高屏峽谷之底棲生物食物網中的碳循環

Carbon Cycling in Benthic Food Web of the Gaoping Submarine Canyon

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Introduction

The Gaoping Submarine Canyon (GPSC) off Southwest Taiwan has been extensively studied for its geology and biological community structure. However, the carbon cycle across the sediment-water interface and environmental control on ecosystem functioning remained unclear. This study attempts to contribute knowledge gap in benthic foodweb by quantifying the carbon cycling in this SMR-fed submarine canyon ecosystem.

Aims of this study

1. Estimate the biotic and abiotic carbon stocks in the upper GPSC (abbreviated as GC1) and adjacent slope (abbreviated as GS1)
2. Examine whether the seasonal difference existed in these stock estimates.
3. Combine biological and geochemical data collected at GC1 and GS1 from 2014 to 2020 and literature data to compare the carbon fluxes between the two sites.
4. Construct linear inverse models (LIM) to compare carbon flows in simplified food webs.
5. Use selected network indices to examine the ecosystem function and characteristics of the GC1 and GS1 foodwebs.

Materials and Methods

- **Sampling sites**

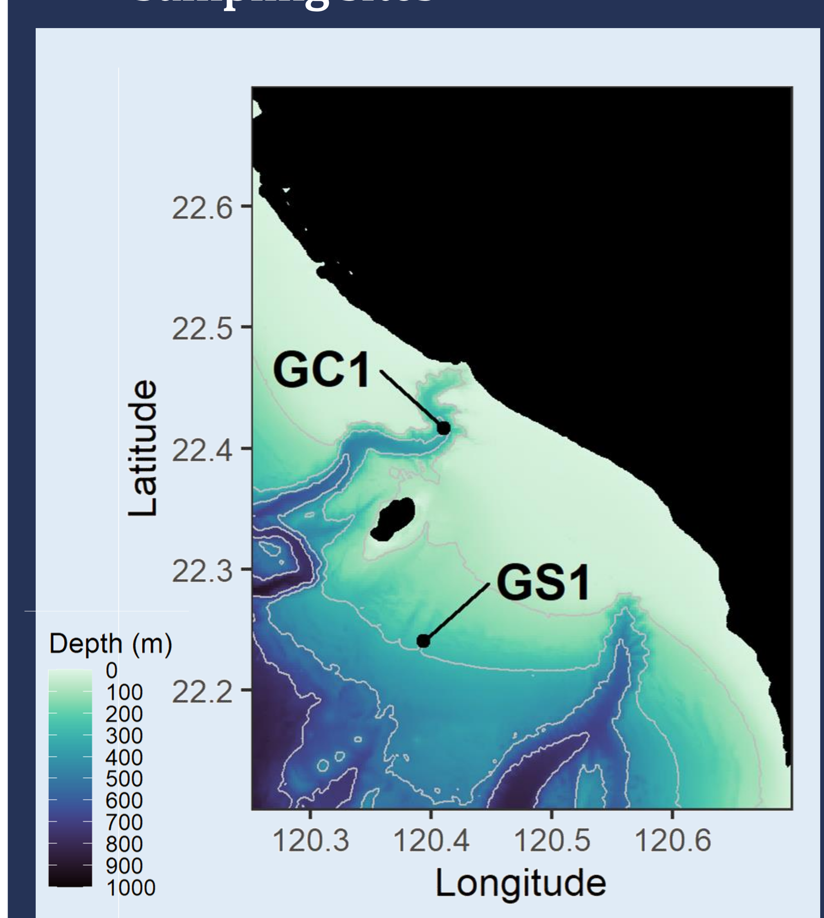
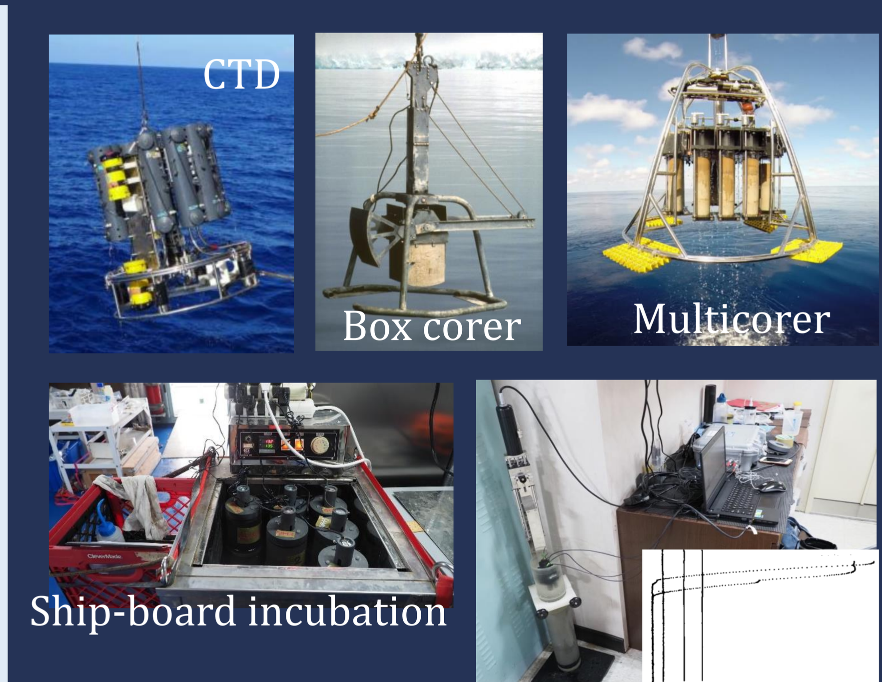


Figure 1. The map of sampling stations of the upper Gaoping Submarine Canyon (GC1) and Gaoping Slope (GS1).

∗ GC1: 120.41°E, 22.41°N
∗ GS1: 120.40°E, 22.23°N

- **Sampling gears**



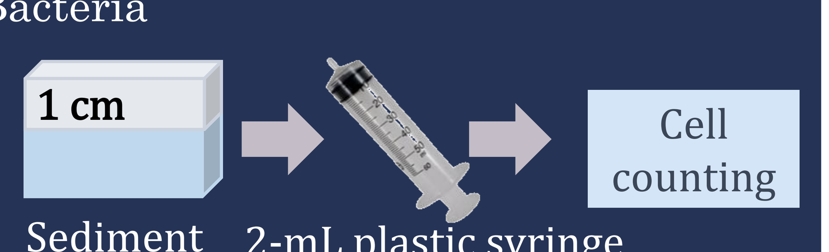
- **Sampling cruises (2014/11-2020/11)**

SP (2-4)	OR1_1099, OR1_1102, OR1_1128, OR1_1132, OR1_1190, OR1_1219
SU (8)	OR1_1026
AU (10-11)	OR1_1096, OR1_1126, OR1_1151, OR1_1242, NOR1_T004

- **Carbon Stocks**

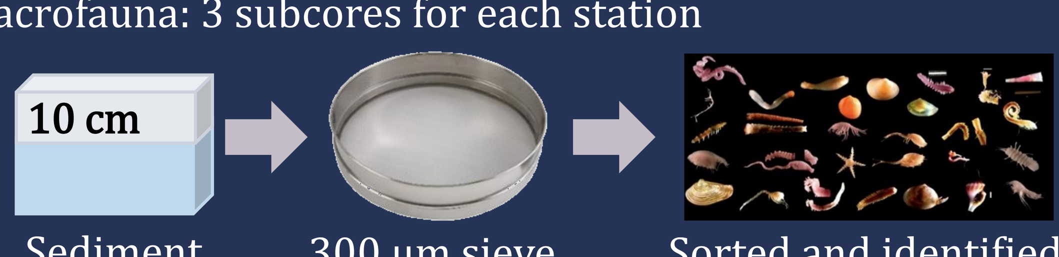
Detritus

Bacteria



Meiofauna: 1 subcore from each deployment

Macrofauna: 3 subcores for each station



All samples were adequate converted to mg C/m^2

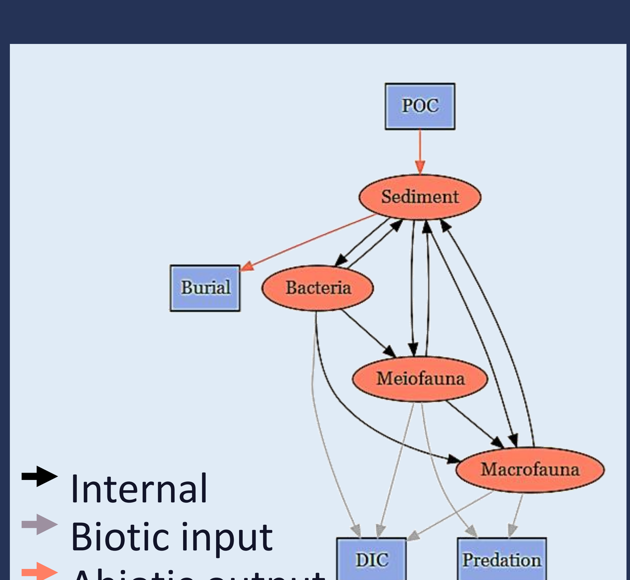


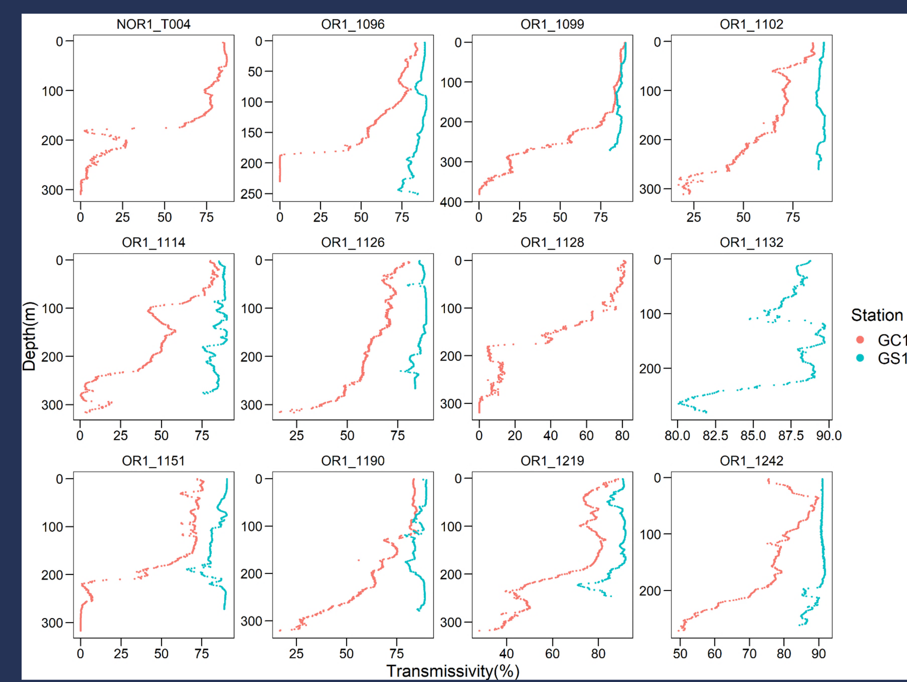
Figure 2. The conceptual model of the food web structure formed the basis of our linear inverse model (LIM).

- **LIM modelling**

1. Decide structure
2. Set carbon stocks
3. Set Constraints
   - Sedimentation rate (Site)
   - Sediment burial efficiency (Site)
   - Growth efficiency (Ref)
   - Maintenance respiration (Ref)
   - Production to Biomass ratio (Ref)
4. Calculate by MCMC algorithm

Results

- **Environment data**



Station	Average bottom water temp (°C)	*Tlim*
GC1	13.54	1.05
GS1	13.90	1.09

Table 1. Average bottom water temperature and the calculated *Tlim* of GC1 and GS1.

Figure 3. Light transmission profile for each cruise of the two sites. Note that GC1 has a very low light transmission below 200 meter depth in almost all the sampling cruises.

- **Carbon stocks** N.S.D in Seasonality in all stocks

Compartment	GC1	GS1
Detritus	350270 ± 104003.4	**524425.7 ± 34800.15**
Bacteria	**65.31 ± 12.74**	42.80 ± 6.75
Meiofauna	1.49 ± 1.53	**33.39 ± 26.48**
Macrofauna	3.65 ± 7.70	**80.20 ± 66.10**

Table 2. Standing stocks (in mg C/ m^2) as mean± standard deviation of the food web compartments for GC1 and GS1.

- **Model results**

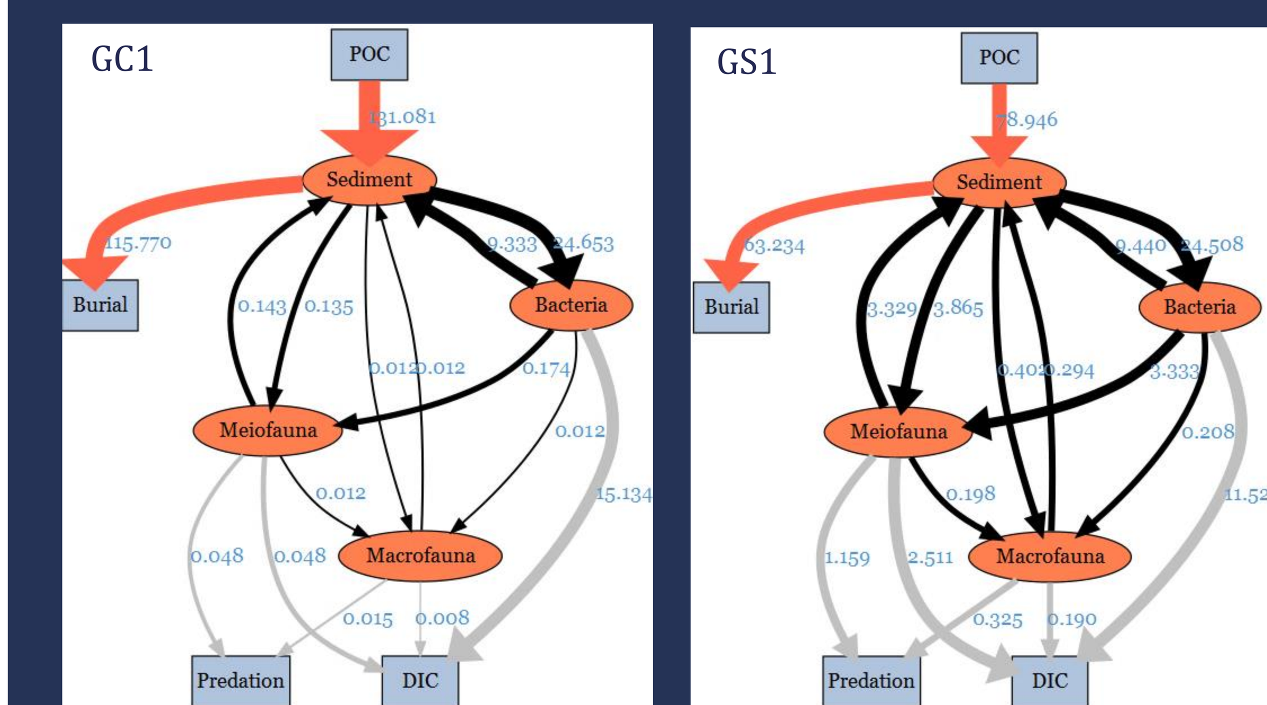


Figure 4. The conceptual model plotted with LIM results of GC1 and GS1 processed with the MCMC algorithm. The flows were drawn to scale.

GC1
- POC demand: 131.08 mg C/ m^2/ d
- Burial: 88% of the POC input
- Strong interactions between bacteria and the environment
- Remaining flows less than 1 mg C/ m^2/ d

GS1
- POC demand: 131.08 mg C/ m^2/ d
- Burial: 80% of the POC input
- Metazoan contribution increased

- **Turnover rate**

Station	OC_{Total}/TOU (yr)	OC_{Bac}/DOU	$OC_{(Meio+Macro)}$/BMU	Method
GC1	13.22	3.2970	0.0824	Direct measurement
	62.94	4.3155	44.6422	Model results
GS1	19.80	3.6654	1.8318	Direct measurement
	101.02	3.7129	42.0642	Model results

Table 3. Stock turnover calculated with the two different estimations of oxygen utilization rates.

- **Network indices**

Network indices	Fraction	Significance
Total system throughput (T..)	0.9987	*** (GC1>GS1)
Total system throughflow (TST)	0.9623	*** (GC1>GS1)
Finn cycling index (FCI)	0.1034	Marginally GC1< GS1

Table 4. Comparison of network indices calculated for GC1 and GS1.The numbers indicate the fraction of network values that are higher in GC1.

Conclusion

This study is the first to use the food web model to understand carbon cycling in the GPSC and on the adjacent slope. Moreover, it is the first study that applied the LIM technique in Taiwan. The standing stocks of each compartment were significantly different between the two habitats. The relatively lower biodiversity and faunal carbon stocks show that the canyon is a fragile ecosystem under severe physical perturbation. The model results revealed that the bacteria-related process dominated the canyon head of the GPSC. By contrast, the higher contribution of fauna in carbon processing on the adjacent slope presents a relatively mature ecosystem. In addition, our models revealed a higher carbon burial rate in GC1, indicating that the GPSC not only transports sediment to the deep SCS but functions as a carbon sink, contributing to carbon sequestration. Owing to the ongoing climate change, the geohazards in the submarine canyons might become more frequent due to new weather systems with a higher intensity of flooding in SMRs. By better understanding carbon cycling in submarine canyons like GPSC, we may be able to predict the impact of climate change or human influence on deep-sea ecosystems.