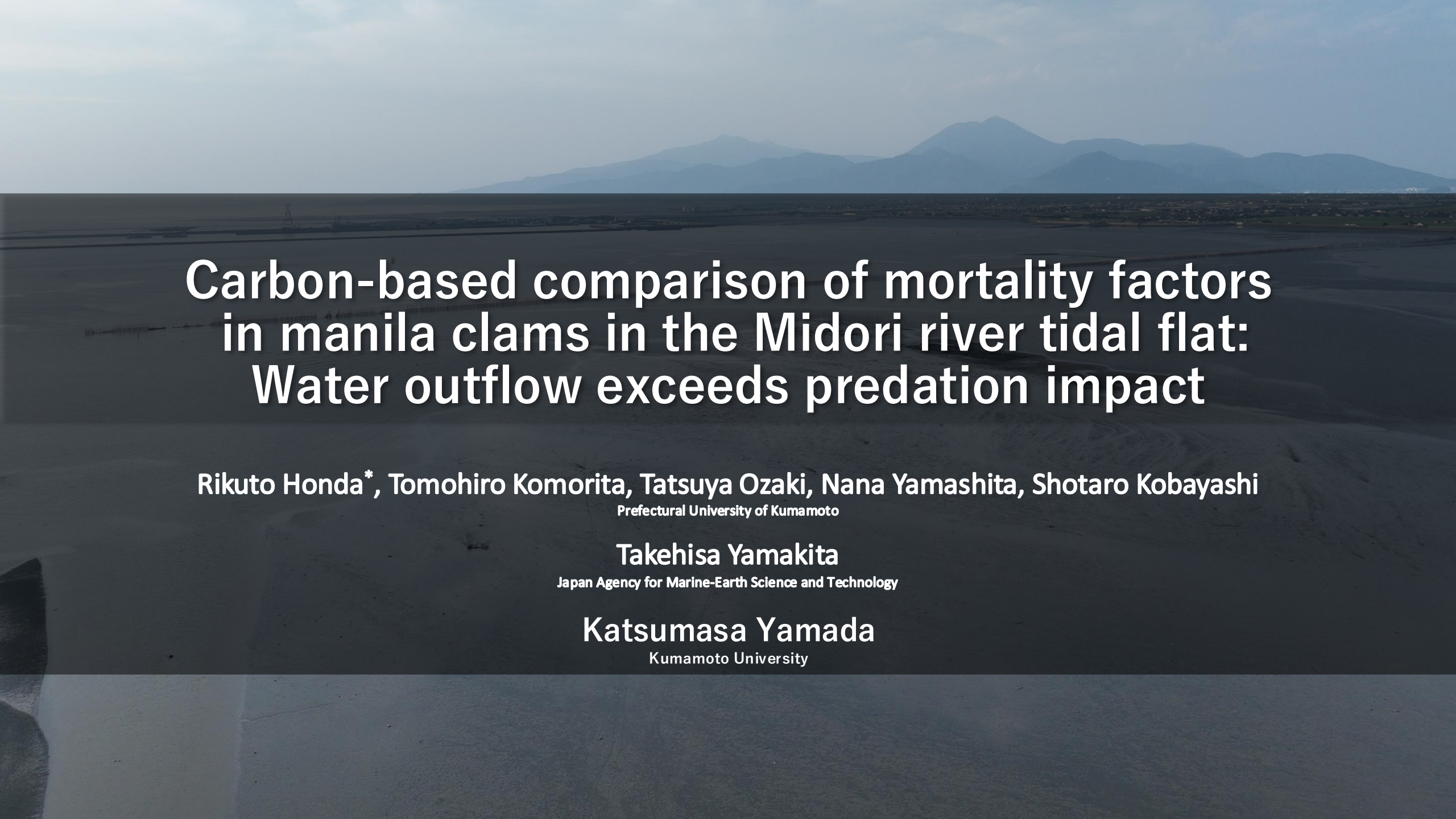

Carbon-based comparison of mortality factors in manila clams in the Midori river tidal flat: Water outflow exceeds predation impact

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The importance of bivalves in tidal flat

Manila clam
https://x.gd/RtC89

Hard clam
https://x.gd/LiZNs

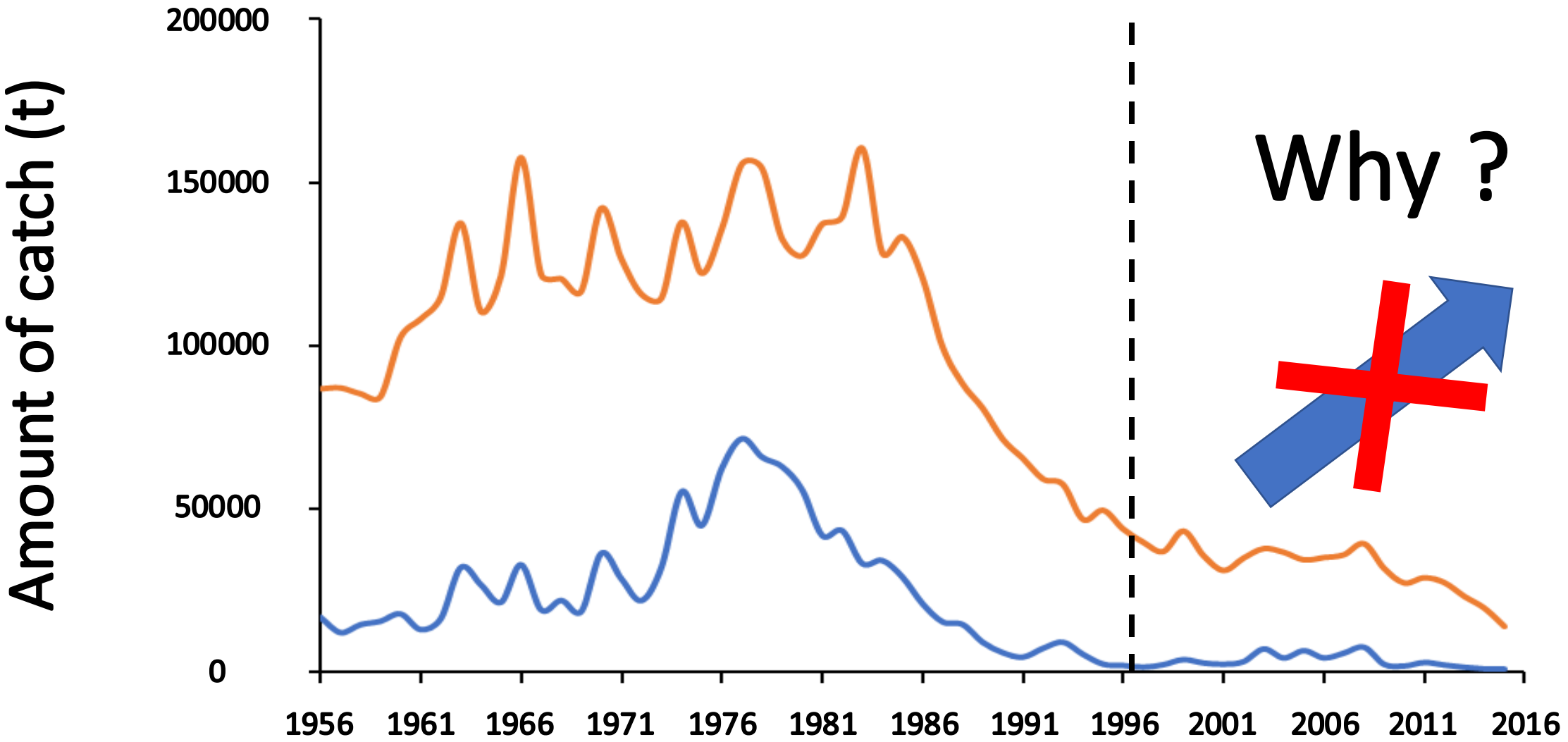
・Key drivers of material cycling and productivity in tidal flat

・Water purification, transfer primary production to higher trophic levels
(Nakamura and Kerciku 2000, Olivier et al. 2020)
(Vaughn and Hoellein 2018)

→Populations of bivalves have been declining worldwide.

(Peterson 2002, Philippart et al. 2003, Laing et al. 2006, 堤 2006, Beukema 2010, Andréfouët et al. 2013)

Decline in bivalve catches in Japan and Kumamoto



Bivalves catches, especially manila clams, have drastically declined.

Factor 1: Predation by higher trophic predators

Aetobatus narutobiei

Rays：summer

・Gut content analysis -> Manila clams

(Tsutsumi et al. 2018, modified)

・Feeding experiments in captivity

->Consumption up to 10 times the fishery catch

(Kumamoto prefectural Fisheries Research Center 2017)

Anas platyrhynchos

Ducks：winter

・Gut content analysis

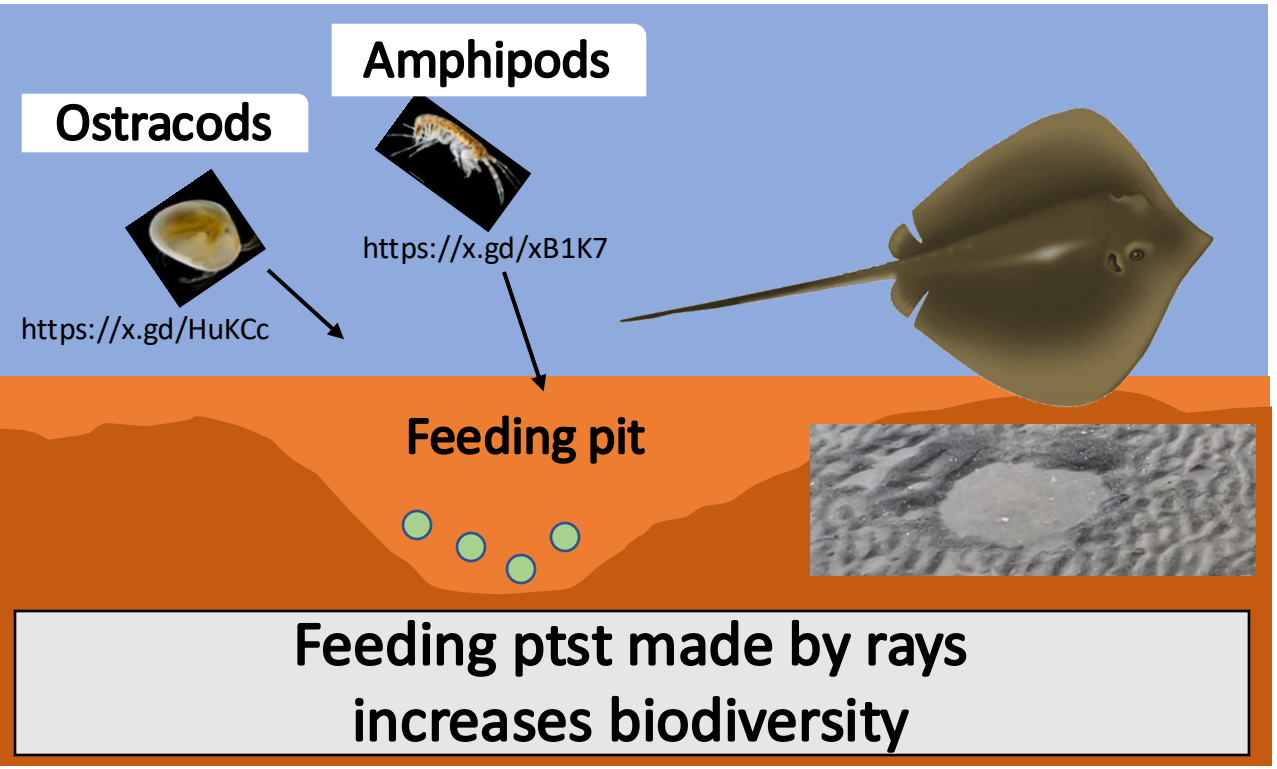
->Razor clams and wedge clams detected

(Takeda et al. 2016)

High predation -> predator control

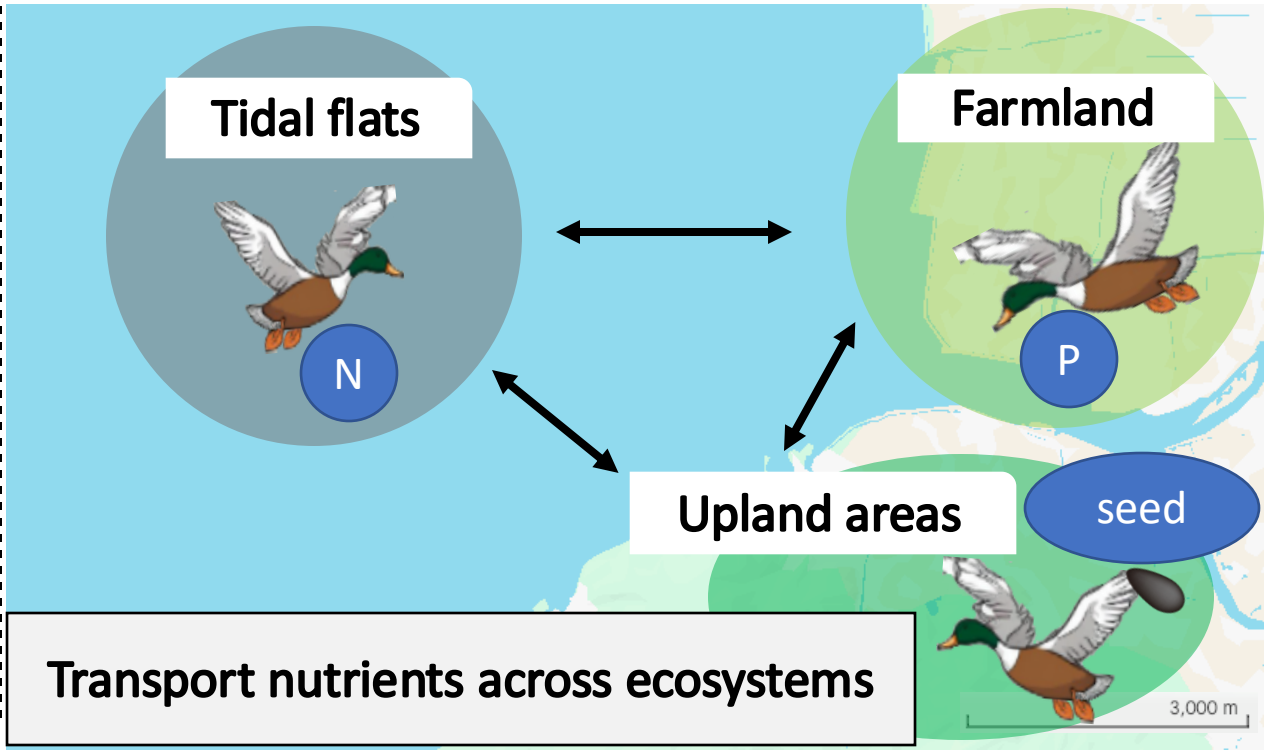
Ecological roles of stingrays and ducks

Rays



(VanBlaricom 1982 , O'shea et al. 2012)

Ducks



(Frisch et al. 2007 , Michel et al. 2020)

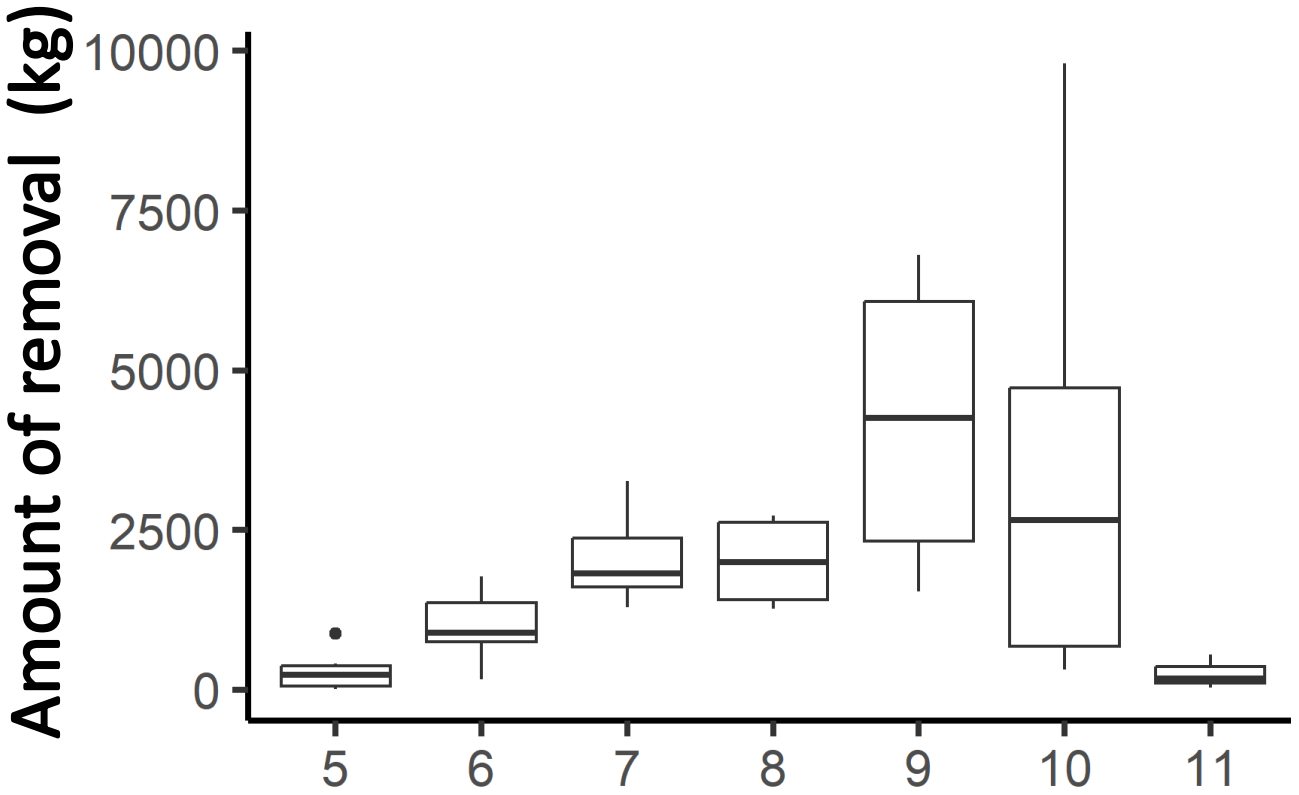
The removing them without correct evaluation is unjustified.
→Accurate assessment of predation impact is essential.

Study site：Midori river tidal flat

- Biggest tidal flat in Japan, facing the Ariake Bay (about 2200 ha)
- Dominated by Manila clams (*Ruditapes philippinarum*)

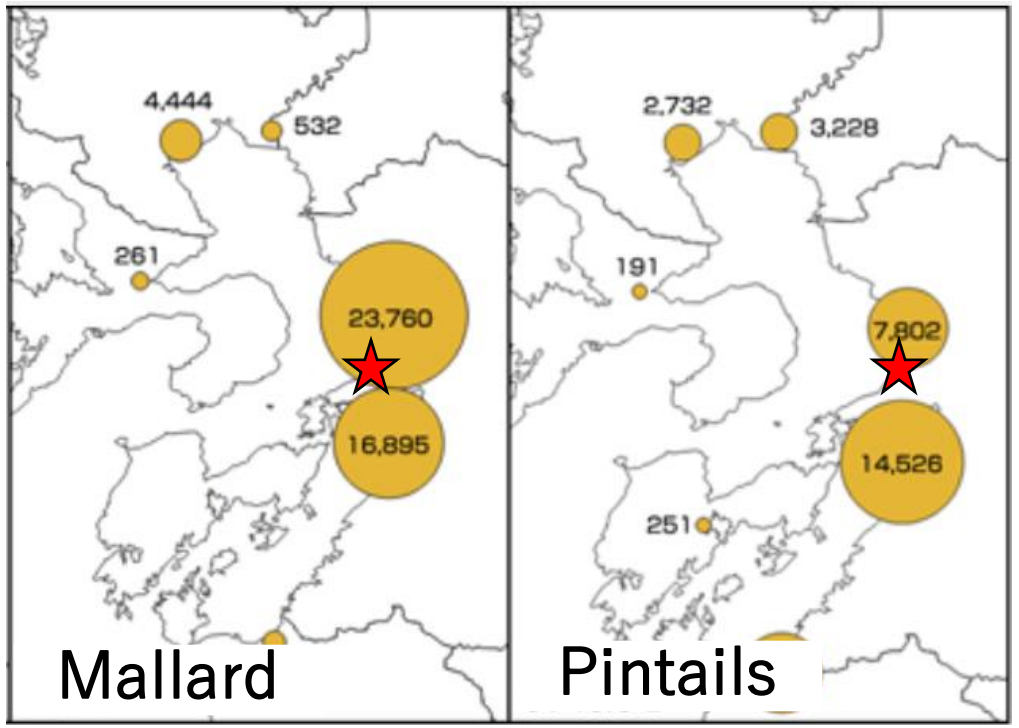
Occurrence of rays and ducks in this tidal flat

Removal of Longheaded eagle ray



(Kawaguchi fisheries cooperative association 2005~2010)

Number of wintering ducks

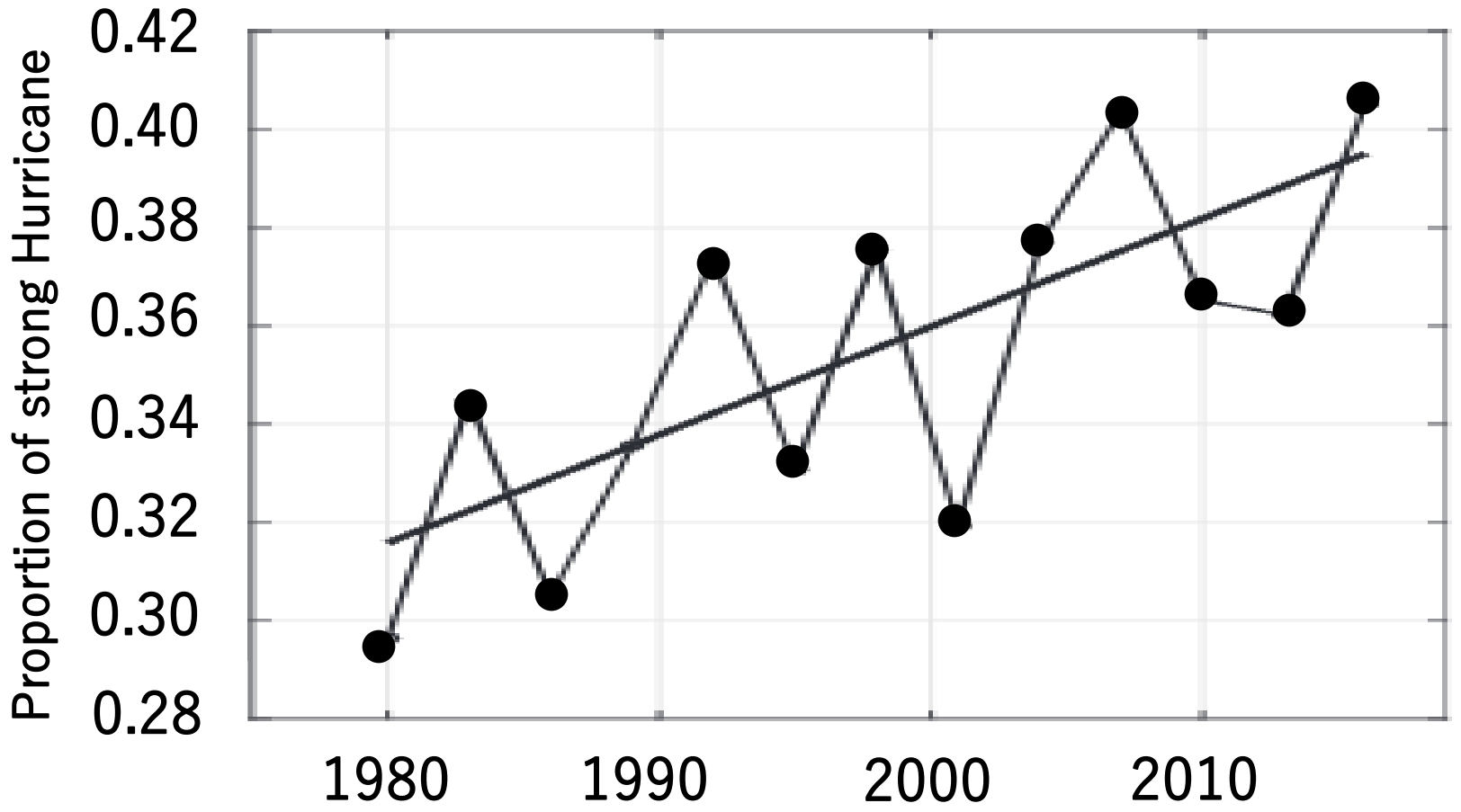


★: Study site

(NPO corporation Bird Research 2020)

Rays and ducks likely influence the clams in this tidal flat.

Factor 2: Burial in mud and low salinity



Cyclones has become stronger over the past four decades.

(Kossin et al, 2020, modified)

The effects of burial in mud and low salinity

low salinity

Reduced growth rate
(Navarro 1988)

Choromytilus chorus
https://x.gd/VoW6B

Increased mortality
(Bae et al. 2021)

Ruditapes philippinarum
https://x.gd/RtC89

Burial in mud

Reduced growth rate
(Goeji and Luttikhuizen 1998)

Macoma balthica
https://x.gd/DZLaZ

Increased mortality
(Hutchson et al. 2016)

Modiolus modiolus
https://x.gd/jEnGA

Field-based evaluations remain limited

Problems in mortality estimation methods

target	Ray 	Duck 	Water outflow 
method	Feeding experiment	Energy requirement	The difference of clam density
unit	t／Bay area／half year	Kg／individual／day	inds／m^2

(Kumamoto prefectural Fisheries Research Center 2017)

(Oka 2010)

(Tai et al. 2018)

Inconsistent units prevent direct comparison among the factors.

Limits of previous studies and approaches of this study

Issue①:
The in situ effect of predation and water outflow is unclear

Issue②:
Inconsistent units prevent direct comparison among the factors.

Approach of this study
Evaluating both predation and water outflow simultaneously in the field and quantifies their impacts using a unified carbon-based metric.

Objectives

To clarify the relative importance of each mortality factor using a carbon-based measurement.

Outline of this description

1. Estimate secondary production of clams

2. Predation by rays

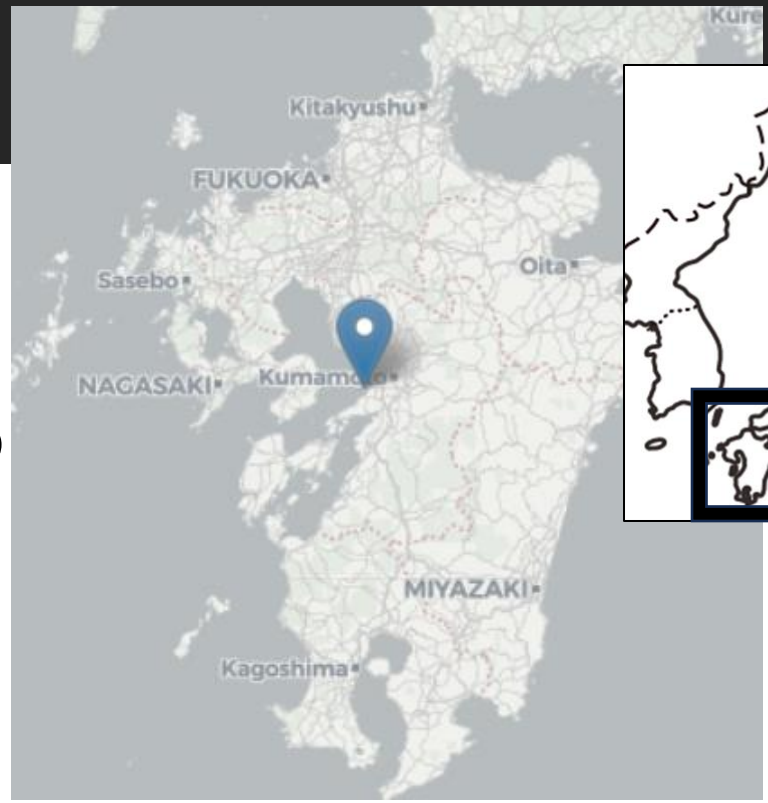
3. Predation by ducks

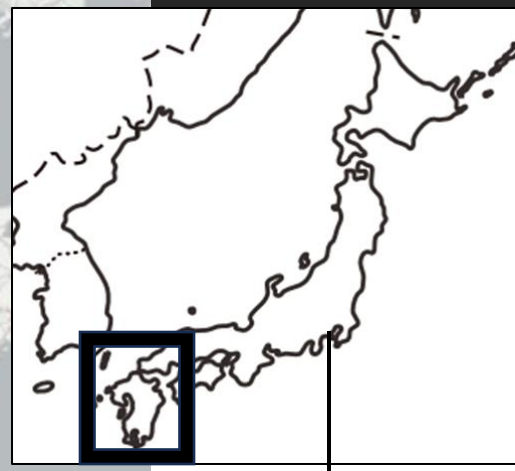
4. Effects of water outflow

5. Compare the effects of mortality factors

Estimate secondary production of clams

Study site and period





Site : Midori river tidal flat
Period : Apr 2022-Aug 2023 (whole period)

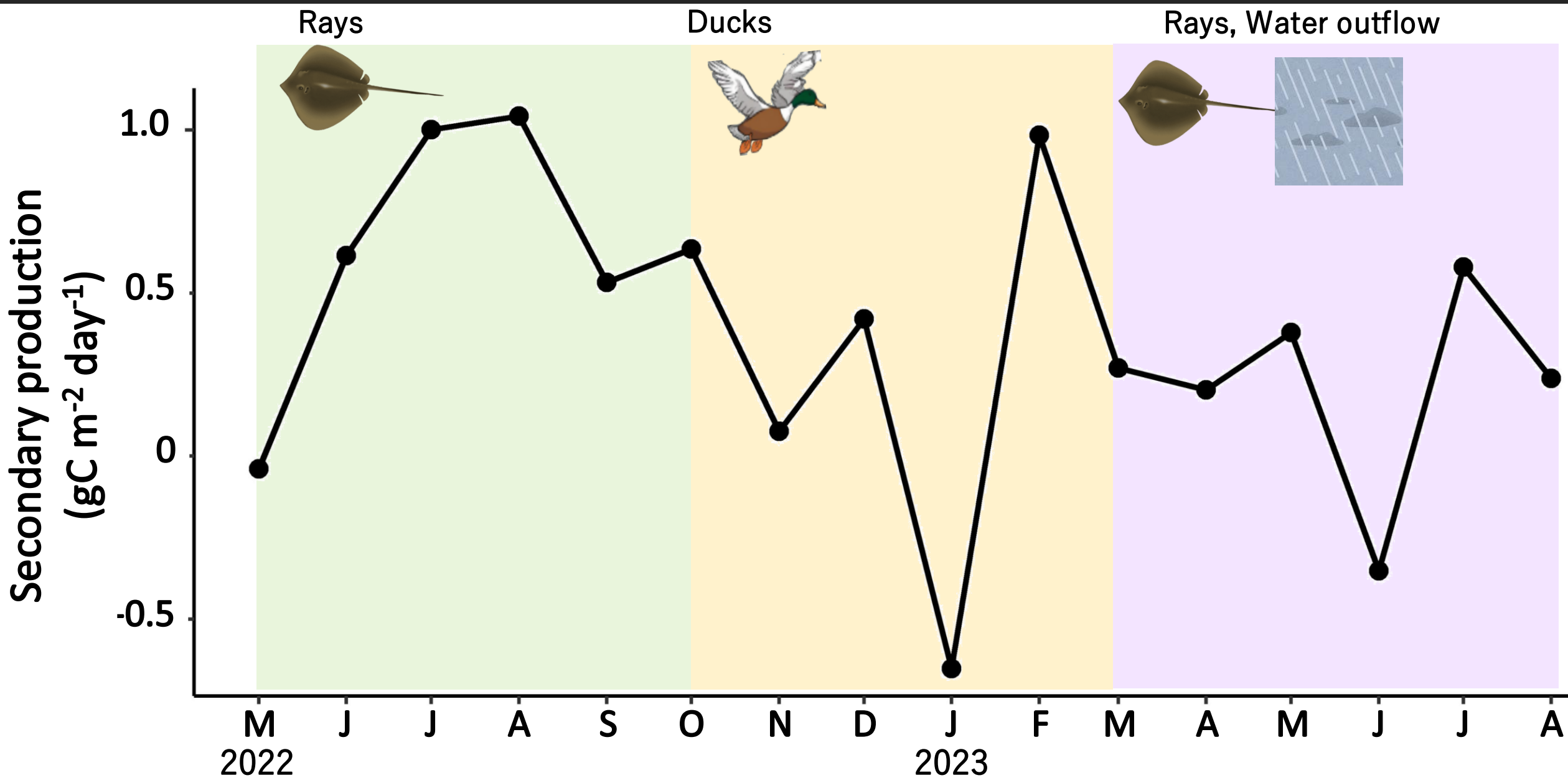
Contents

Clam monitoring : Biomass, Shell length

One month later

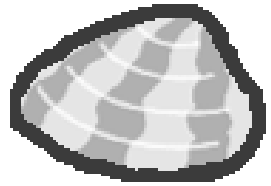
Increase in biomass
→ Secondary production
(Crisp 1984)

Temporal variation in secondary production and mortality factors

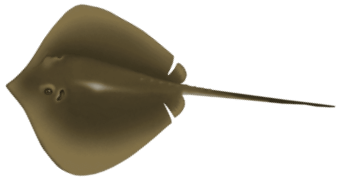


Outline of this description

1. Estimate secondary production of clams



2. Predation by rays



3. Predation by ducks

4. Effects of water outflow

5. Compare the effects of mortality factors

Predation by rays

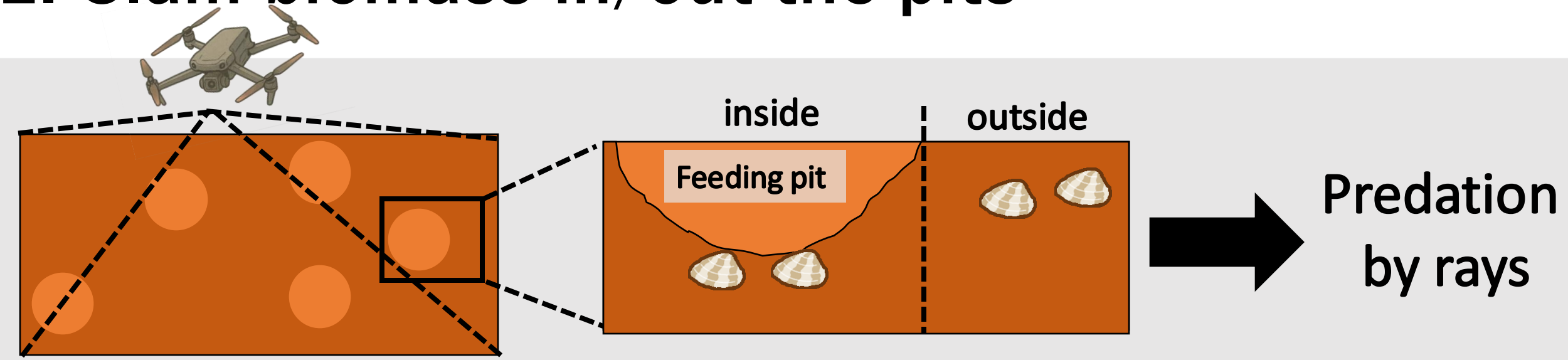
Study site and period

Site：Midori river tidal flat

Period：Summer (Apr 2022-Aug 2023)

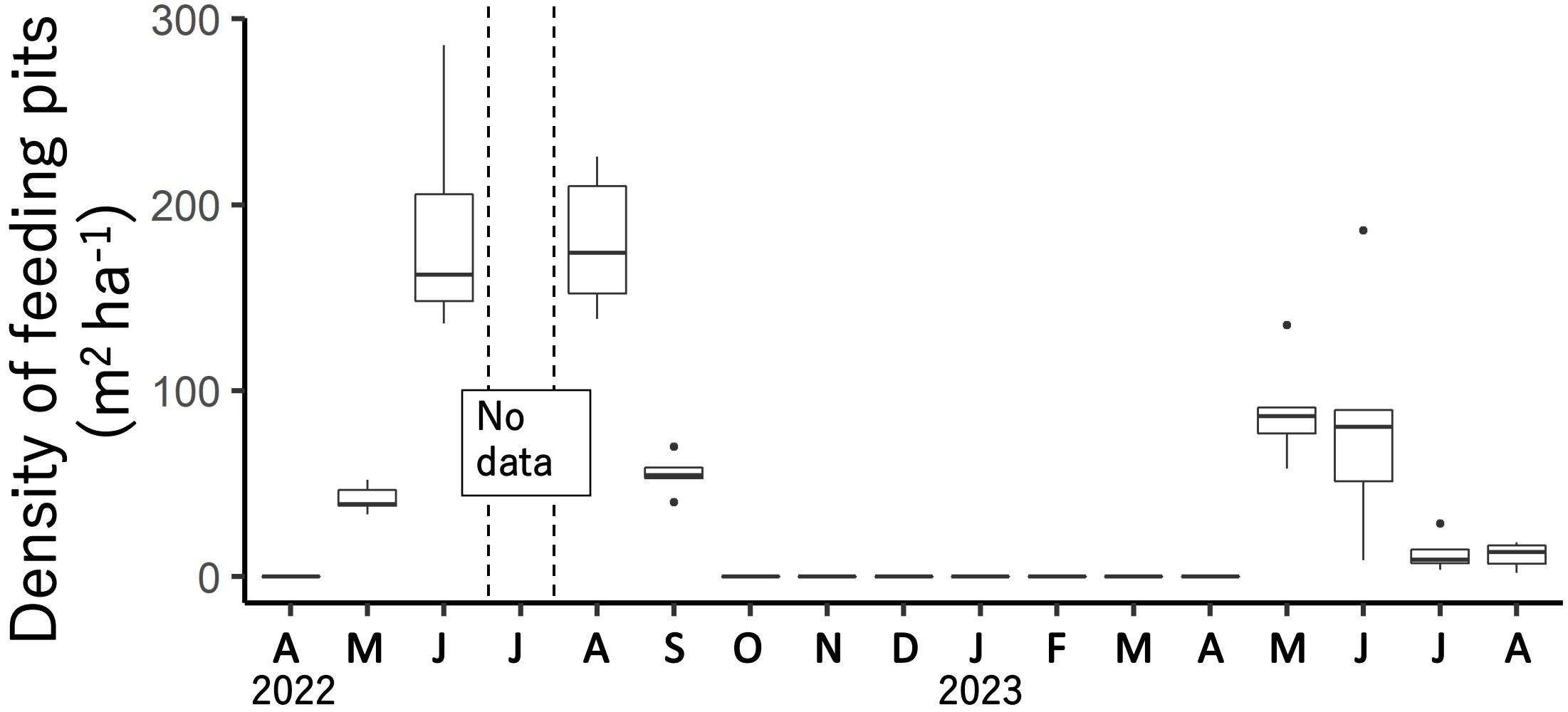
Contents

1. Density of feeding pits
2. Clam biomass in/out the pits



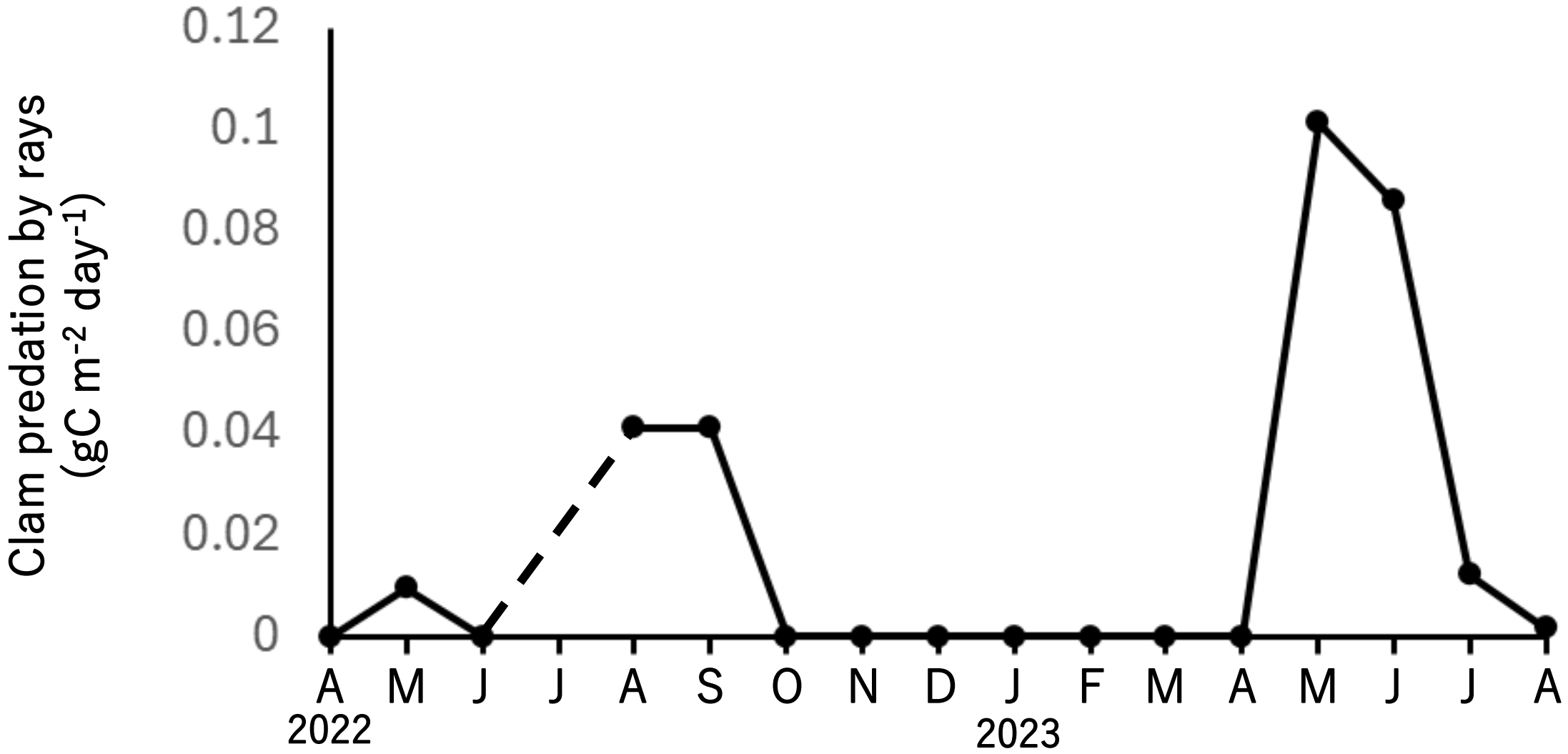
Result

Seasonal variation in feeding pit density



Increased from early summer to midsummer.
Decreased toward autumn.

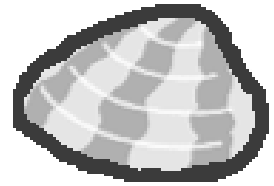
Monthly variation in clam predation by rays



Maximum predation (gC m^{-2} day^{-1}) : 0.041 in 2022, 0.104 in 2023

Outline of this description

1. Estimate secondary production of clams



2. Predation by rays

3. Predation by ducks

4. Effects of water outflow

5. Compare the effects of mortality factors

Predation by ducks

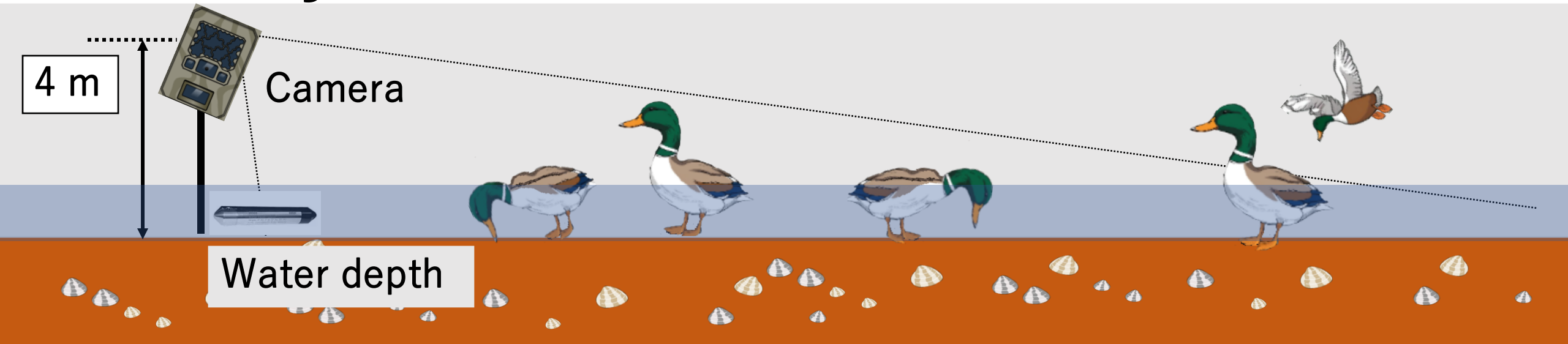
Study site and period

Site：Midori river tidal flat

Period：Winter (Oct 2022-May 2023)

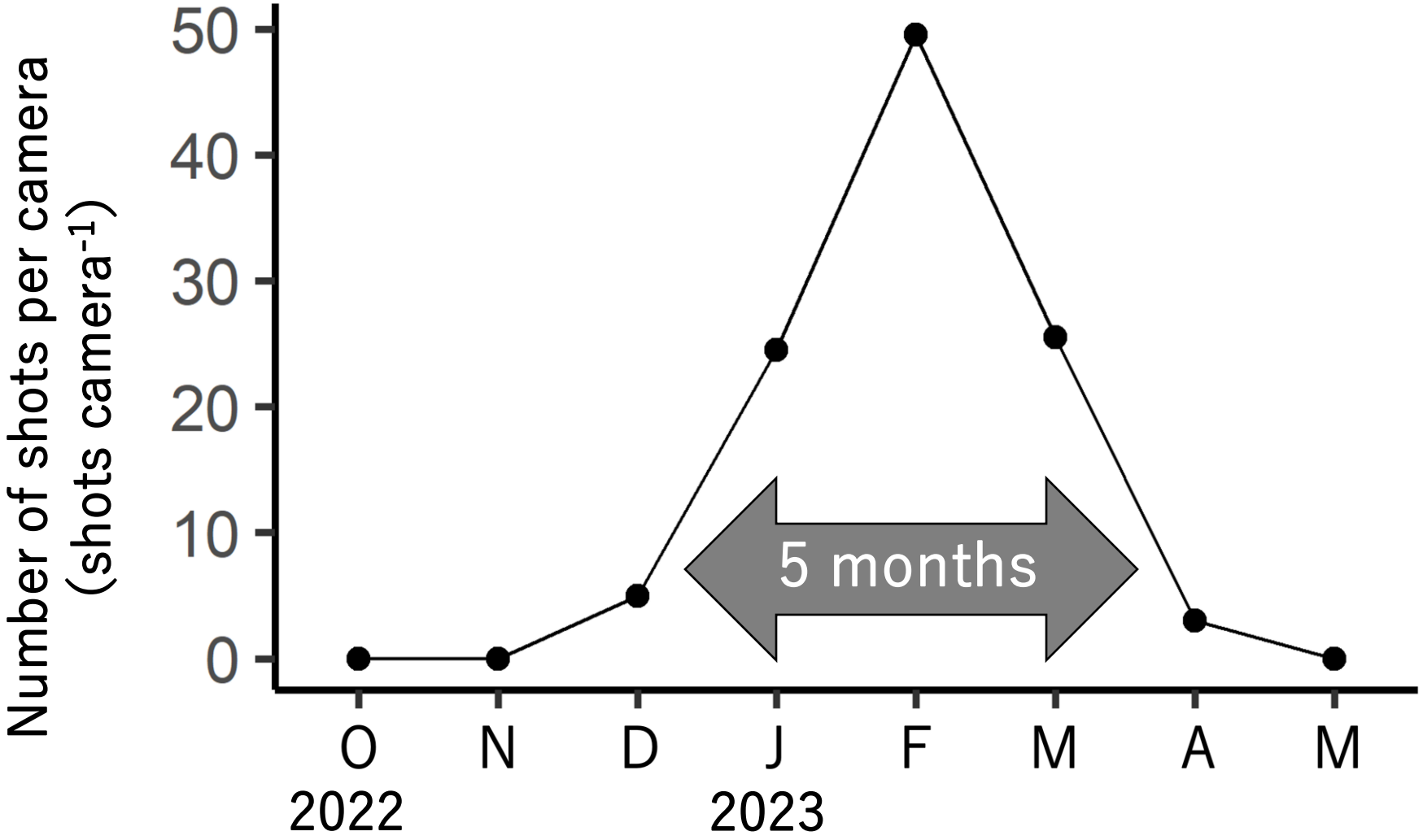
Contents

1. Frequency of duck arrival
2. Activity of ducks



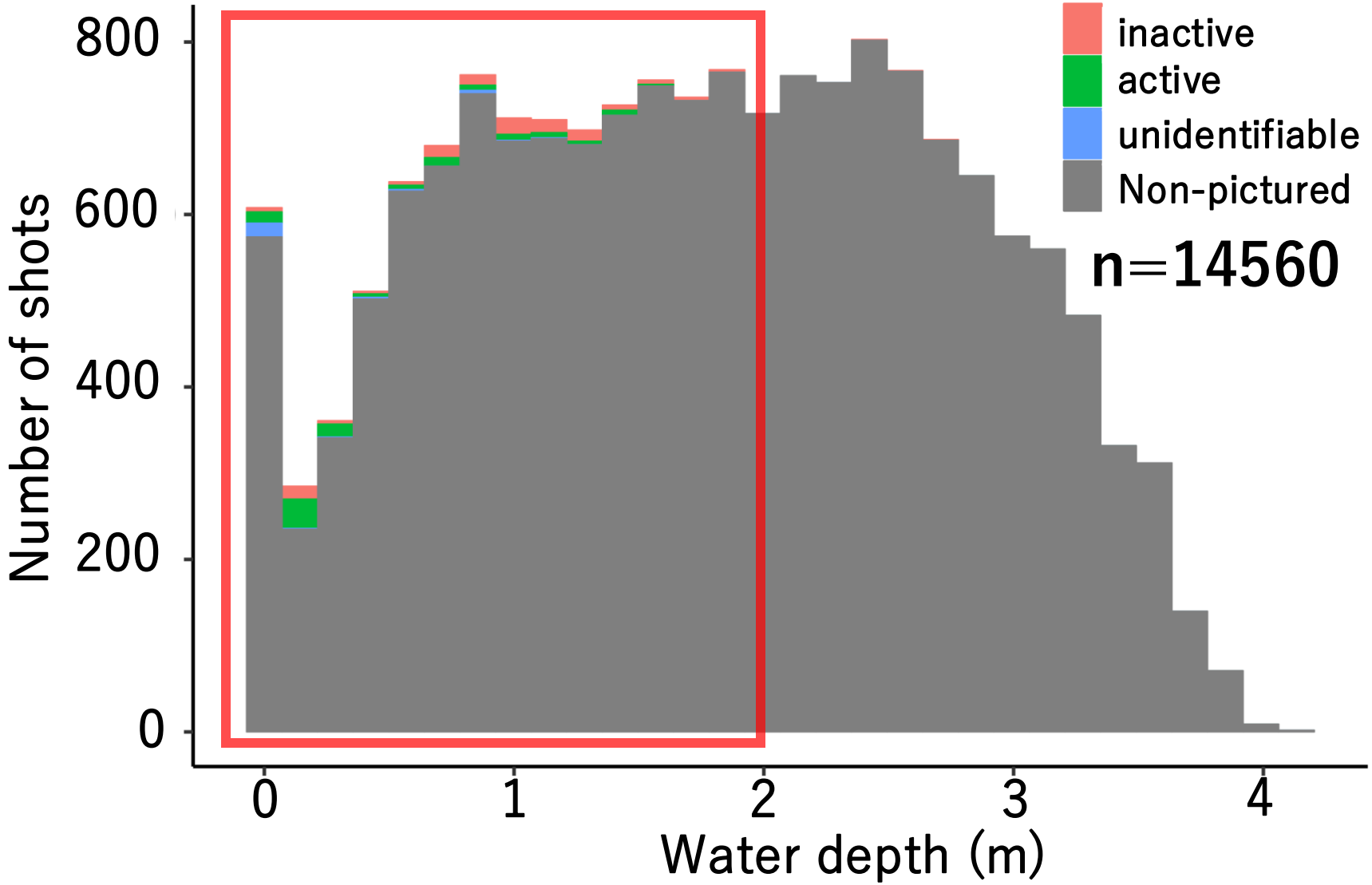
Result

Occurrence frequency of ducks



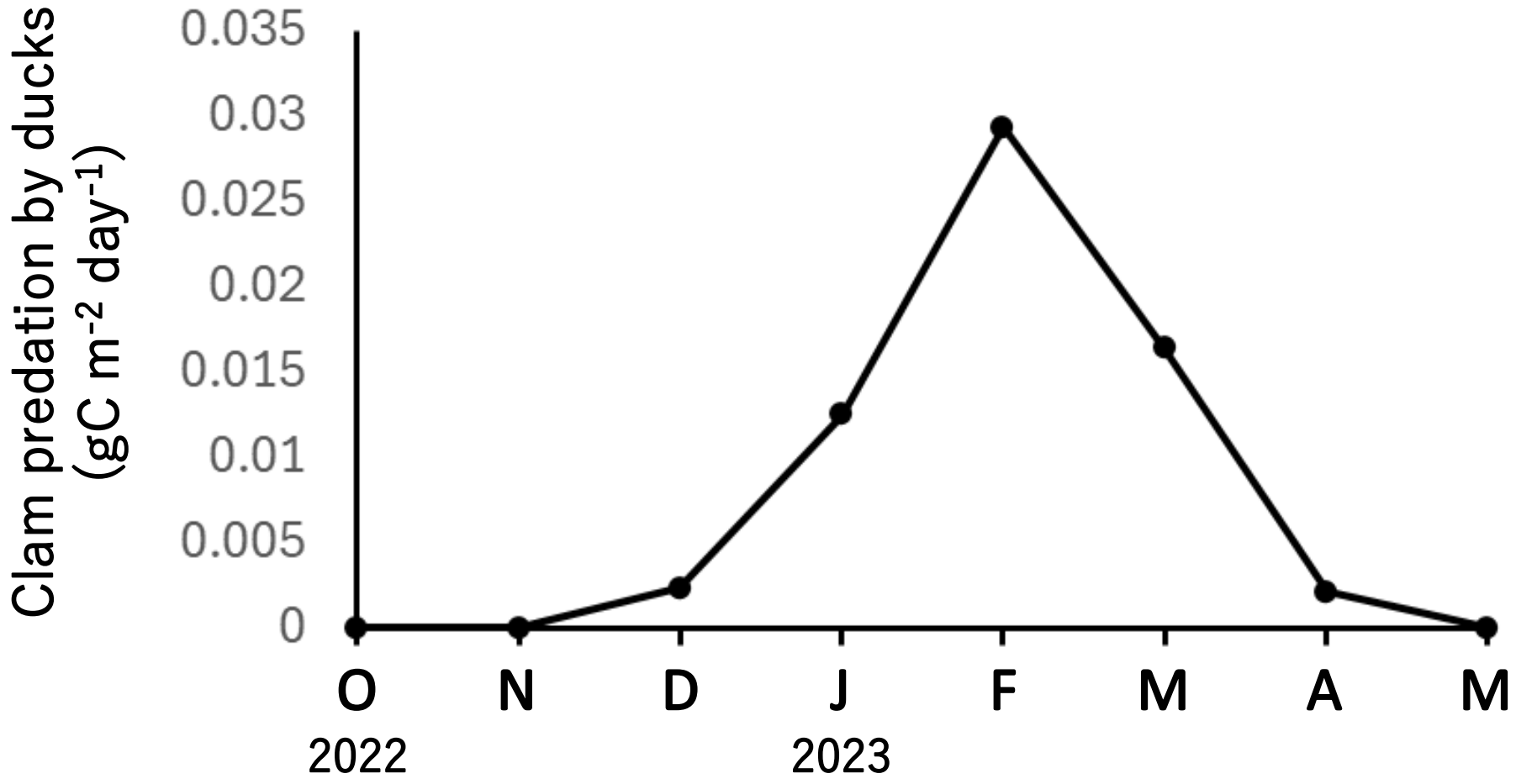
Ducks were observed from December to April.

Relationship between water depth and duck activity



Water depth ≦2 m: Ducks are active.

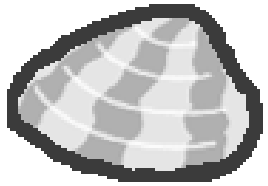
Monthly variation in clam predation by ducks



Maximum predation: 0.03 gC m^{-2} day^{-1} in February

Outline of this description

1. Estimate secondary production of clams



2. Predation by rays

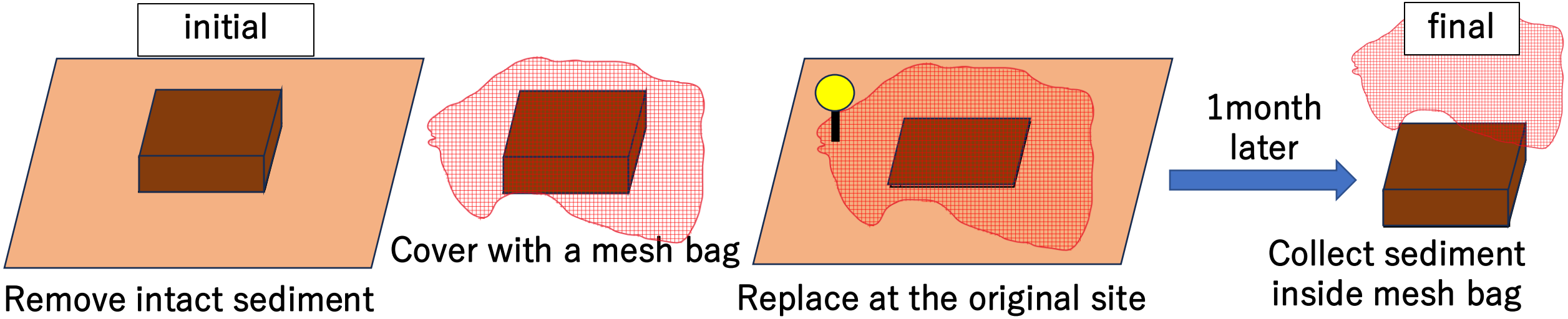
3. Predation by ducks

4. Effects of water outflow

5. Compare the effects of mortality factors

Effects of water outflow

Evaluation of the effect of water outflow



mesh bag: excludes the effects of predation and movement

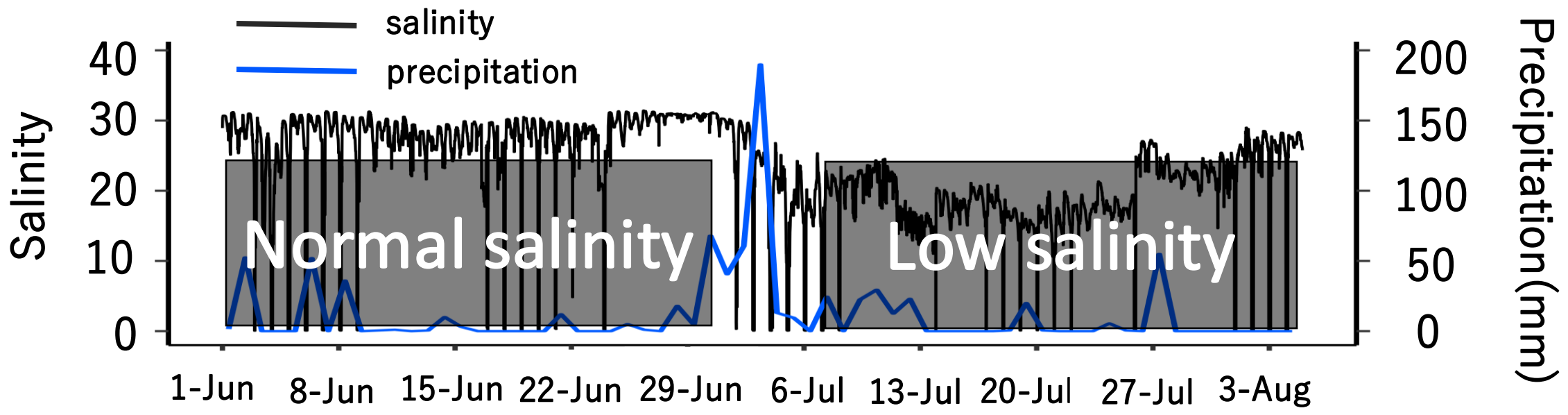
Initial vs final…

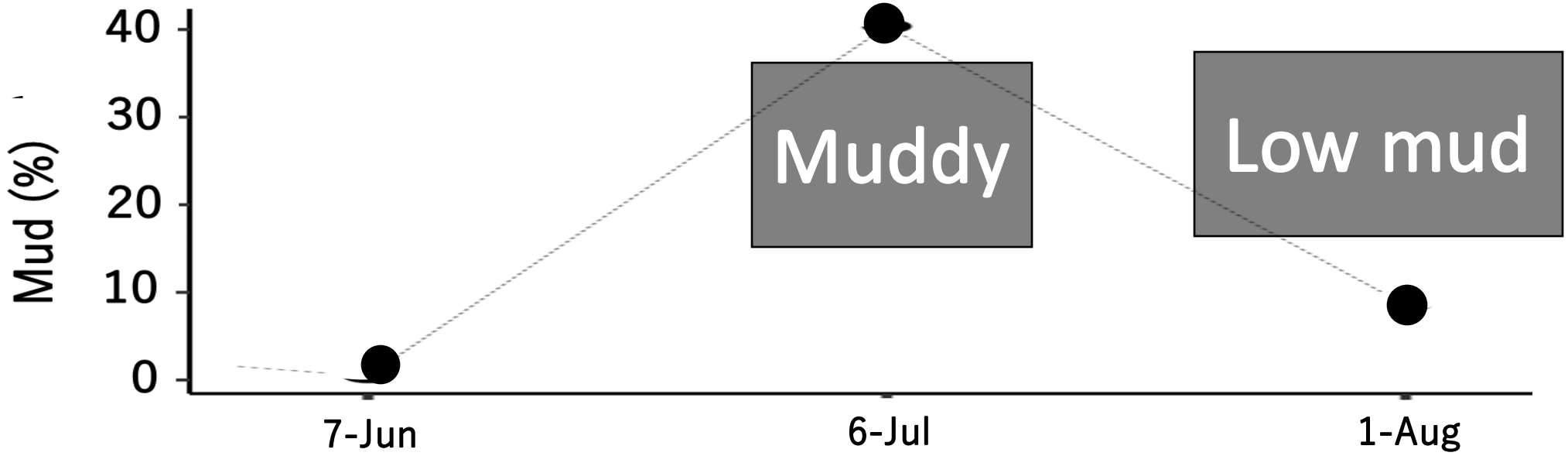
Initial ≒ final → effect of water outflow was minor

Initial > final → effect of water outflow was significant

Result

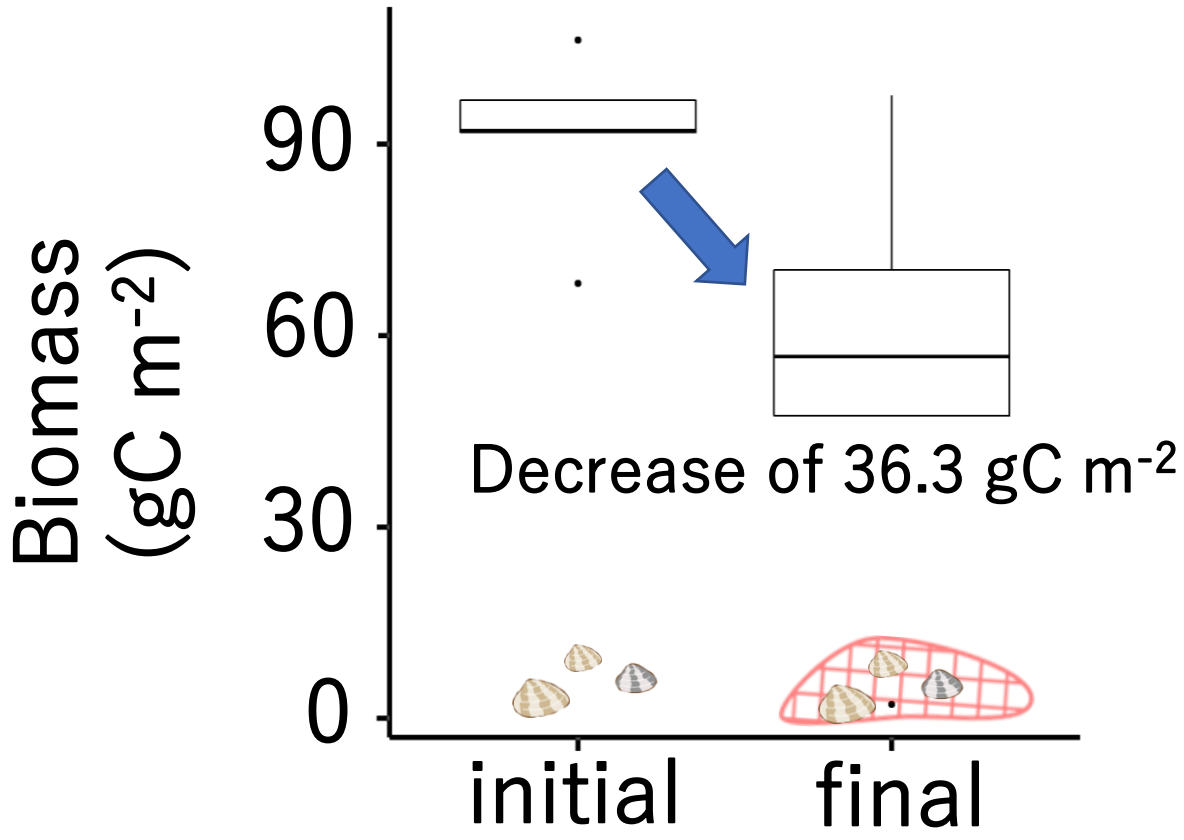
Effect of water outflow on environmental condition



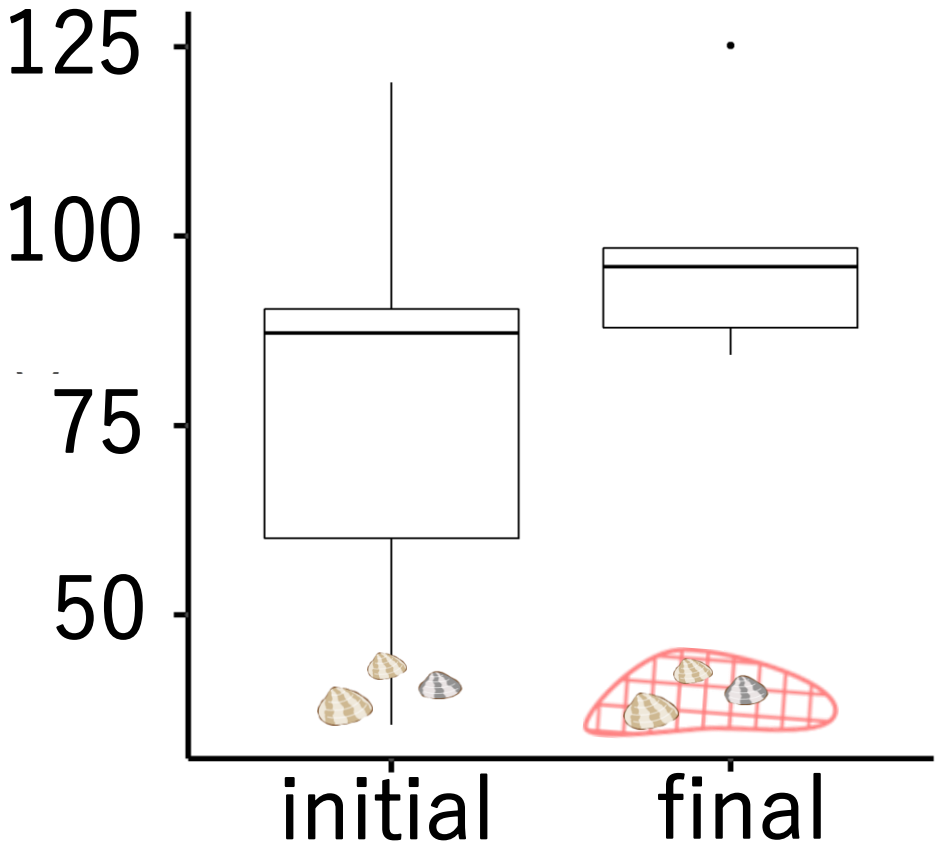


Effect of water outflow by mesh-bag experiment

Jun-Jul:
Normal salinity, Muddy



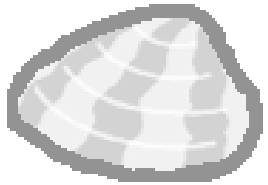
Jul-Aug:
Low salinity, Low mud



Effect: low salinity << mud burial

Outline of this description

1. Estimate secondary production of clams



2. Predation by rays

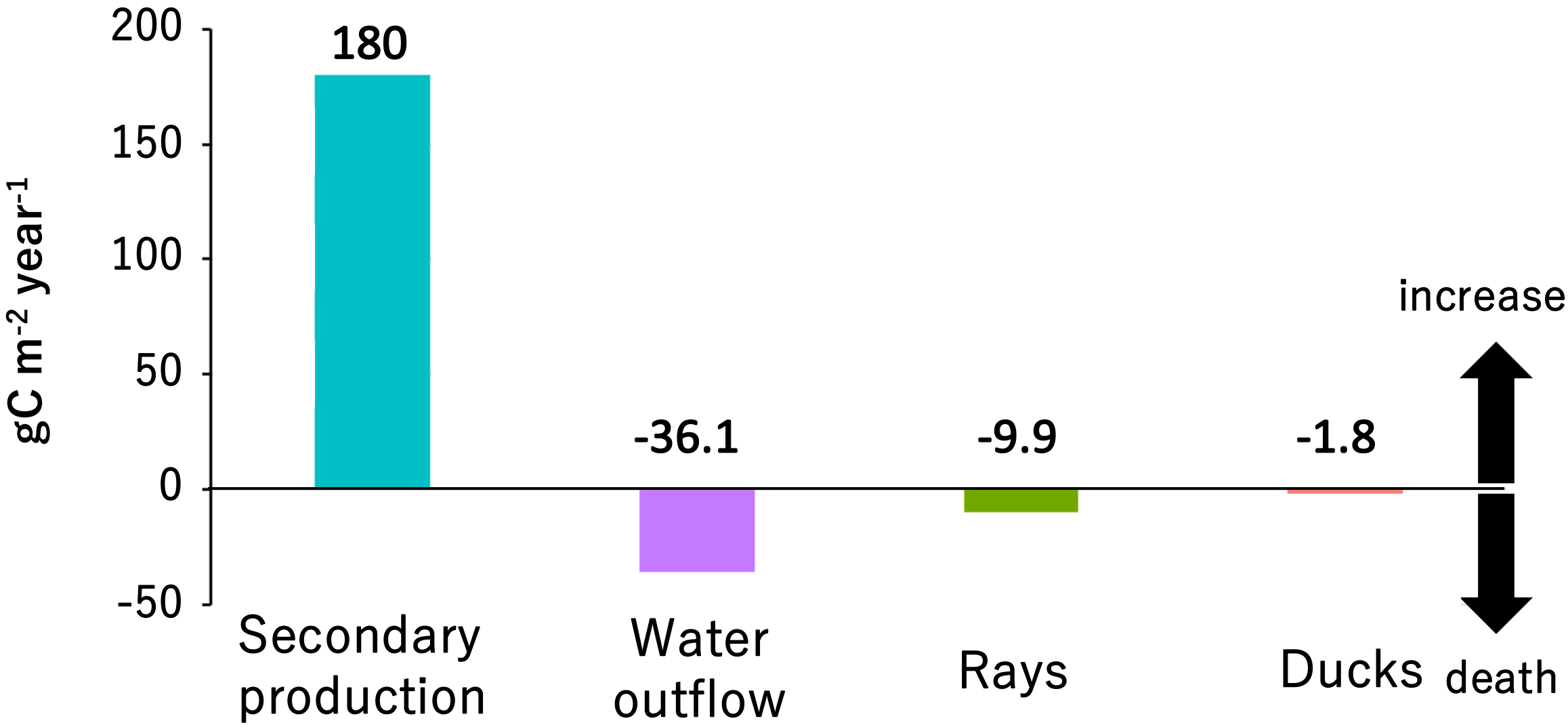
3. Predation by ducks

4. Effects of freshwater discharge

5. Compare the effects of mortality factors

Compare the effects of mortality factors

Comparison: Secondary production and mortality factors



Single water outflow event >> annual predation

Summary

Result:

Single water outflow event >> annual predation

->Short-term water outflow can have catastrophic impact on clam population.

The adaptation for water outflow should be prioritized to sustain clam populations.