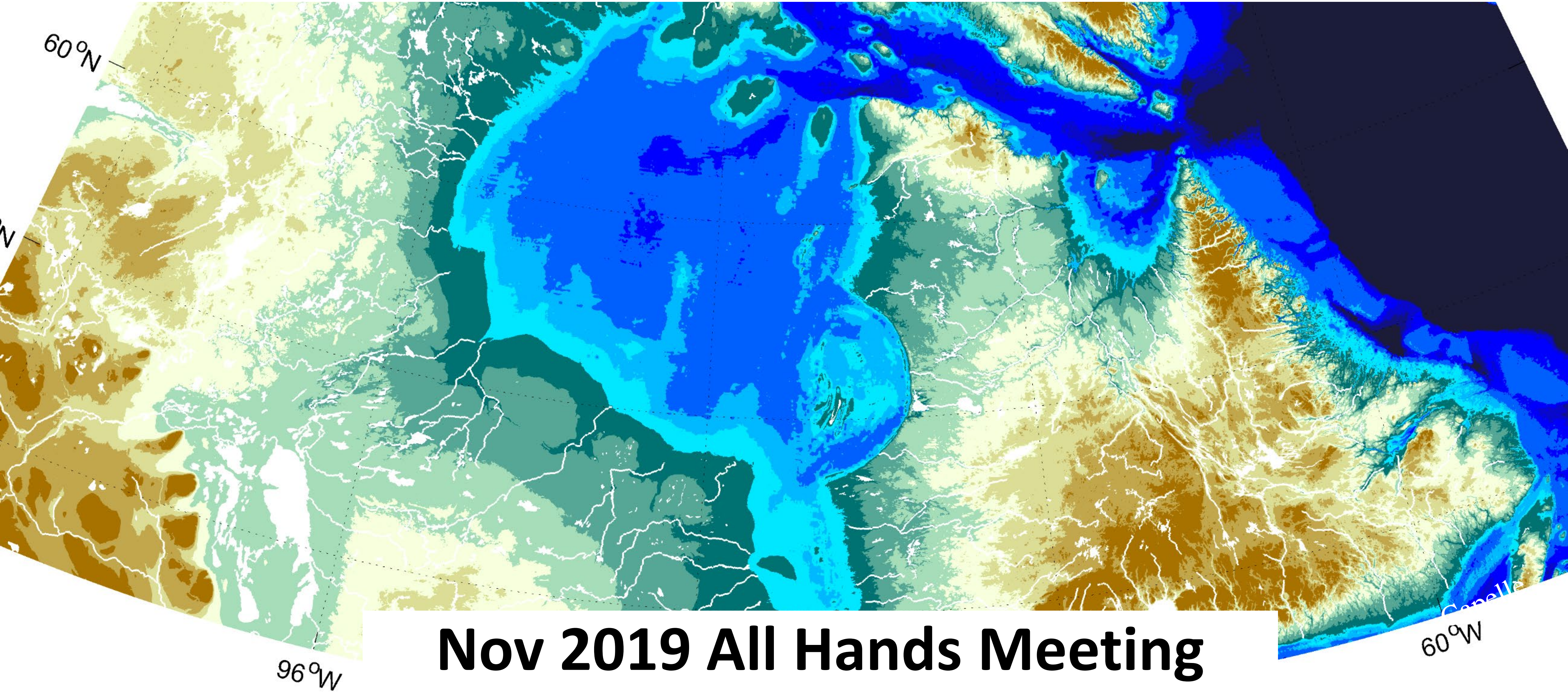
Baysys Team 4 Update



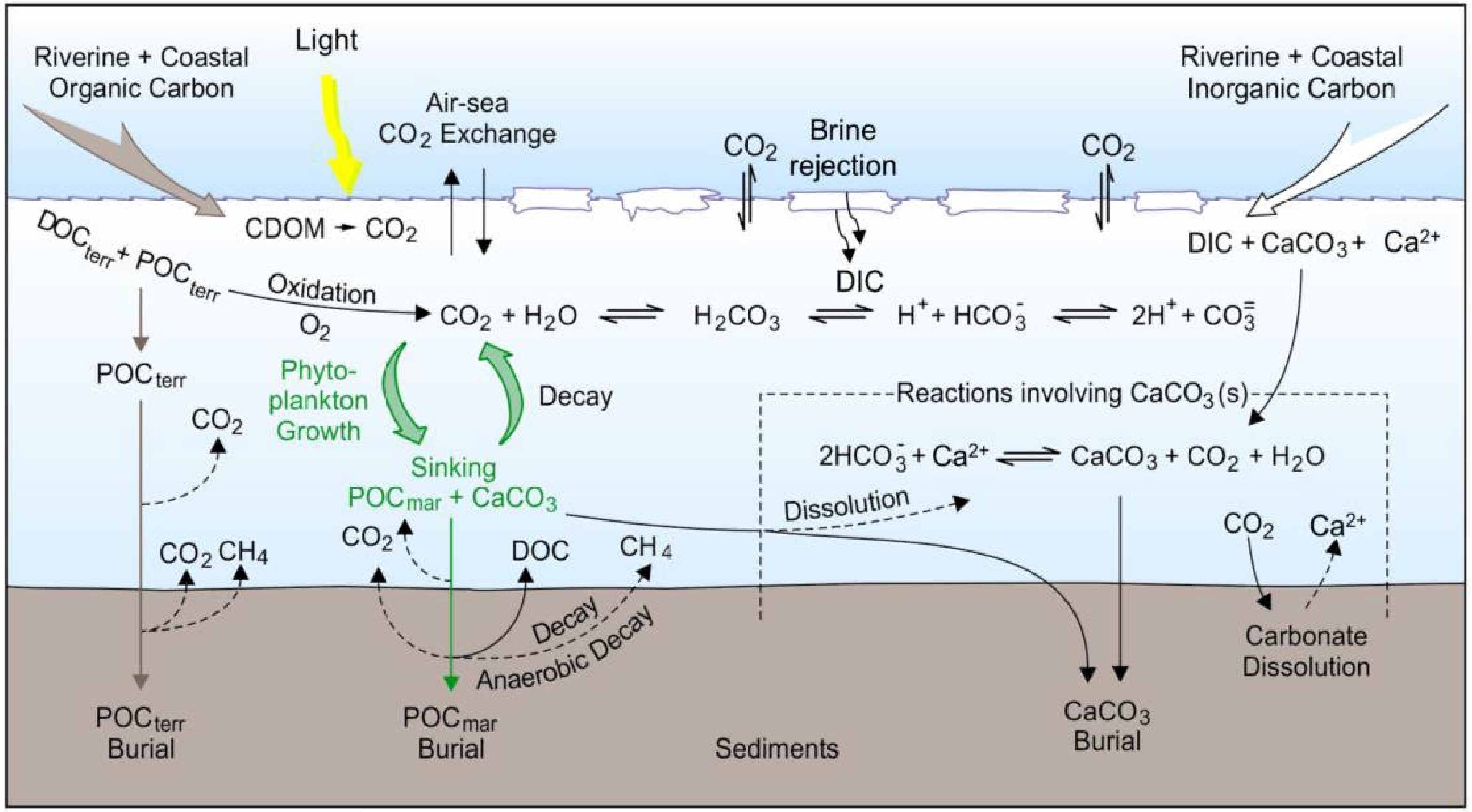
Nov 2019 All Hands Meeting

Team 4: Carbon Cycling

- Tim Papakyriakou (Academic Lead)
- Bob Gill (Industry Lead)
- Brent Else (pCO_2, flux and remote sensing)
- Céline Guéguen (Organic carbon)
- Zou Zou Kuzyk (Organic carbon)
- Fredrick Maps (BGC modeling T4/T3)
- Lisa Miller (Inorganic carbon)
- Paul Myers (Modeling lead, T6)
- Søren Rysgaard (Over-all carbon system)
- David Capelle
- Mohamed Ahmed
- Inge Descepper
- Zakhar Kazmiruk
- Samantha Huyghe
- Sohidul Islam
- Robie Macdonald
- Richard Sims
- Brian Butterworth
- Rachel Mandryk
- Kate Yezhova

Hypotheses: Carbon system affected by…

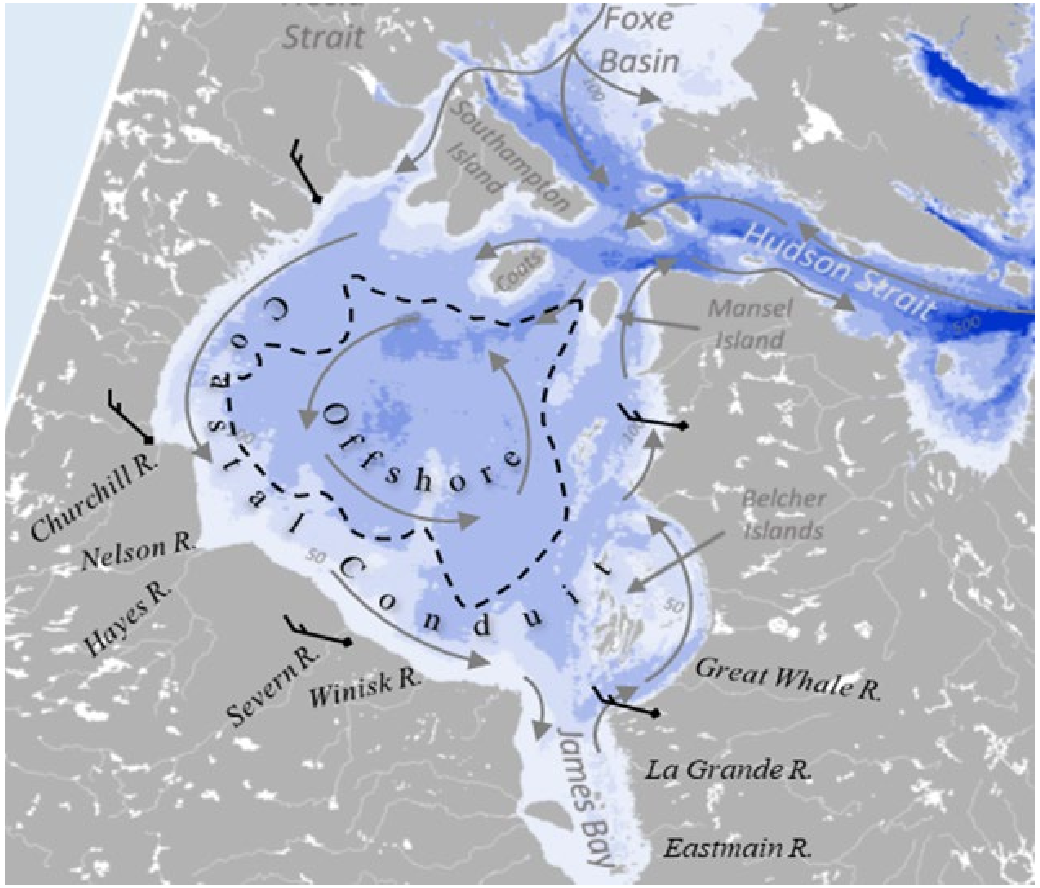
- seasonal changes in runoff, sea ice, and biology (H4.1)
- long-term changes (regulation and climate change) (H4.2)



Capelle et al. Prog. In Ocgy. *In review.*

HB Background

- Lots of terrestrial Carbon
- Moderate / low primary production rates
- Low C burial rates



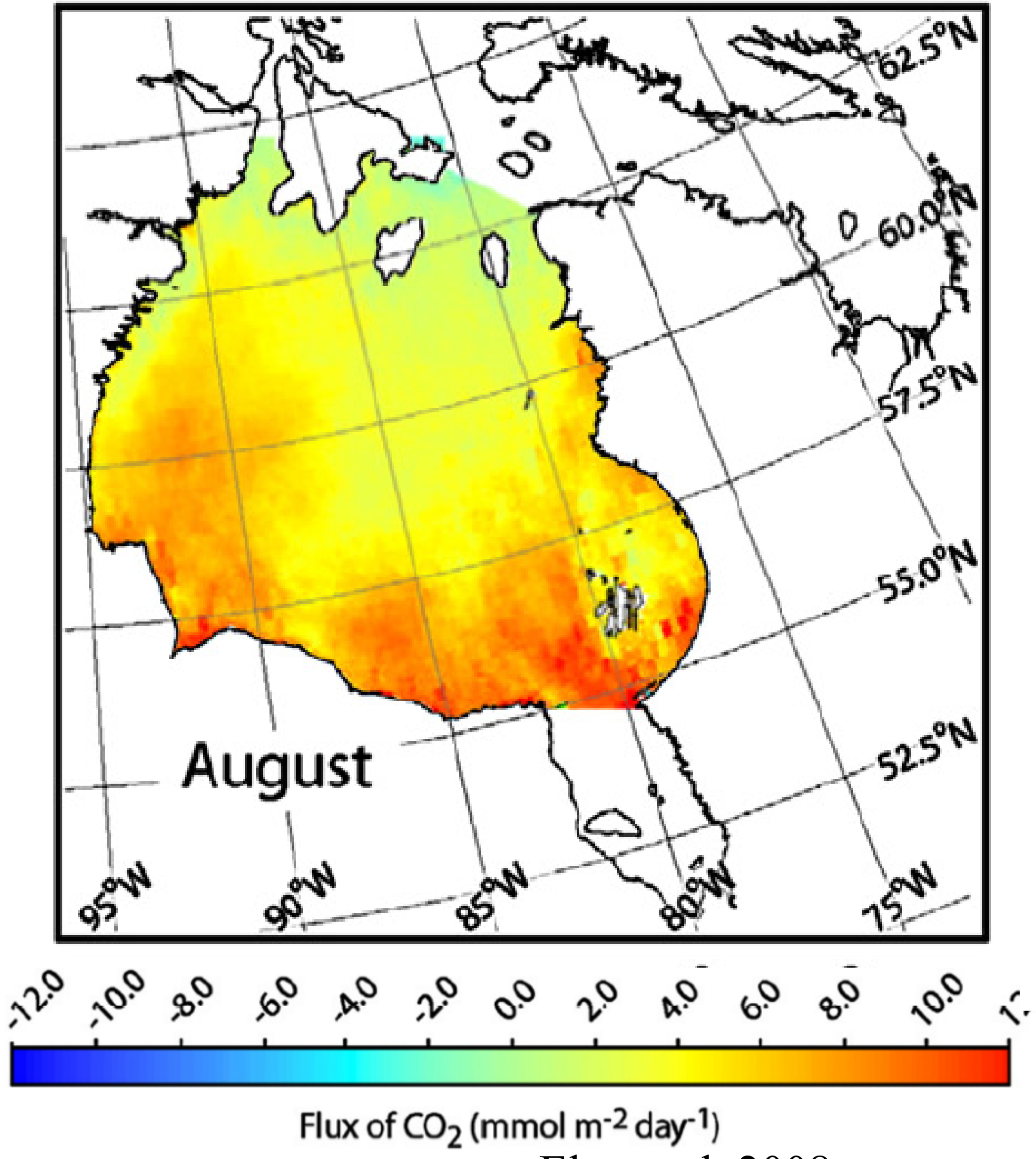
Capelle et al. Prog. In Ocgy. *In review.*

High terrestrial carbon degradation?

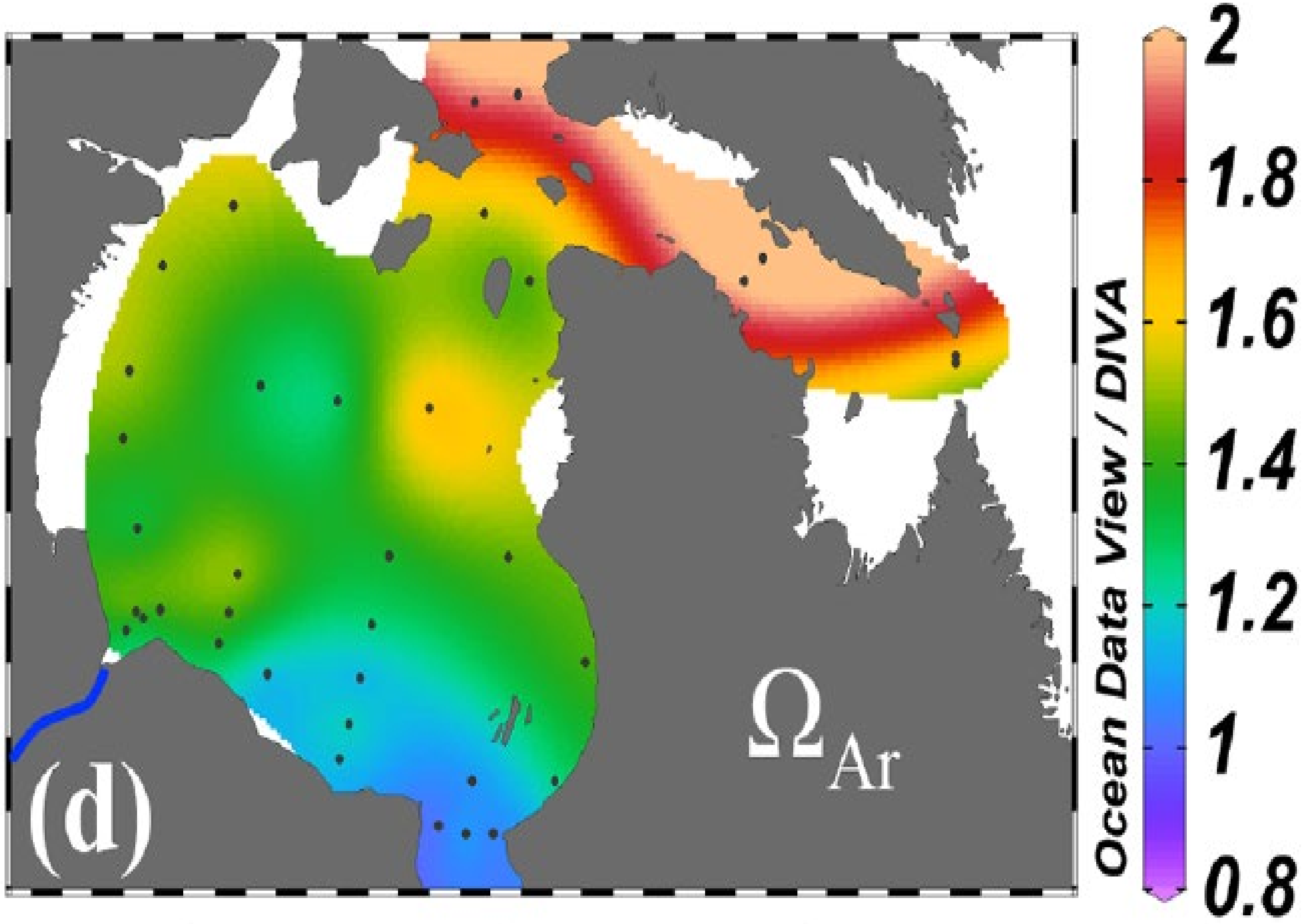
could promote CO_2 outgassing and acidification

- *Susceptible to both Hydro and Climate change*

FW influences CO_2 and acidification along SW coast



Else et al. 2008



Burt et al. 2016

Unknowns (pre-Baysys)

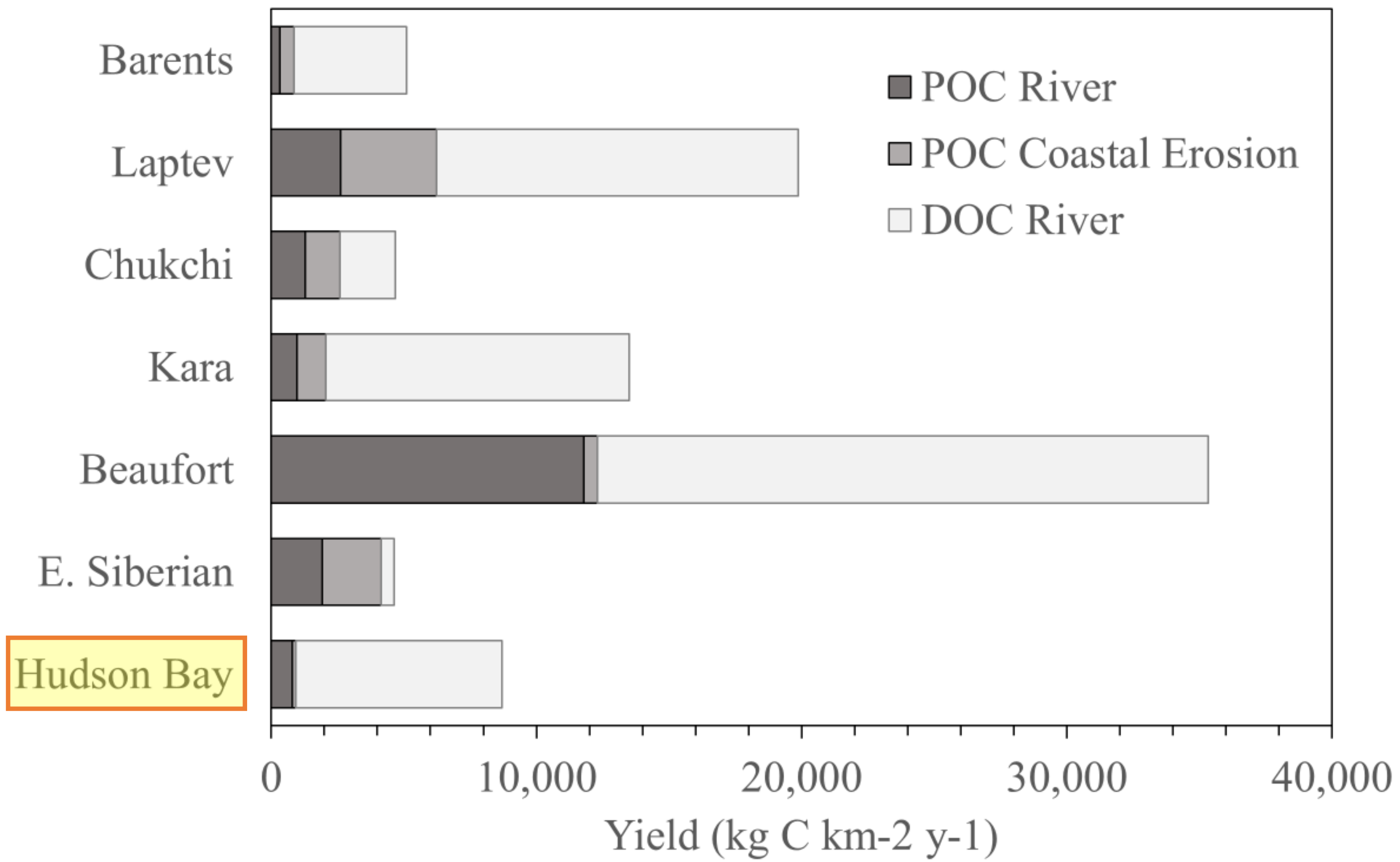
- How much CO_2 and acidification are supported/offset by….
  - Terrestrial carbon degradation?
  - Marine PP/remineralization?
  - Runoff, Brine, Sea-ice melt?

- Seasonal Carbon-system variability (esp. Winter and Spring)
  - River inputs
  - Degradation rates
  - Air-sea flux

- Improved C-burial estimates

Terrestrial C delivery

- Dominated by DOC
- Little POC, erosion

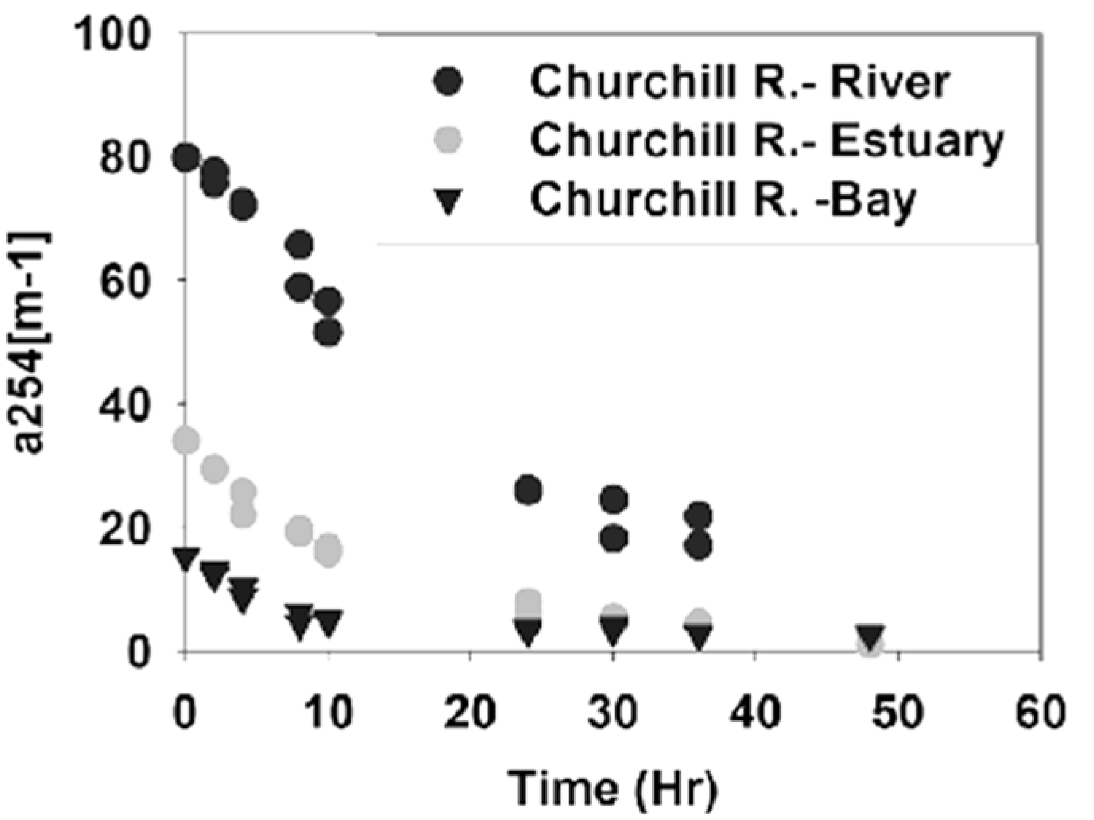


Capelle et al. Prog. In Ocgy. *In review.*

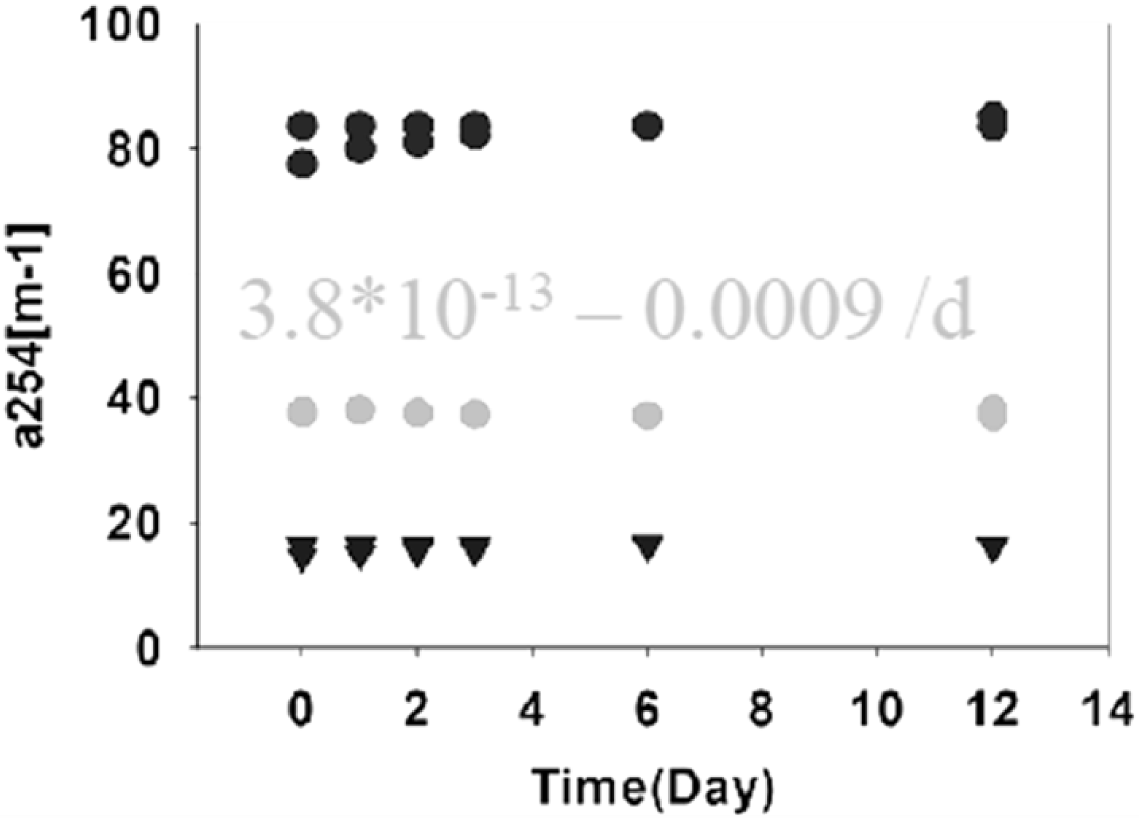
CDOM remineralization by sunlight vs. microbes

Photochemical oxidation

Rapid: Up to 90% loss of CDOM within 24 hours

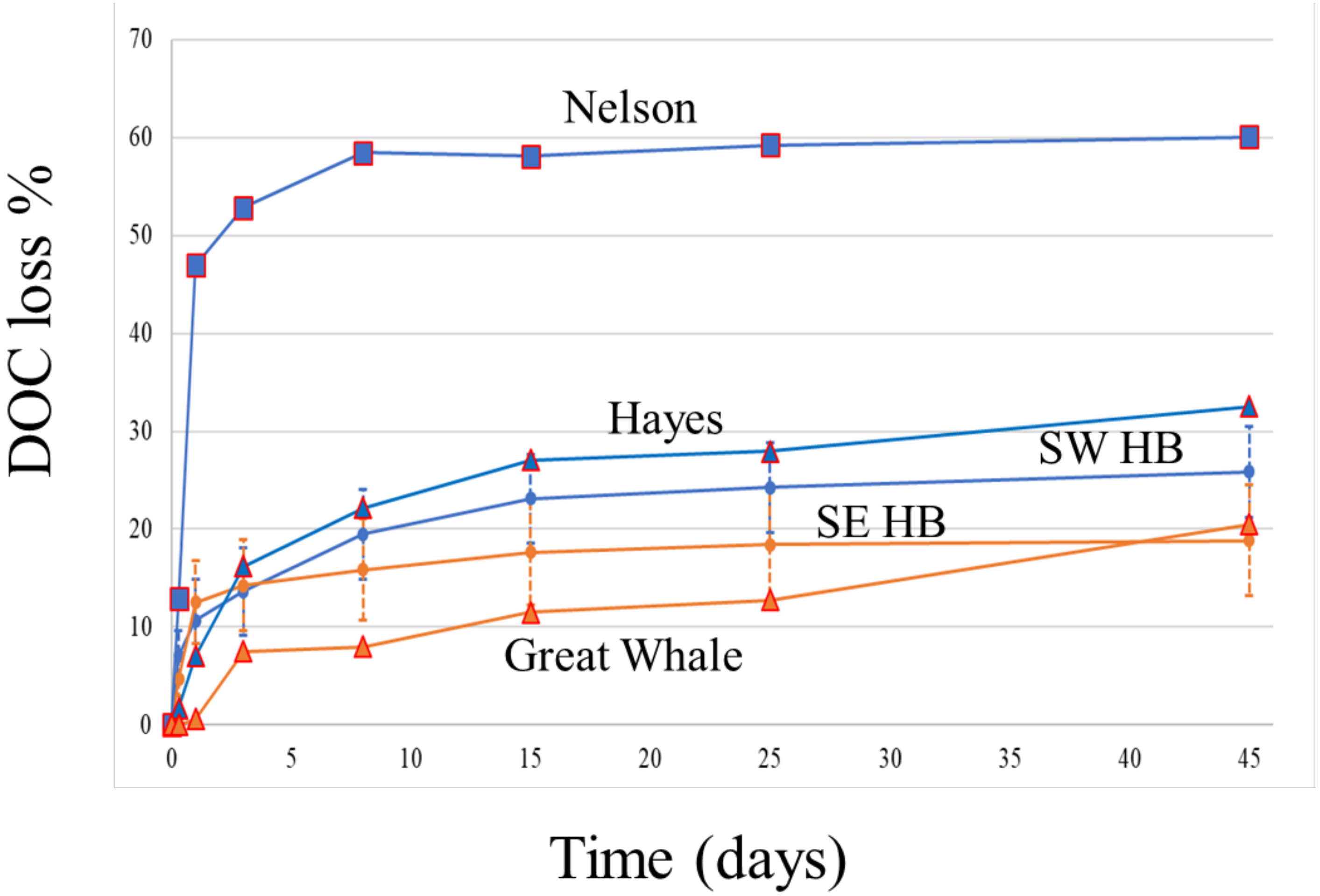


Microbial oxidation



Islam and Gueguen *in prep.*

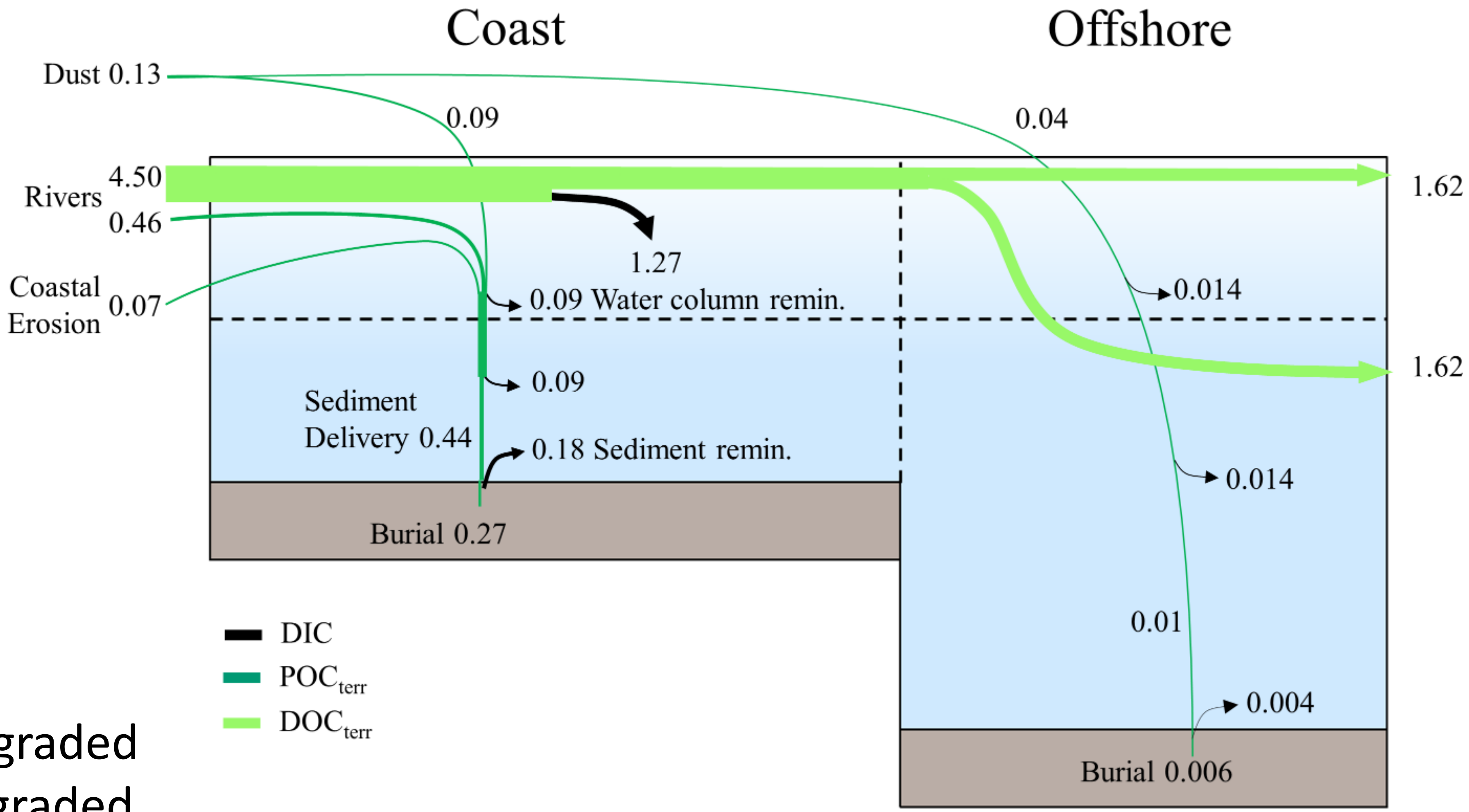
Bio-degradation rates of terrestrial DOC



- Nelson River highly biodegradable
- Great Whale less degradable than coastal water.
- Watershed characteristics, nutrients, community structure likely play a role

Kazmiruk et al. *in prep.*

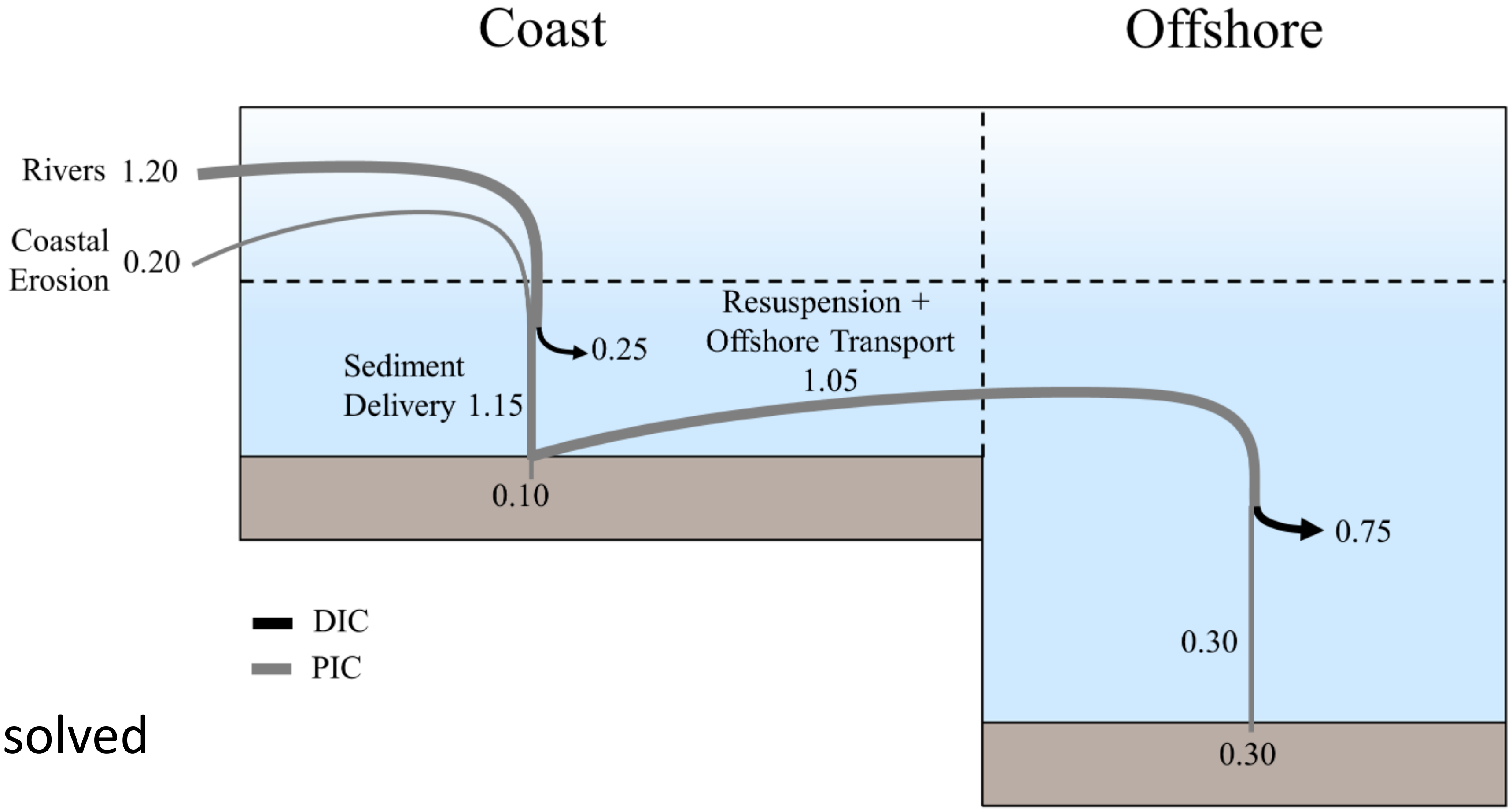
Terrestrial OC Budget (mean annual)



30% DOCterr degraded
50% POCterr degraded

Capelle et al. Prog. In Ocgy. *In review.*

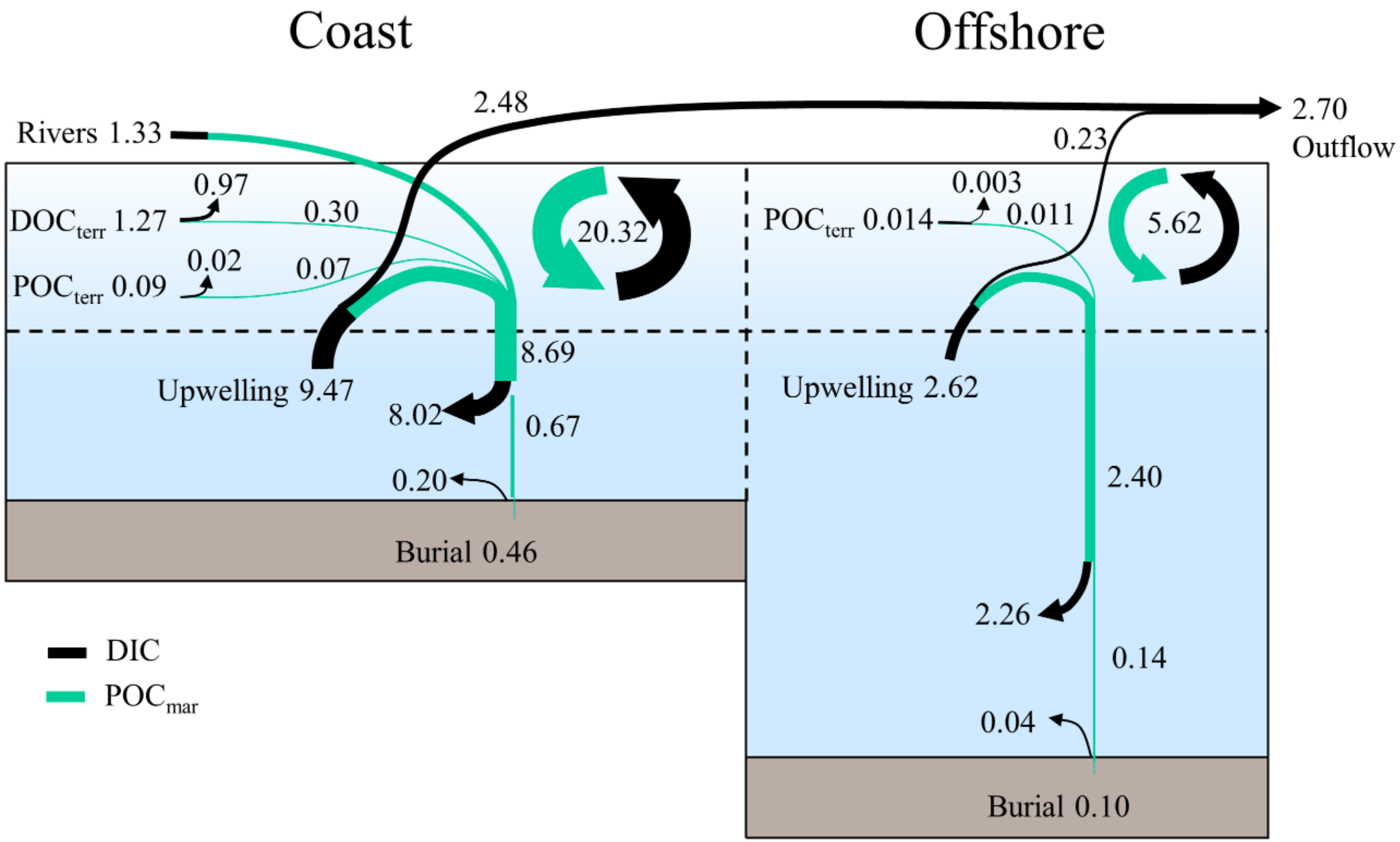
PIC (CaCO3) Budget (mean annual)



60% PICterr dissolved

Capelle et al. Prog. In Ocgy. *In review.*

Marine OC Budget (mean annual)



- >90% OCmar degraded

Capelle et al. Prog. In Ocgy. *In review.*

Carbon:Nitrogen of DOC

- Carbon:Nitrogen of DOM > POM
- DOM deg. Produces more 'excess inorganic carbon' than POM degradation
- DOM deg has larger net impact on CO2 efflux and acidification than POM

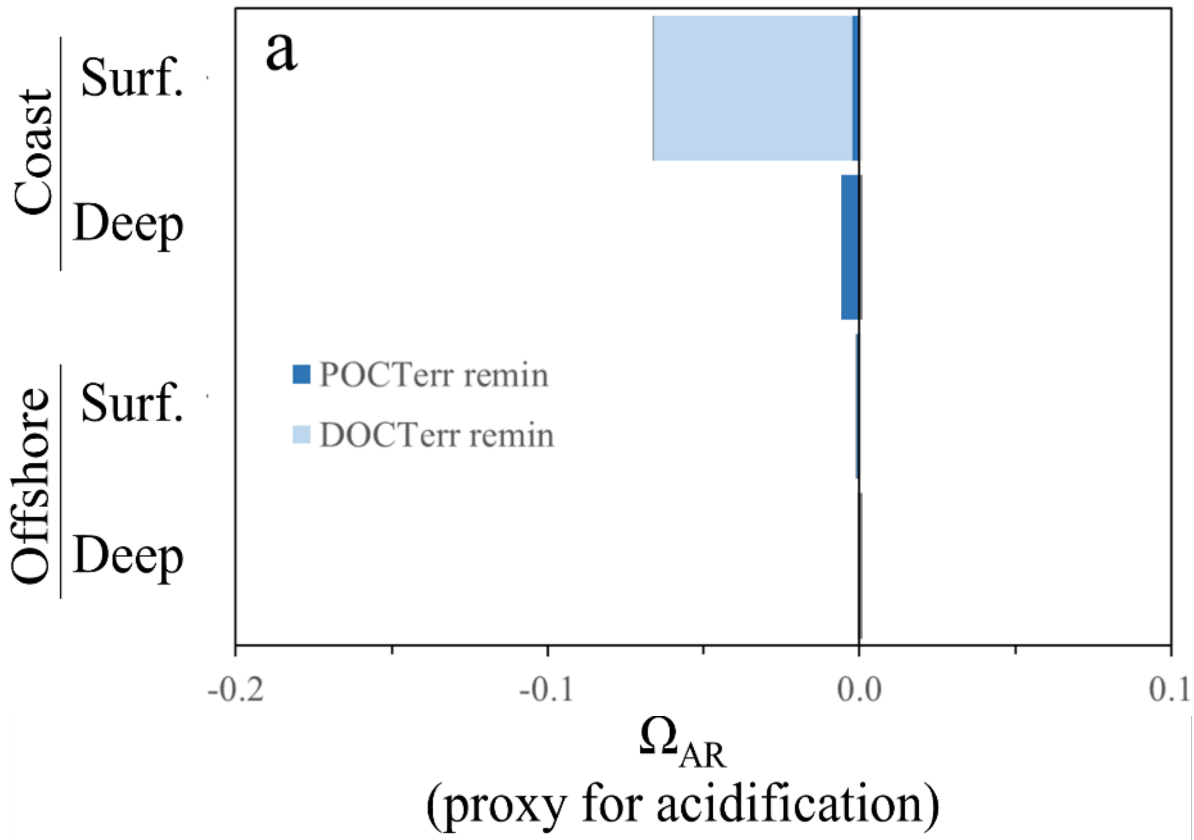
River	Latitude	Longitude	Sampling Date (Day of Year)	Drainage Basin Area (km^2)	Annual Q (km^3/yr)	Peak Flow (Day of Year)	C:N of POC	C:N of DOC
East								
Povungnituk	60.05	77.22	191	28,000	11.9	184	13.5	23.4
Kogaluk	59.61	77.48	191	11,300	5.0	171	16.3	26.7
Polemud	59.43	77.30	191	N/A	1.5	170	14.0	29.0
Innuksuak	58.46	78.08	192	11,200	3.3	174	12.8	36.8
Nastapoca	56.92	76.43	193	12,500	8.0	173	13.2	22.6
Little Whale	55.97	76.67	193	11,700	3.7	164	13.7	24.9
Great Whale	55.27	77.57	194	43,200	19.8	153	10.8	37.1
Northwest								
Josephine	63.13	90.98	199	N/A	2.5	180	9.2	20.1
Wilson	62.33	93.13	199	N/A	2.6	180	11.0	22.3
Ferguson	62.08	93.35	199	12,400	2.6	181	12.8	31.2
Tha'anne	60.55	94.92	200	29,400	6.3	175	8.7	22.8
Thlewiaza	60.52	95.02	200	27,000	6.9	183	12.1	29.0
Southwest								
Churchill	58.78	94.20	201	288,880	20.6	161	10.2	27.9
Severn	55.87	87.82	209	94,300	21.3	149	11.9	35.0
Winisk	55.15	85.30	209	54,710	14.7	148	12.5	40.4
Average							**12.2**	**28.6**

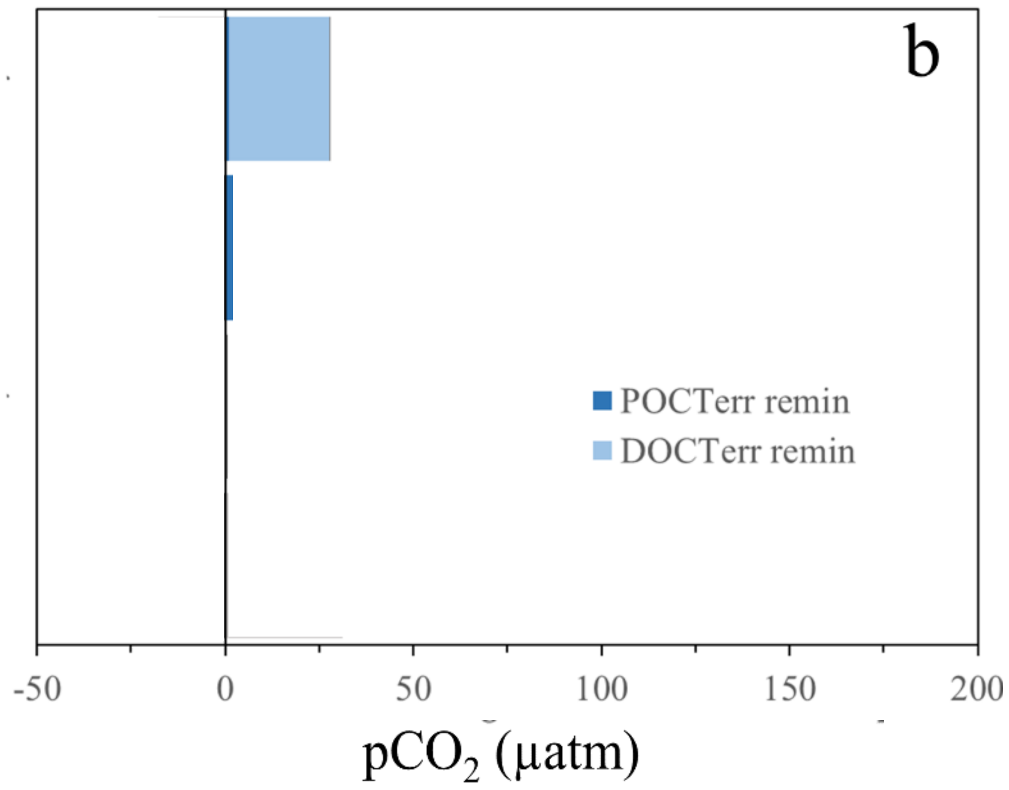
Table 1. Carbon : Nitrogen ratios of POM and DOM measured at the mouth of 15 Hudson Bay rivers during August 2011.

Capelle et al. Prog. In Ocgy. *In review.*

C-cycle affects CO_2 and acidification

mostly from DOC terr remin
offset by marine PP, PIC remin

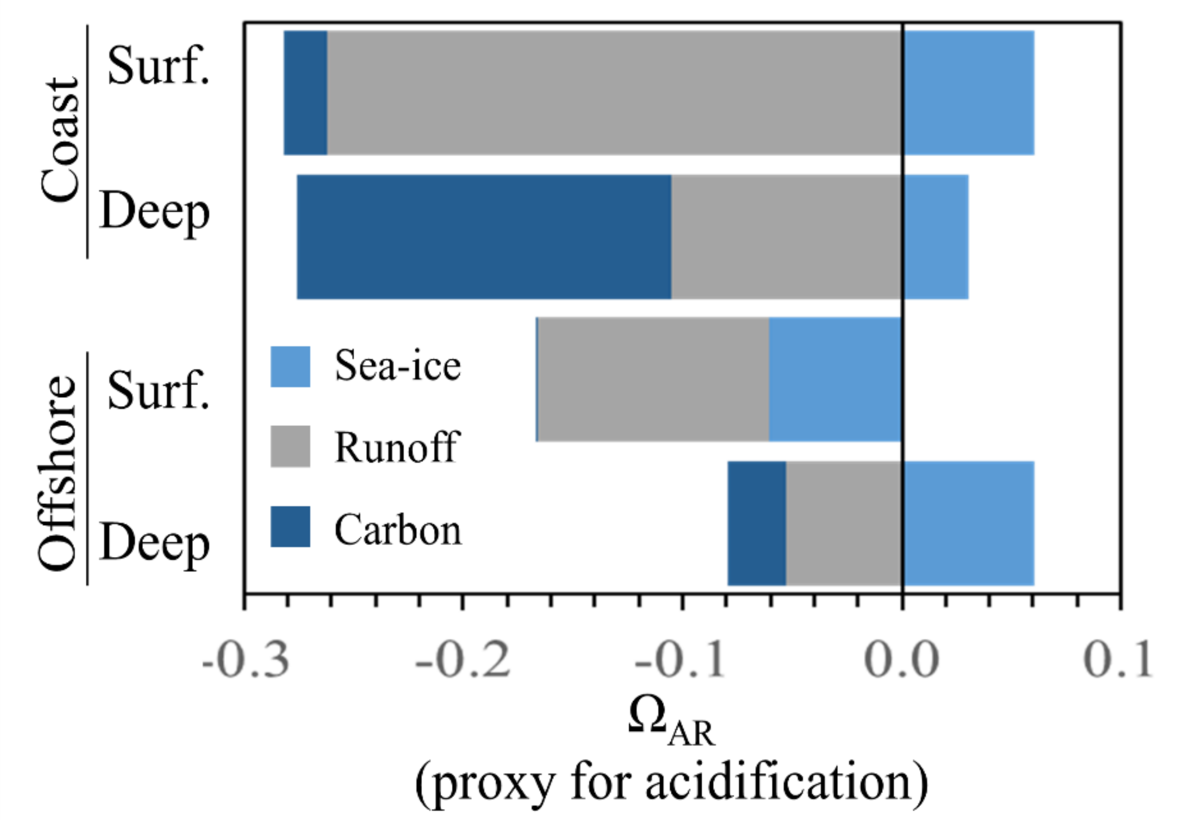


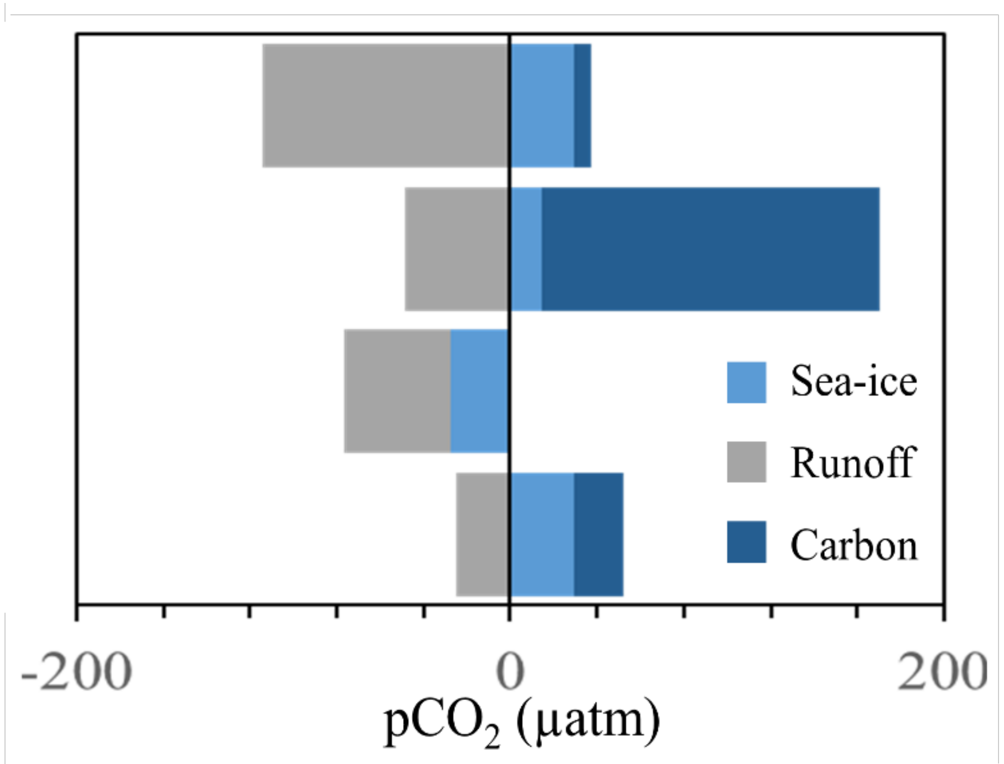


Capelle et al. Prog. In Ocgy. *In review.*

Runoff, Sea ice affects CO_2 and acidification

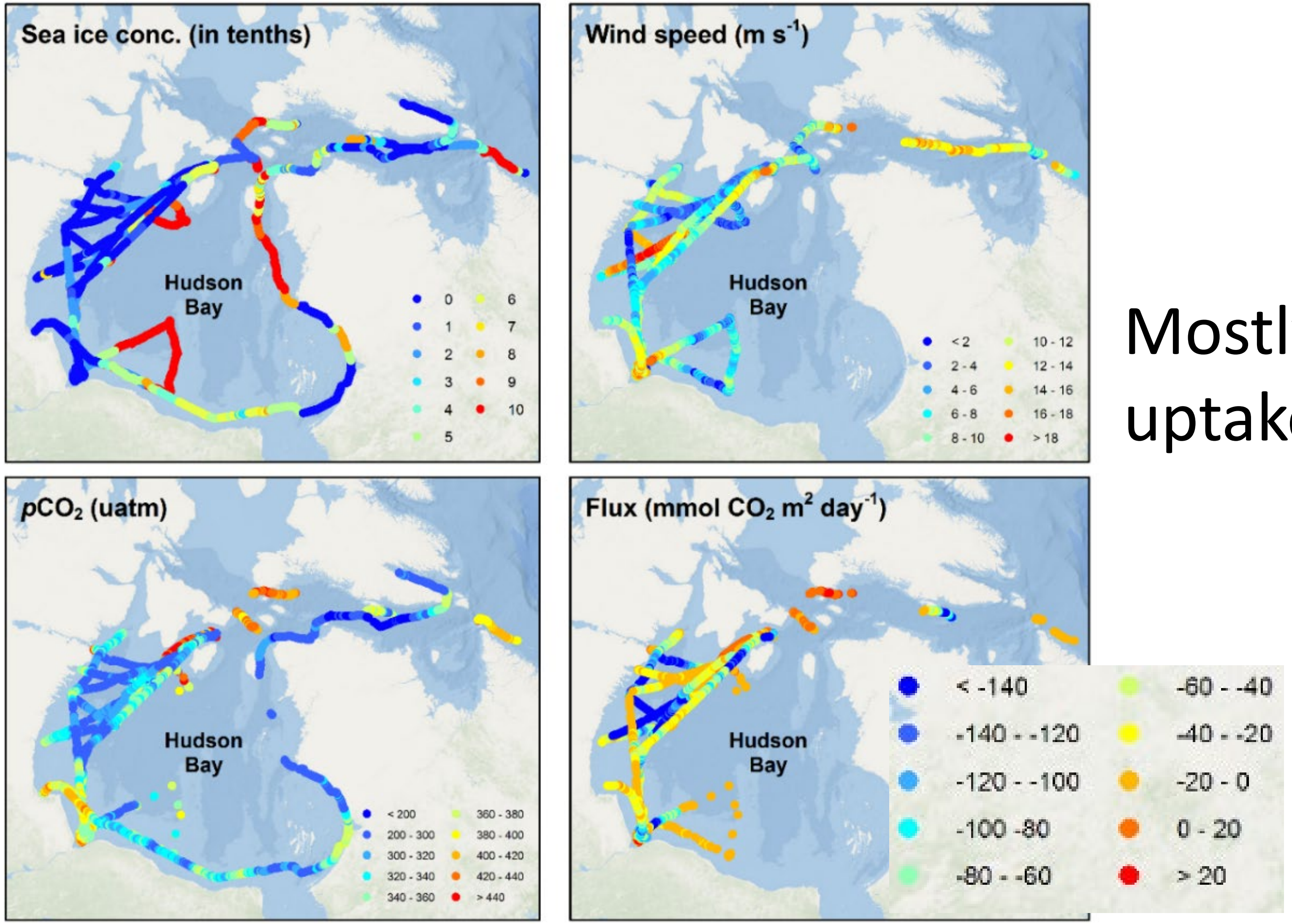
more than C-cycle in some regions





Capelle et al. *In prep*

Near-surface pCO_2 variability and flux



Mostly CO_2 uptake in spring

Ahmed et al. *in prep*

pCO2 from Remote Sensing

SST

SSS

CDOM

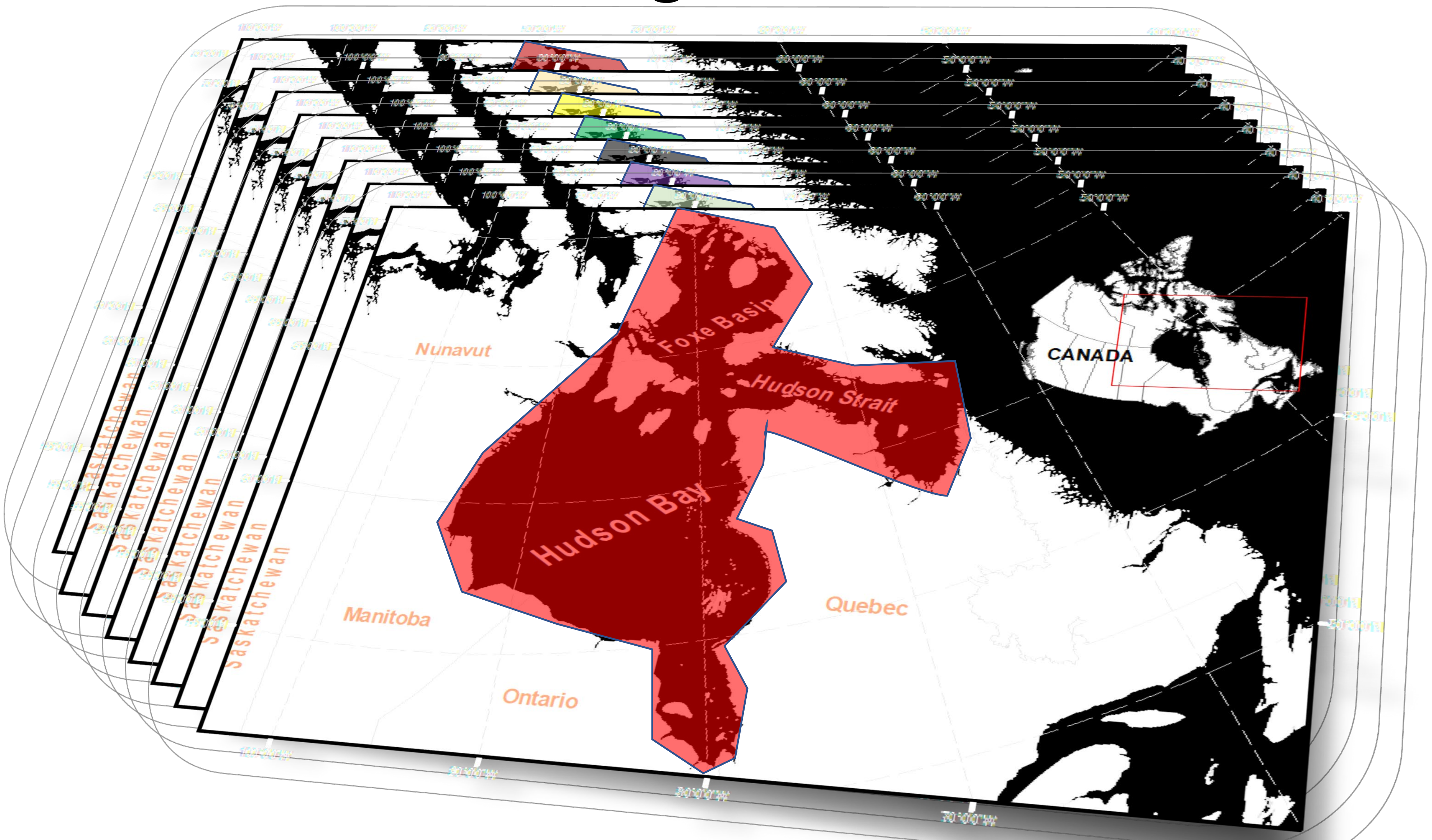
CHLa

Sea Ice

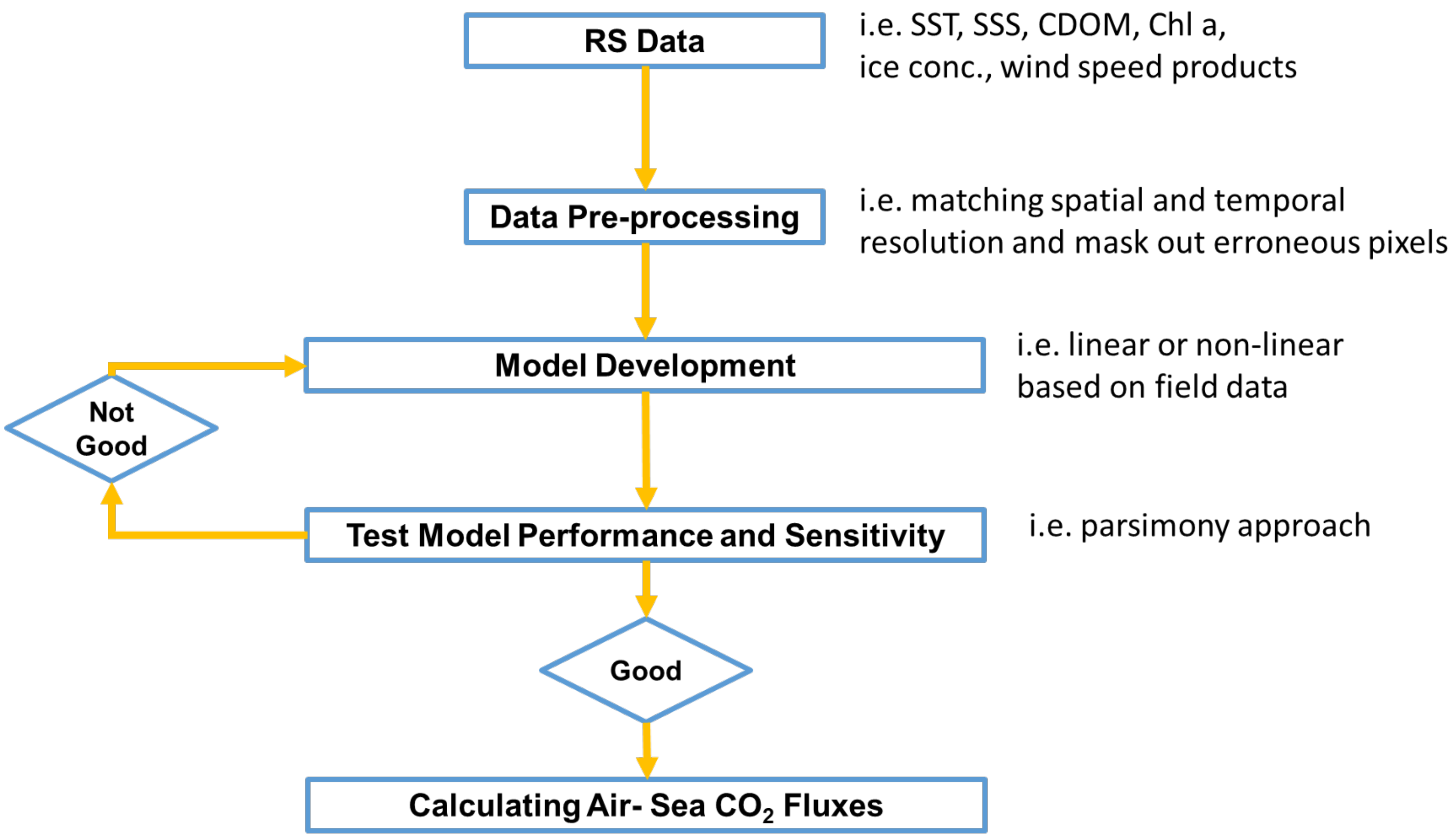
***P*CO_{2sw}**

Wind Speed

CO_2 Flux



pCO2 from Remote Sensing



Eddy covariance CO_2 and CH_4 flux

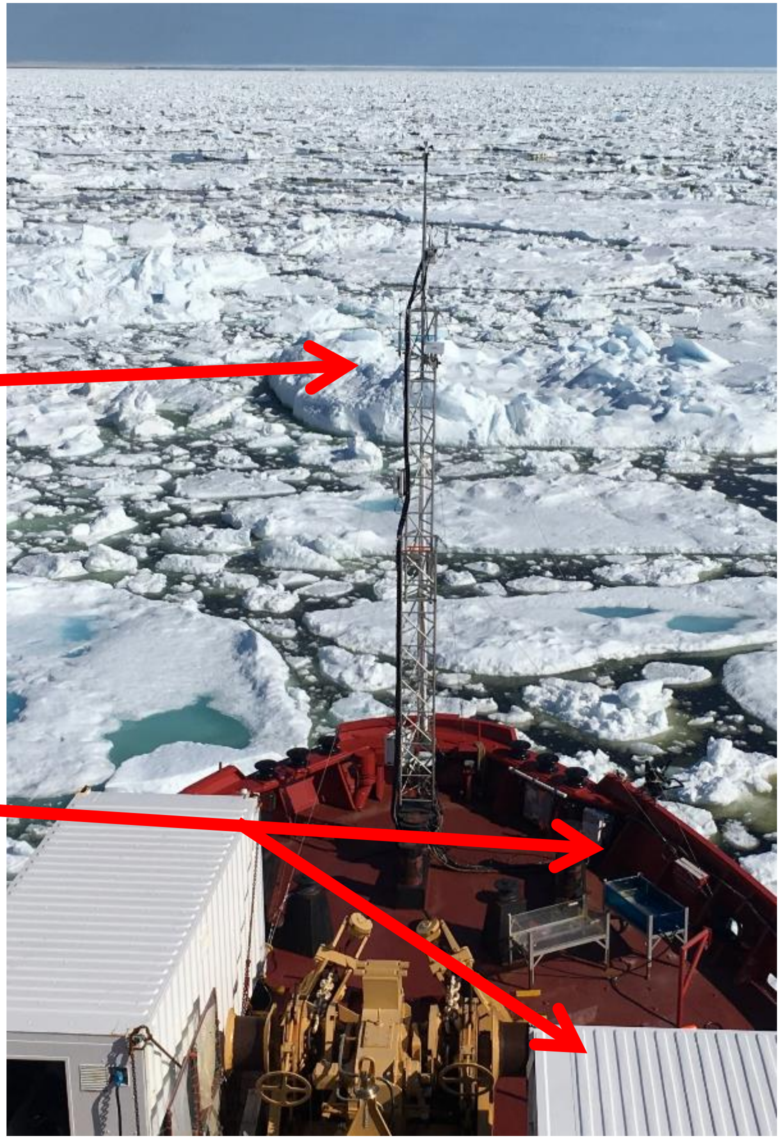
Else et al. *in prep*

Eddy covariance CO_2 and CH_4 flux

$$F_c = \overline{\rho_a}\,\overline{w'c'} = k\ s\ \Delta pCO_2$$

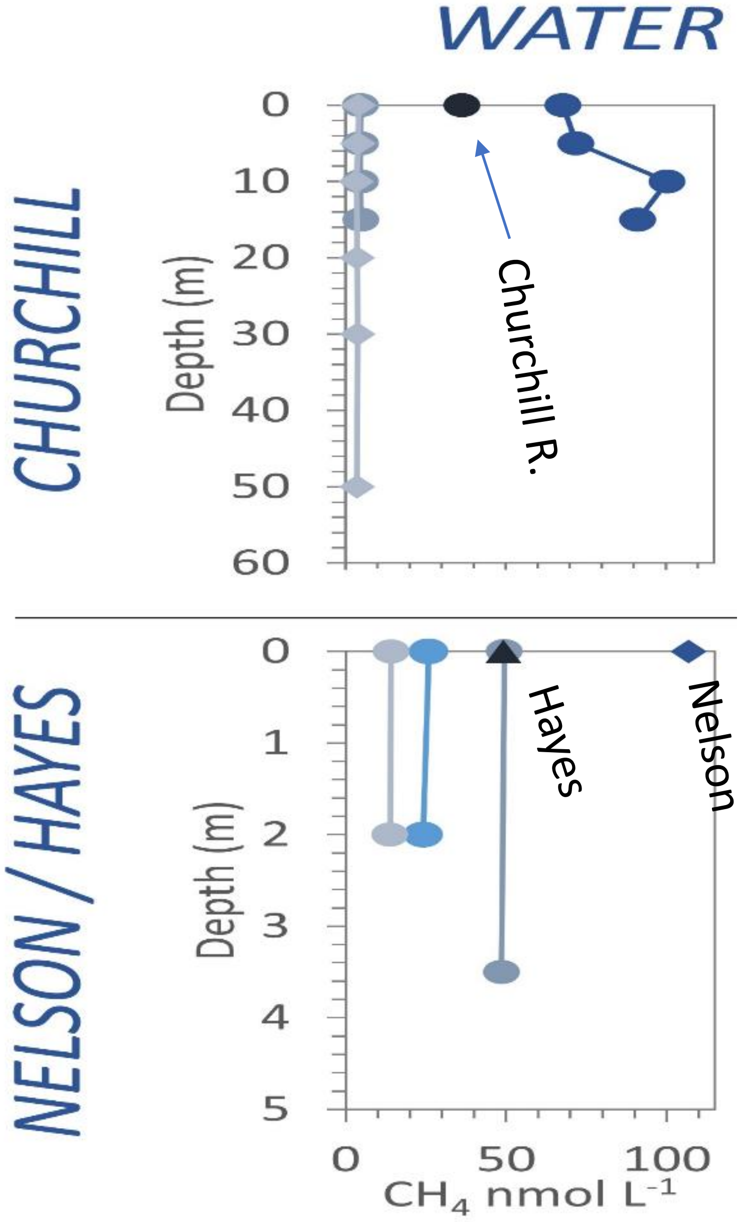
<u>Mast</u>
sonic anemometers
motion sensor
sample air inlets

<u>Deck</u>
gas analyzers
pumps



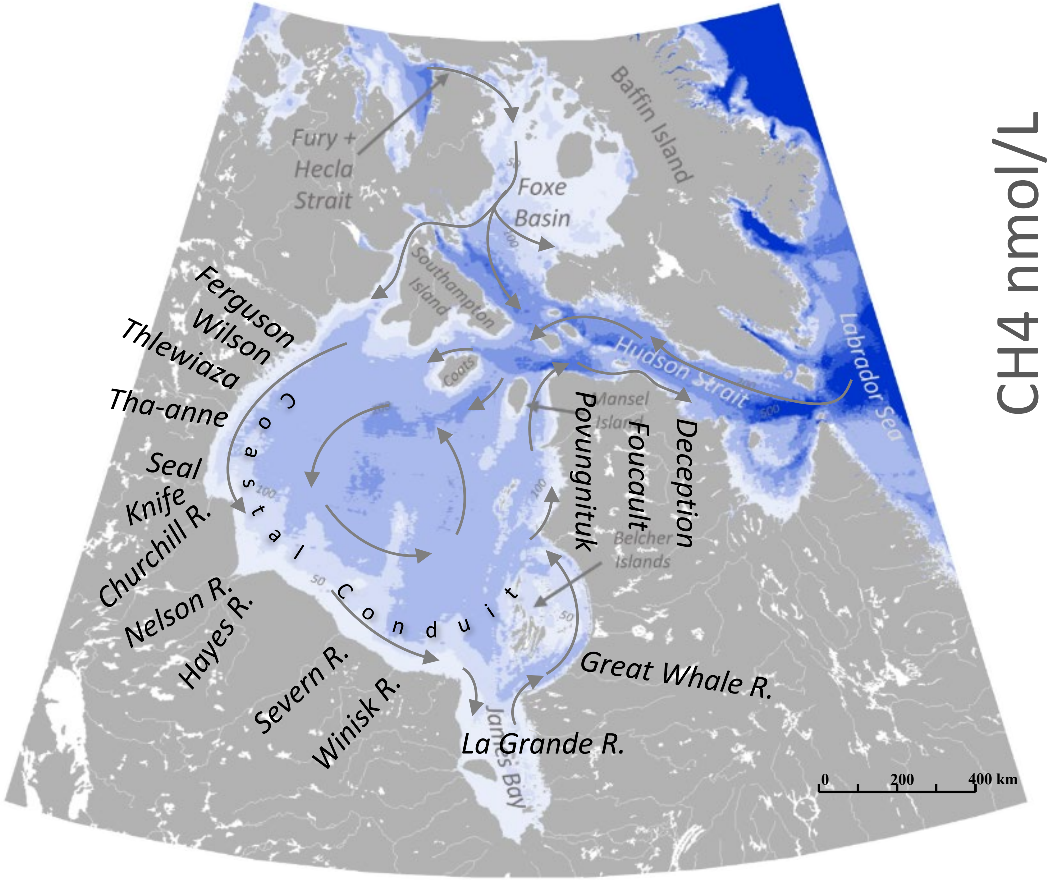
Raw data – 10 Hz
Flux averages – 20 minutes

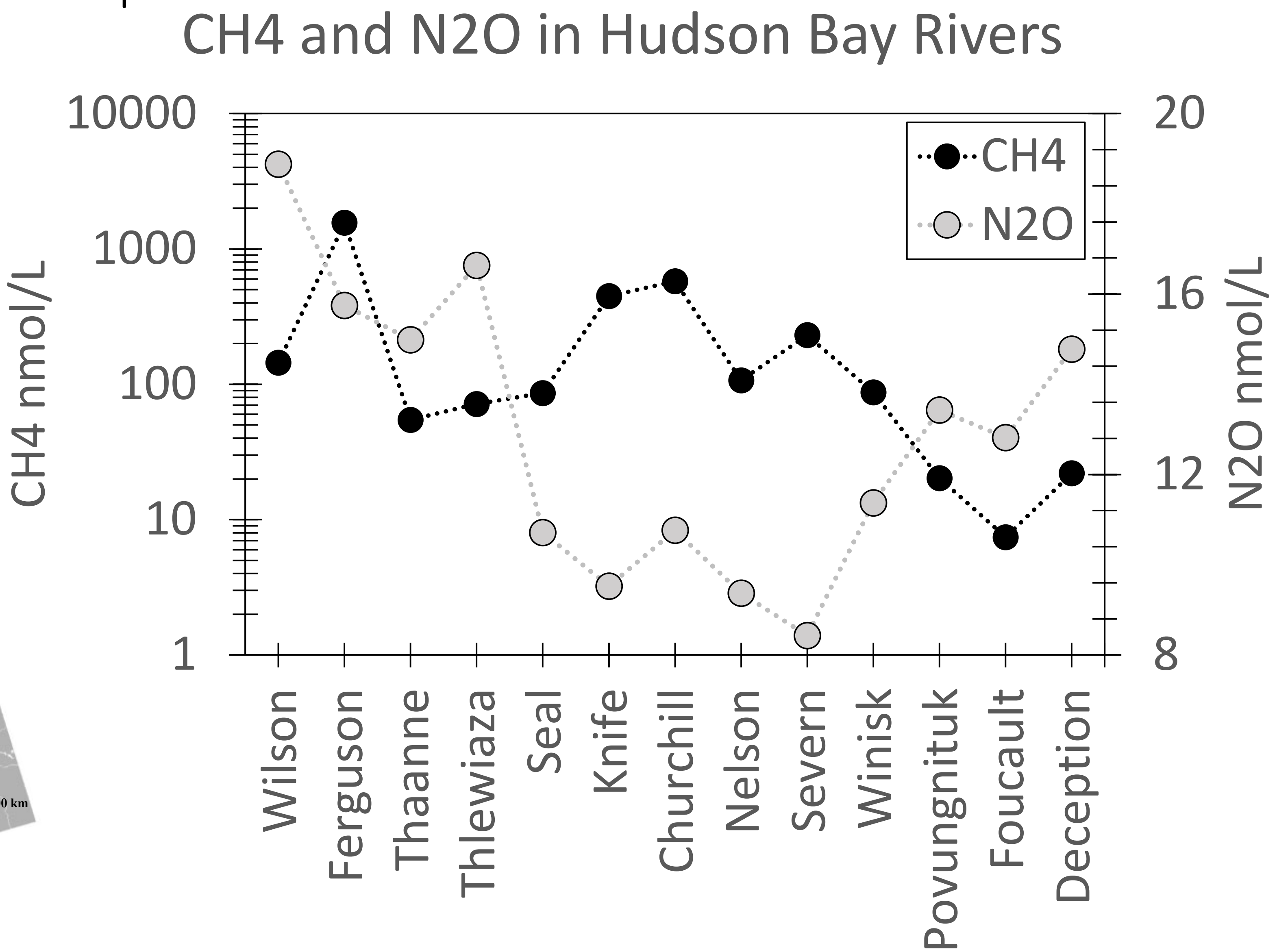
Rivers significantly CH_4 saturated



Capelle et al. *in prep*

Rivers significantly CH_4 saturated



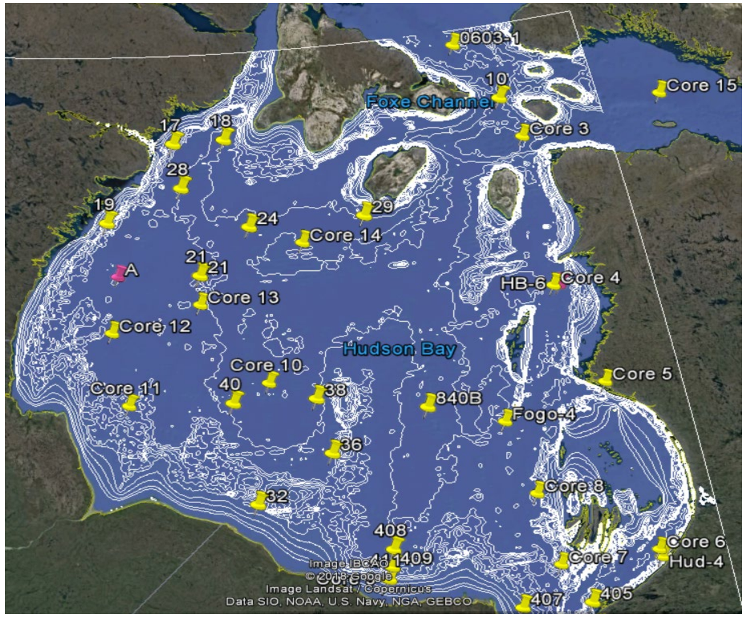


Capelle et al. *in prep*

Overall HB sediment sink, drivers of spatial and seasonal variability

Subbottom lines from 1977, 1978, 2003-2018 reviewed for this study

Distribution of sediment cores (yellow symbols) in the compiled database

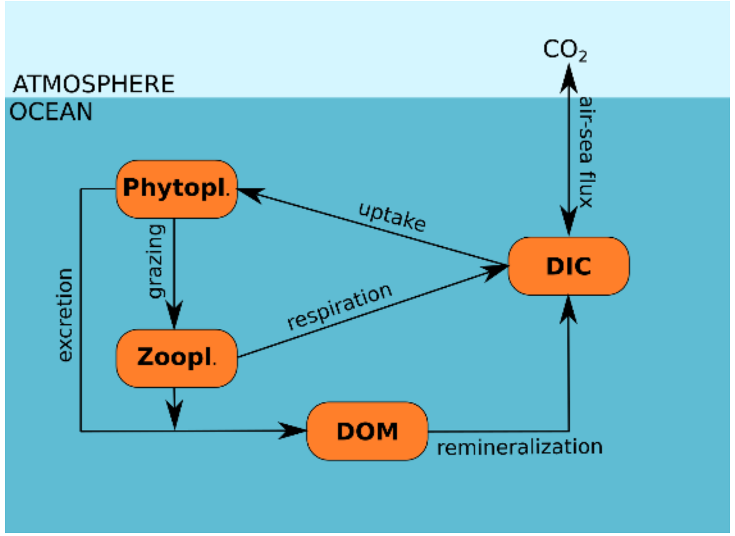


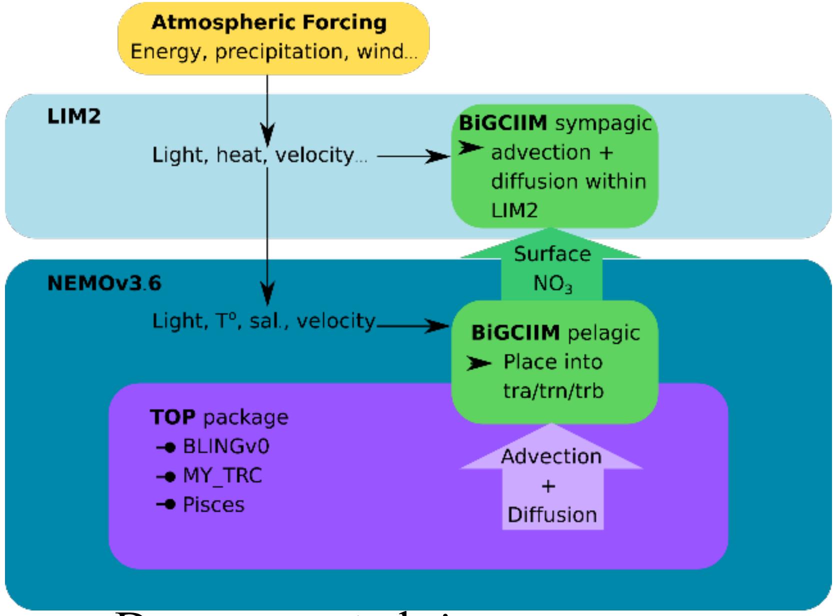
- Four sequential sediment traps recovered. Will provide one-year record of sedimentation from Churchill, Nelson and James Bay areas.
- Fourteen new sediment cores collected and analyzed for radioisotopes.

Huyghe et al. *in prep.*

Biogeochemical Model

- CO_2 flux and $CaCO_3$ saturation under-different scenarios
  - Carbon module (Lavoie)
  - physical water properties (temp, salinity)
  - meteorological data (wind speed, ice cover)
- Role of Hydro on C-cycle?
  - 1981-2010 models under regulated and re-naturalized conditions
- Role of climate change?
  - 2010-2070 RCP 8.5 scenario; regulated and re-naturalized





Descepper et al. *in prep*

Unknowns – future work

- Need residence time to constrain spatial footprint of terrestrial DOM degradation (Team 6)

- Winter + spring CO_2 sink/source, acidification status (data being interpreted now)

- Questions:
  - Baysys funds for publication in non-Elementa?