Comparisons of amount of movement and degree of aggregation by adult *Haliotis discus hannai* between spawning and non-spawning seasons

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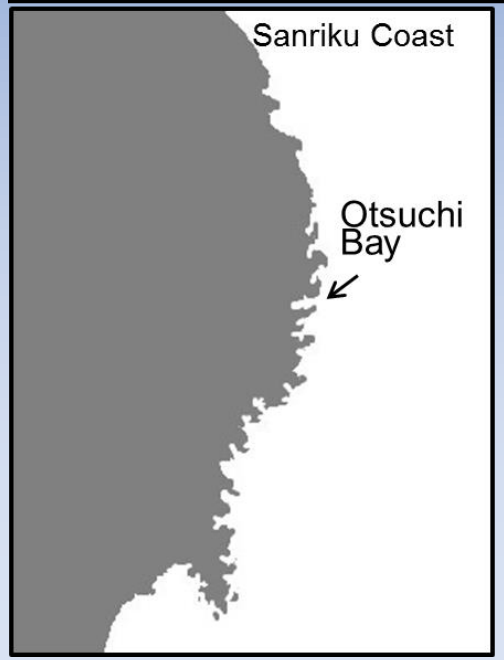
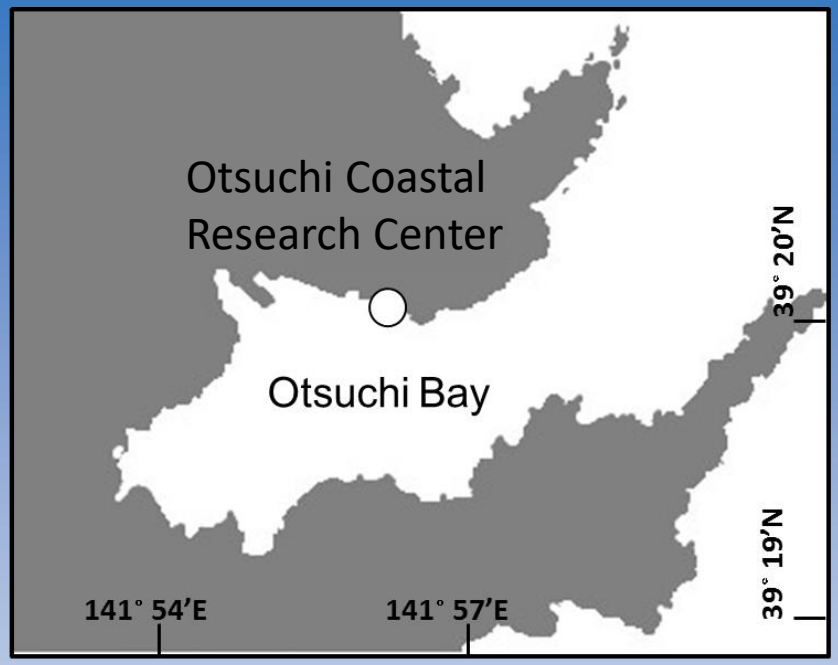
Introduction





Introduction

Haliotis discus hannai

- Imporatnt fishery target species on Sanriku coast (northern Pacific coast of Japan)
- Listed as an endangered species in the IUCN Red List (*Haliotis discus*)

Ally effects associated with reduced population densities are a concern.

Aggregations of adults are observed during the spawning season (Hayakawa et al. 2021). (It may compensate to some extent for the negative impact of the Ally effect.)

Introduction

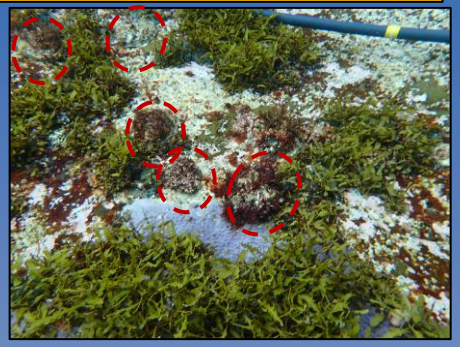
Years in which the aggregation was confirmed

Dominant macroalgal brown algae

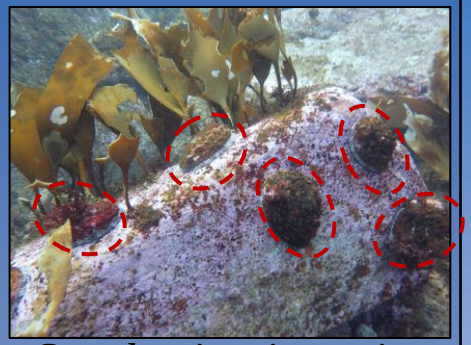
2016: *Sargassum yezoense*

2019: *Saccharina japonica* var. religiosa

Algal beds of these species remained during the spawning season of the abalone (Aug-Oct in Sanriku Coast).



Sargassum yezoense



Saccharina japonica var. religiosa

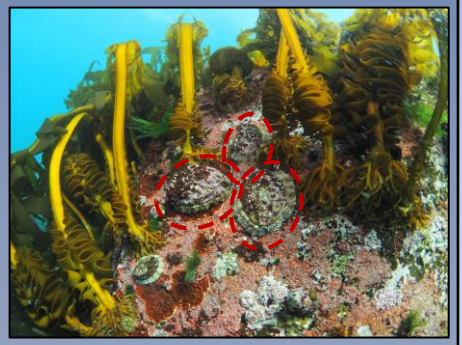
Years in which the aggregation was not confirmed

Dominant macroalgal brown algae

2017: *Undaria pinnatifida*

2019: None

Algal beds disappeared before the spawning season of the abalone.



Undaria pinnatifida

Differences in the species and the cover degree of macroalgae by year are considered to influence the degree of the aggregation of the abalone.

Introduction

Objectives of this study

1) To examine whether behavioural patterns of the abalone change between the spawning and non-spawning seasons.

The abalone may aggregate even without algal beds, by lower travel distance and/or distance from other individuals during the spawning season.

2) To examine what factors in kelp beds affect the aggregation during the spawning season.

Which is more important for reducing the travel distance of the abalone: diets or refuges ?

Material and method

Adult *H. discus hannai* were collected from Otsuchi Bay in May 2021.

Each individual was identified by number and color of tag glued to the shell.

12 male individuals
(Shell length: 89.1 ±4.3 mm)

12 female individuals
(SL: 88.4 ±4.1 mm)

Behavioural observations in outdoor tanks were conducted in 2021,

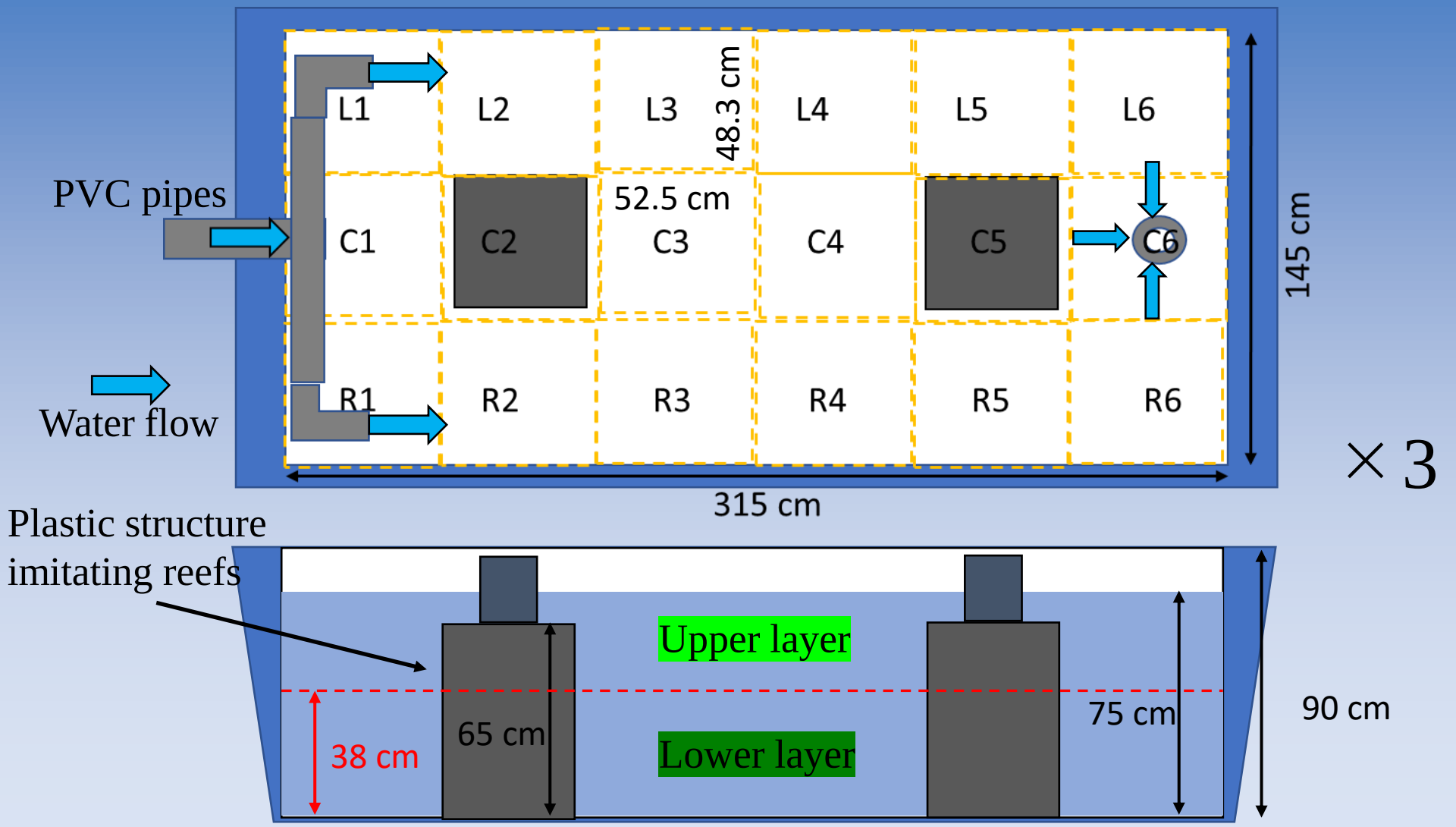
3 times before spawning season (late Jun, early and late Jul)

5 times during spawning season (early and late Aug, early and late Sep, late Oct)

3 times after spawning season (early and late Nov, early Dec)

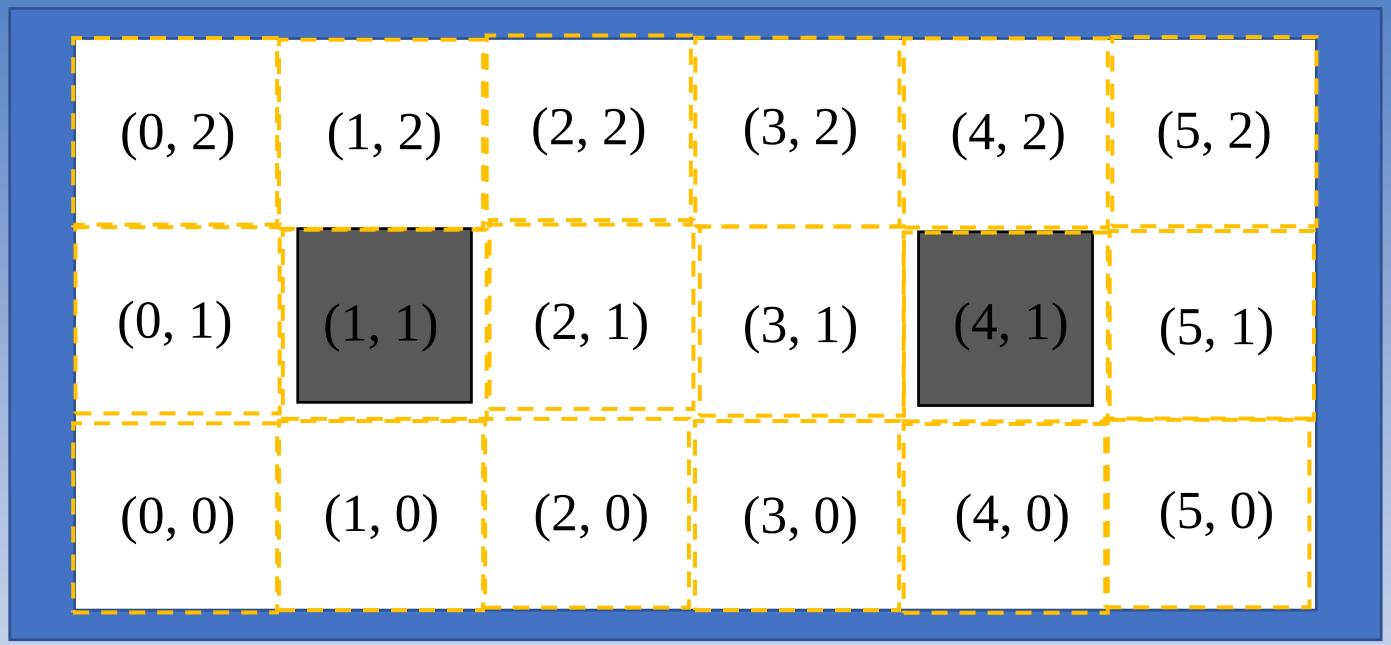
Material and method

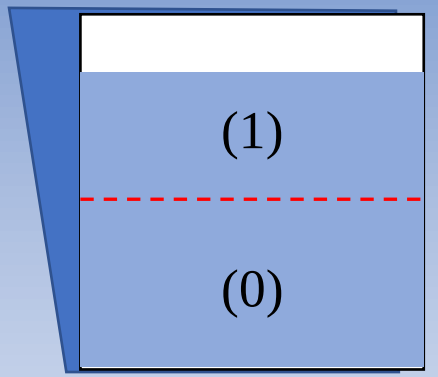
4 males and 4 females were kept in each of the three outdoor tanks.



Material and method

Relative amount of movement (RAM)





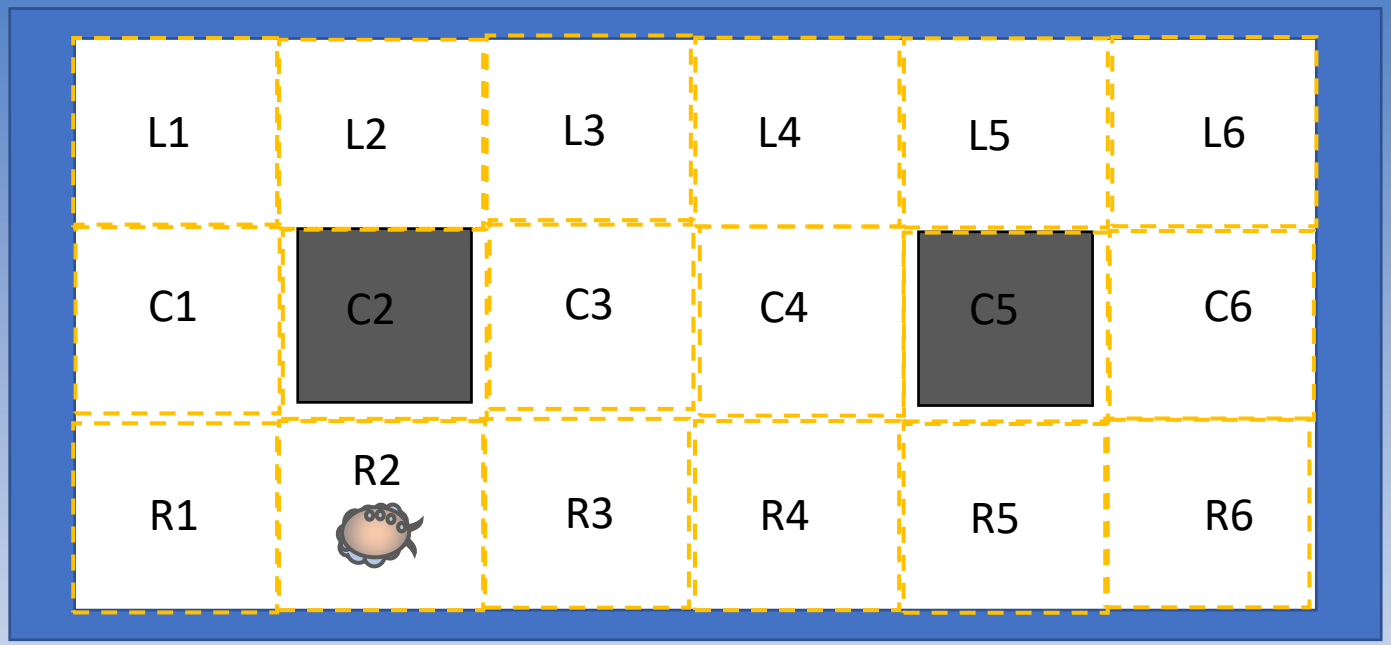
$$R_t = \sqrt[2]{((X_t - X_{t-1)2} + (Y_t - Y_{t-1)2}} + 0.5 \times |Z_t - Z_{t-1}|$$

R: RAM

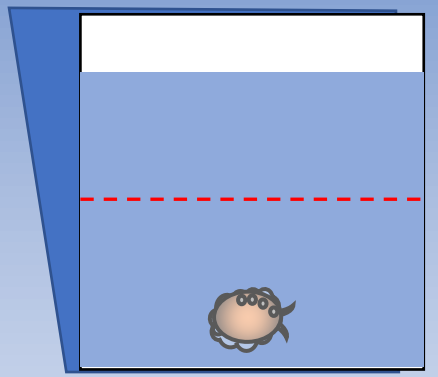
X, *Y*, *Z*: Coordinates of the location (x, y and z, respectively)

Material and method

Relative amount of movement (RAM)

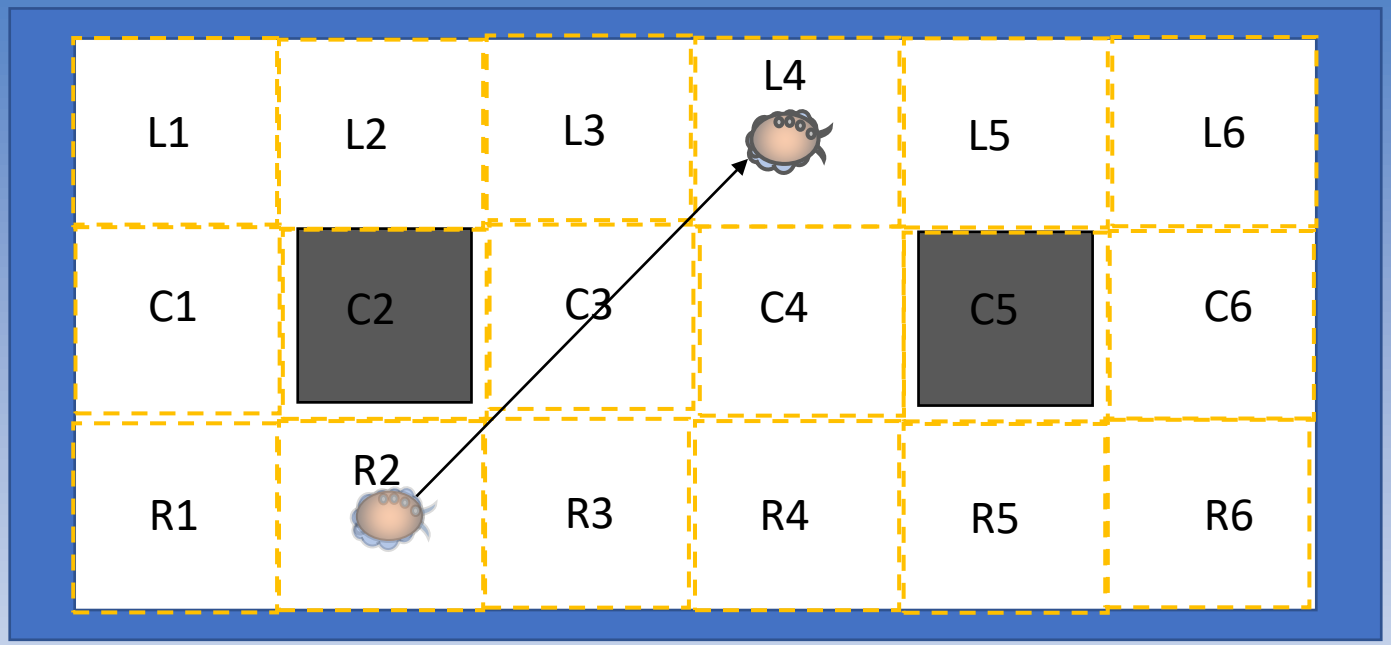


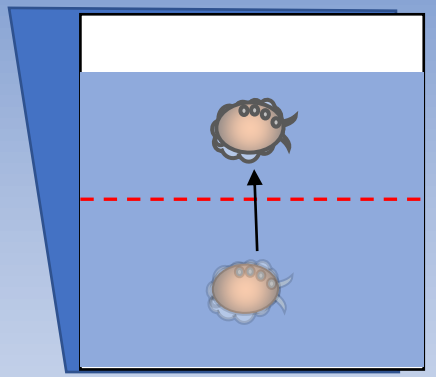
9pm



Material and method

Relative amount of movement (RAM)

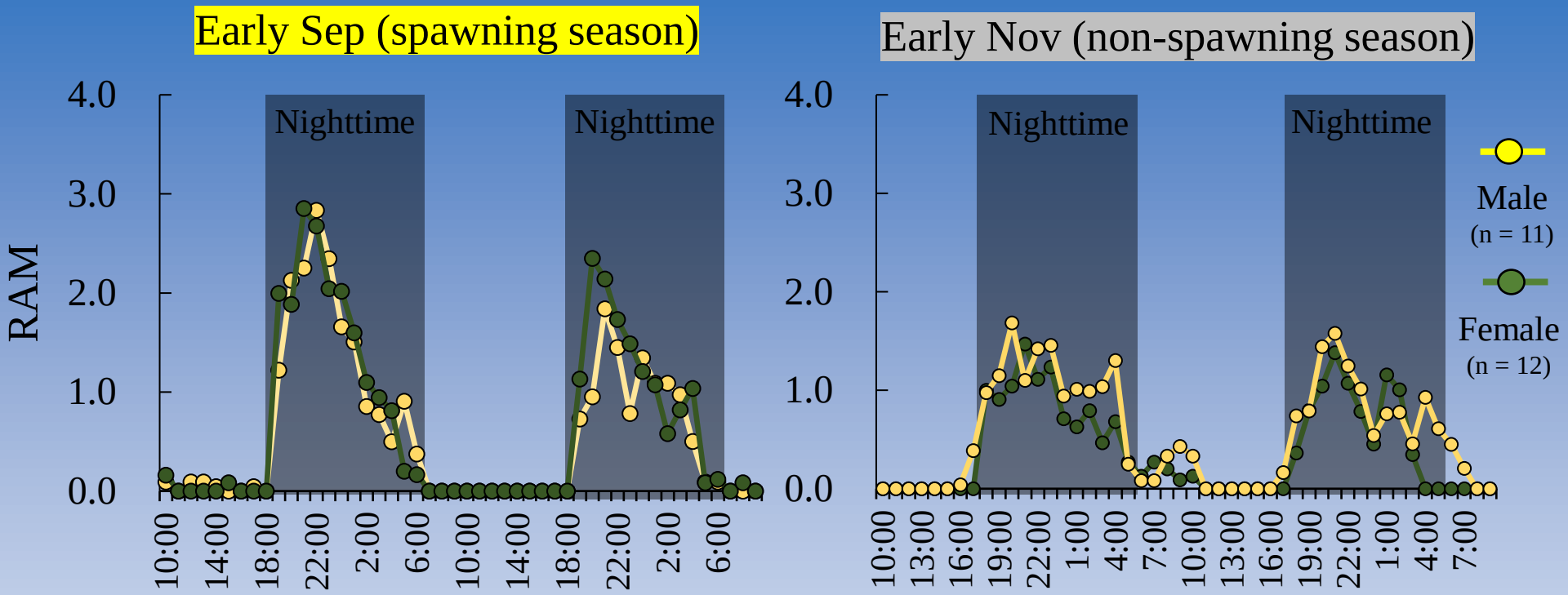




$$R_{10\ \mathrm{pm}} = \sqrt[2]{((4-2)^2 + (2-0)^2} + 0.5 \times |1\text{-}0| \approx 3.33$$

Location of each individual was recorded hourly for 48 hours, and RAM of each individual was calculated hourly.

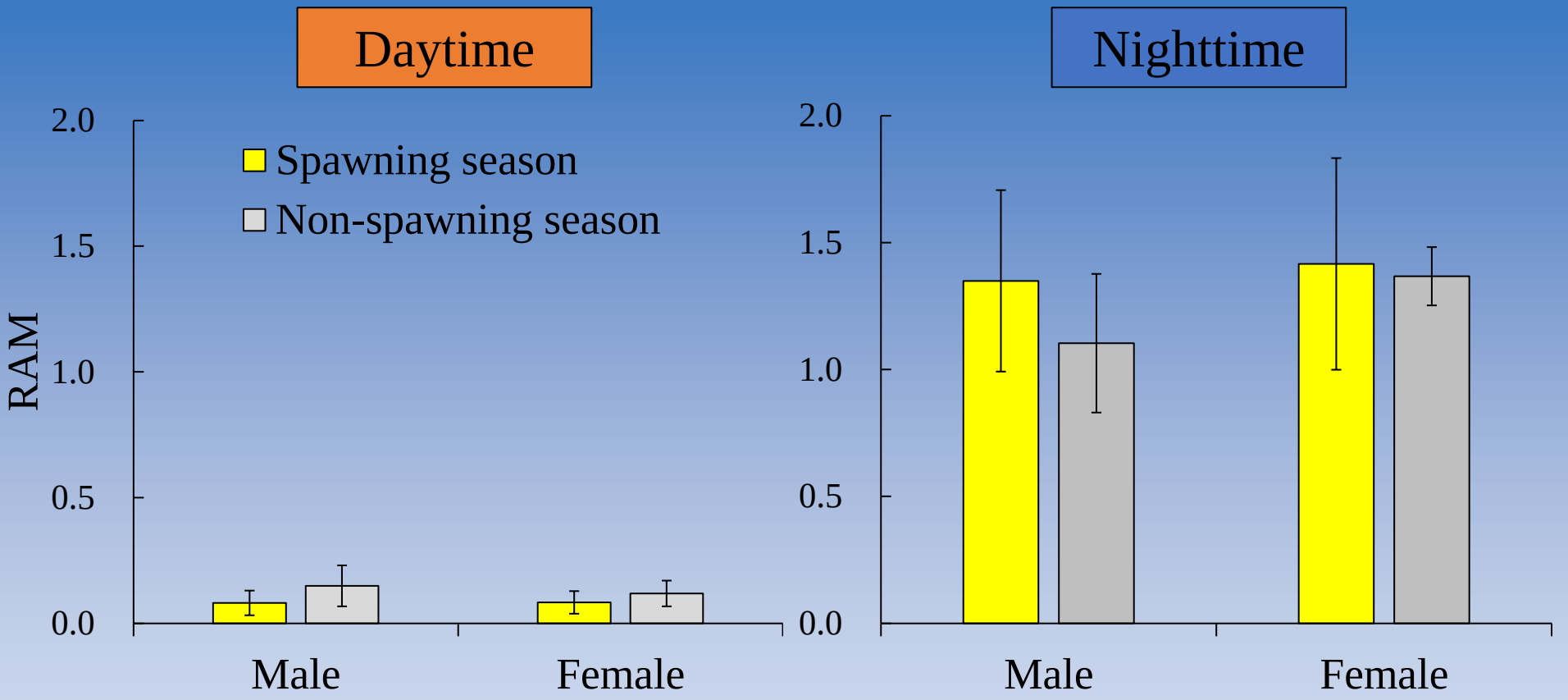
Results



The abalone showed distinct nocturnality with higher nighttime RAM than daytime, during both spawning and non-spawning seasons.

No clear difference in RAM was found between the sexes throughout the experiment.

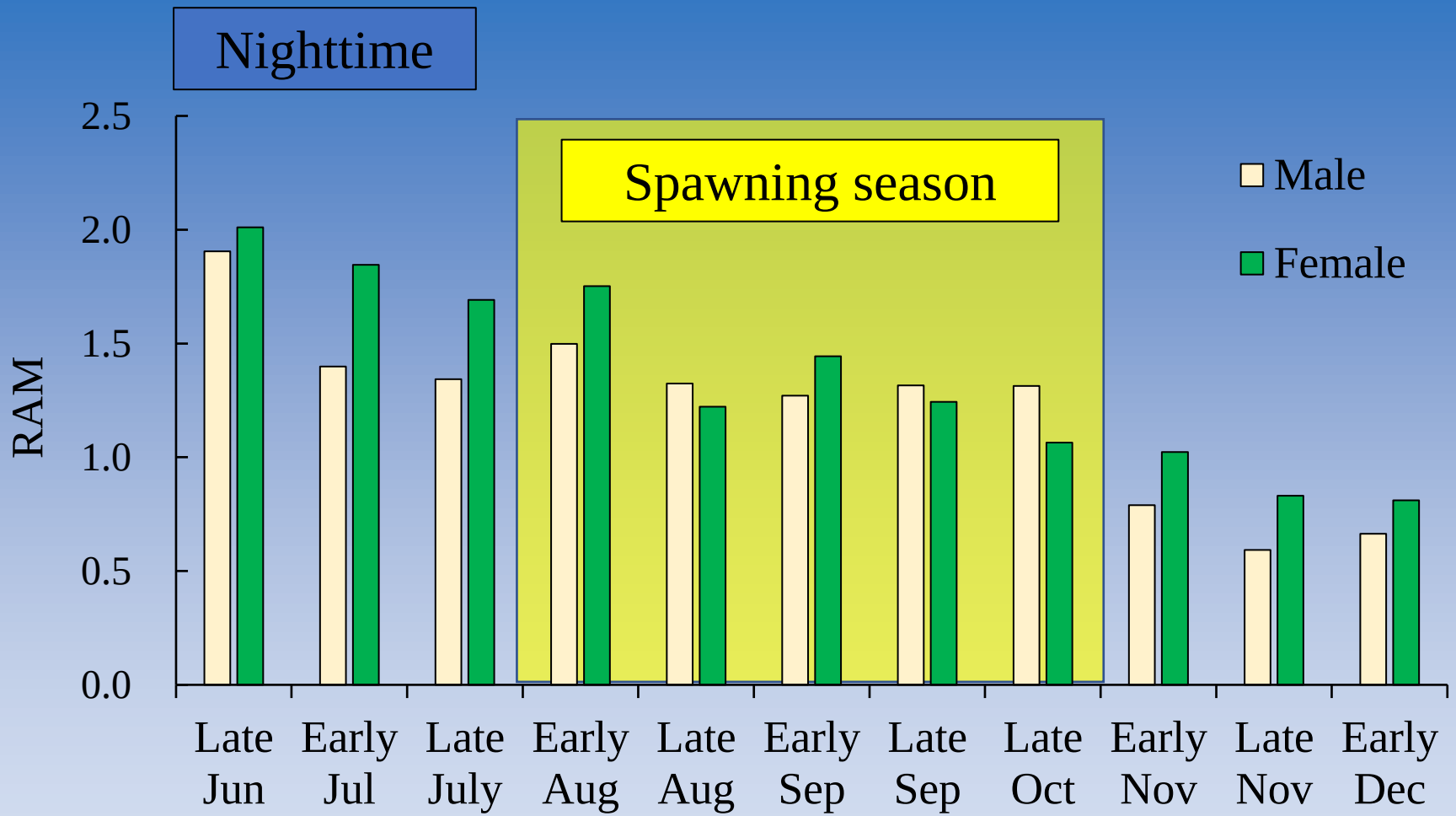
Results



$p > 0.05$ (paired-sample t-test)

In both sexes, no significant difference in daytime and nighttime RAM was found between the spawning and non-spawning seasons.

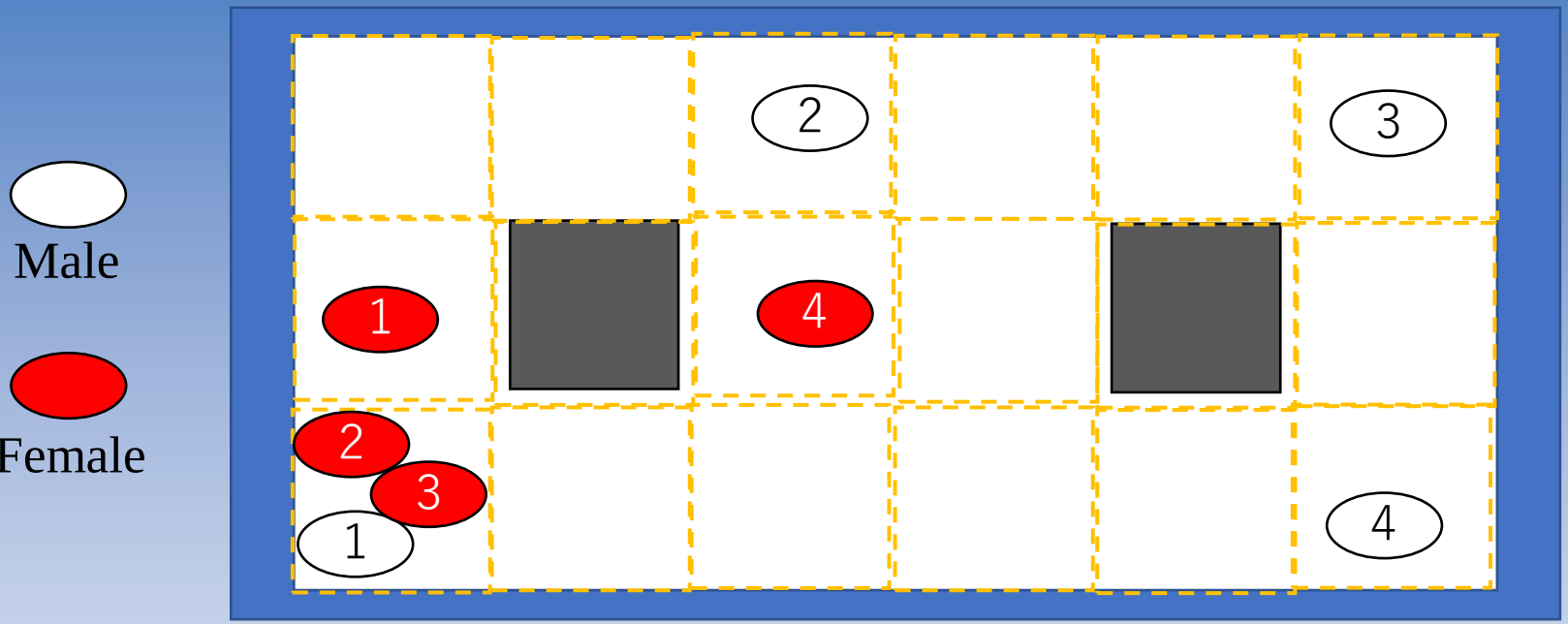
Results



Nighttime RAM showed a decreasing trend through the experiment.
(No trend of lower travel distance was identified during the spawning season.)

Material and method

Score of the number of neighboring individuals with opposite sex (SNNIOS)



$$S_t = 2I_t + N_t$$

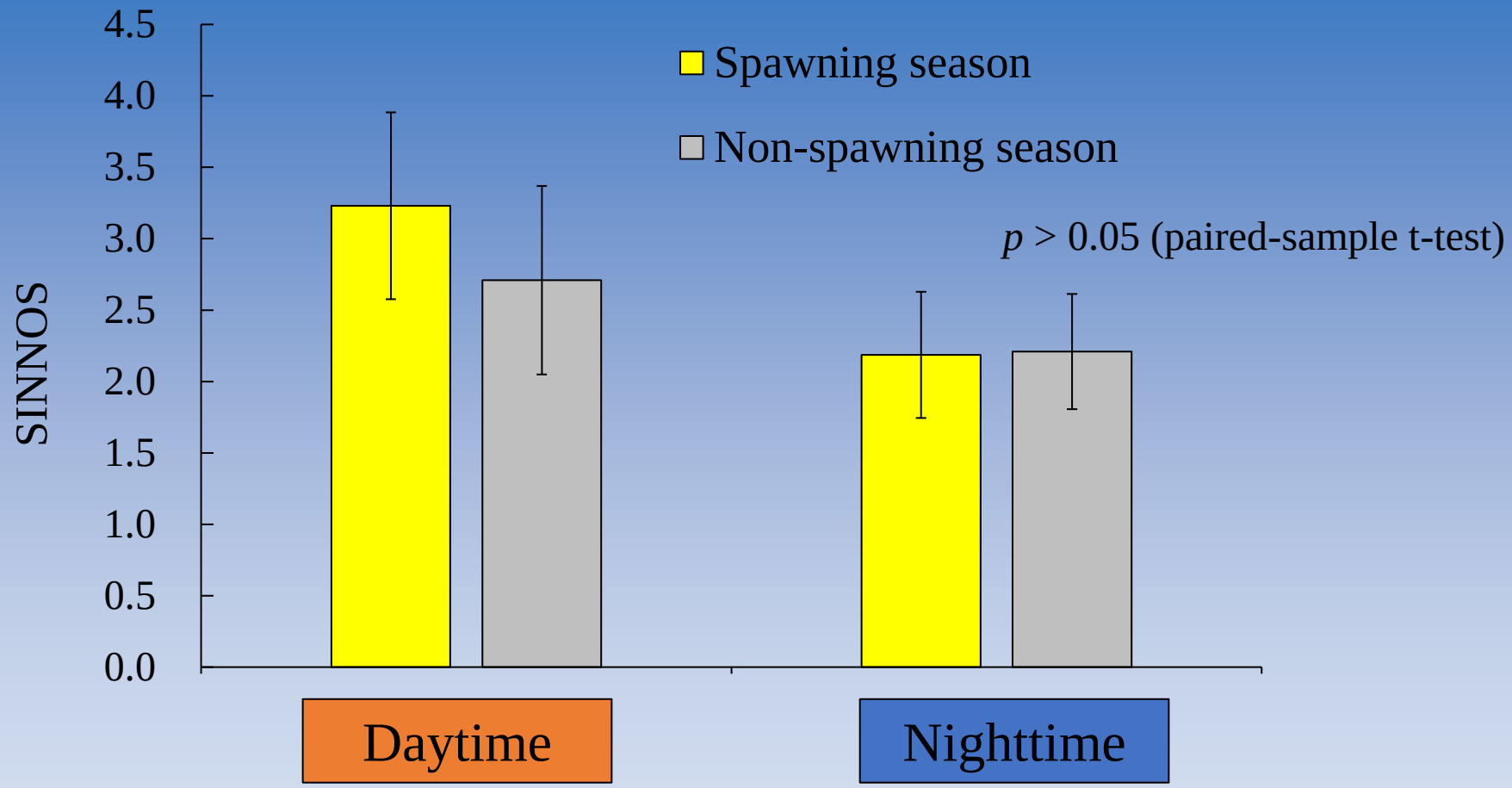
S: SNNIOS

I: The number of individuals of opposite sex inside same compartment

N: The number of individuals of opposite sex inside neighboring compartments

In the above case, SNNIOS of Male 1 is 5 and that of Male 3 is 0.

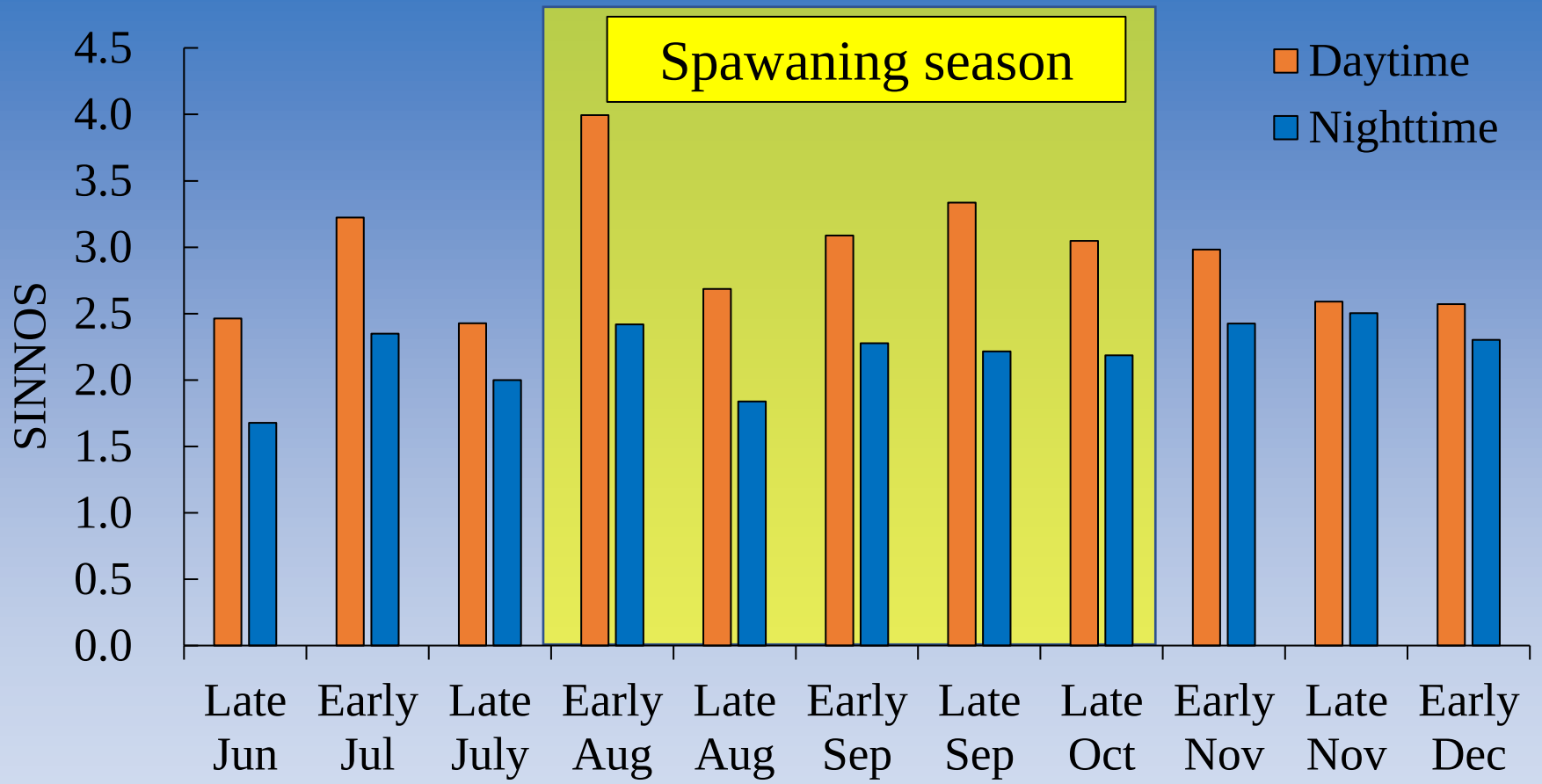
Results



Daytime SINNOS was higher than Nighttime during both the seasons.

No significant difference in SINNOS was found between the seasons.

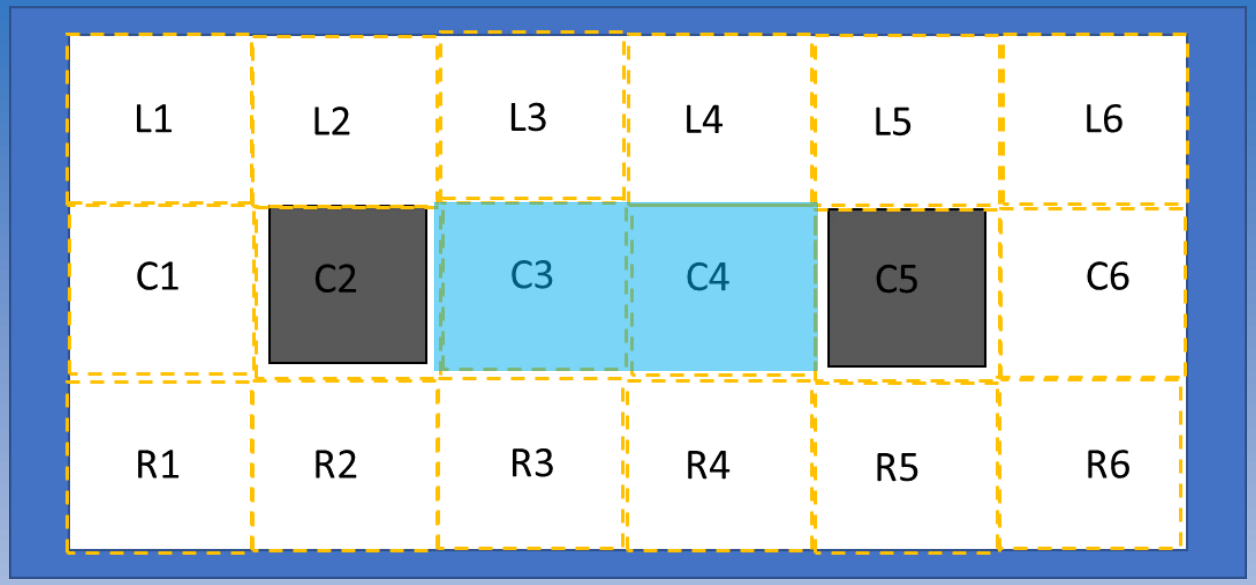
Results



No clear trend in SINNOS was found throughout the experiment.

No trend of lower distance from other individuals was identified during the spawning season.

Material and method



Saccharina japonica
(60-70 cm length)

Mimic plastic kelp
(67 cm length)

A kelp *S. japonica* was placed across two compartments (C3 and C4) at 4pm on 24 Jul.

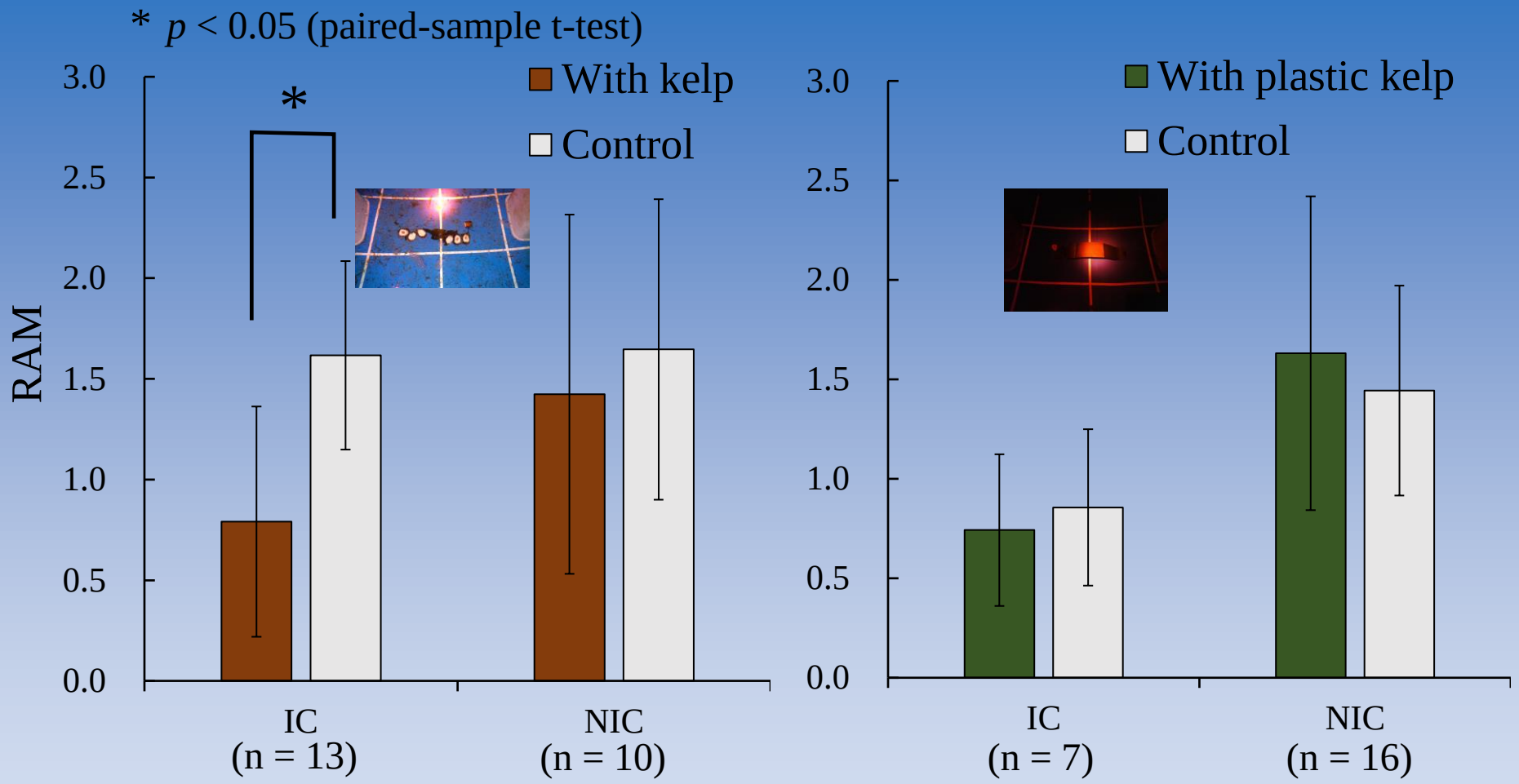
Mimic plastic kelp was placed across two compartments (C3 and C4) at 4pm on 21 Aug

RAM from 6pm to 1am was calculated for each individual

1. in contact with natural or mimic kelp (IC), found in C3 or C4 during experiments.
2. not in contact with natural or mimic kelp (NIC), not found in C3 and C4.

Compared with RAM of each individual during the same time period in controls (the data of the last observation in late Jul and late Aug were used as the controls).

Results



Only nighttime RAM of the individuals in contact with natural kelp was significantly lower than the control.

Dissucusion

1) To examine whether behavioural patterns of the abalone change between the spawning and non-spawning seasons.

→ The behavioural patterns of the abalone did not change between the seasons.

→ External factors are considered more important for the aggregation during the spawning season.

2) To examine what factors in kelp beds affect the aggregation during the spawning season.

→ The existence of the kelp significantly decreased the nighttime RAM, although the mimic kelp did not.

→ The abalone moves at night, probably searching for diets, and stops moving when encountering kelp beds.

The existence of kelp beds important as diets may sustain the aggregation.

(Spawning event when typhoon 16 passed, during the experiment)