Monitoring of estuarine fish compositions using an environmental DNA metabarcoding

Shinya Hosokawa

Head of Marine Environmental Information Group,
Port and Airport Research Institute (PARI), Japan

Topics

- What's environmental DNA (eDNA)?
- Advantages of the eDNA technology
- Challenges in using eDNA technology in estuaries and coasts
- What will eDNA technologies contribute?
- Collaborations with open data platform
- Conclusions

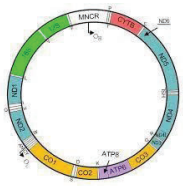
What's environmental DNA (eDNA)?

- Environmental DNA (eDNA): DNA released in the environments
- eDNA technology: Technology for detecting trace amounts of eDNA

DNA released from each individuals in the environments

https://ednasociety.org

Nuclear DNA
(Wikipedia)

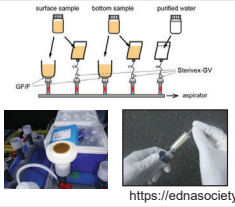


Mitochondrial DNA
(Nagoya City University)

What's environmental DNA (eDNA)?

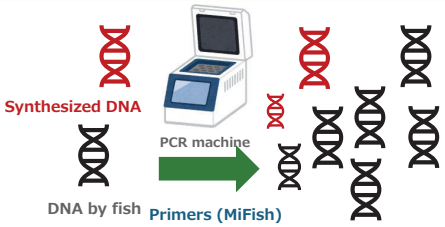
- A process for detecting fish species using eDNA technology

Water sampling → to laboratory → Filtration → DNA extraction



https://ednasociety.org

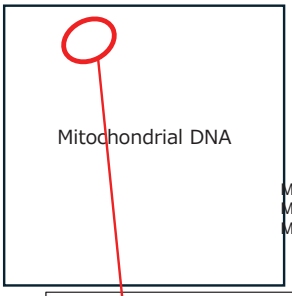
DNA amplification → Next generation sequencer → Data analysis



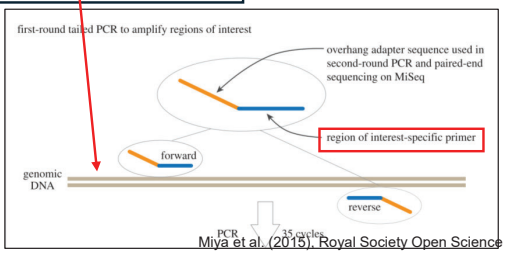
Copy numbers of each species

What's environmental DNA (eDNA)?

- Detection performance is dependent on "primers."
- MiFish is a powerful primer set for detecting fish composition.

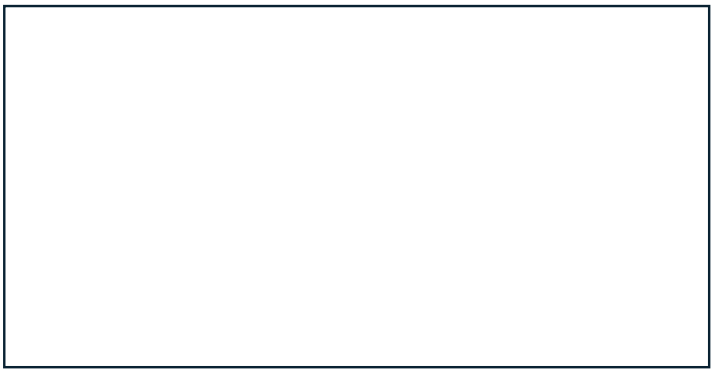


MiFish-U: Universal primer
MiFish-Ev2: Primer for elasmobranchs
MiFish-U2: Primer for Pseudoblennius species



Miya et al. (2015), Royal Society Open Science

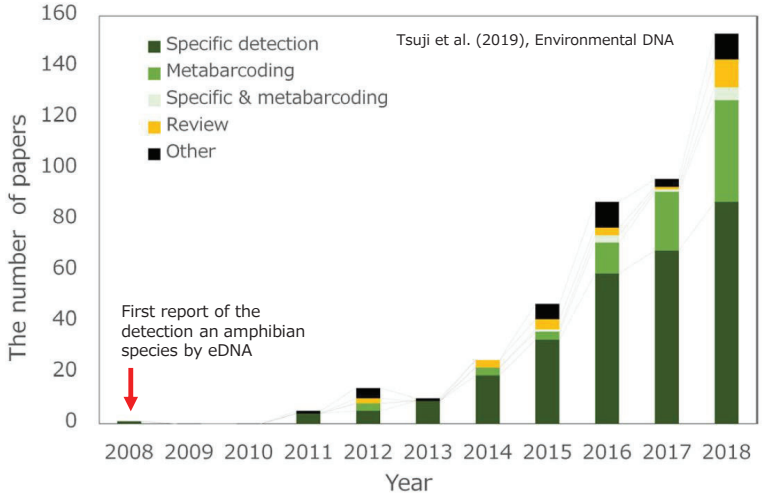
Universal region for fish | Hypervariable region (*ca* 170 bp) | Universal region for fish



Base (A: Adenine, T: Thymine, G: Guanine, C: Cytosine)
Colors mean the types of base.

What's environmental DNA (eDNA)?

- Widely studied and used in the fields of research and development
- Many suppliers of the eDNA technology (in Japan)

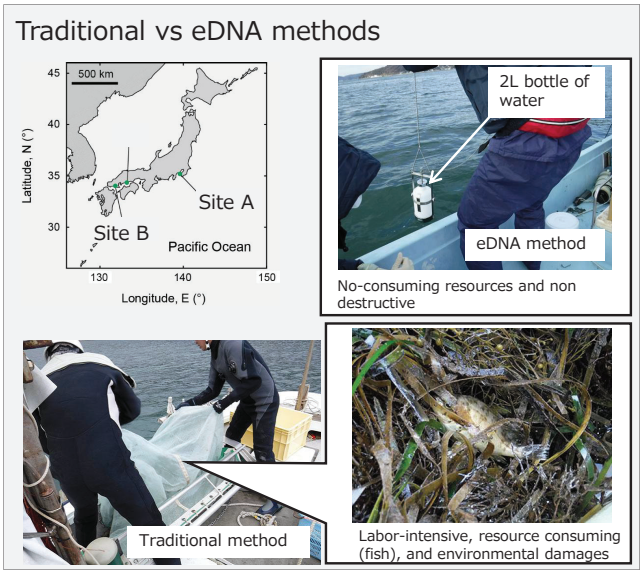


Specific detection:

Metabarcoding:

Advantages of the eDNA technology

- Performance of the eDNA metabarcoding in fish species
- Detection by eDNA metabarcoding >> Catchment by a traditional method



	Site A (Kurihama Bay)	Site B (Kasado Bay)
Traditional and eDNA methods	Acentrogobius pflaumii (21/24)	Acentrogobius pflaumii (13/24)
	Aulichthys japonicus (1/24)	Paracentropogon rubripinnis (1/24)
	Ditrema viride (24/24)	Pseudoblennius cottoides (3/24)
	Favonigobius gymnauchen (10/24)	Rudarius ercodes (9/12)
	Gobiidae (24/24)	Sebastes cheni (15/24)
	Heteromycteris japonica (1/24)	Sebastes inermis (15/24)
	Paracentropogon rubripinnis (22/24)	Syngnathus schlegeli (1/24)
	Plotosus japonicus (2/24)	
	Pseudoblennius cottoides (7/24)	
	Pseudoblennius percoides (7/24)	
	Pterogobius (5/24)	
	Rudarius ercodes (14/24)	
	Sebastes cheni (19/24)	
	Sebastes inermis (19/24)	
	Syngnathus schlegeli (1/24)	
	Takifugu pardalis (23/24)	
Only traditional	Apogonichthyoides niger	Hippocampus coronatus
	Hippocampus coronatus	
	Pholis crassispina	
Only eDNA	Carassius cuvieri, ゲンゴロウブナ (1/24)	Carassius spp., フナの種 (3/24)
	Cyprinus carpio, コイ (21/24)	Lepomis macrochirus, ブルーギル (1/24)
	Oncorhynchus sp., タイヘイヨウサケ属の1種 (1/24)	Other 44 species
	Paramisgurnus, ドジョウ属 (1/24)	
	Other 58 species	

Hosokawa et al. (2020), Tech Note PARI, No.1373

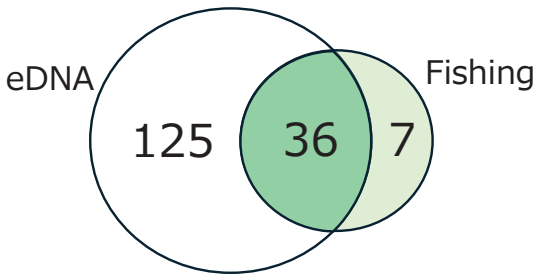
Advantages of the eDNA technology

- Performance of the eDNA metabarcoding in fish species
- Detection by eDNA metabarcoding >> Catchment by fishing

YFP（https://honmoku.yokohama-fishingpiers.jp/choka.php）

- Fish records by the Yokohama Fishing Piers (YFP)
- eDNA sampling and metabarcoding analysis

Between
January 2021 and March 2023



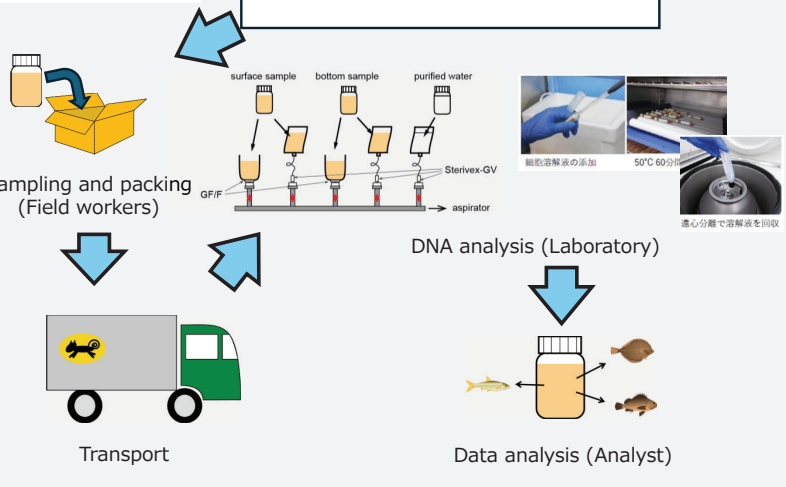
Munakata et al. (2024), the 71st Coastal Engineering, JSCE

Advantages of the eDNA technology

- Good performance
- Non-destructive
- Cost-effective: Need several processes but effective

Methods using eDNA technology

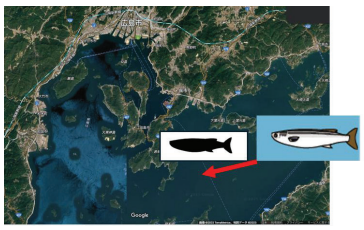
Traditional methods
- Need many workers
- Time-consuming
- Environment-destruction



Challenges in using eDNA technology in estuaries and coasts

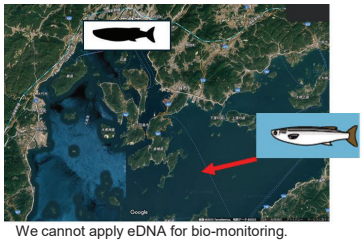
- Does the eDNA distribution mean the fish distribution?

Suitable eDNA degradation:

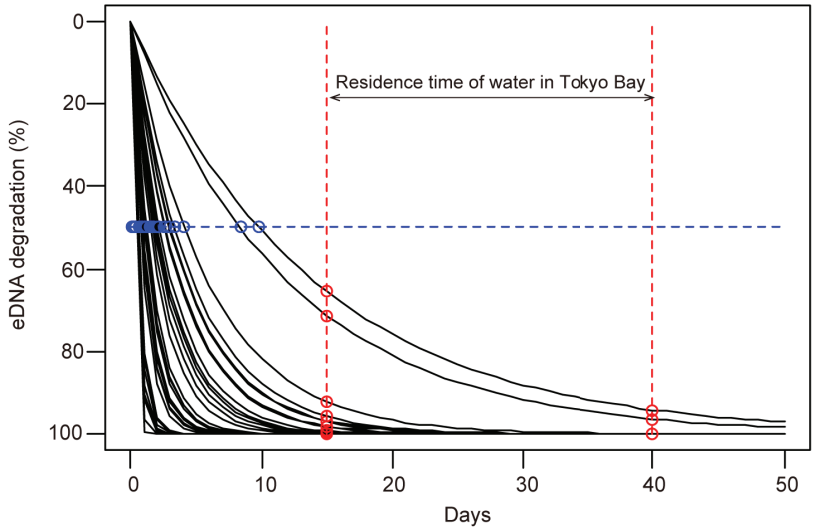


We can use eDNA for bio-monitoring.

Without eDNA degradation:



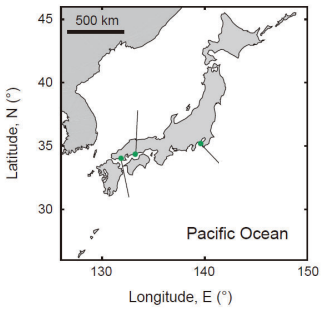
We cannot apply eDNA for bio-monitoring.



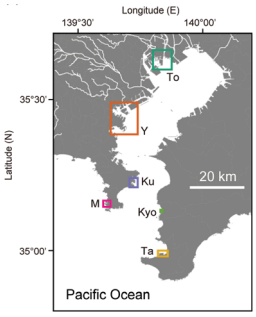
Collins et al. (2018) Communications Biology

Challenges in using eDNA technology in estuaries and coasts

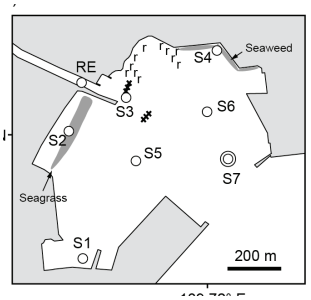
- Thousands of meters of dispersal in marine areas (Jo et al. 2025)



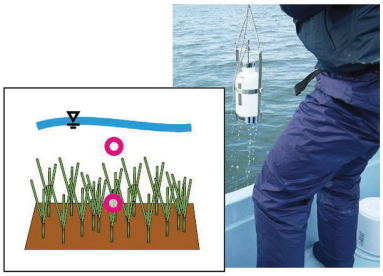
Hosokawa et al. (2020), Tech Note PARI, No.1373
Hosokawa et al. (2023), Tech Note PARI, No.1406



Hosokawa & Homma (under review)
Environmental DNA



Homma et al. (2025),
Environmental DNA



Momota et al. (2022), MEPS

✓ Regional scale

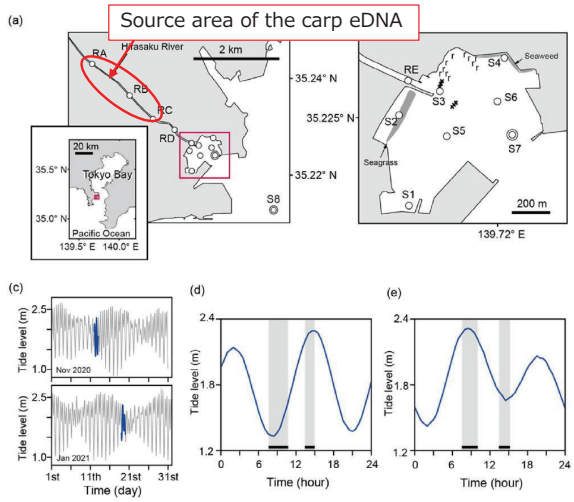
✓ Tokyo Bay scale

Hundreds of kilometer — Few meters

Spatial scale

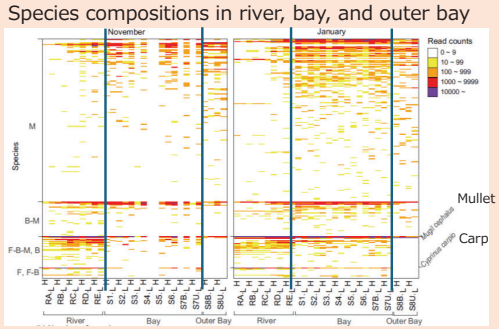
Challenges in using eDNA technology in estuaries and coasts

- Topographical changes govern the distribution of eDNA.



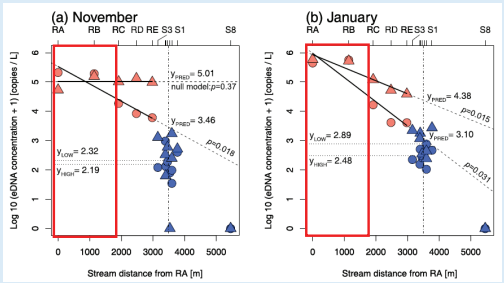
Homma et al. (2025), Environmental DNA

Metabarcoding: Species compositions in river, bay, and outer bay



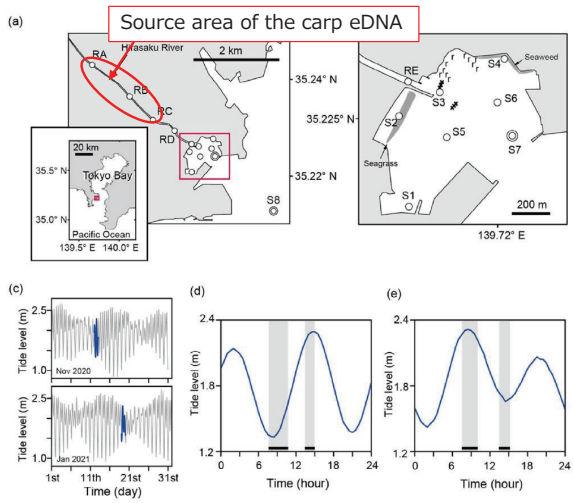
F: Freshwater species
B: Brackish species
M: Marine species

Species-specific analysis: The eDNA conc. of carp decreased in the bay.



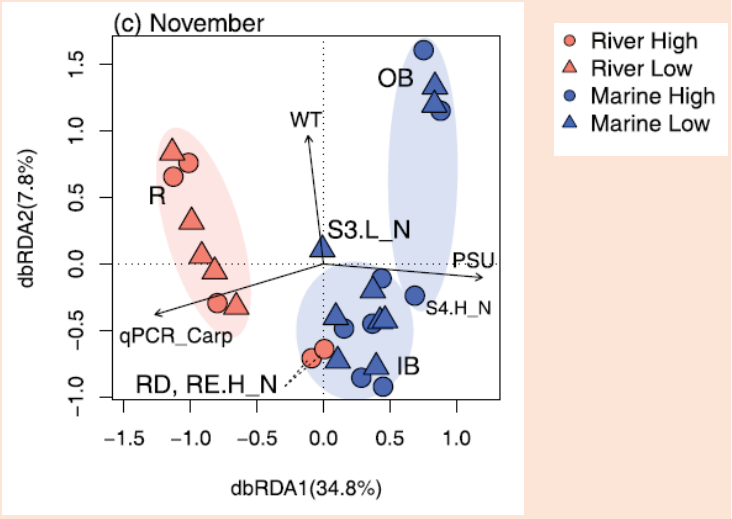
Challenges in using eDNA technology in estuaries and coasts

- Geographical transition zone is not suitable for eDNA monitoring.



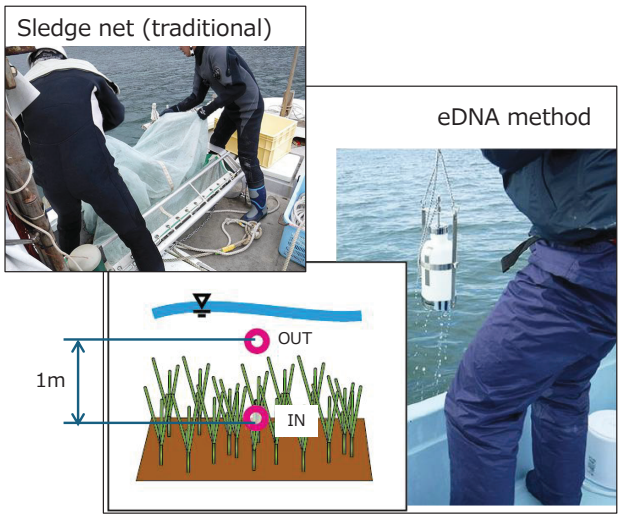
Homma et al. (2025), Environmental DNA

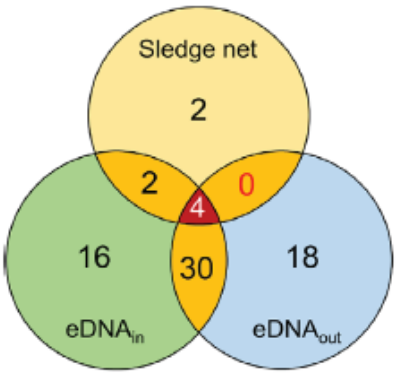
Metabarcoding: Species compositions in river, bay, and outer bay



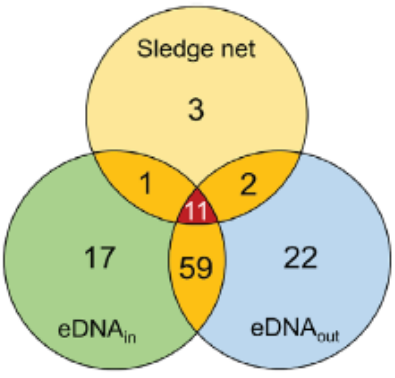
Challenges in using eDNA technology in estuaries and coasts

- eDNA captures the small-scale heterogeneity of fish diversity in the vegetations.





Site B (Kasado Bay)

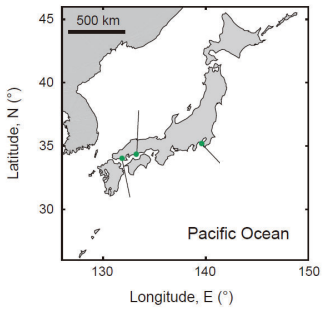


Site A (Kurihama)

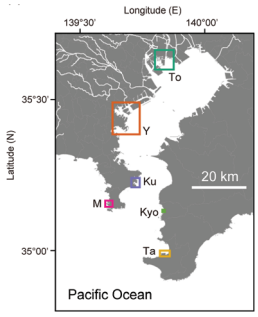
Momota et al. (2022), MEPS

Challenges in using eDNA technology in estuaries and coasts

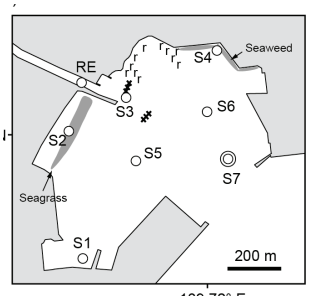
- Thousands of meters of dispersal in marine areas (Jo et al. 2025)
- Topography and vegetations are key factors of the eDNA distributions in fine scale.



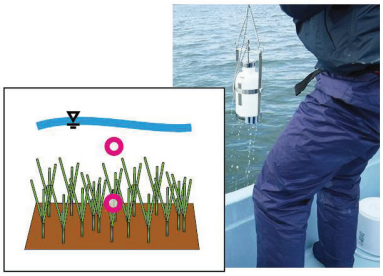
Hosokawa et al. (2020), Tech Note PARI, No.1373
Hosokawa et al. (2023), Tech Note PARI, No.1406



Hosokawa & Homma (under review)
Environmental DNA



Homma et al. (2025),
Environmental DNA



Momota et al. (2022), MEPS

✓ Regional scale

✓ Tokyo Bay scale

Hundreds of kilometer — Few meters

Spatial scale

Challenges in using eDNA technology in estuaries and coasts

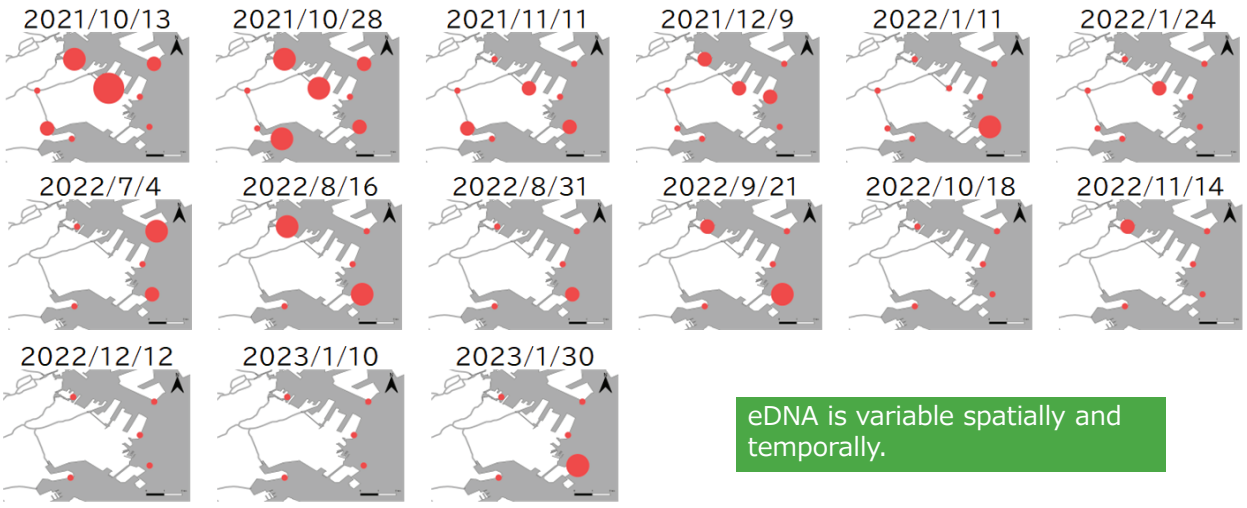
- DNA concentration of Black sea bream in Yokohama Port (yy/mm/dd)

Wikipedia

Acanthopagrus sp. (Black sea bream)

eDNA (copies/uL) : 0 — 603

(quantified by qMiFish)



eDNA is variable spatially and temporally.

Munakata et al. (2024), the 71st Coastal Engineering, JSCE

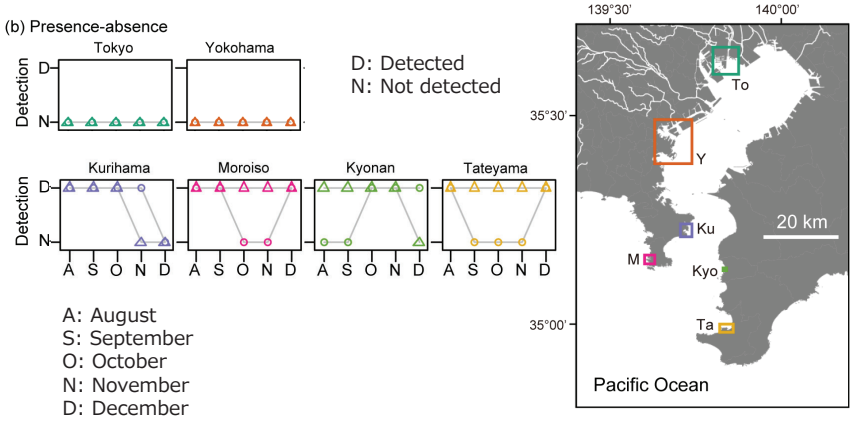
What will eDNA technologies contribute?

- Vegetations have been damaged by the mottled spinefoot in recent years.
- eDNA can detect the presence of the mottled spinefoot along the Pacific Ocean.

Siganus fuscescens (Mottled spinefoot)

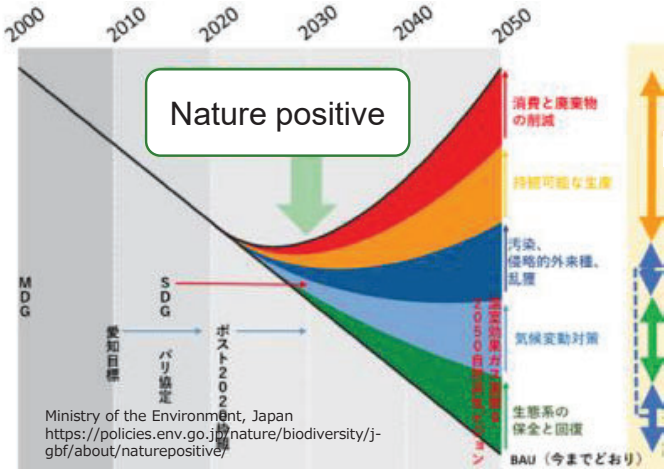
Fig. 9. A thallus of *Ec. cava* with bare medullary layers of a stem that was forced to be exposed by heavy browsing of *S. fuscescens*.

Fig. 10. Bite marks left on a *Ec. cava* stem by *S. fuscescens*. Bundles of short linear grooves are due to the jaw teeth of *S. fuscescens*. Bars = 5 mm.



What will eDNA technologies contribute?

- Monitoring for the biodiversity change is important. However, targets are unclear.
- eDNA metabarcoding can capture the biodiversity and is suitable for the monitoring many species and biodiversity changes.



Ministry of the Environment, Japan
https://policies.env.go.jp/nature/biodiversity/j-gbf/about/naturepositive/

Kunming-Montreal Global Biodiversity Framework
2050 Vision

A world of living harmony with nature

Ministry of the Environment, Japan
https://policies.env.go.jp/nature/biodiversity/j-gbf/about/naturepositive/

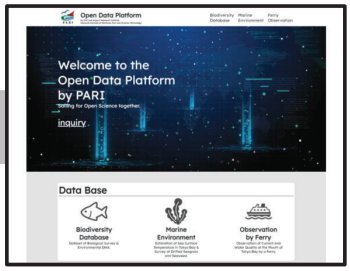
2030 Mission

To take urgent action to halt and reverse biodiversity loss to put nature on a path to recovery

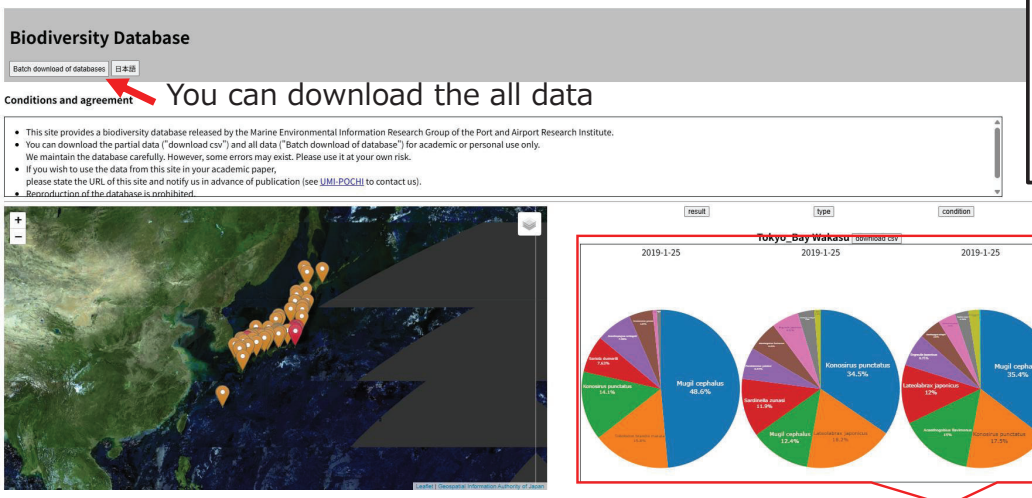
Nature positive

Collaborations with open data platform

- Visualization tool for eDNA data (UMI-POCHI)



https://pari.mpat.go.jp/biodiversity/



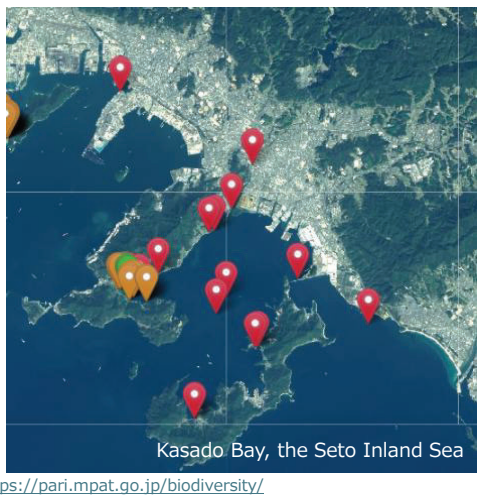
UMI-POCHI is an open data platform produced in PARI

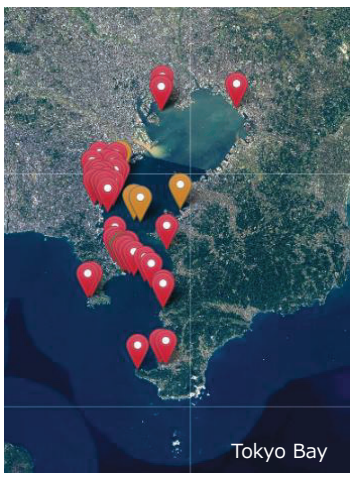
Visualization of the eDNA results

Collaborations with open data platform

- Dense eDNA data in Tokyo Bay and Kasado Bay
- Why don't you share your eDNA data?

"UMI-POCHI"

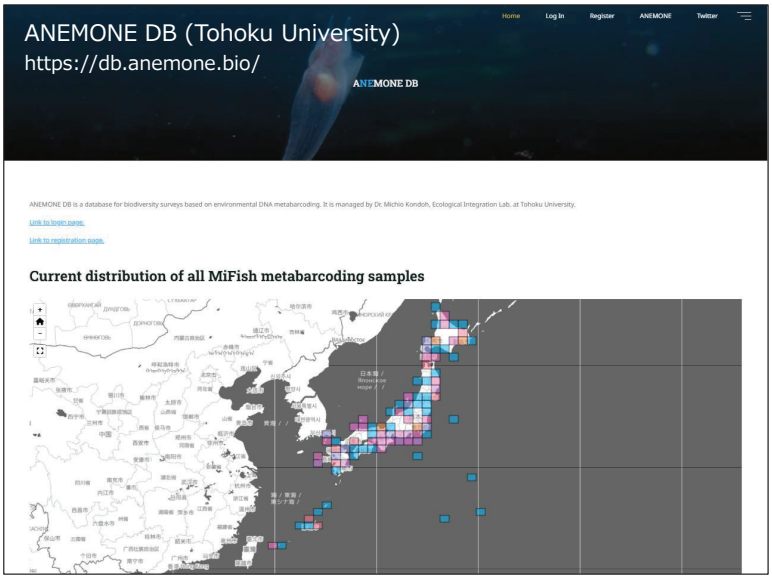




https://pari.mpat.go.jp/biodiversity/

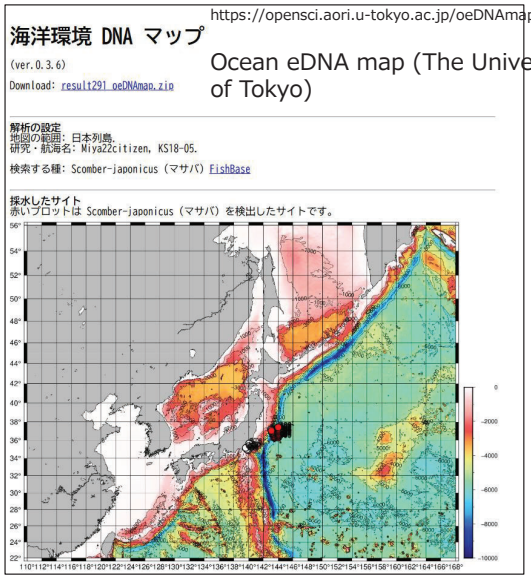
Collaborations with open data platform

- Open data platforms that share eDNA data are being launched to accelerate scientific progress.



https://opensci.aori.u-tokyo.ac.jp/oeDNAmap-en.html

Ocean eDNA map (The University of Tokyo)



Conclusions

- Environmental DNA (eDNA) technologies are non-destructive and cost-effective, and demonstrate good performance.
- Challenges remain in using eDNA technology in estuaries and coasts. However, eDNA technology is a powerful tool for capturing the spatial scale greater than several kilometers.
- eDNA technologies will serve as a tool for monitoring invasive species and biodiversity changes.
- Open data platforms that share eDNA data are being launched. Collaborating with the platform will accelerate scientific progress based on eDNA data.

Thank you for your attention

Acknowledgements

Our eDNA researches were supported by the Yokohama Research and Engineering Office for Port and Airport of the Kanto Regional Development Bureau, and by the Hiroshima Research and Engineering Office for Port and Airport of the Chugoku Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism