Lateral Carbon and Nitrogen Exchanges from a Mangrove Tidal Creek

A Multi-Stable Isotope Approach

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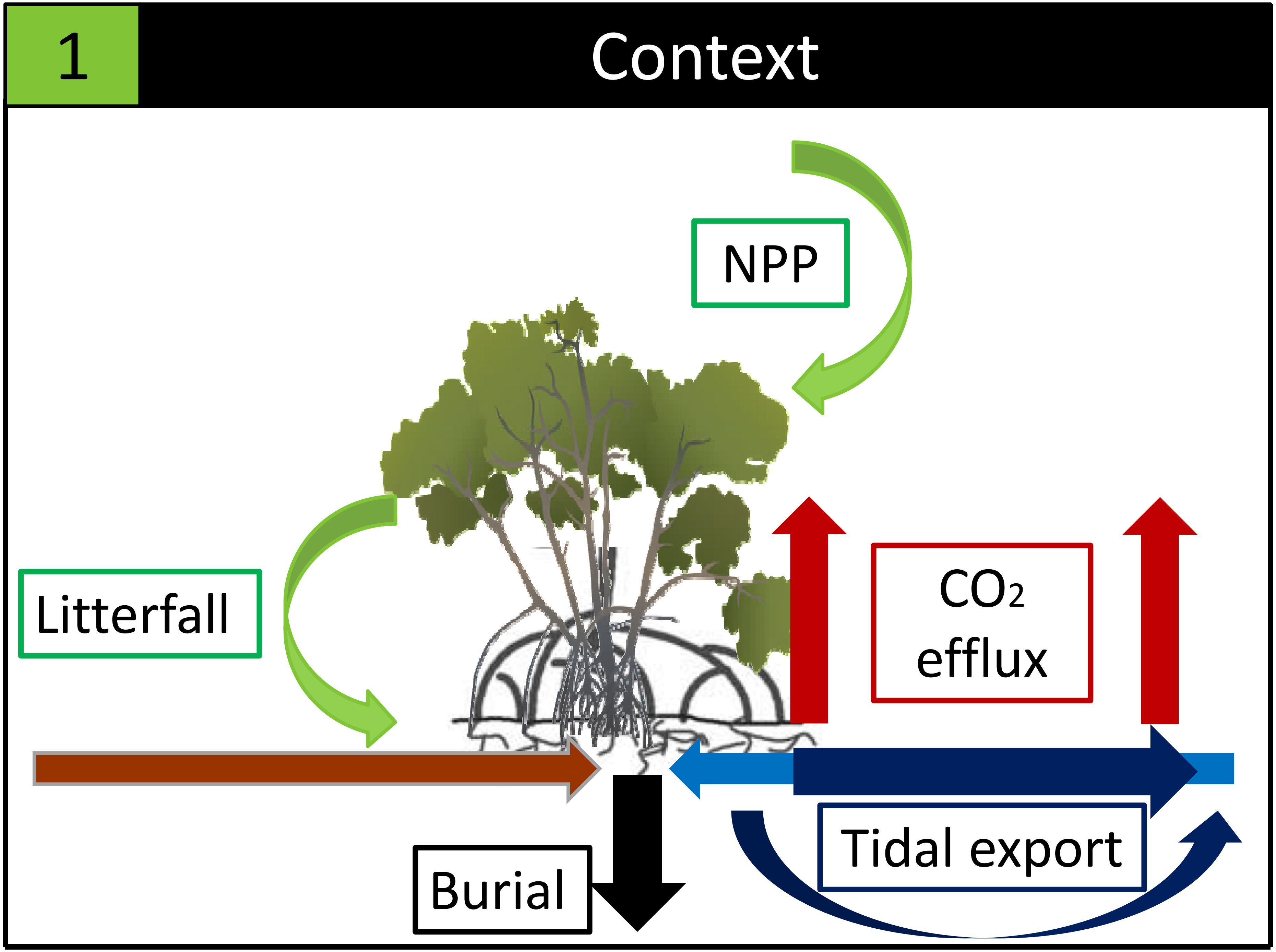
National University of Singapore

geotop UQÀM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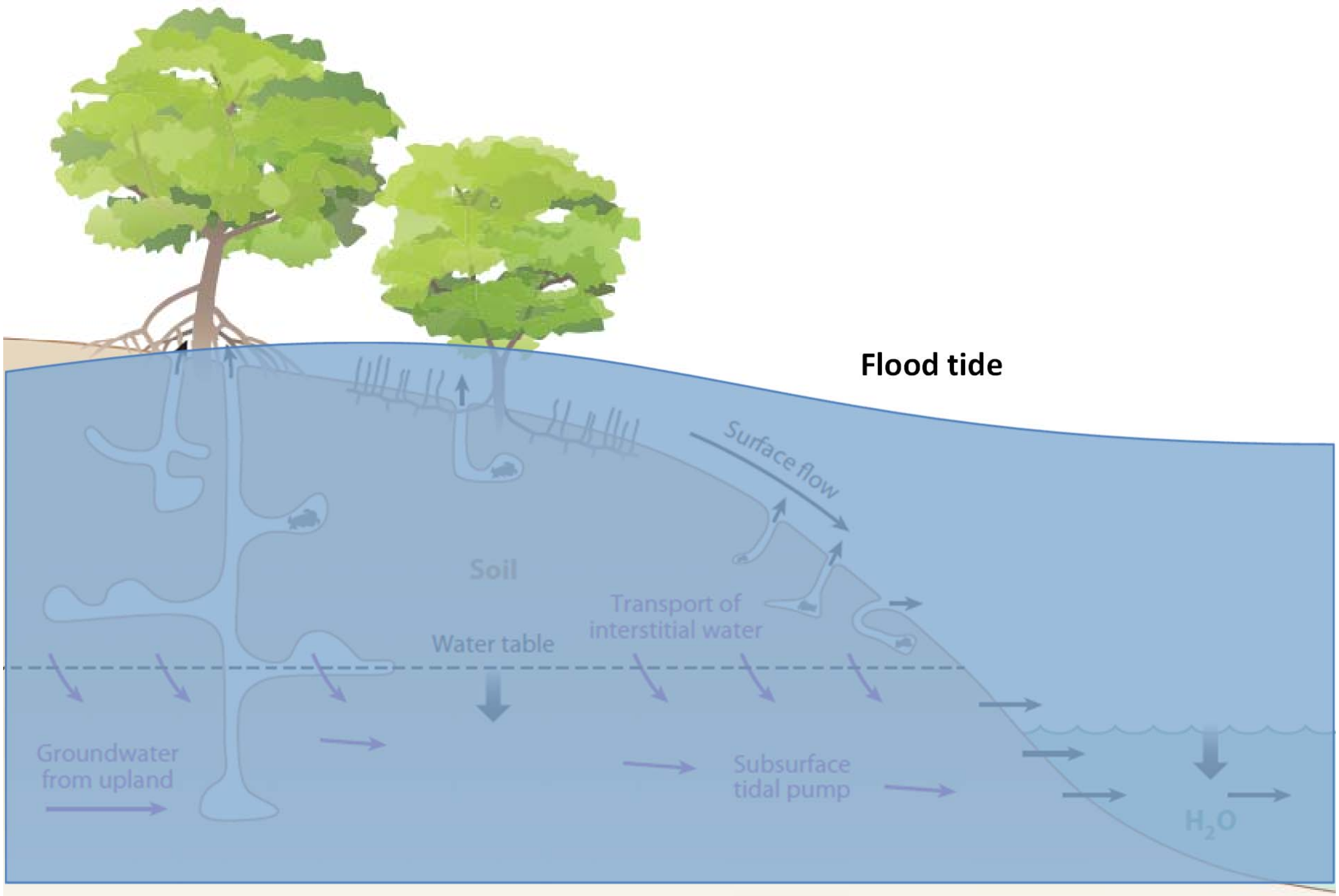
Context
NPP
Litterfall
CO2
efflux
Tidal export
Burial

1 Processes



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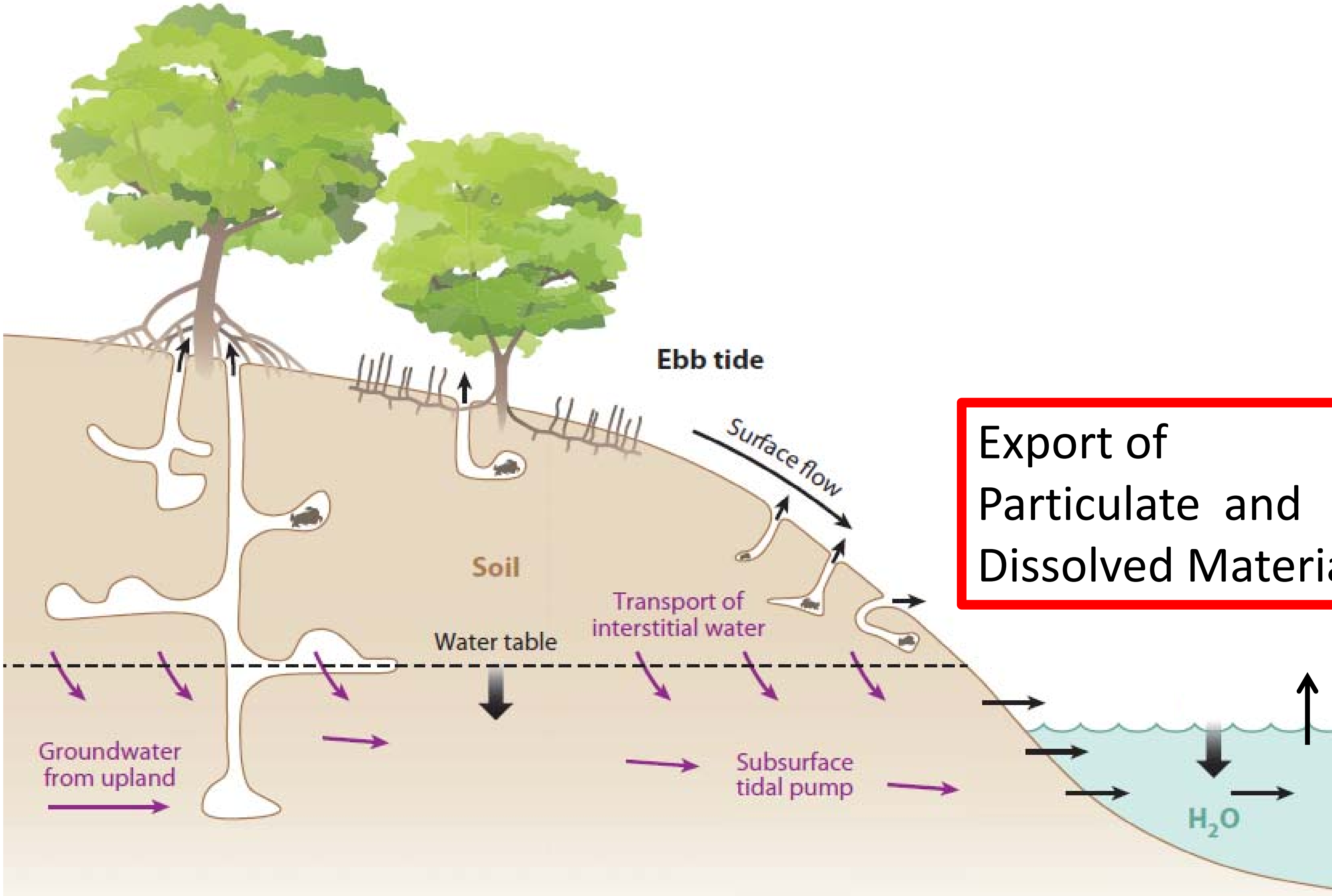
1 Processes



Export of Particulate and Dissolved Material

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1

Research Questions

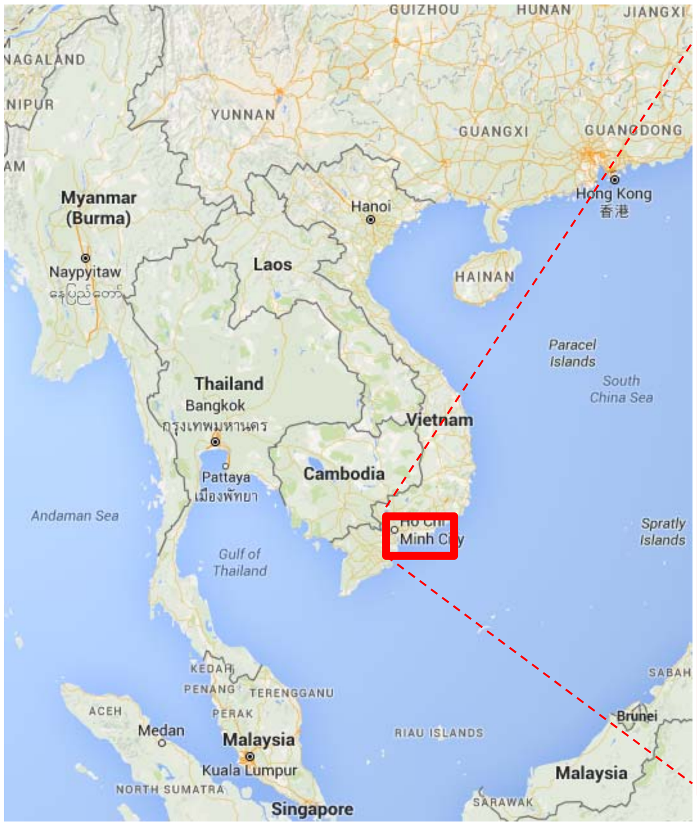
1. What is the contribution of **Porewater Discharge** for C and N?

2. Can we constrain the magnitude and processes of **carbon exchanges** in a **mangrove tidal creek**?

3. Do Mangroves **Assimilate or Release Nitrate**?

[Outwelling vs. Biofiltration]

2 Study Site – Can Gio Mangrove



Eastern Side of Mekong Delta (South Vietnam)

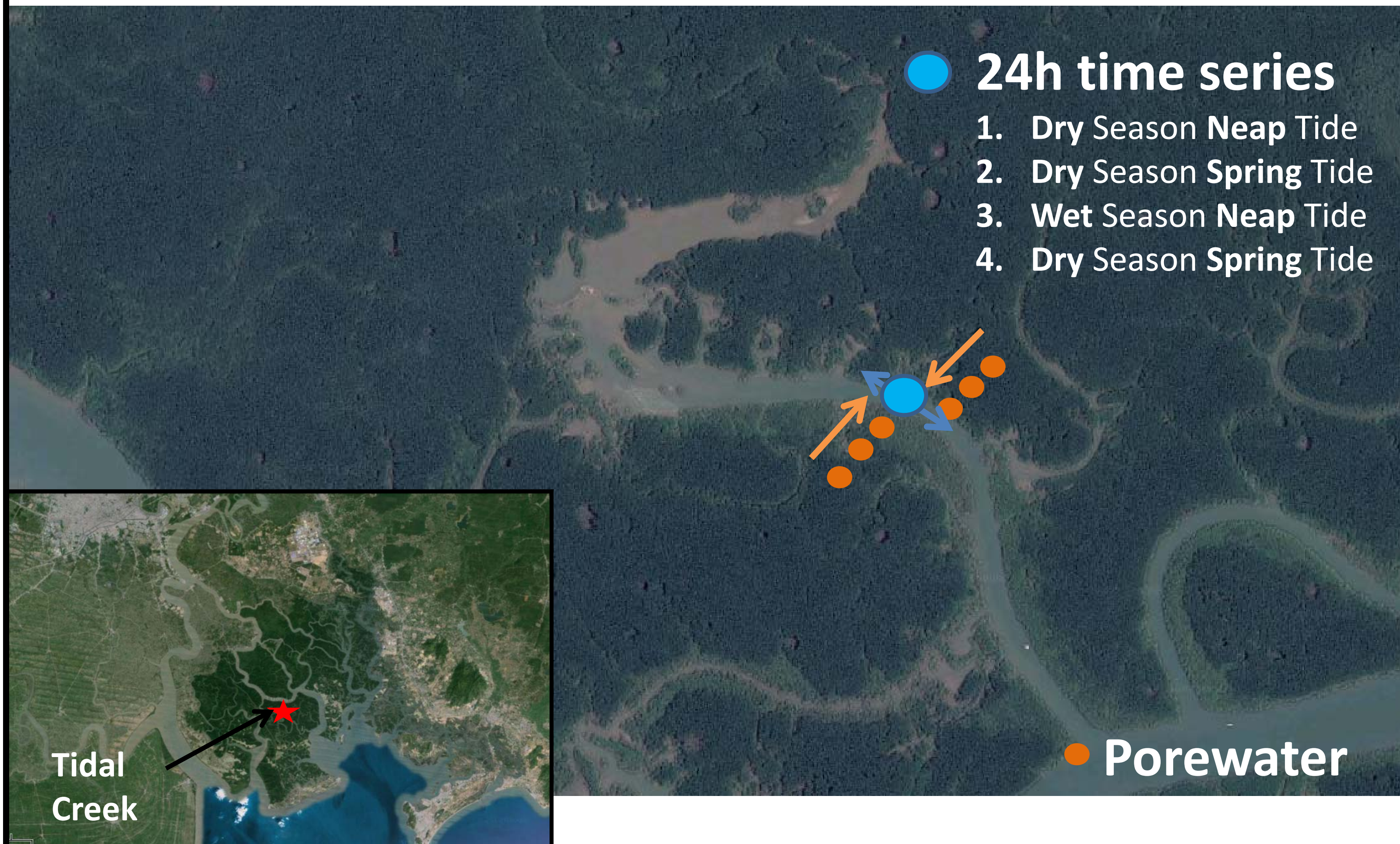
Can Gio UNESCO Biosphere Mangrove Reserve

Surface area: 35,000 ha

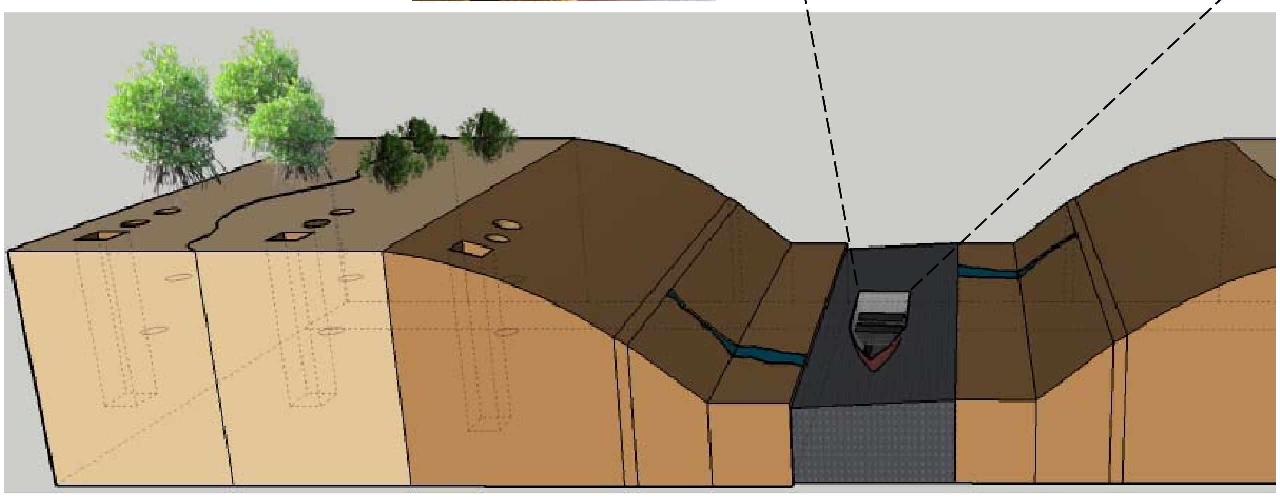
Dominant specie: Rhizophora A.

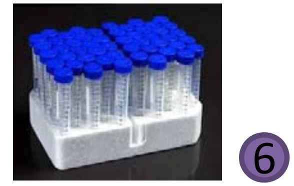
2

Study Site – Tidal Creek



2 Data collection – 24h time series





Continuous *in situ* measurements

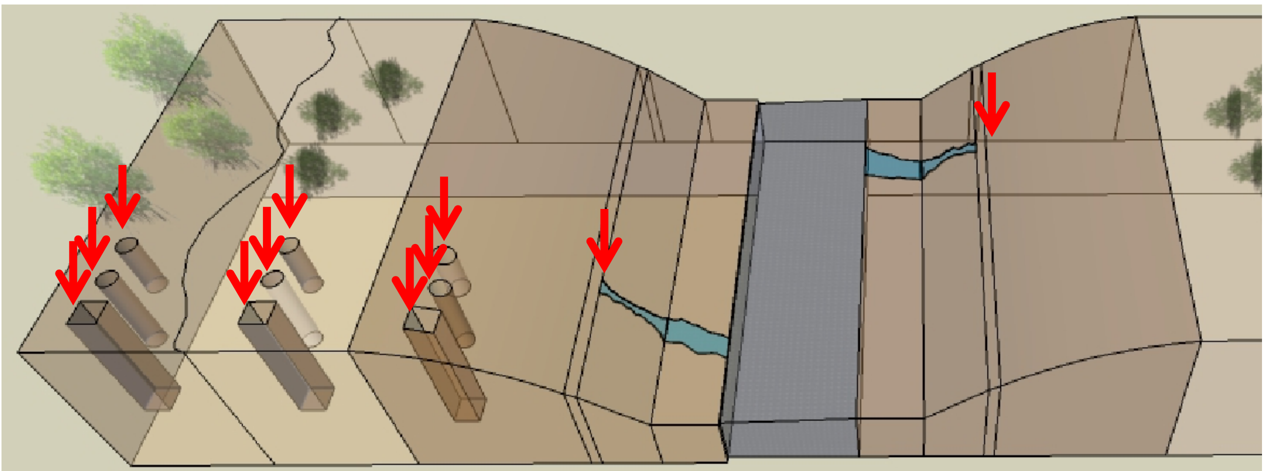
1 Air Temperature
1 Rainfall
1 Wind speed
1 Wind direction

2 Water Temperature
2 pH
2 Salinity
2 Dissolved Oxygen
3 ^{222}Rn

4 pCO_2
5 CO_2 efflux$_{(water/atm)}$

6 Surface and bottom water collection (n=13 X 4)

2 Data collection – Porewater



in situ measurements
2 Water Temperature
2 pH
2 Salinity
3 ^{222}Rn
4 Porewater collection (n=50)

Triplicated sampling

2

Data Analysis

	Concentrations			Stable Isotopes		Radioactive isotopes
Carbon	POC	DOC DIC	pCO_2 CO_2 efflux	$\delta^{13}C_{POC}$	$\delta^{13}C_{DIC}$ $\delta^{13}C_{DOC}$	
Nitrogen	PN	NH_4^+ NO_3^- NO_2^-		$\delta^{15}N$	$\delta^{15}N_{NO3}$ & $\delta^{18}O_{NO3}$	
Environmental Variables	pH, Salinity, Dissolved Oxygen, $Temp_{Water}$					^{222}Rn

Significance of each element

Origins and processes of transformation

Proxy for determining subsurface discharge

2 Data Analysis

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High definition

Multi criteria

Biogeochemical analysis

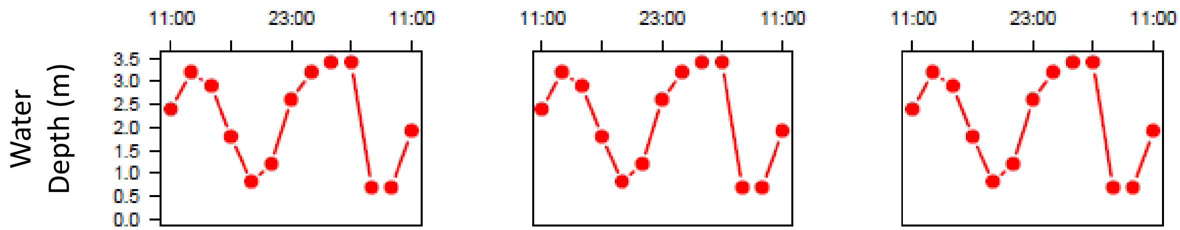
24

Significance of each element

Origins and processes of transformation

Proxy for determining subsurface discharge

3 Results - Carbon

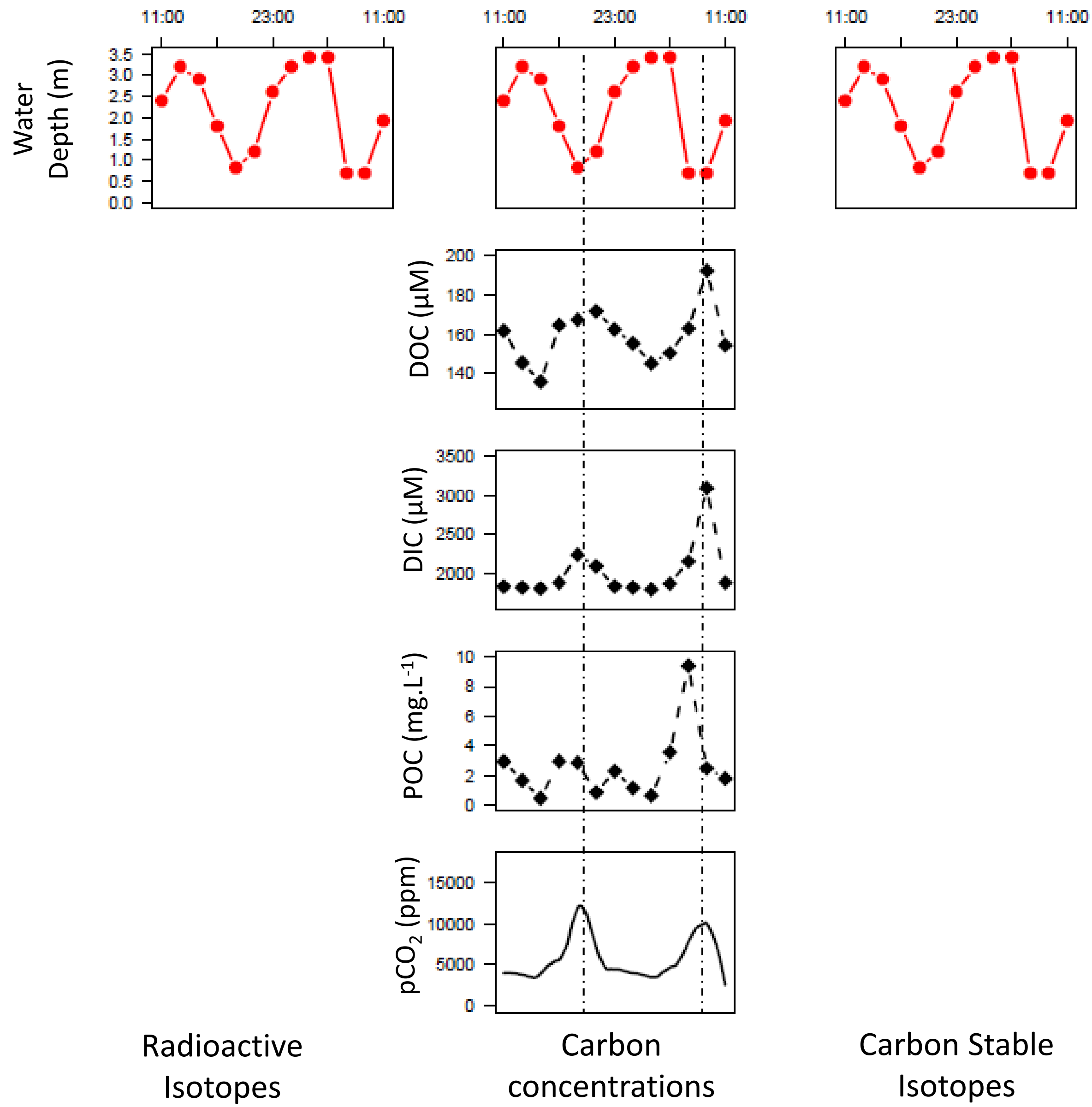


Radioactive Isotopes

Carbon concentrations

Carbon Stable Isotopes

3 Results - Carbon



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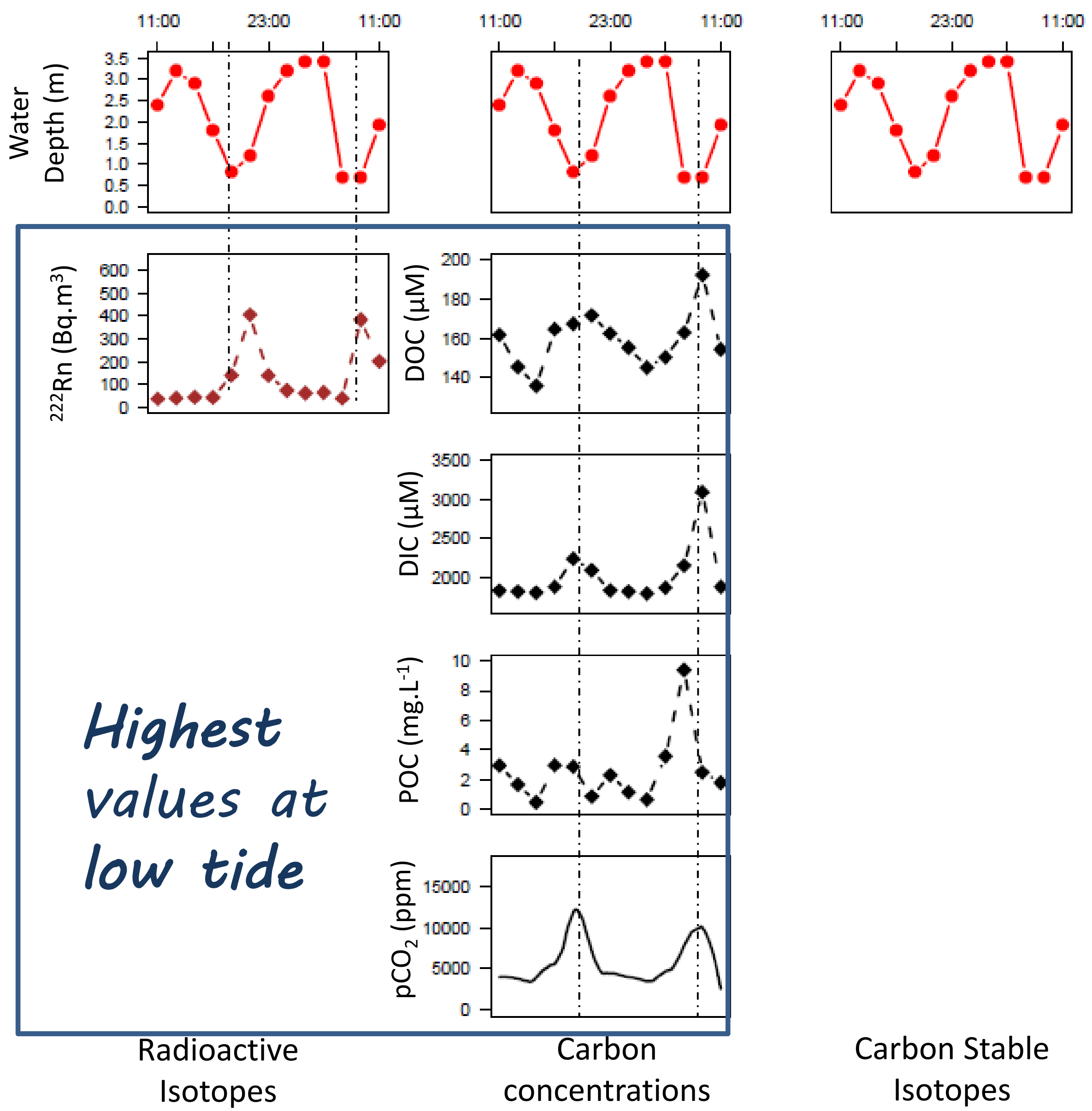

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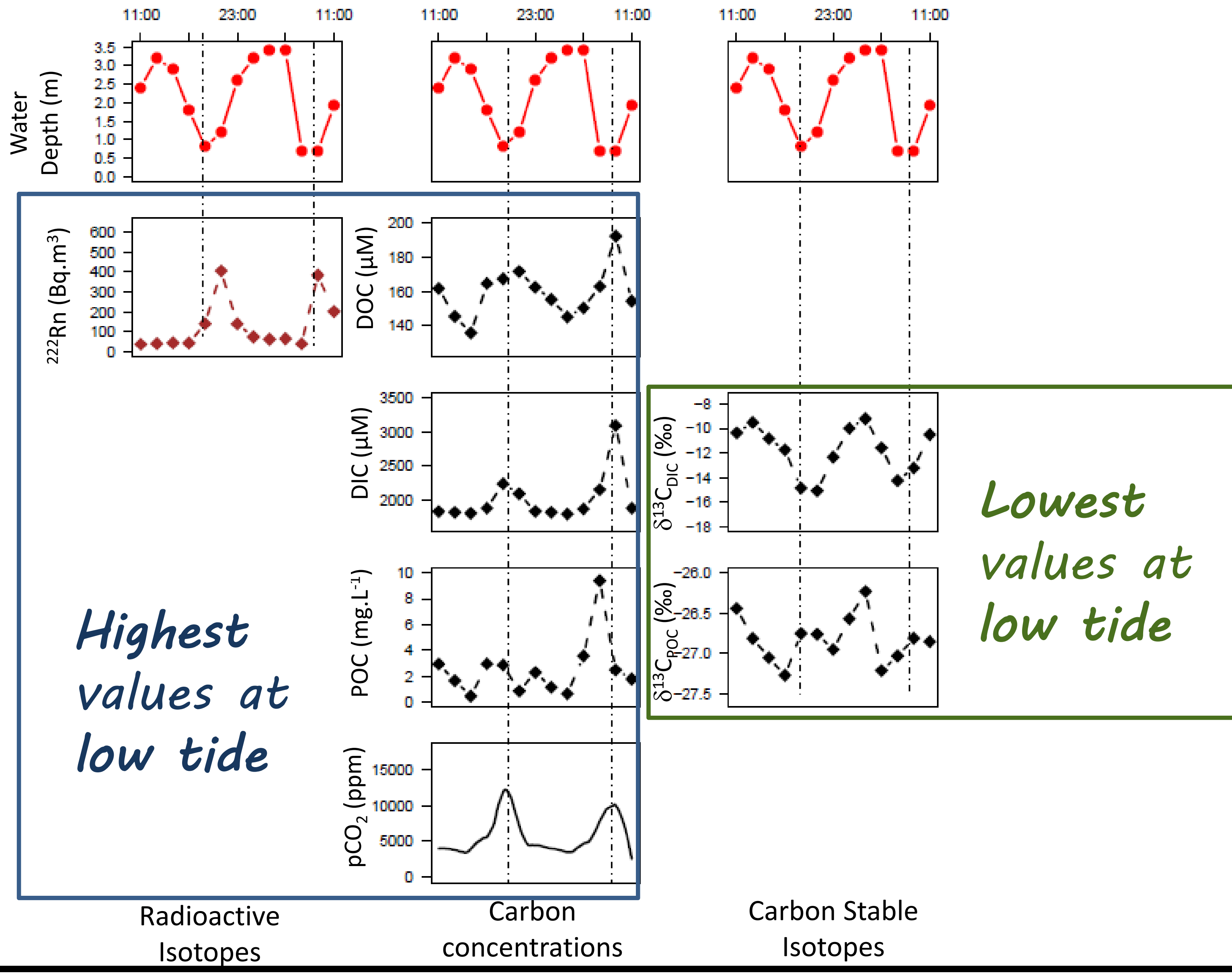

3 Two Sources Mixing Model

	<u>Source 1:</u> Mangrove (Porewater)	Low Tide	<u>Source 2:</u> Estuary (High Tide)
^{222}Rn ($Bq.m^{-3}$)			
DIC (µM)			
DOC (µM)			
$\delta^{13}C_{POC}$ (‰)			

DIC (µM)	
$\delta^{13}C_{dic}$ (‰)	

3 Two Sources Mixing Model

	Source 1: Mangrove (Porewater)		Low Tide		Source 2: Estuary (High Tide)
^{222}Rn (Bq.m^{-3})	$1214_{\pm 658}$	>	$265.68_{\pm 193}$	>	$56.8_{\pm 11.38}$
DIC (µM)	$4124_{\pm 2302}$	>	$2164_{\pm 492}$	>	$1880_{\pm 88}$
DOC (µM)	$249.4_{\pm 197}$	>	$159.9_{\pm 15}$	>	$147.7_{\pm 8.2}$
$\delta^{13}C_{POC}$ (‰)	$-27.91_{\pm 0.92}$	<	$-26.93_{\pm 0.64}$	<	$-26.7_{\pm 0.71}$

$$Porewater\ contribution = \frac{C_n[\delta_n] - C_{estuary}[\delta_{estuary}]}{C_{porewater}[\delta_{porewater}] - C_{estuary}[\delta_{estuary}]}$$

DIC (µM)	$4124_{\pm 2302}$	>	$2164_{\pm 492}$	>	$1880_{\pm 88}$
$\delta^{13}C_{dic}$ (‰)	$-19.29_{\pm 2.42}$	<	$-12.78_{\pm 2.57}$	<	$-9.19_{\pm 1.1}$

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	Source 1: Mangrove (Porewater)	Low Tide	Source 2: Estuary (High Tide)
^{222}Rn ($Bq.m^{-3}$)	$1214_{\pm 658}$	$265.68_{\pm 193}$	$56.8_{\pm 11.38}$
	22%$_{\pm 2.4\%}$	**78%**$_{\pm 2.4\%}$	
DIC (µM)	$4124_{\pm 2302}$	$2164_{\pm 492}$	$1880_{\pm 88}$
	14%$_{\pm 1.8\%}$	**86%**$_{\pm 1.8\%}$	
DOC (µM)	$249.4_{\pm 197}$	$159.9_{\pm 15}$	$147.7_{\pm 8.2}$
	14%$_{\pm 0.7\%}$	**86%**$_{\pm 0.7\%}$	
$\delta^{13}C_{POC}$ (‰)	$-27.91_{\pm 0.92}$	$-26.93_{\pm 0.64}$	$-26.7_{\pm 0.71}$
	26%$_{\pm 4.7\%}$	**74%**$_{\pm 4.7\%}$	

$$Porewater\ contribution = \frac{C_n[\delta_n] - C_{estuary}[\delta_{estuary}]}{C_{porewater}[\delta_{porewater}] - C_{estuary}[\delta_{estuary}]}$$

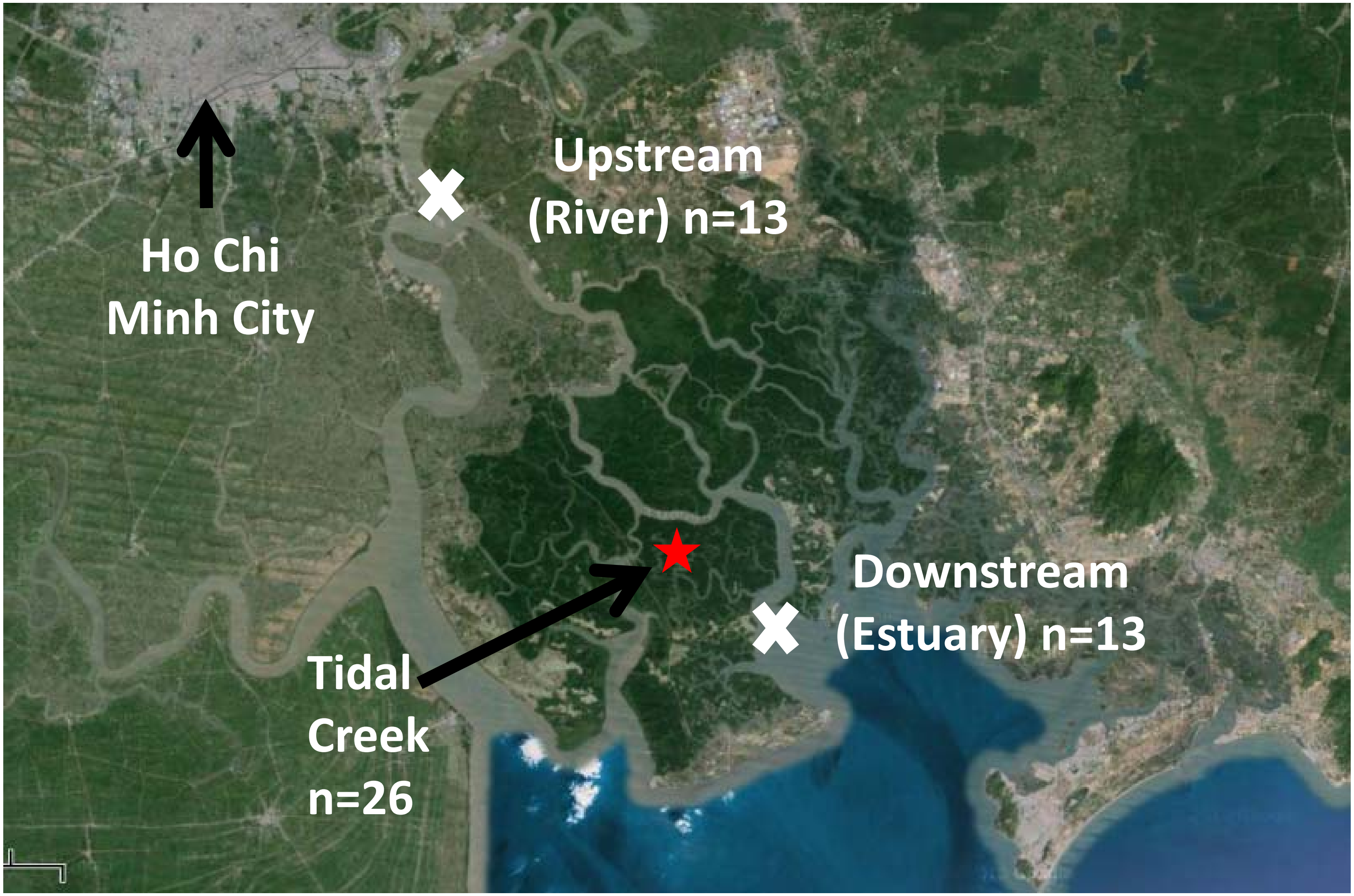
DIC (µM)	$4124_{\pm 2302}$	$2164_{\pm 492}$	$1880_{\pm 88}$
$\delta^{13}C_{dic}$ (‰)	$-19.29_{\pm 2.42}$	$-12.78_{\pm 2.57}$	$-9.19_{\pm 1.1}$
	19%$_{\pm 4.7\%}$	**81%**$_{\pm 4.7\%}$	

3

Discussion - Carbon

- Clear **tidal influence** with **highest concentrations at low tide**
- Release of **mangrove porewater at low tide** (^{222}Rn)
- Results refined previous study on (**sub)tropical mangroves** (Bouillon 2008, Maher 2013)
- Mangrove tidal creeks are **emitting sources of carbon** towards the coastal ocean and the atmosphere

3 Results - Nitrate



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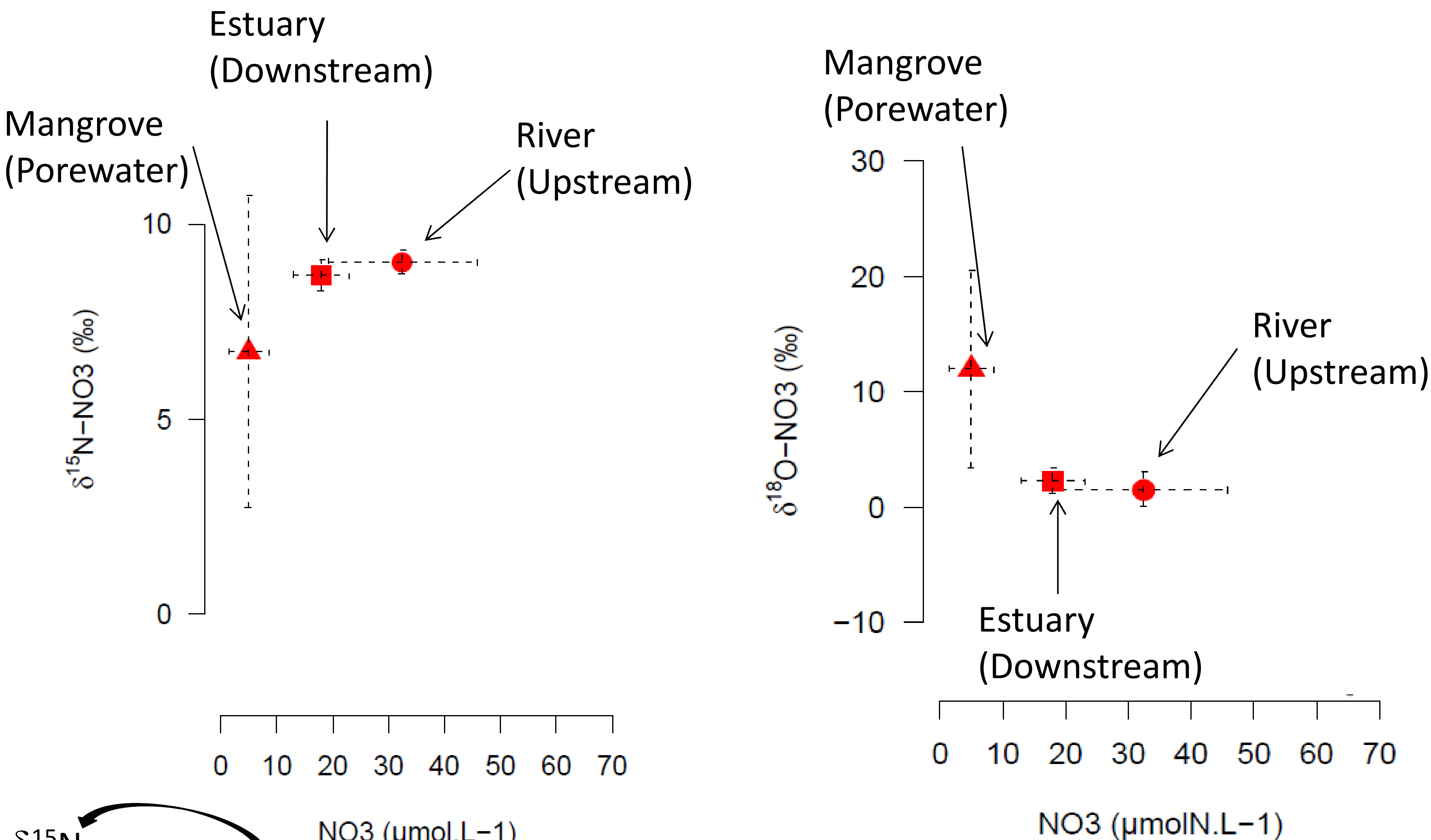

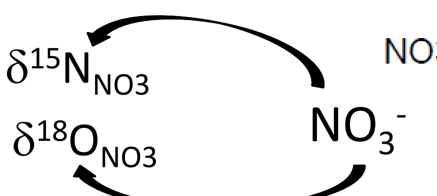

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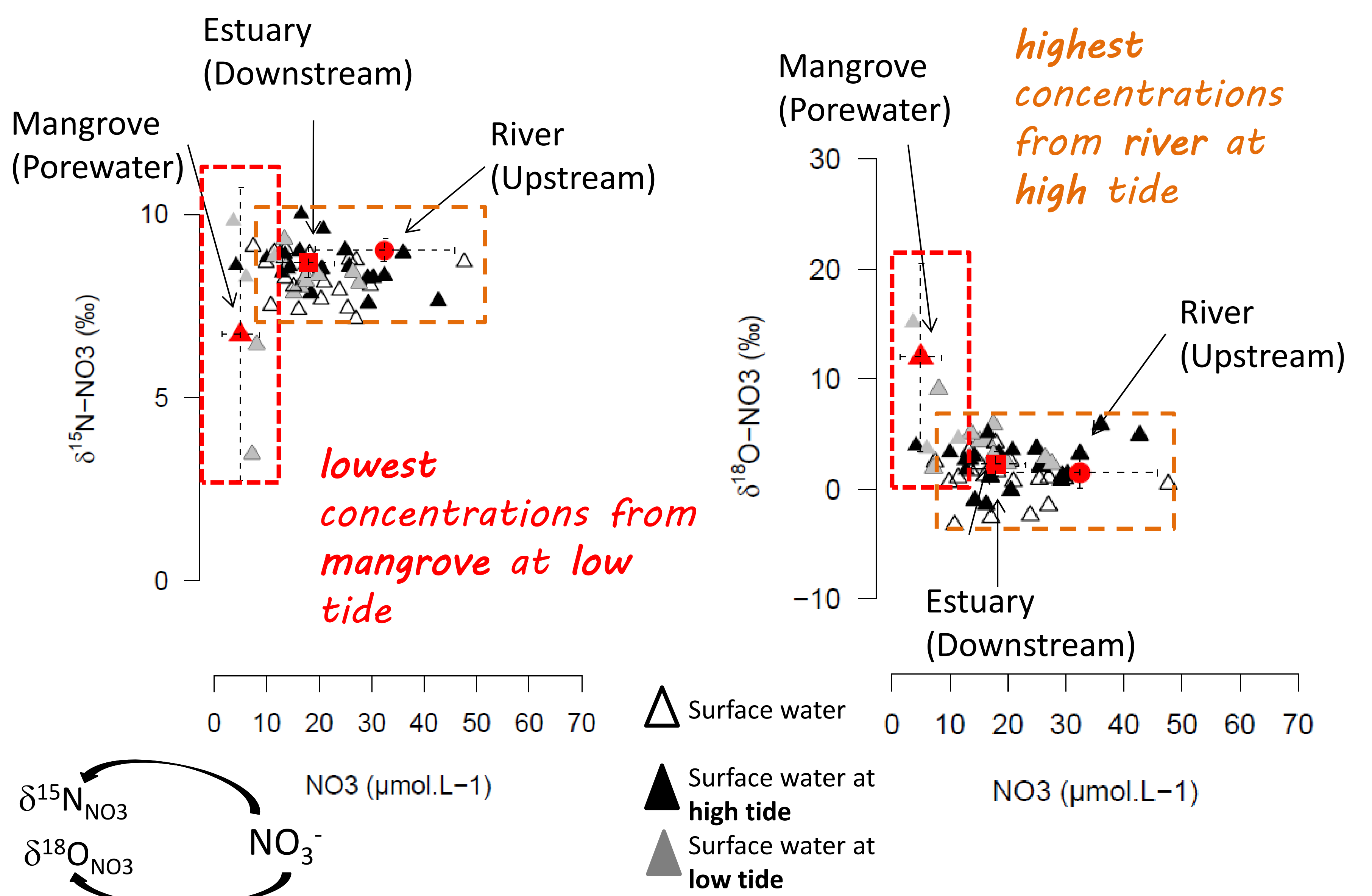


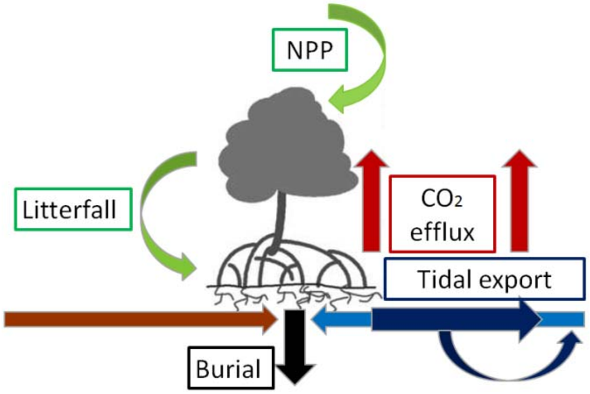
3 Discussion - Nitrate

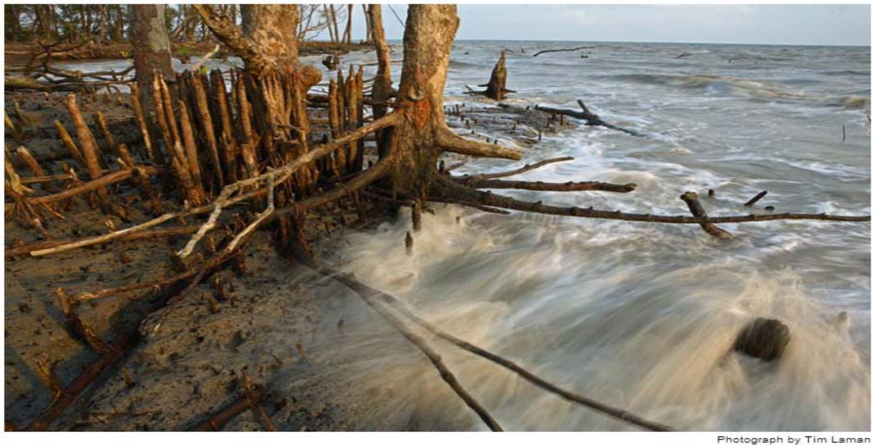
- Nitrate originating from **mangroves** is of **lower concentrations** (<15µM)

- **Highest nitrate** concentrations at **high tide** (>15µM), coming from **external (anthropogenic) source(s)**

- **Mangroves receive more nitrate** from external sources (anthropogenic) than they release it

4 Concluding Remarks





- Clear **influence of the tide variation** on biogeochemical lateral processes

- Significant **output** from mangrove **porewater seepage**

- Mangrove tidal creeks act as:
  - emitting **source of carbon** towards the coastal ocean and the atmosphere
  - **transiting area** for natural and anthropogenic **nitrate**

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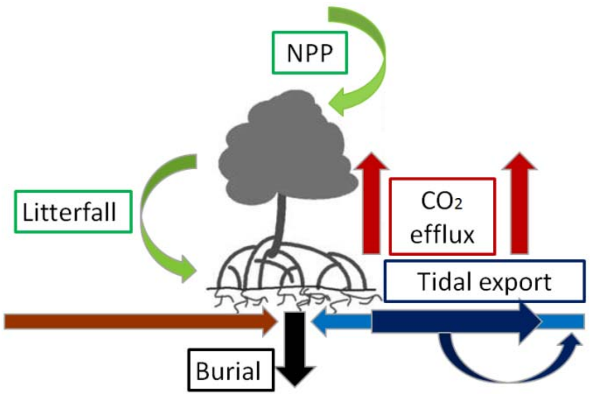

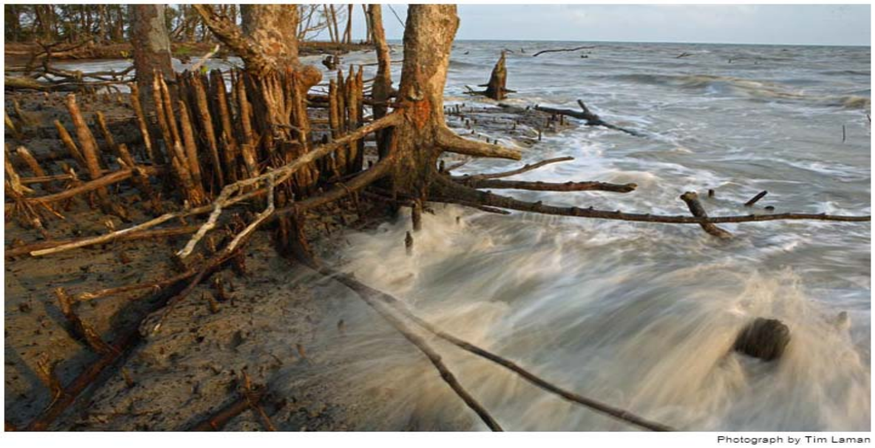

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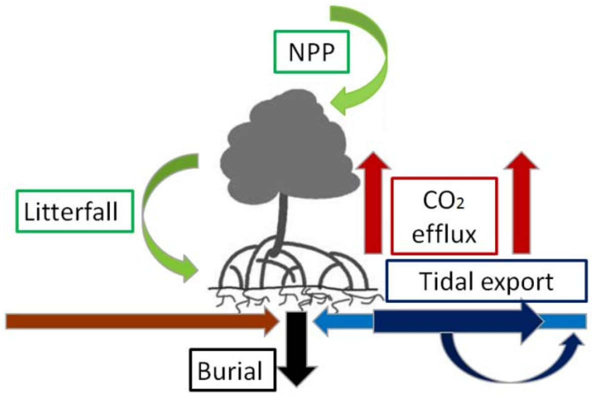
4 Future perspectives



Photograph by Tim Laman

- Describing the **CO_2 efflux** in the tidal creek
- Describing the **N cycle** within its **different forms and isotopes**
- Describing the **porewater properties** regarding the **vegetation stands**
- Applying the same research design to a **smaller** and more **impacted Mangrove Estuary** (Ranong Province, Thailand)

4

References

- Alongi DM. (2014) Carbon cycling and storage in mangrove forests. *Annual Review of Marine Science* 6: 195-219.

- Alongi DM and Mukhopadhyay SK. (2014) Contribution of mangroves to coastal carbon cycling in low latitude seas. *Agricultural and Forest Meteorology*.

- Bouillon S, Borges AV, Castañeda-Moya E, et al. (2008) Mangrove production and carbon sinks: a revision of global budget estimates. *Global Biogeochemical Cycles* 22: GB2013.

- Donato DC, Kauffman JB, Murdiyarso D, et al. (2011) Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience* 4: 293-297.

- Kuenzer C and Tuan VQ. (2013) Assessing the ecosystem services value of Can Gio Mangrove Biosphere Reserve: Combining earth-observation- and household-survey-based analyses. *Applied Geography* 45.