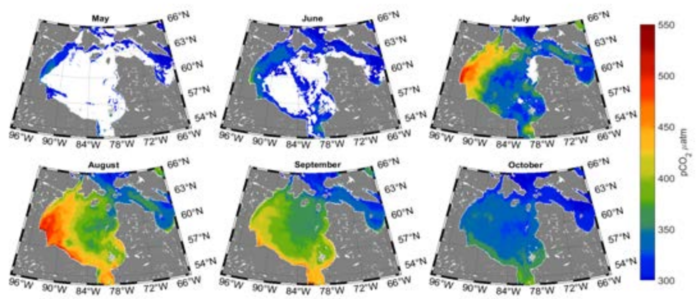
The CO_2 Source/Sink Balance of Hudson Bay

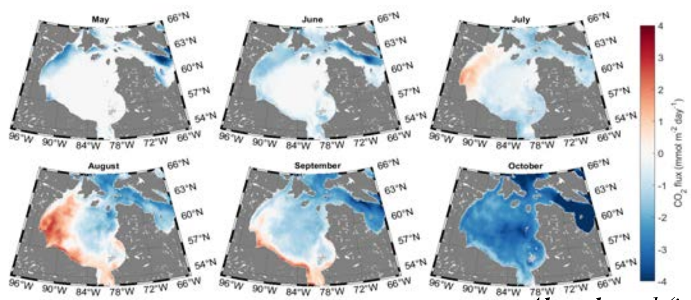
Hudson Bay is a weak CO_2 sink

Shelf sea	Area (10^3 km^2)	Mean depth (m)	River inflow (Km^3 yr^{-1})	Sea-air CO_2 flux (mmol m^{-2} day^{-1})	Season	Reference
Barents Sea	1512	200	463	−11.1	Annual	Lauvset et al. (2013)
Kara Sea	926	131	1133	−18.3 to −32.8	Summer-Fall	Pipko et al. (2017)
Laptev Sea	498	48	767	−0.8 to −15.7	Summer-Fall	Pipko et al. (2017)
E. Siberian Sea	987	58	213	0.8 to 11.5	Summer	Pipko et al. (2011)
Chukchi Sea	620	80	78	−14.8	Annual	Bates (2006)
Beaufort Sea	178	124	330	−10.0	Summer	Murata and Takizawa (2003)
Canadian Archipelago	1490	290	270	−3.0	Annual	Ahmed and Else (2019)
Hudson Bay	841	150	900	−0.73 1.98	Fall Summer-Fall	Else et al. (2008a) Else et al. (2008b)
Hudson Bay & Hudson Strait	1041	150	900	−4.8 −4.3	Spring-early Summer Open water	Ahmed et al. (in review)

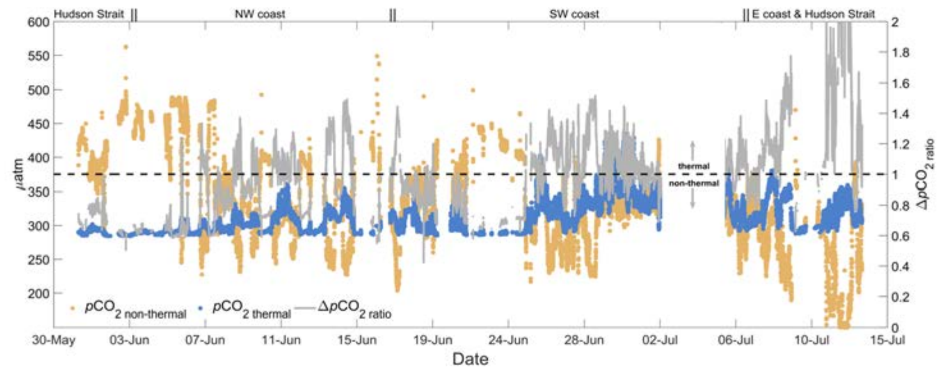
[a] Negative annual CO_2 fluxes indicate oceanic sink.

***Ahmed**, et al. (in review)*





***Ahmed**, et al (in prep)*



***Ahmed**, et al. (in review)*

- Different methodologies produced slightly different estimates for the ice-free CO_2 budget.
- Highest confidence based on an empirical relationship for pCO_{2sw} incorporating Tsw, sal, FDOM⁺ and *Chl a* using ship-, reanalysis-, and satellite-based fields. We estimate **net CO_2 <u>uptake</u> for ice-free Hudson Bay to be -3.3 (±1.2) TgC**

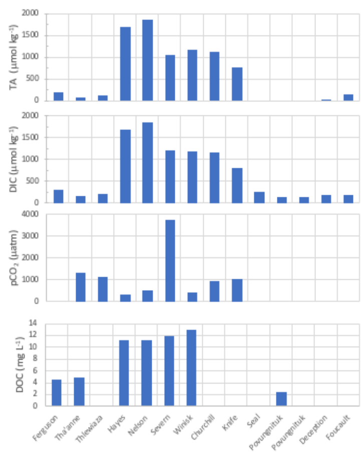
  ***Ahmed**, Else, Butterworth, Capelle, Guéguen, Miller, Meilleur, Papakyriakou (in review)*

- While an estimate based on our <u>current</u> satellite inversion model <u>lacks biology</u>, it provides realistic space/time assessment. Mean flux appears well represented, however missing is variability relative to observation. Uptake in spring, early summer and fall are in excess of summertime outgas. Hudson Bay remains a CO_2 sink of -2.3 TgC (~-0.9 mmol m^{-2} day^{-1}). ***Ahmed**, et al (in prep)*

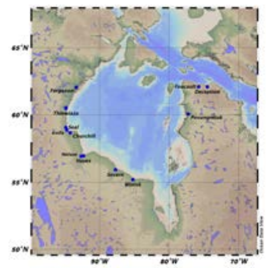
⁺ FDOM=fluorescing dissolved organic matter

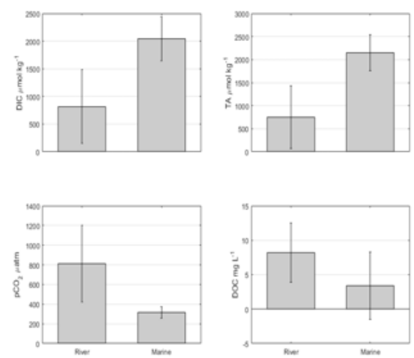
First order impacts of rivers on inorganic carbon systems appears local in Hudson Bay

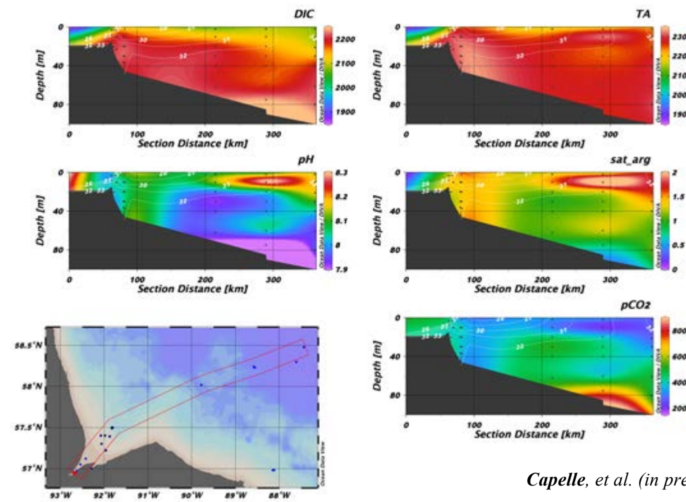
Rivers import pCO_2 and DOC



Capelle, et al. (in prep)

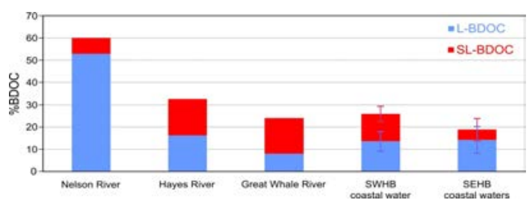






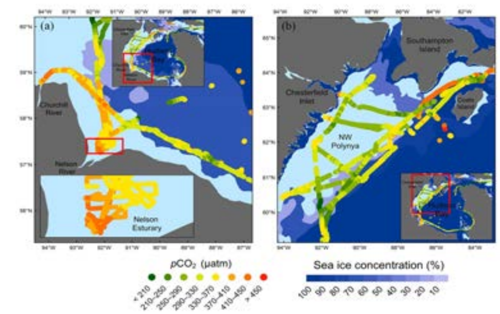
Capelle, et al. (in prep)

- Carbon load of rivers depends on source
- Rivers export DOC and pCO_2, but dilute TA and DIC



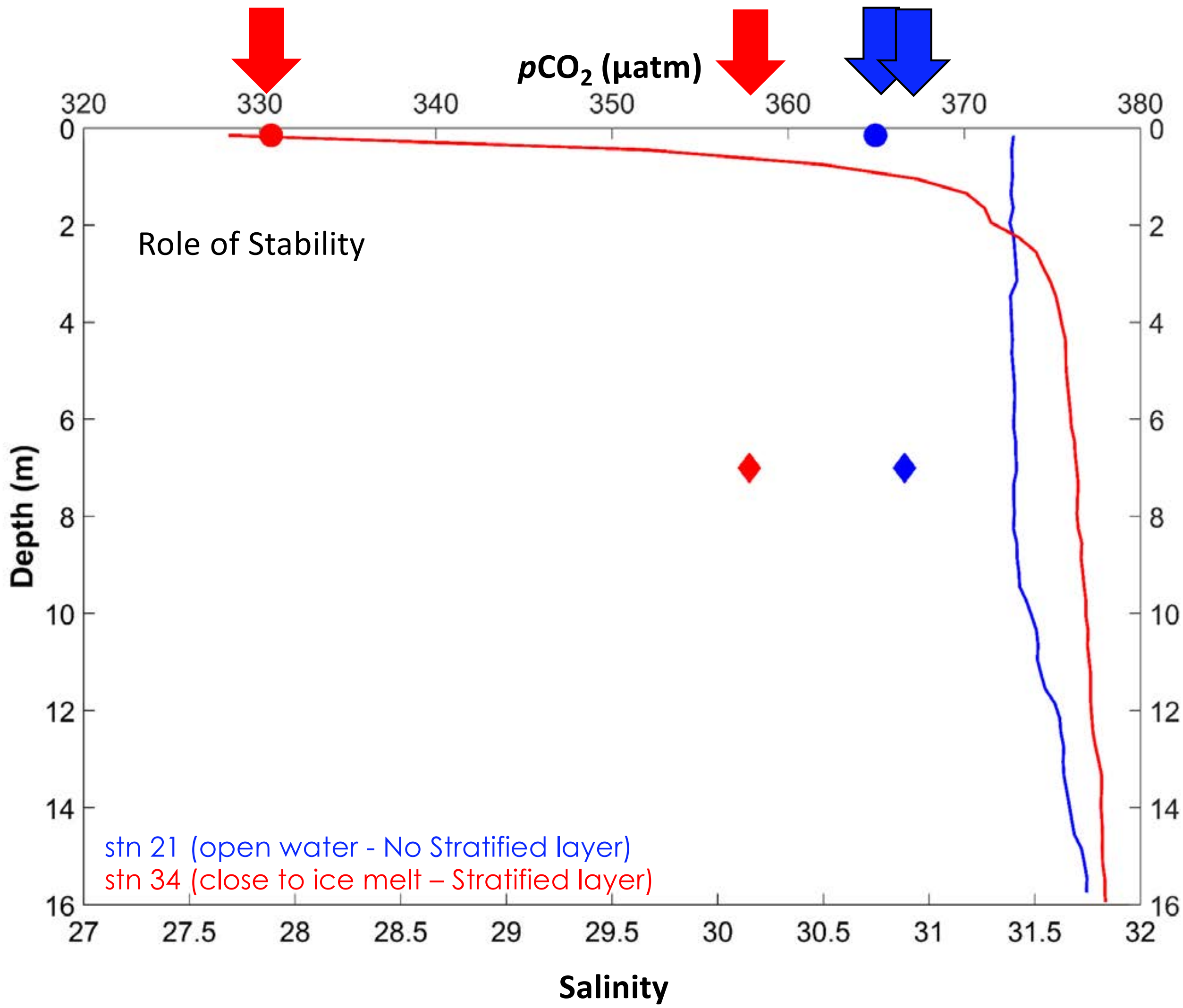
Kazmiruk, et al. (in review)

- Riverine DOC degrades to CO_2 thoroughly and fast



Ahmed, et al. (in review)

- Impact of OC_{terr} from rivers is realized locally



Stn 21

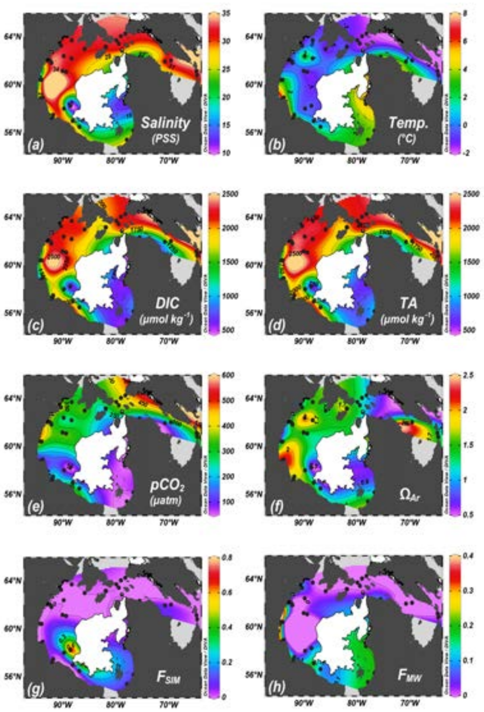
Stn 34

Ahmed, et al. (2020)

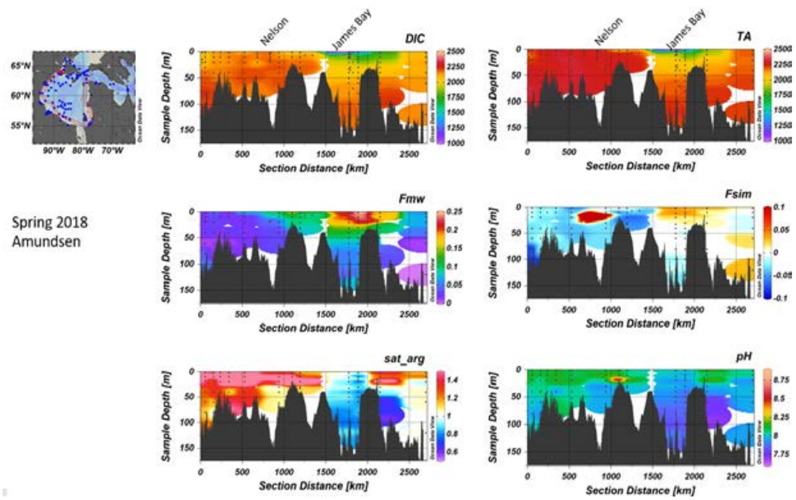
Team 1

Local impacts can be important on the inorganic carbon in Hudson Bay

Surface Water

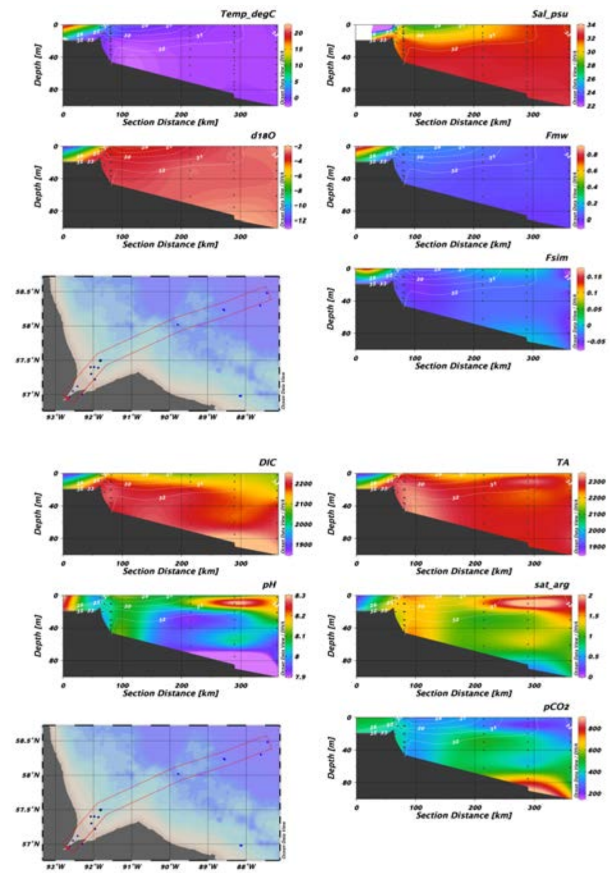


Long Transect



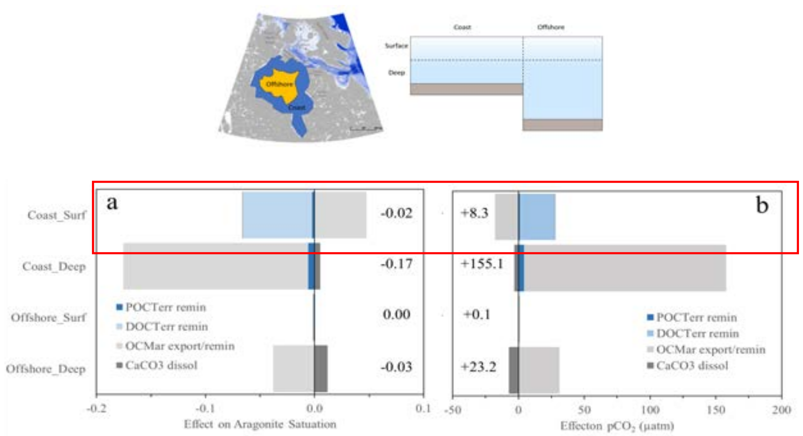
Spring 2018
Amundsen

Inorganic Carbon Species: Long Transect



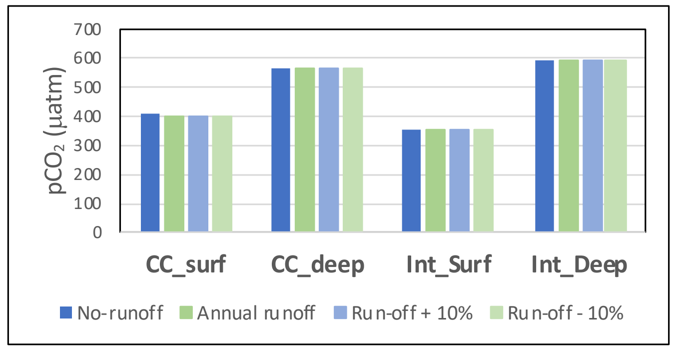
Untangling the impact of rivers on the inorganic carbon system of Hudson Bay

Rivers import pCO_2 and DOC



Capelle, et al. (2020)

- Role of OC_{terr} from rivers is to raise pCO_2 and lower Ω_{ar} in the **coastal surface waters** – promotes outgassing and OA



CC_surf = coastal corridor surface
CC_deep = coastal corridor deep
Int_Surf = Interior surface
Int_Deep = Interior deep

- However, rivers have little effect on both pCO_2 and Ω_{ar} of the coastal zone and interior when the river influx of DIC and TA is considered in addition to OC_{terr}. Impact of dilution.
- Impact of rivers on the carbon system is seen locally - based on observation and simple box-model

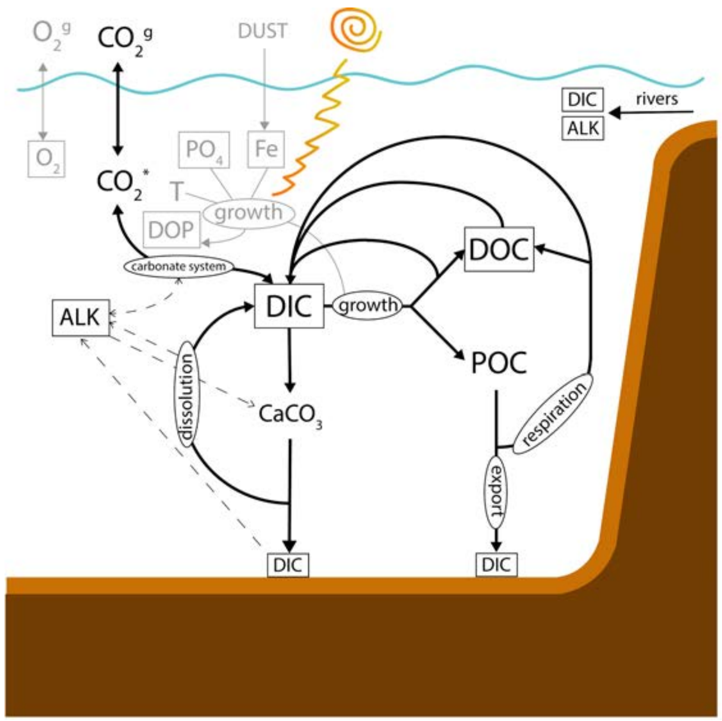
Team 2

Team 6

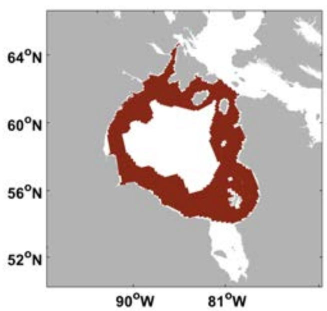
Capelle, et al. (in prep)

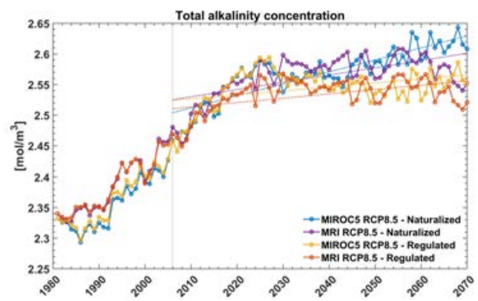
BLING – Link to Team 6

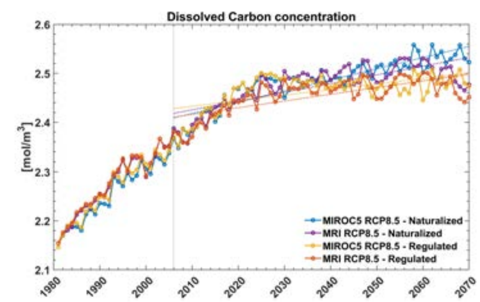
The Biogeochemistry with Light Iron Nutrient and Gas model (BLINGv0; Galbraith *et al.* 2010; Galbraith *et al.,* 2015) is a phosphorus based biogeochemical model that includes iron, nutrient and light limitation. This model is a simplified Nutrient, Phytoplankton, Zooplankton, Detritus (NPZD) biogeochemical model with only ocean (pelagic) components that also models the carbon cycle (BLINGv0 +DIC). BLING was designed to reduce computational demand by only calculating 4 prognostic tracers. These are dissolved inorganic carbon (DIC), total alkalinity concentration (TALK), dissolved oxygen concentration (OXY) and diagnosed chlorophyll-a concentration (CHLa). The diagnostic variables calculated are the rates of matter flux between the prognostic variables.



Annual Results from BLING: Boundary Above the Mixed Layer







- Temperature increase is similar for respecting forcings – MIROC > MRI
- Salinity decreases: MIROC shows little difference in salinity for regulate and naturalized, (regulated lower than naturalized) but when subjected to MRI salinity drops, more slow for regulated
- TA increases slightly for naturalized – should follow trends in salinity
- **DIC increases – appears a stronger function of climate forcing than regulations**
- **pH – shows a decrease in all scenarios** – results from the fact that atmospheric CO_2 is increasing; rate of decrease appears a stronger function of climate forcing
- **DIC flux – virtually no difference for regulated and unregulated**; MRI forcing however shows greater uptake relative to MIROC5

Team 2 Team 6