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Rapid Estimation of Marine Benthos Abundance Using "sedimentary DNA": A Case Study of the Burrowing Decapod *Upogebia major* in Tidal Flats

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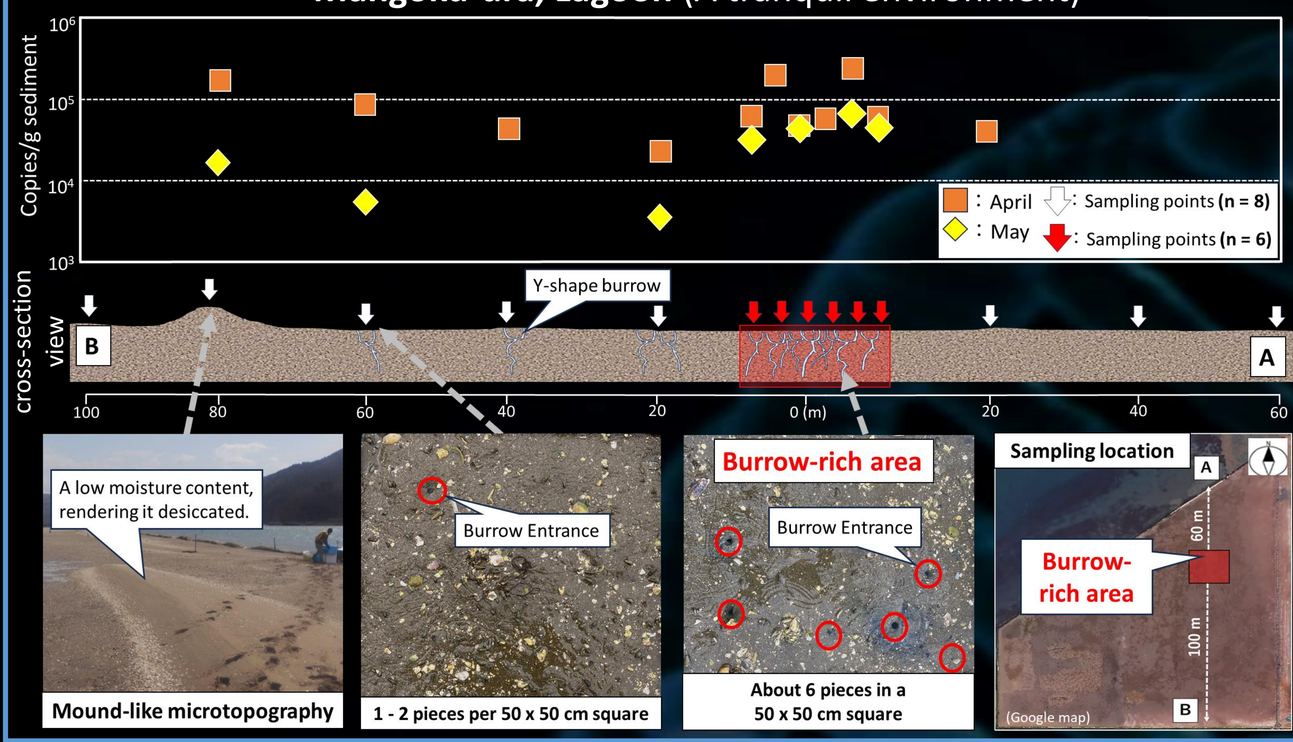
Summary

- A quantitative assessment of environmental DNA (**sedimentary DNA**; sedDNA) within sedimentary deposits originating from the **marine benthos—a pioneering study**!
- **The concentration of sedDNA has the potential to reflect the extant biomass of benthos**, yet it is suggested to be subject to fluctuations due to **biological** and **physical factors**.
- Further accumulation of fundamental research is required to apply sedDNA analysis for estimating the current biomass of **fisheries resources**.

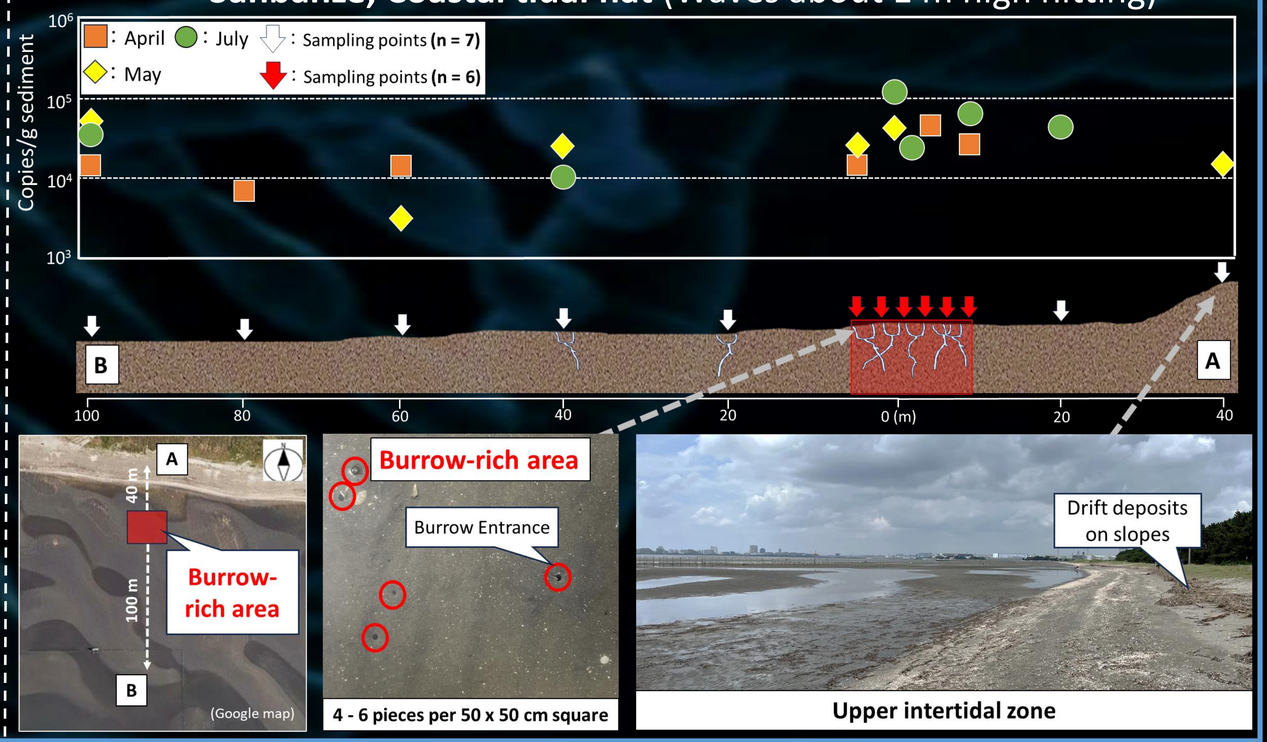
Results

Seasonal sedDNA concentration (copy numbers) of *Upogebia major* in lagoon and coastal tidal flat

Mangoku-ura, Lagoon (A tranquil environment)



Sanbanze, Coastal tidal flat (Waves about 1 m high hitting)



Discussion

① Difference in sedDNA concentration between the burrow-rich area and others

【Mangoku-ura】 F-test, $p > 0.05$

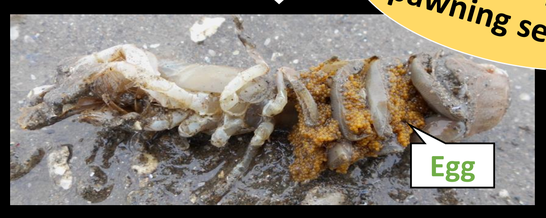
April: No significant difference. Detected in **wide area**.

May: **The burrow-rich area were significantly higher**.

May ⇒ There is a possibility that it **reflects abundance**

April ⇒ Is the spawning period involved?

Is April the peak spawning season?



Egg-bearing individuals were collected only in **April** at Mangoku-ura.

【Sanbanze】

Every month: **No significant difference & widely detected.**

Is **wave action** involved?

Strong water flow → transported at the **concentration at the time of generation**. (Jane et al. 2015)

Due to the effects of **wave action**...
Concentration differences ↓
Detection range ↑ ?

Did the eggs and larvae, among others, **disperse extensively**?

The diffusion of eDNA during the spawning period has also been reported for *Acanthopagrus schlegelii*. (Sasano et al. 2022)

② Relationship between microtopography and sedDNA

High concentrations of sedDNA were detected in raised sediments.

There is a possibility of being transported by water flow and subsequently **re-deposited**.

sedDNA can be **preserved over the long term** through adsorption to **clay minerals**. (Turner et al. 2015)

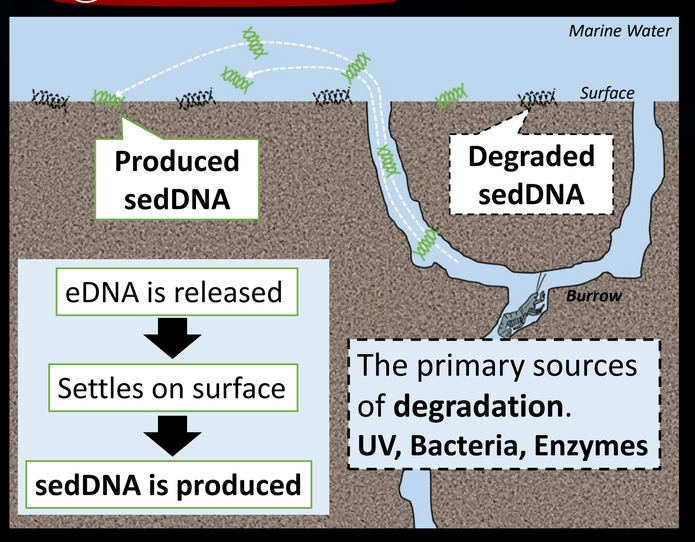
Future prospects

To interpret concentration data ...

Estimation of **production** and **degradation rates** is necessary!

Through tank experiments, we are empirically measuring the production and degradation rates for each of **"Season", "Growth stage", "Particle size"**

① Future tasks



② Application to fisheries

sedDNA concentrations fluctuate depending on biological and physical factors... However, **they may also reflect existing abundance**!

Potential for application in **fisheries** if this novel method is established.

For example,
Asari clams ***Ruditapes philippinarum***,
(an important fisheries resources both in France and in Japan)

The commonality between *U. major and R. philippinarum* is...

Low mobility **Filter-feeder** **Benthic infauna** → **Knowledge of *U. major* can be applied to other species .**

In the future, **fundamental research will be indispensable** for the application of sedDNA analysis in **fisheries**!

Introduction

Upogebia major × sedimentary DNA (sedDNA)

Upogebia major

- **Filter-feeder**
  → Contributes to **water purification** (Dworschak, 1981)
- **Forms Y-shaped burrows more than 2 m deep**
  →Hosts a variety of **symbionts** in its burrows and body (e.g. Seike & Goto, 2020)
- **Dominant species in parts of Japan and Korea** (Hong, 2013)

In order to quantitatively assess the impact of the presence and behaviour of *U. major* on the coastal environment...
→ **distribution** and **abundance** needs to be determined!

Conventional methods of quantification are...
Collection & counting of burrows

We aimed to develop a novel method utilizing **environmental DNA** (eDNA).

The detection of American bullfrog DNA in the water of a pond in **France** served as the **inception of eDNA analysis**.

The concentration of eDNA is...
Sediment > Water (e.g. Sakata et al. 2020)

Estimating presence/absence with a sample of about **1 g**
→ **distribution** area can be estimated with high accuracy! (Sakata et al. 2021)

About a spoonful

The purpose of this study

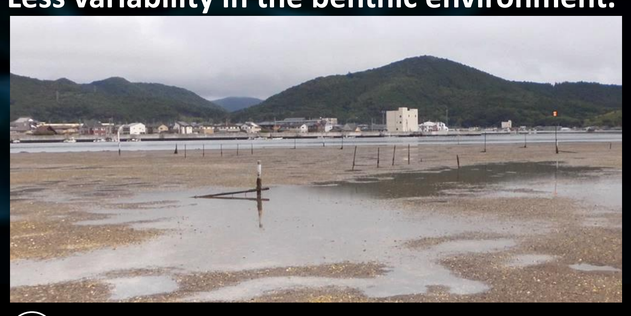
To estimate current **abundance** from sedDNA...

Verification of the concordance between the abundance of *U. major* (Burrow Density) **and the concentration of sedDNA!**

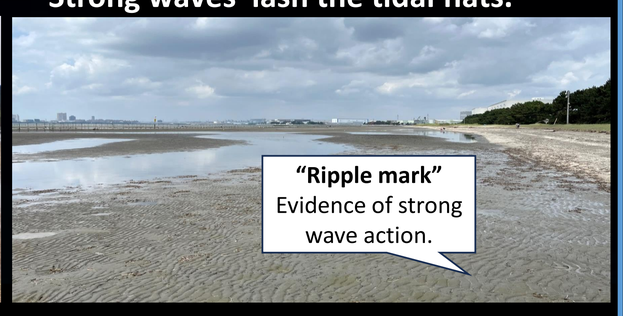
Materials & Methods

① Sampling sites

- **Mangoku-ura, Lagoon** (Miyagi)
  Less variability in the benthic environment.



- **Sanbanze, Coastal tidal flat** (Chiba)
  Strong waves lash the tidal flats.



② Sampling of sediments

- **6 samples** from high-abundance areas (burrow-rich areas).
- Within 100 m of the burrow-rich area, **1 sample** was collected every 20 m.

About a spoonful

③ sedDNA analysis

Sampling → **sedDNA extraction** → **Quantification of copy numbers using qPCR**

Species-specific primers and **probes** were designed based on the molecular phylogenetic data of the *U. major* (Kitabatake et al., in press).

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