KYUSHU UNIVERSITY

# Effects of light quality on the initiation and development of *Skeletonema costatum* blooms

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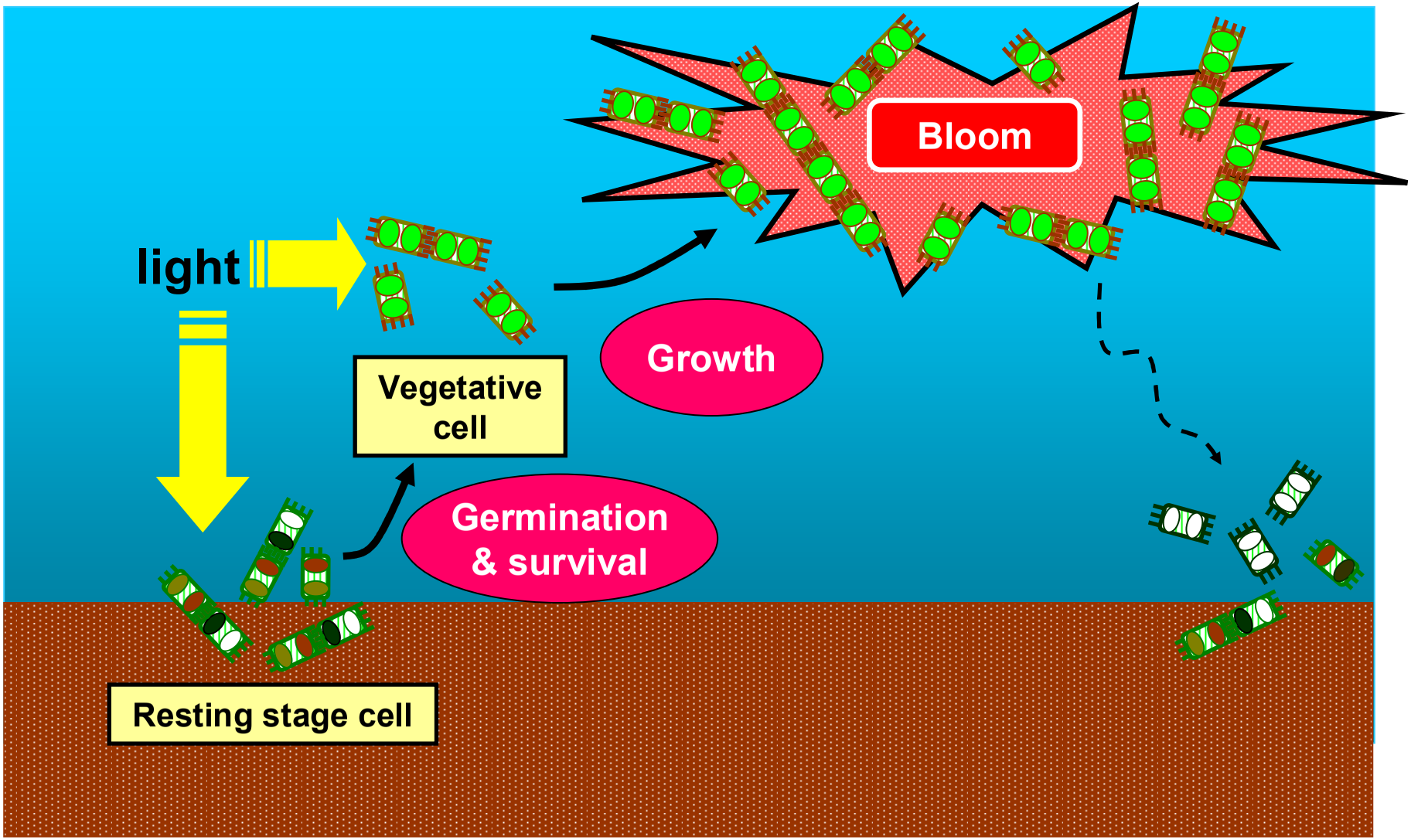
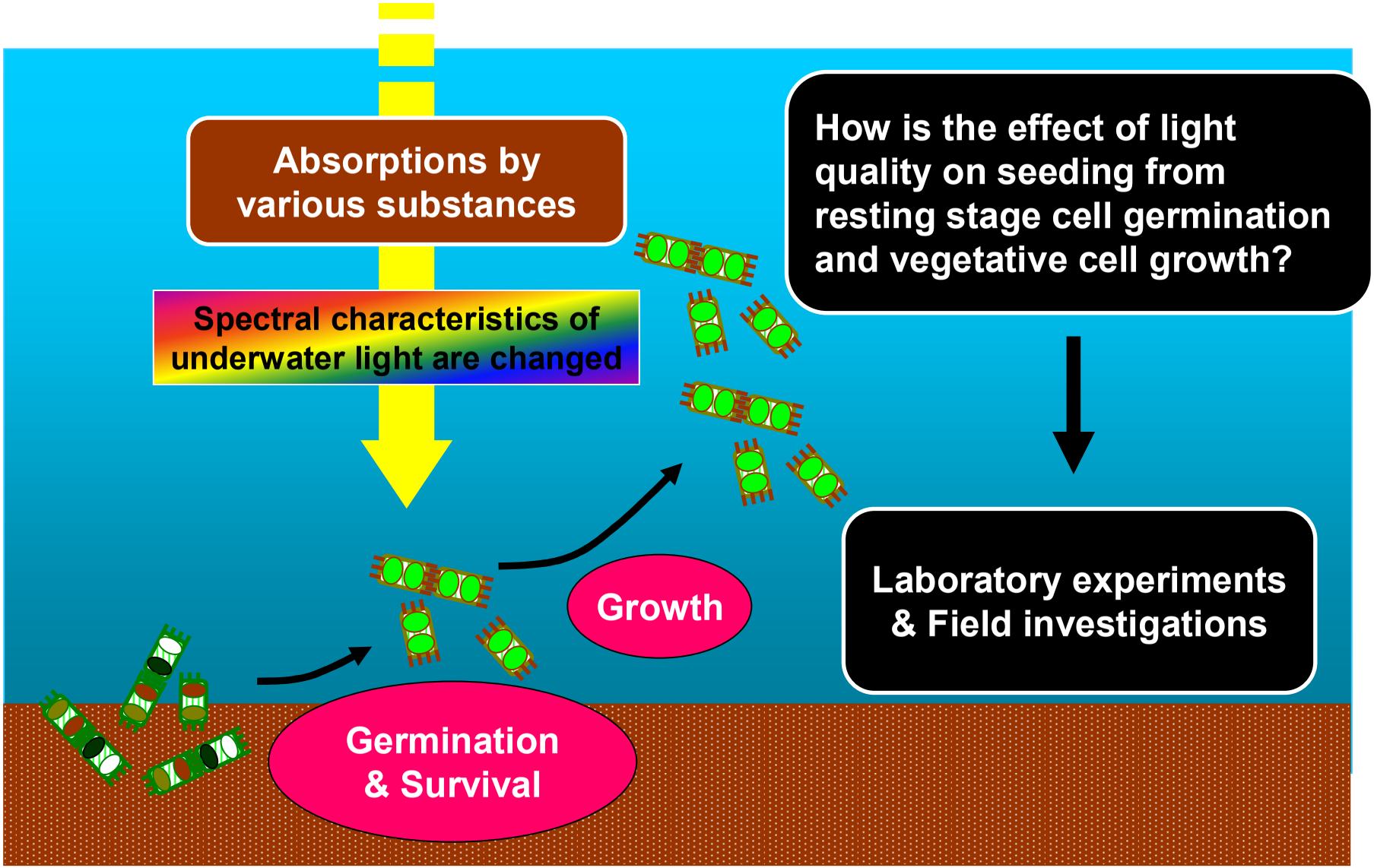
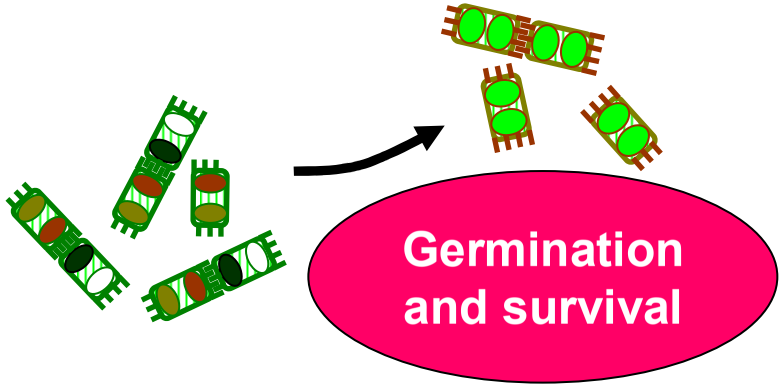
# General idea on blooming mechanism of meroplanktonic diatoms



# Light quality changes in water column

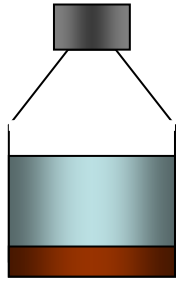


**Testing the effects of light wave-length on germination of resting stage cells and the survival of cells germinated from bottom sediments.**

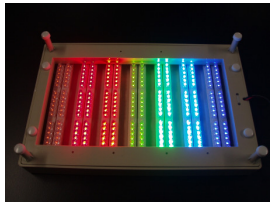


# Methods 1

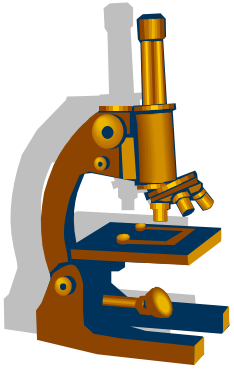
**1. Suspending** the sediment including many resting stage cells to seawater enriched in nutrients.



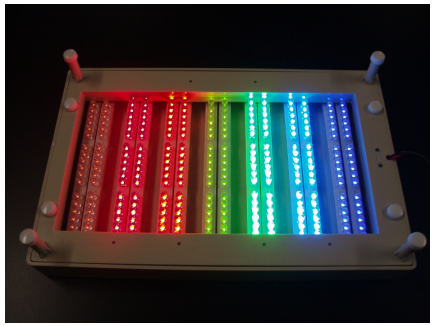
**2. Incubating** the suspension under spectral lights with 6 different wave lengths (**violet**, **blue**, **green**, **orange**, **red**, and **near-infrared**) and in the dark.



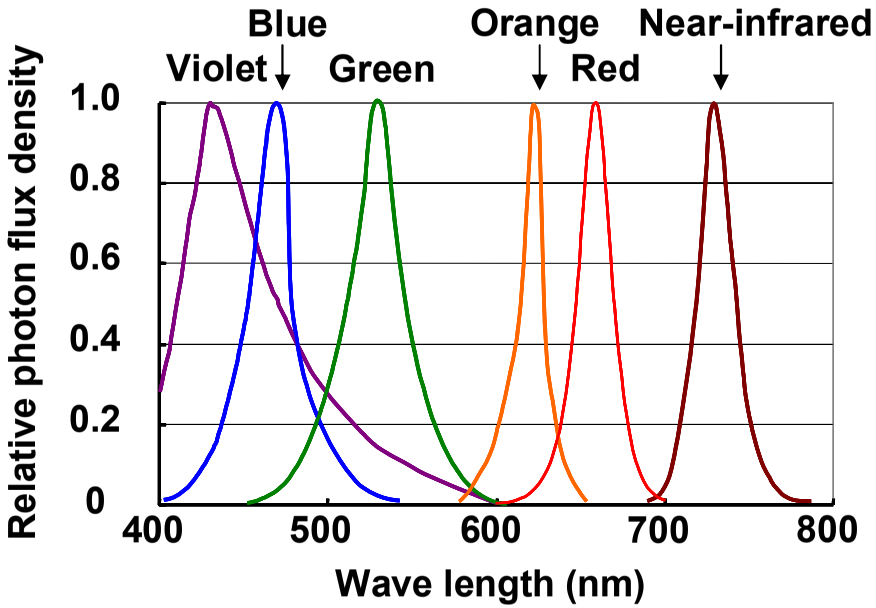
**3. Counting** vegetative cells, which germinated from resting stage cells, in the suspension every two days after the start of the culture.



# Light source for the sediment culture



Light emitting diode (LED)



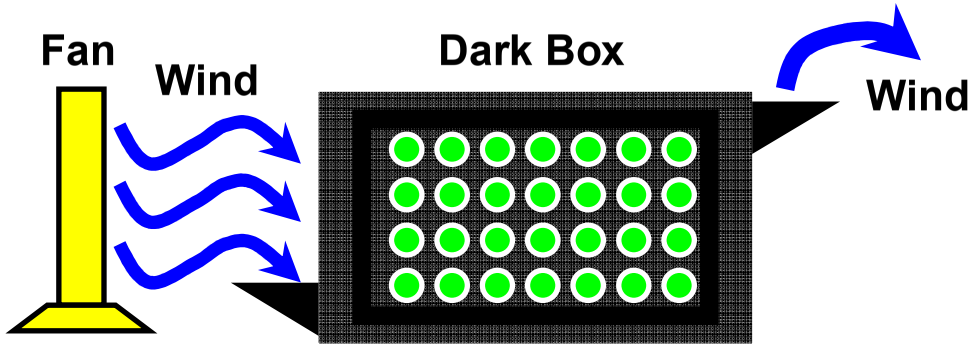

| Light color | Peak wavelength (nm) | Photon density (*) |
|---|---|---|
| Violet | 430 | 40 |
| Blue | 470 | |
| Green | 530 | |
| Orange | 623 | |
| Red | 660 | |
| NIR | 730 | |
| Dark | — | 0 |

*μmol quanta $m^{-2}$ $s^{-1}$

# Culture environment

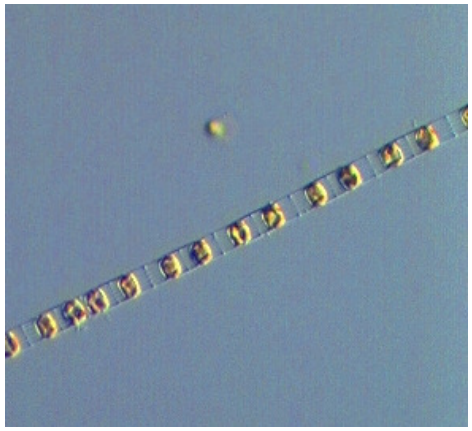
The incubator in the dark room.

Dark boxes with LEDs in of the incubator.

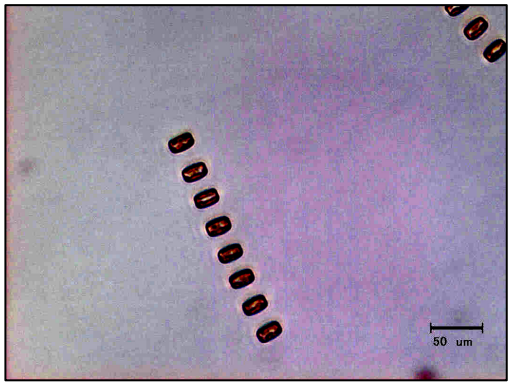



The dark box with LEDs.

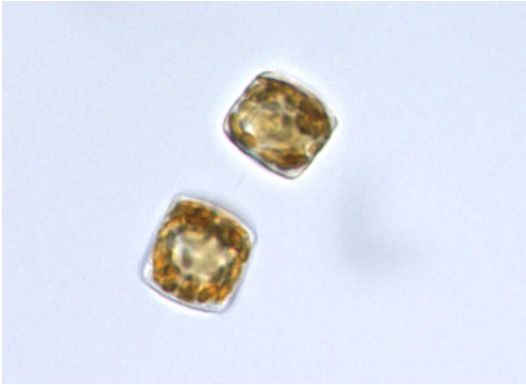
# Result 1-1: Diatoms germinated from the sediment



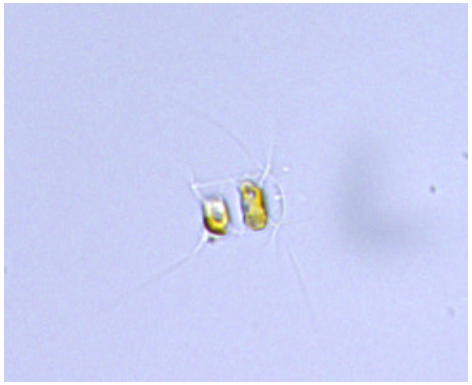
*Skeletonema costatum*




*Thalassiosira minima*

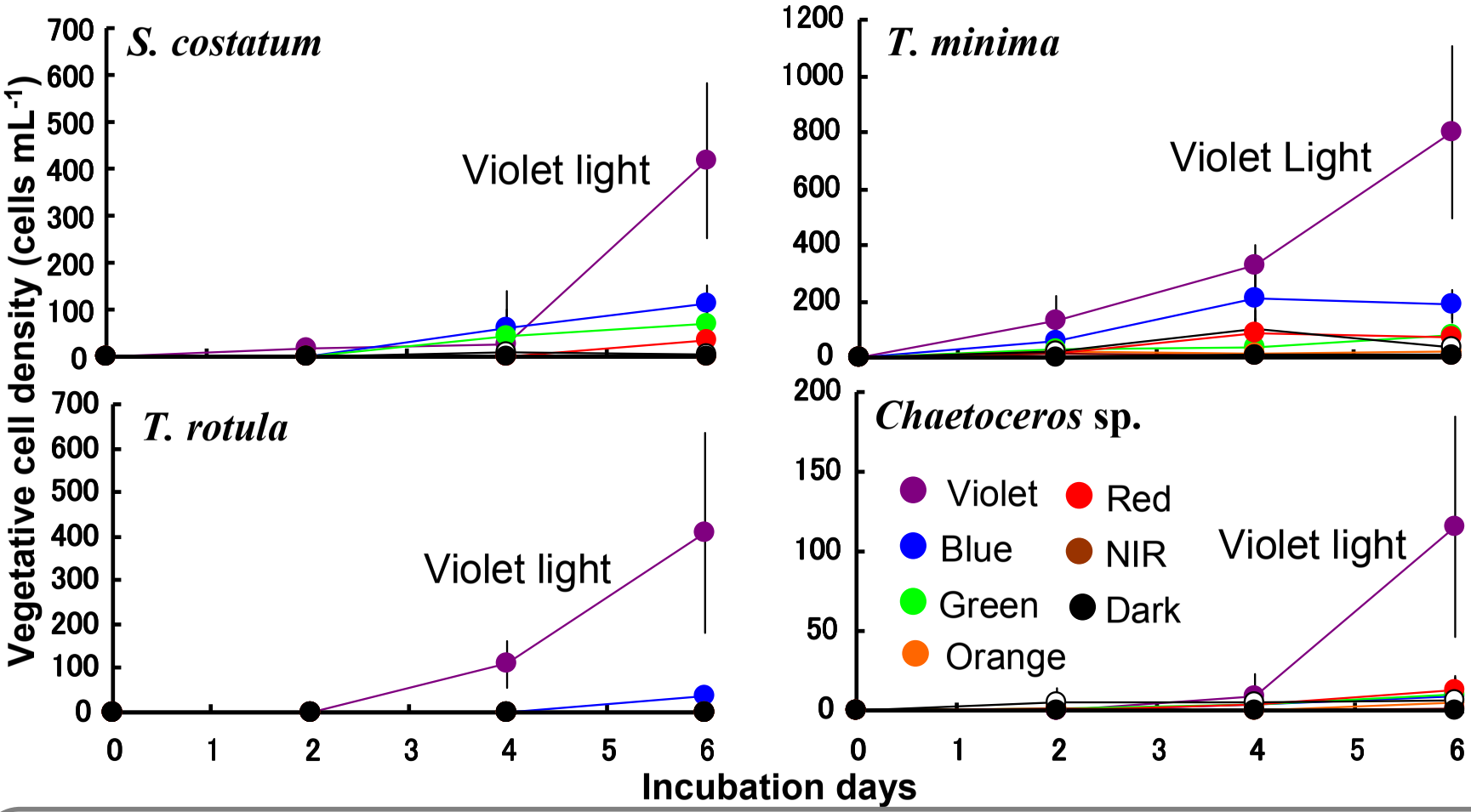


*Thalassiosira rotula*



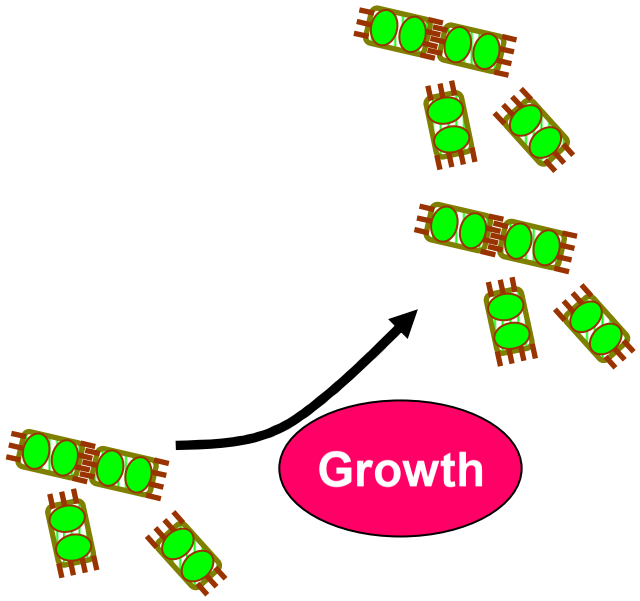
*Chaetoceros* sp.

# Result 1-2: Progressive appearance of vegetative cells




**Only under violet light did the number of resting stage cells increased clearly.**
**→Violet light may be necessary for germination process (resting stage cell germination and survival of the germinated cells) of four diatoms.**

# Testing the effects of light wave-length on vegetative cell growths using cultivated strains

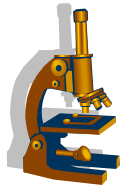


# Methods 2

1. **Pre-incubating** cultivated strains of 5 diatoms and 5 flagellates in the dark for two days.

2. **Incubating** the cultivated strains under 6 different spectral lights from LEDs.

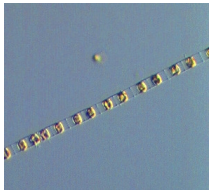
3. **Counting** cells everyday.



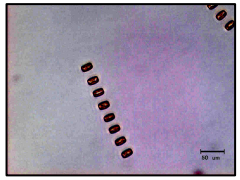
4. **Calculating** the growth rates.

## Tested organisms

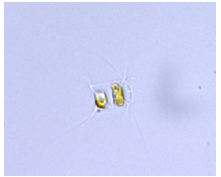
**Diatoms**



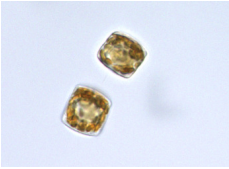
*S. costatum*



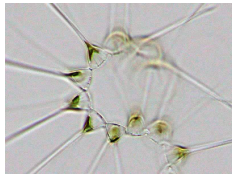
*T. minima*



*Chaetoceros* sp.



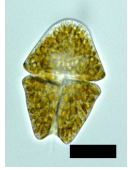
*T. rotula*



*A. gracialis*

**Flagellates**

*H. akashiwo*



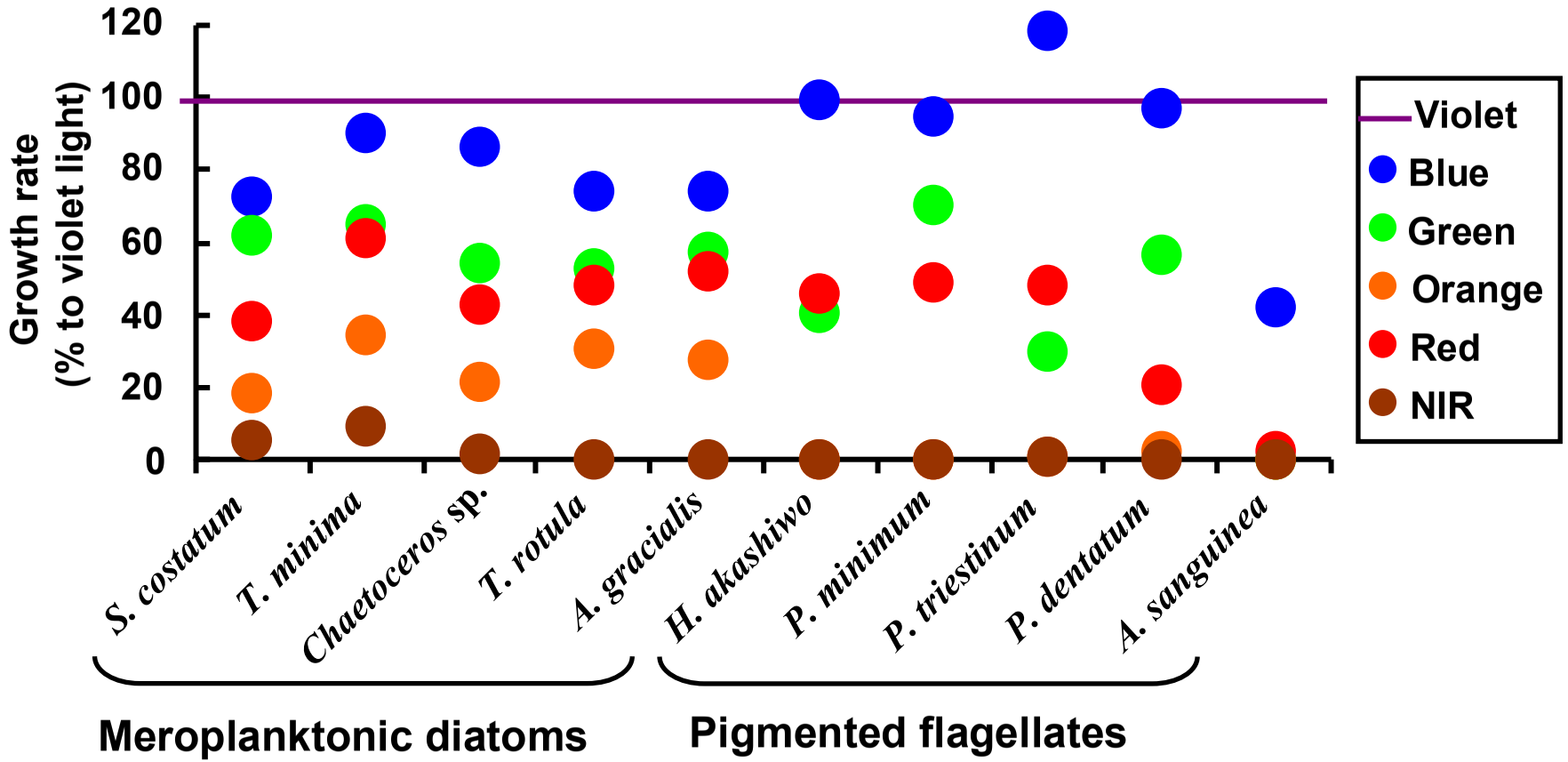
*A. sanguinea*

*P. minimum*

*P. triestinum*

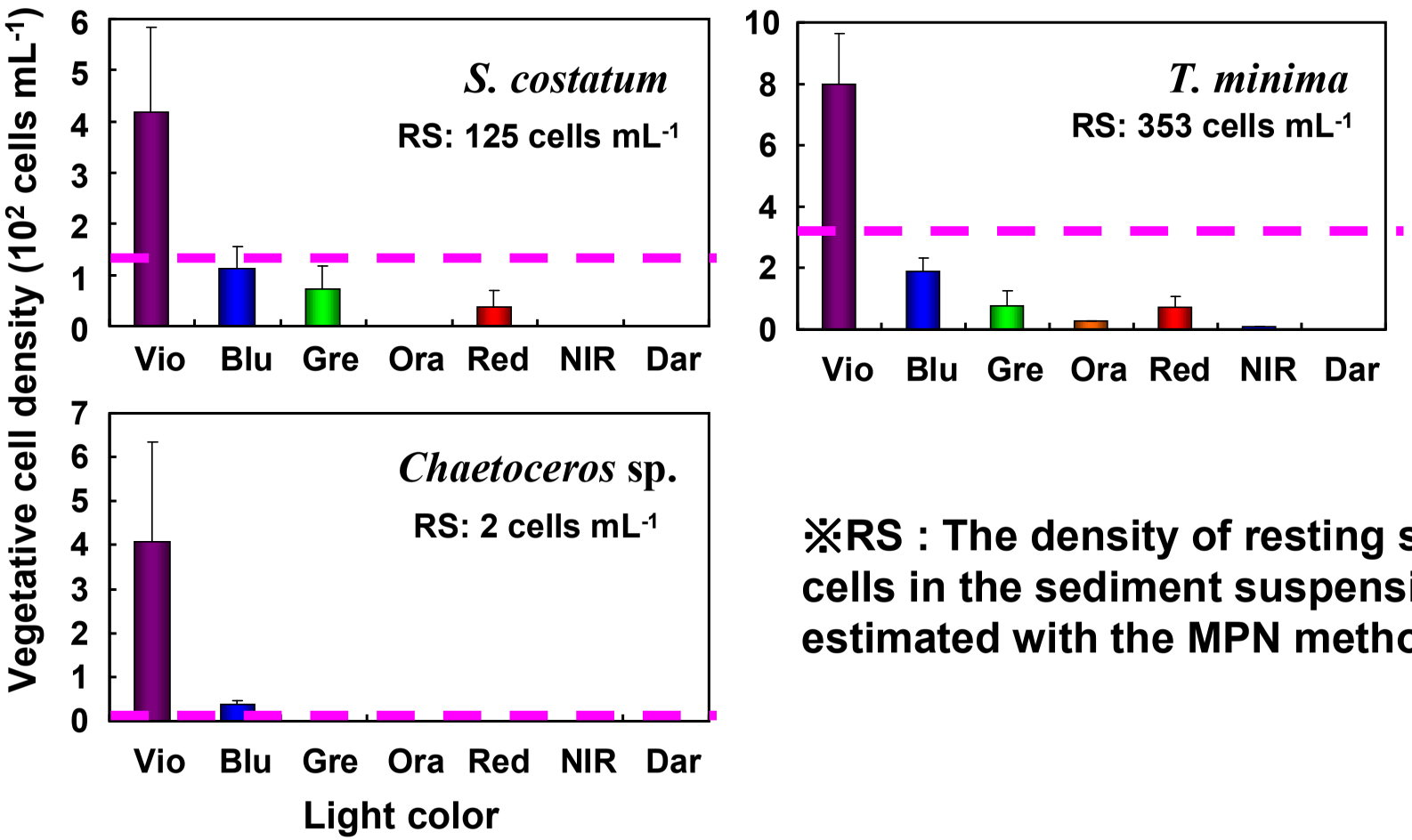
*P. dentatum*

# Results 2-1: Growth rates under various color light




Under violet and blue light, the growth rates of all strains were higher.
→**Violet and blue light would be effective for vegetative growth commonly among diatoms and flagellates.**

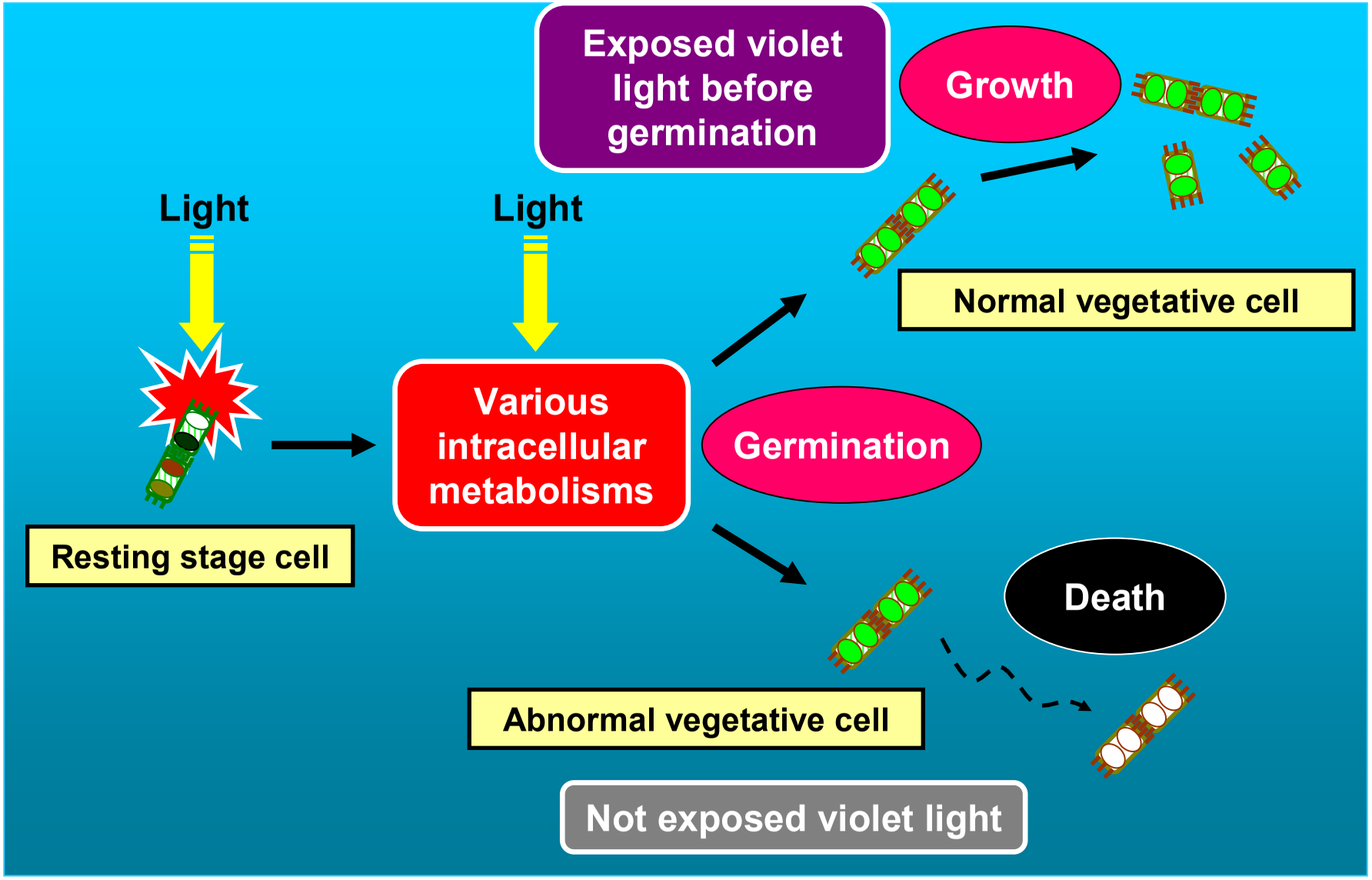
## The number of vegetative cell density on day 6 in the sediment culture




**※RS : The density of resting stage cells in the sediment suspension, estimated with the MPN method.**

**The yield of germinated cells clearly exceeded the original density of resting stage cells only under violet light.**

# Hypothesis on the germination process




Please see Shikata et al. (2007) Harmful Algae 6: 700-706
Shikata et al. (2008) Limnology & Oceanography 53 (6): 2503-2518

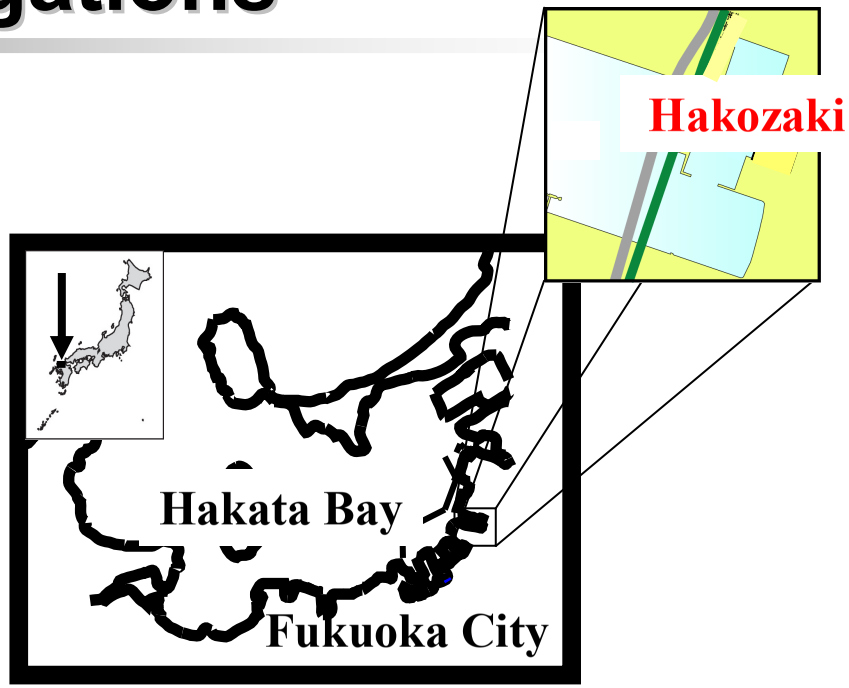
# Methods 3: Field investigations

【Sampling point & Frequency】

Hakozaki Fishing Port

（depth 2.5-4.5 m）, Hakata Bay, Japan

・・・Everyday or Every two days




【Items & Period】

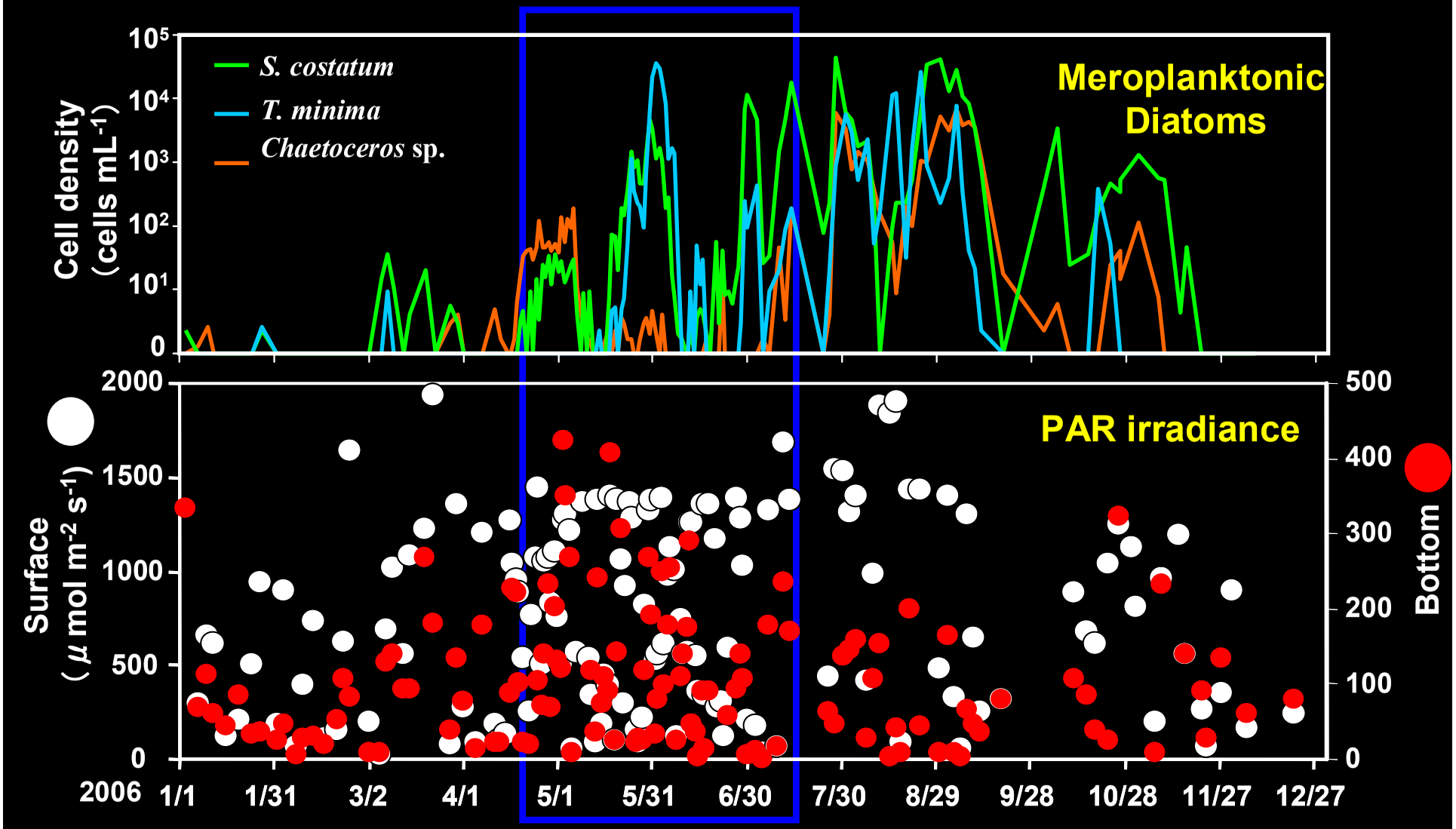
----from January to December, 2006----

- Cell densities of Phytoplankton species at layers of 0.1 m, 1.5 m & bottom
- Underwater light intensity at 0.1 m & 2.5 m layers

----from mid-April to mid-July, 2006 (bloom period)----

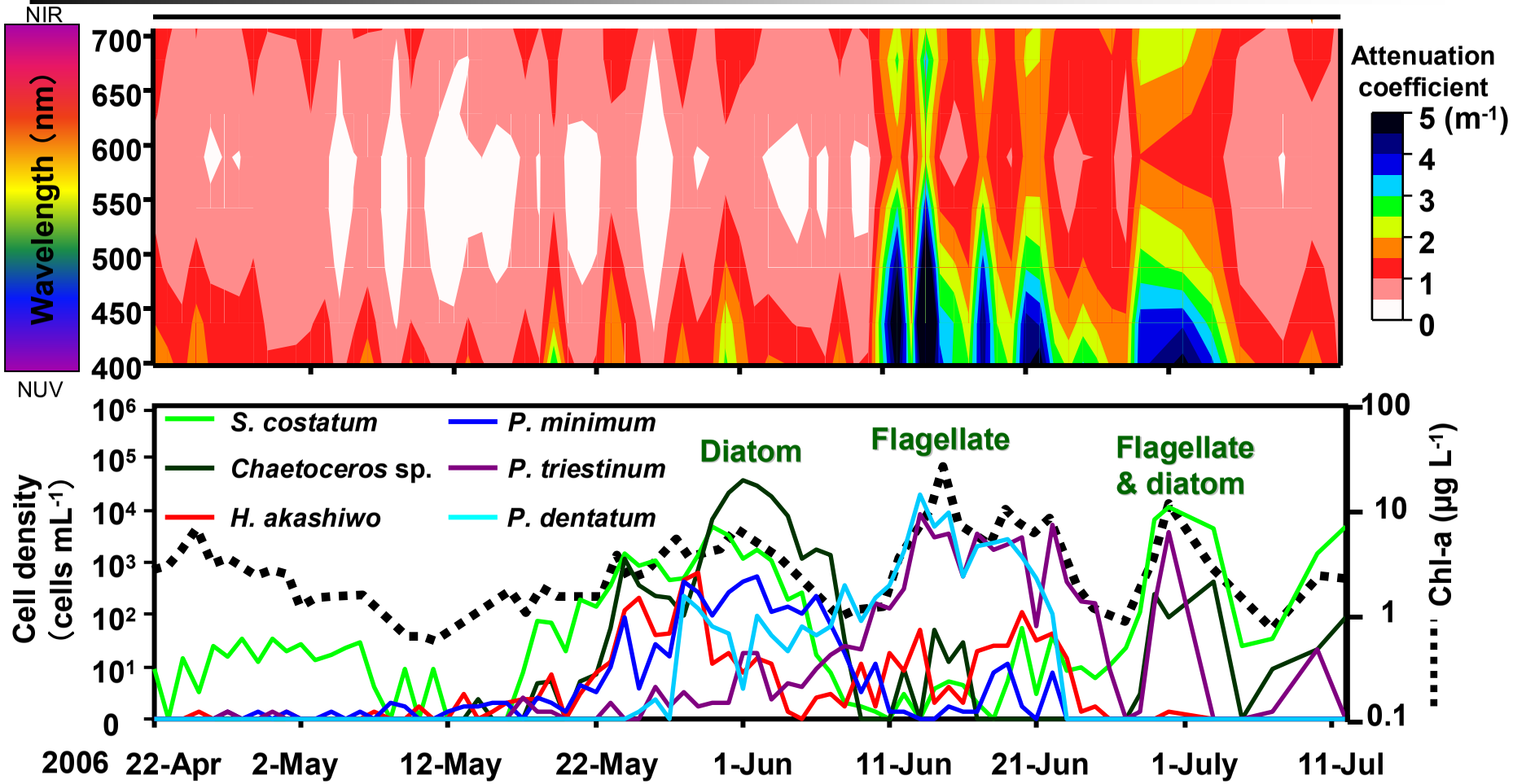
- Relative photon flux density of each light spectrum at intervals of 0.5 m from 0.5 to 2.5 m → Attenuation coefficients
- Chl-a concentration at intervals of 0.1 m from 0.1 m to bottom layer

# Result 3-1: Seasonal dynamics of Phytoplankton & PAR



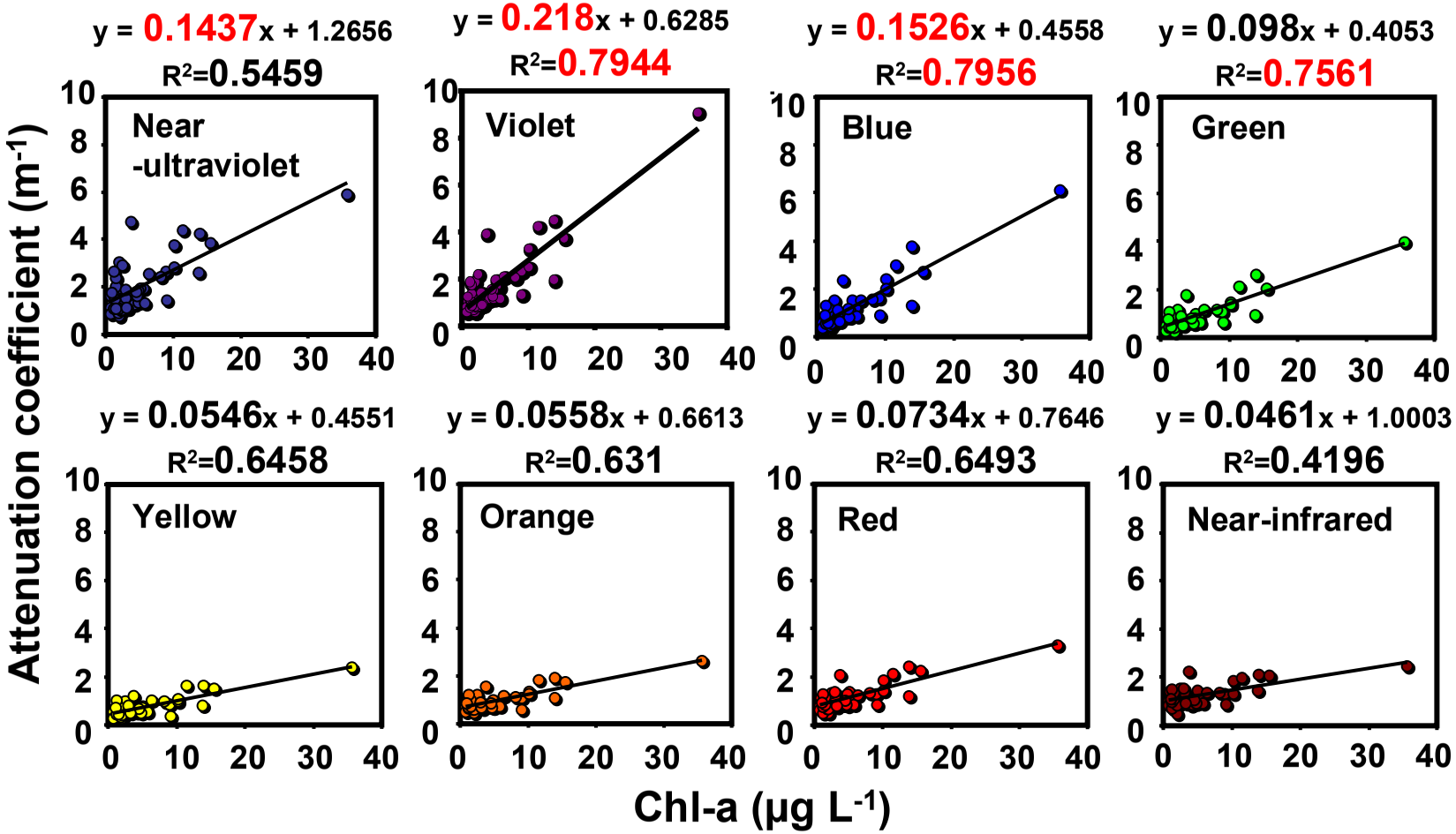

• Meroplanktonic diatom blooms initiated and developed in early summer, when strong light often penetrated to the bottom layer.

# Result 3-2: Temporal dynamics of Spectral-light attenuations & Phytoplankton




- Diatoms started to appear frequently when attenuations of all light spectra were low.
- In late May, early June and late June, meroplanktonic diatoms, flagellates, and flagellates and diatoms, respectively, bloomed.
- Each bloom disappeared within several days.
- Short-wavelength light (violet and blue) attenuated markedly during bloom periods.

# Result 3-3: The relationship between attenuation of different light spectrum & Chl-a concentration




Attenuation of violet and blue light was more highly correlated with Chl-a than the other light spectra, and more attenuated for a given level of fluorescence.

→**Short-wavelength light is the most attenuated by phytoplankton.**

***Chl-a concetration was correlated with total cell number of phytoplankton (figure not shown).**

# Overview

## Laboratory work

- Violet light may be necessary for germination process (resting stage cell germination and survival of the germinated cells) of four diatoms such as *Skeletonema costatum*.

- Violet and blue light would be effective for vegetative growth commonly among diatoms and flagellates.

## Field work in Hakozaki Fishing Port

- Short-wavelength light is the most attenuated by absorption of phytoplankton, and so short wave-length light would be hard to penetrate underwater in the port where phytoplankton biomass is high.

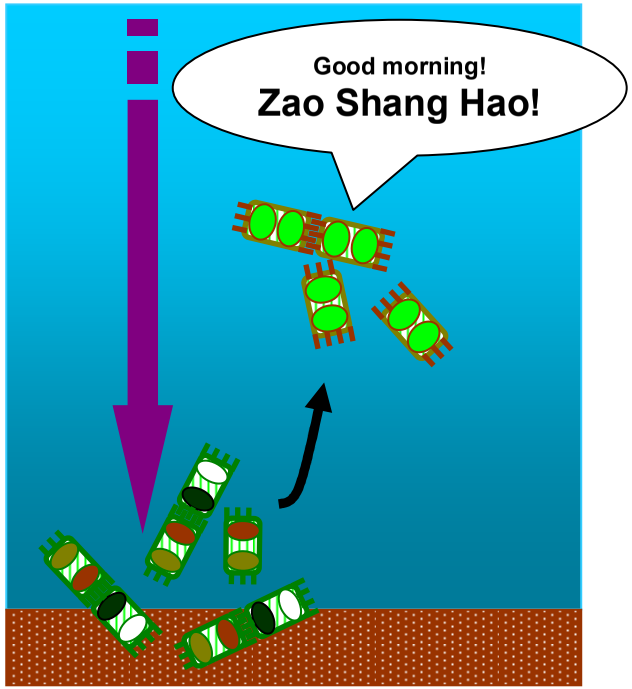
- Underwater light was often strong and attenuation of short-wavelength light was relatively low in bloom initiation periods, when the frequent appearance of vegetative diatom cells started.

- When attenuations of short-wavelength lights were high at blooming period or in bloom initiation, the bloom declined within a short time or did not start.

# Conclusion

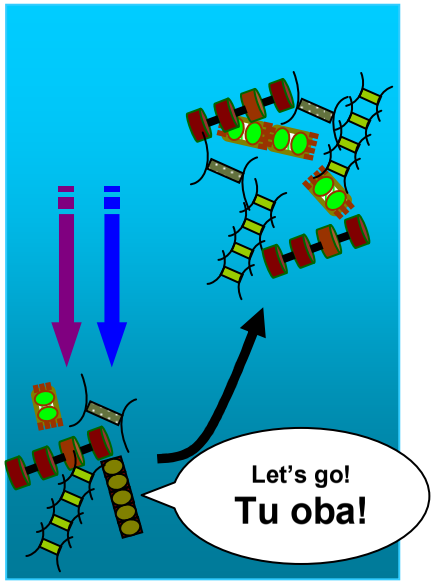
**• Penetration of short-wavelength lights to underwater may be important for initiation and development of meroplanktonic diatom blooms in coastal areas.**

## Initiation



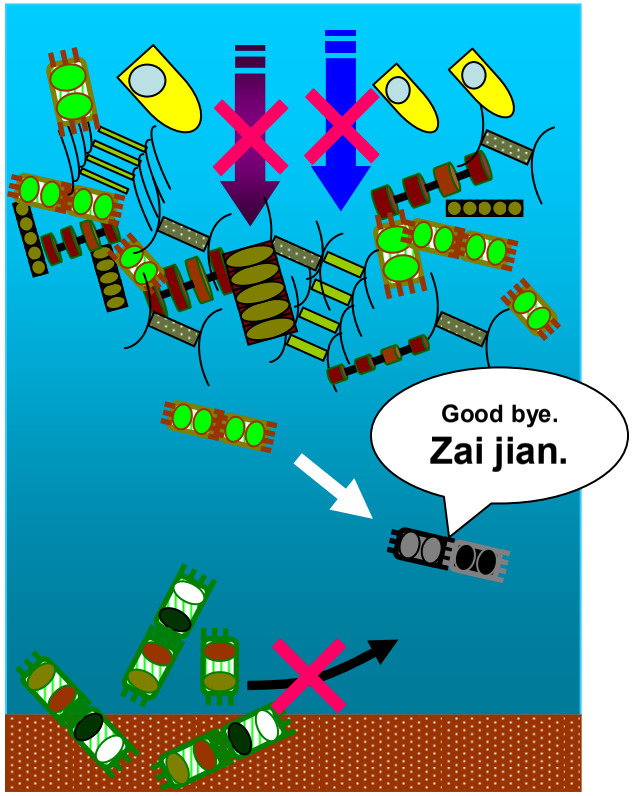

Violet light stimulates release of vegetative cells from bottom sediments.

## Development




Violet and Blue lights promote growth of vegetative cells.

## Blooming



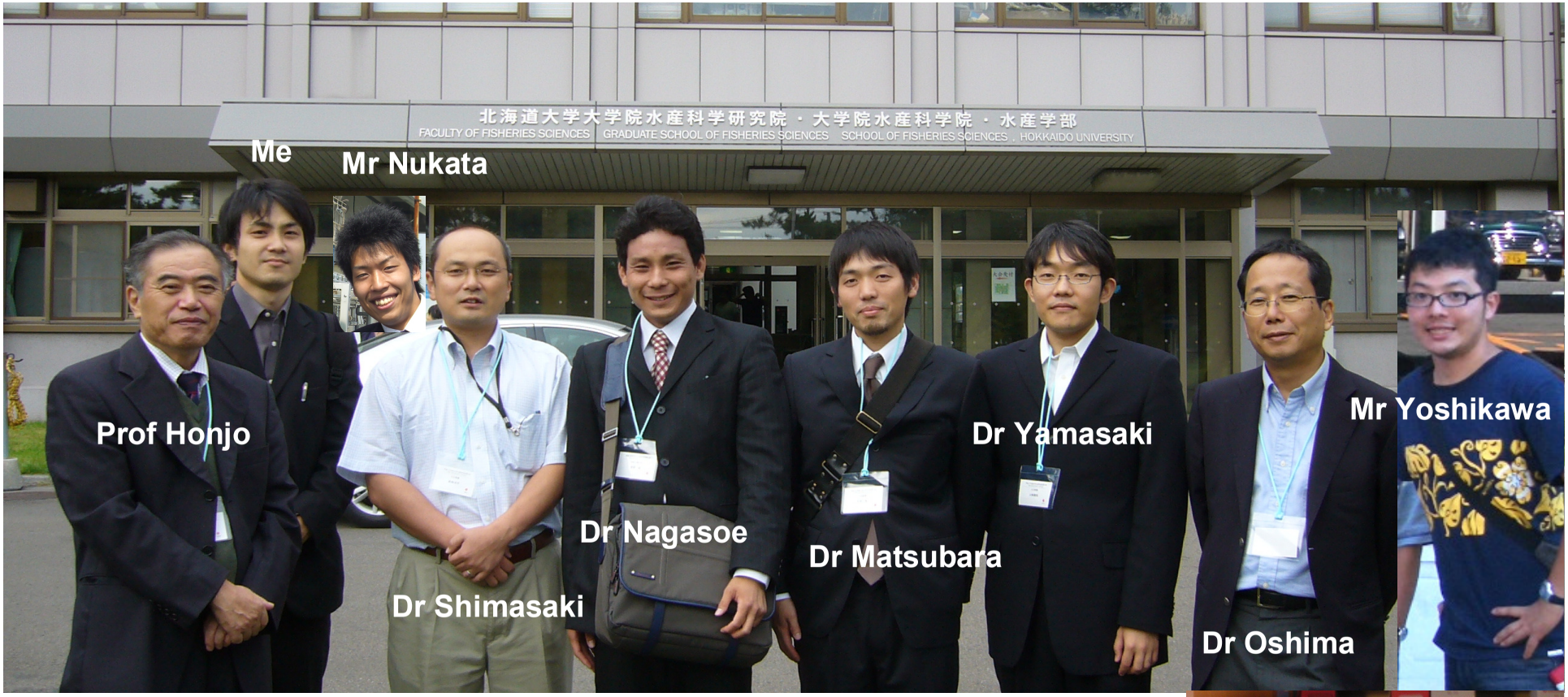

Attenuation of short-wavelength lights inhibits supply and increase of diatom populations.

# Future tasks to verify the hypothesis

How high light intensity do meroplanktonic diatoms require for the resting stage cell germination and vegetative cell growth?

1. Conducting germination and growth experiment at different light intensity under different light wave length.

2. Measuring real value of light intensity ("not relative" value) of each spectral light in the field using the other spectrophotometer.




Thank you for your kind attention!