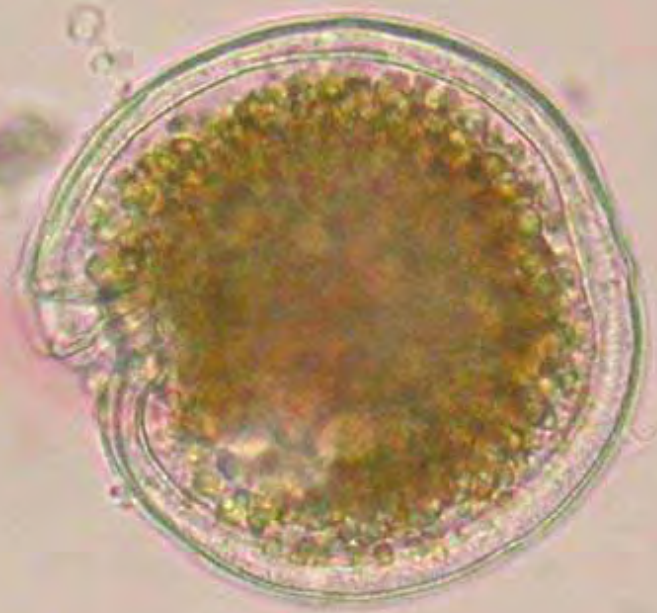
Year-round occurrence of the benthic dinoflagellate *Gambierdiscus* sp. in temperate coastal waters of Japan



Akira Ishikawa, Yumi Takeichi

(Mie University)

Setsuko Sakamoto, Mineo Yamaguchi

(National Researchi Institute of Fisheries and Environment of Inland Sea)

Background

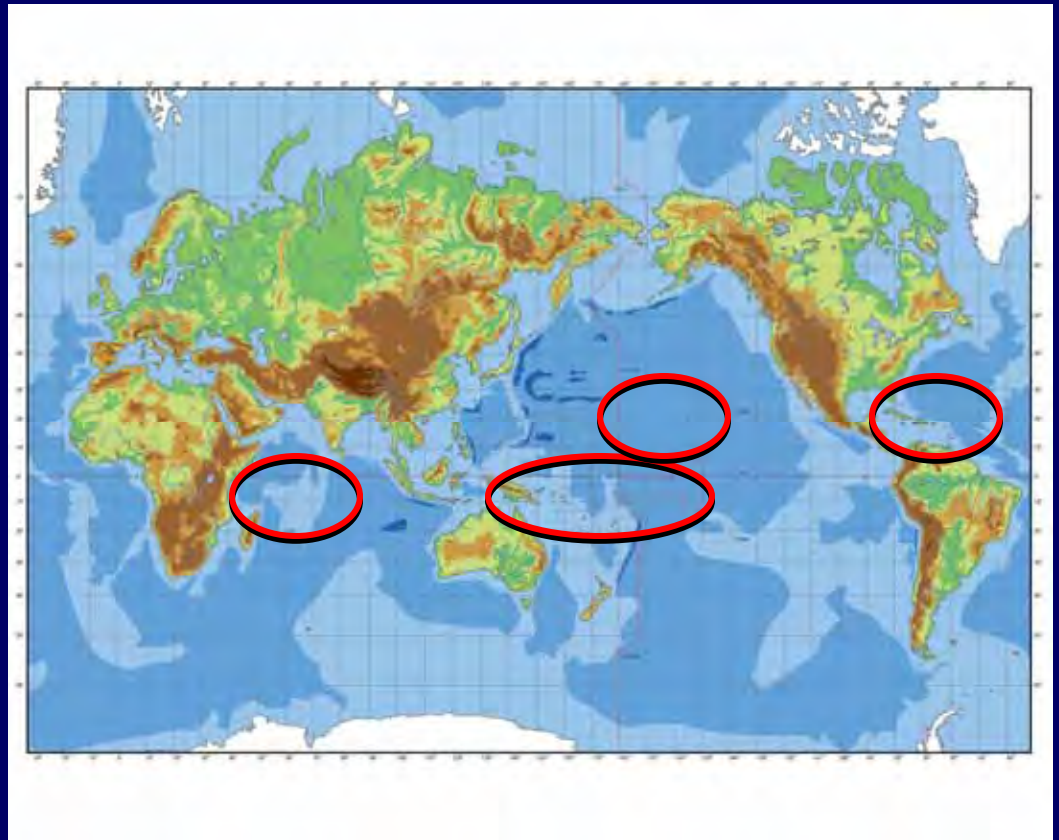
Gambierdiscus spp. is the benthic and epiphytic dinoflagellate, commonly found on the macroalgae in coral reefs.

Some of the *Gambierdiscus* spp. have been confirmed to produce maitotoxins and ciguatoxins, being the primary causative organism of ciguatera fish poisoning (CFP).

Background

They are distributed widely in tropical and subtropical regions, where CFP mainly occurs.

It has been reported that > 50,000 people suffer from CFP annually.



国土地理院承認 平14総複 第149号

In Japan

CFP is endemic in the subtropical regions, Okinawa & Amami Islands.

Several CFP incidents have sporadically occurred in temperate regions.

45° N
40°
35°
30°
25°
130°
140°
150° E

Pacific Ocean

Okinawa/Amami Is.

Temperate regions

Subtropical regions

国土地理院承認 平14総複 第149号

In Japan

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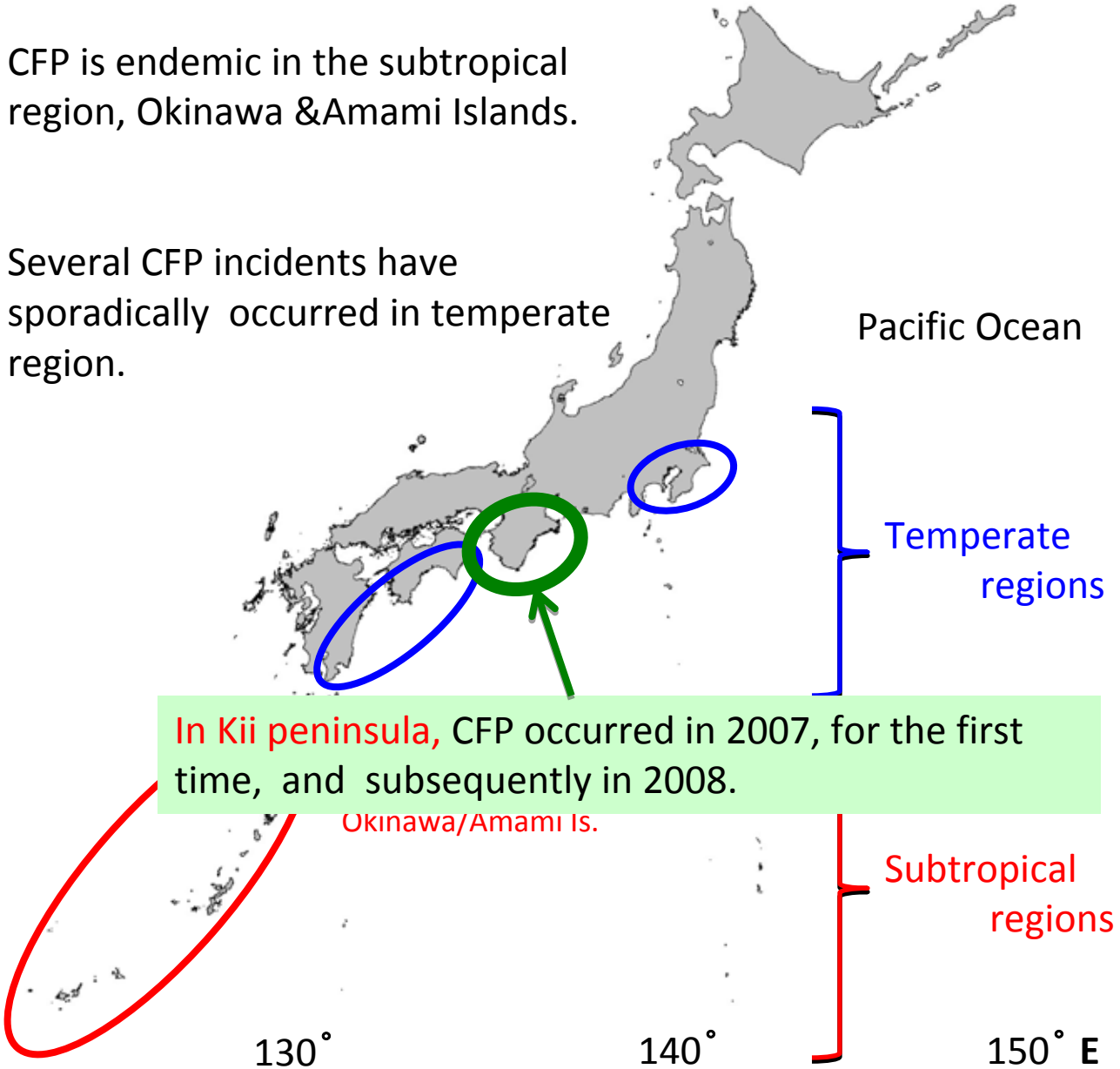
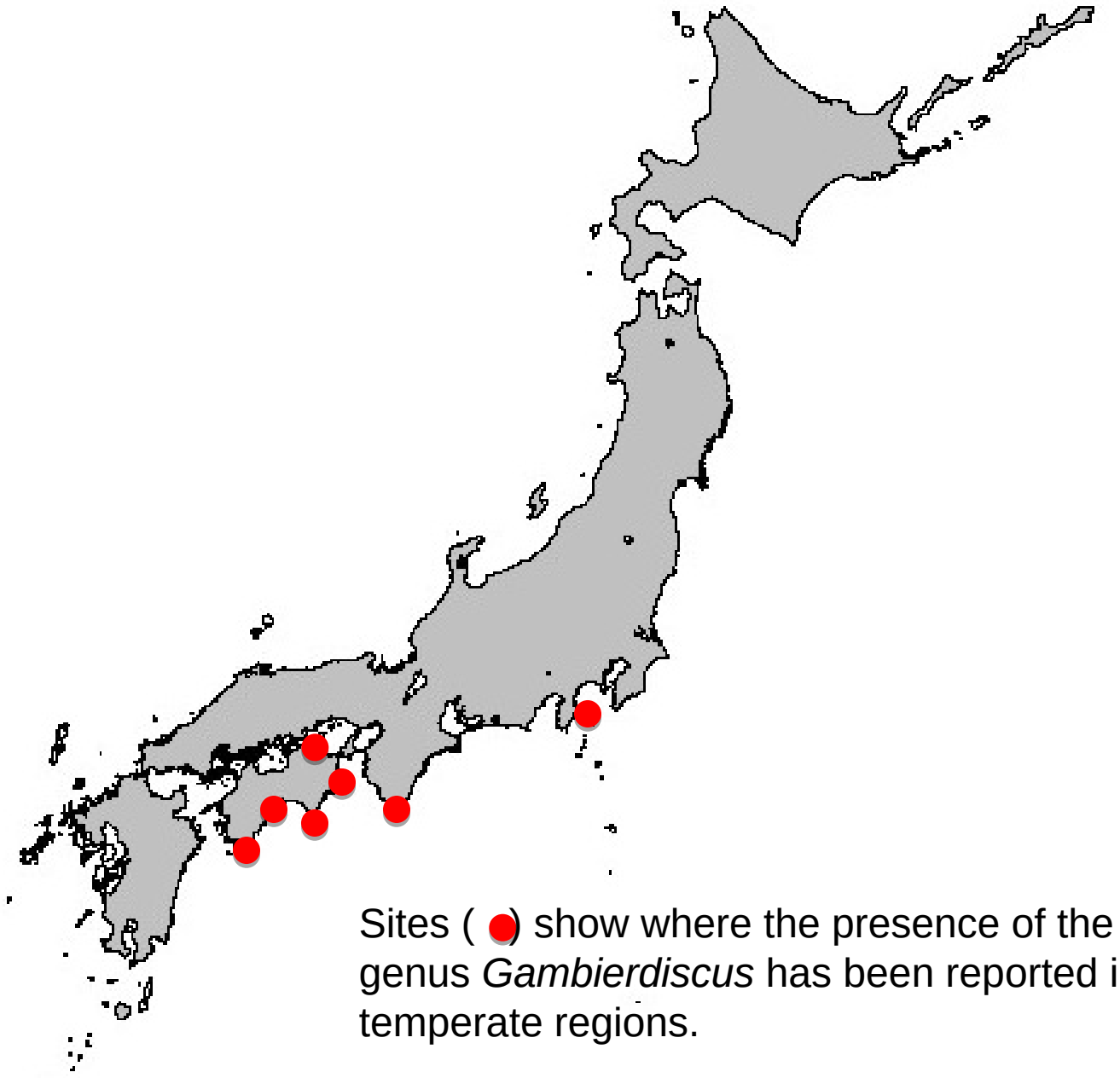
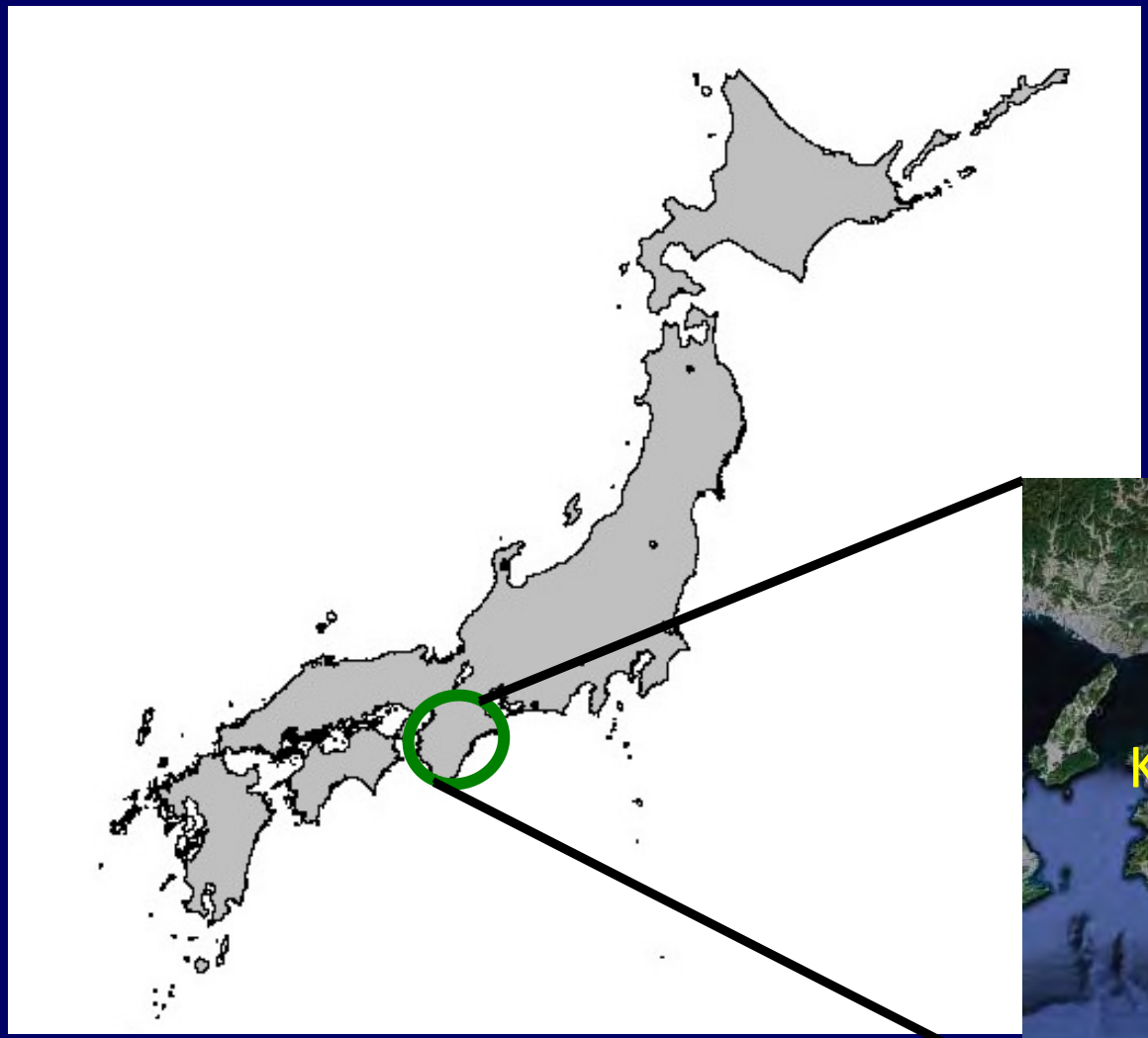




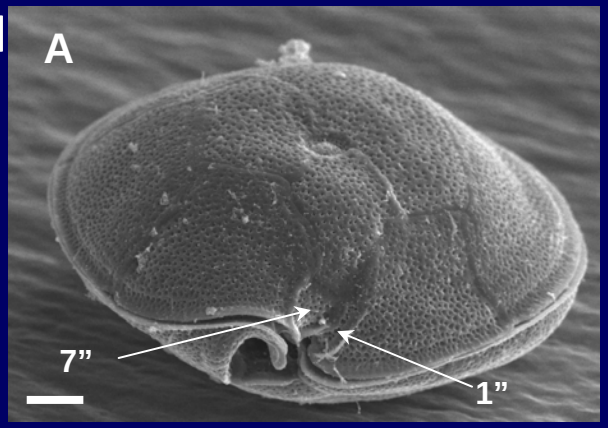
Sites (●) show where the presence of the genus *Gambierdiscus* has been reported in temperate regions.

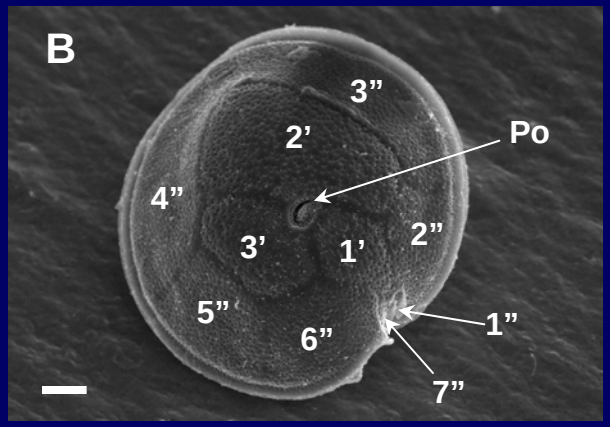
Having recent CFP incidents in Kii Peninsula,
We examined for the presence of the genus *Gambierdiscus* in Ago Bay.



Gambierdiscus found in Ago Bay

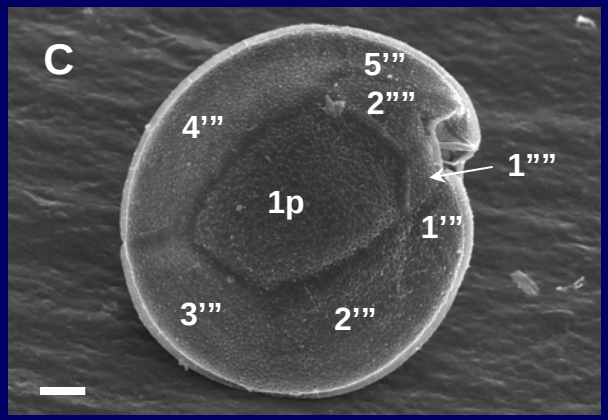
Oblique ventral view

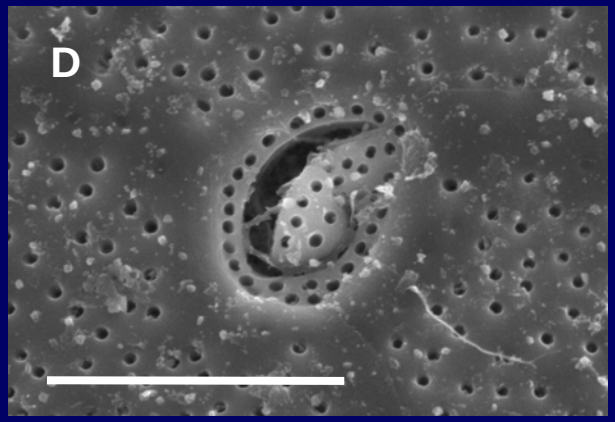




Epitheca

Hypotheca





Apical pore Plate (Po)

Scal bars: 10 µm

Main plate formula：Po, 3’, 7”, 5’”, 1p, 2””

(Ishikawa & Kurashima 2010: Bull Jpn Soc Fish Oceanogr)

Flowchart to distinguish the various *Gambierdiscus* species

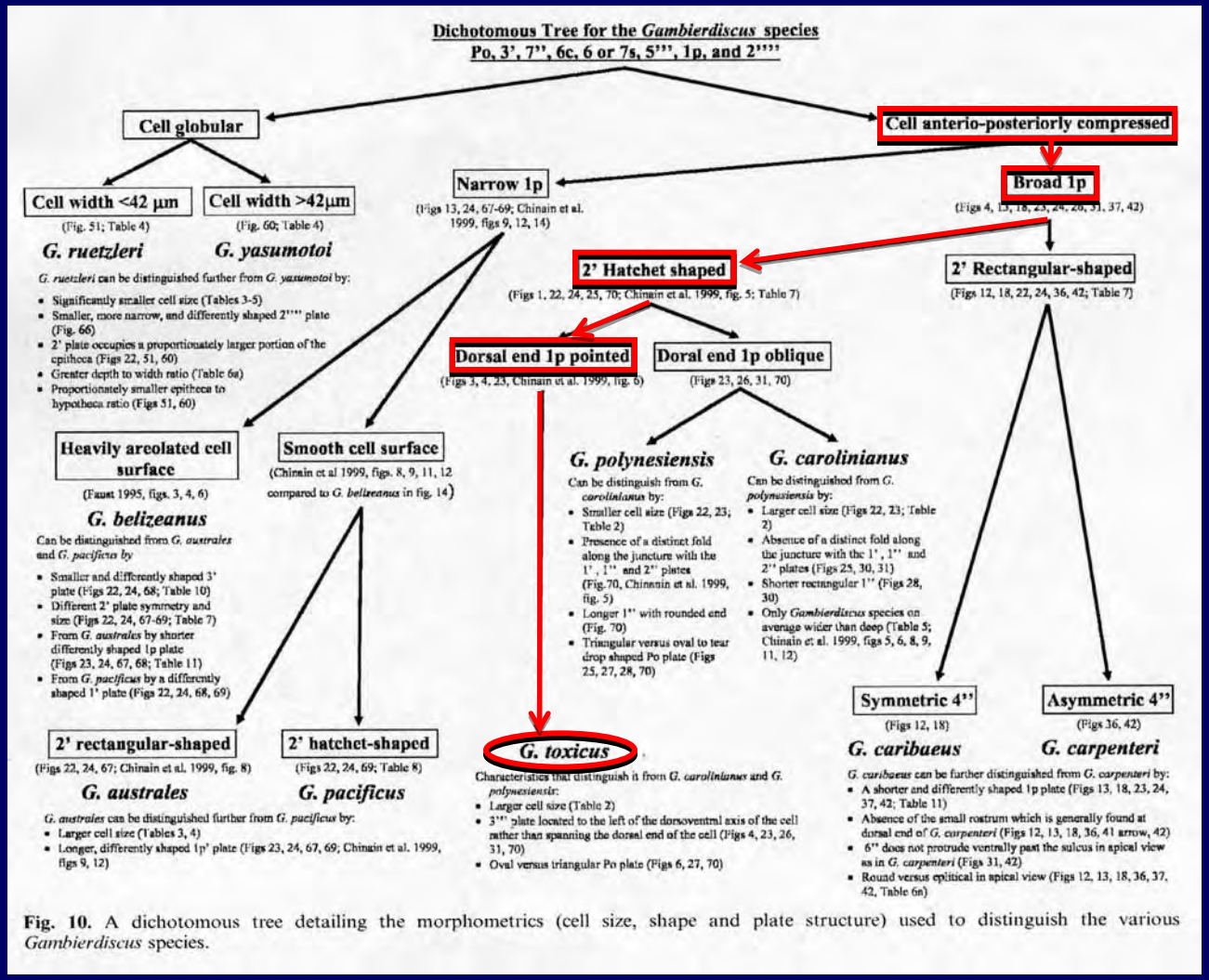
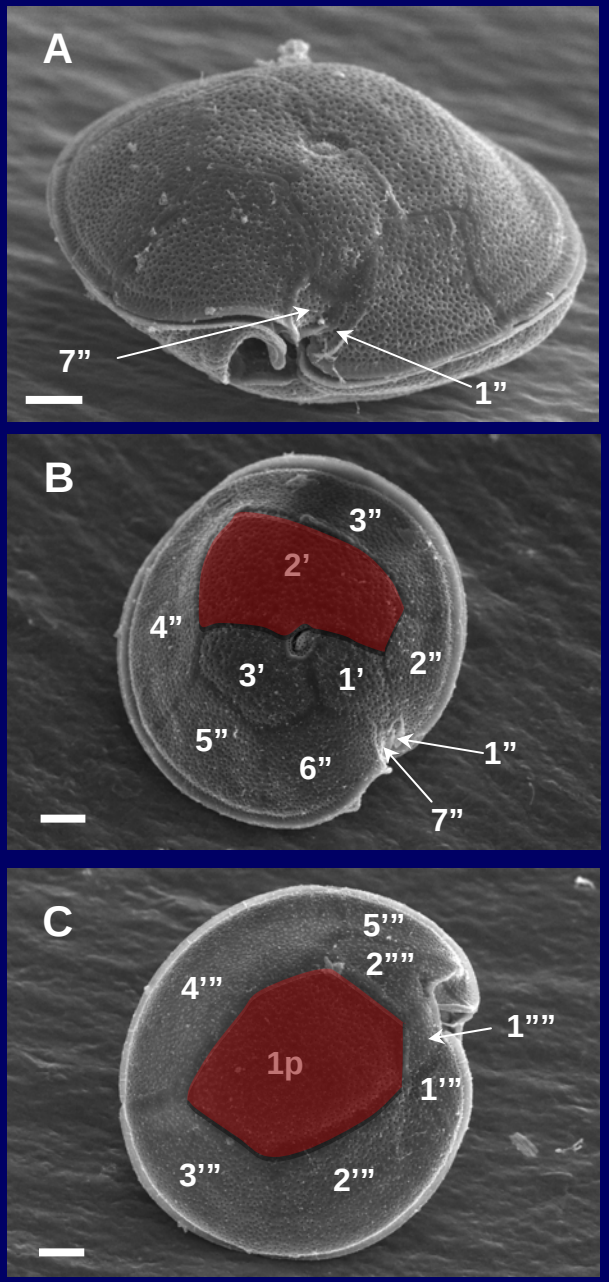


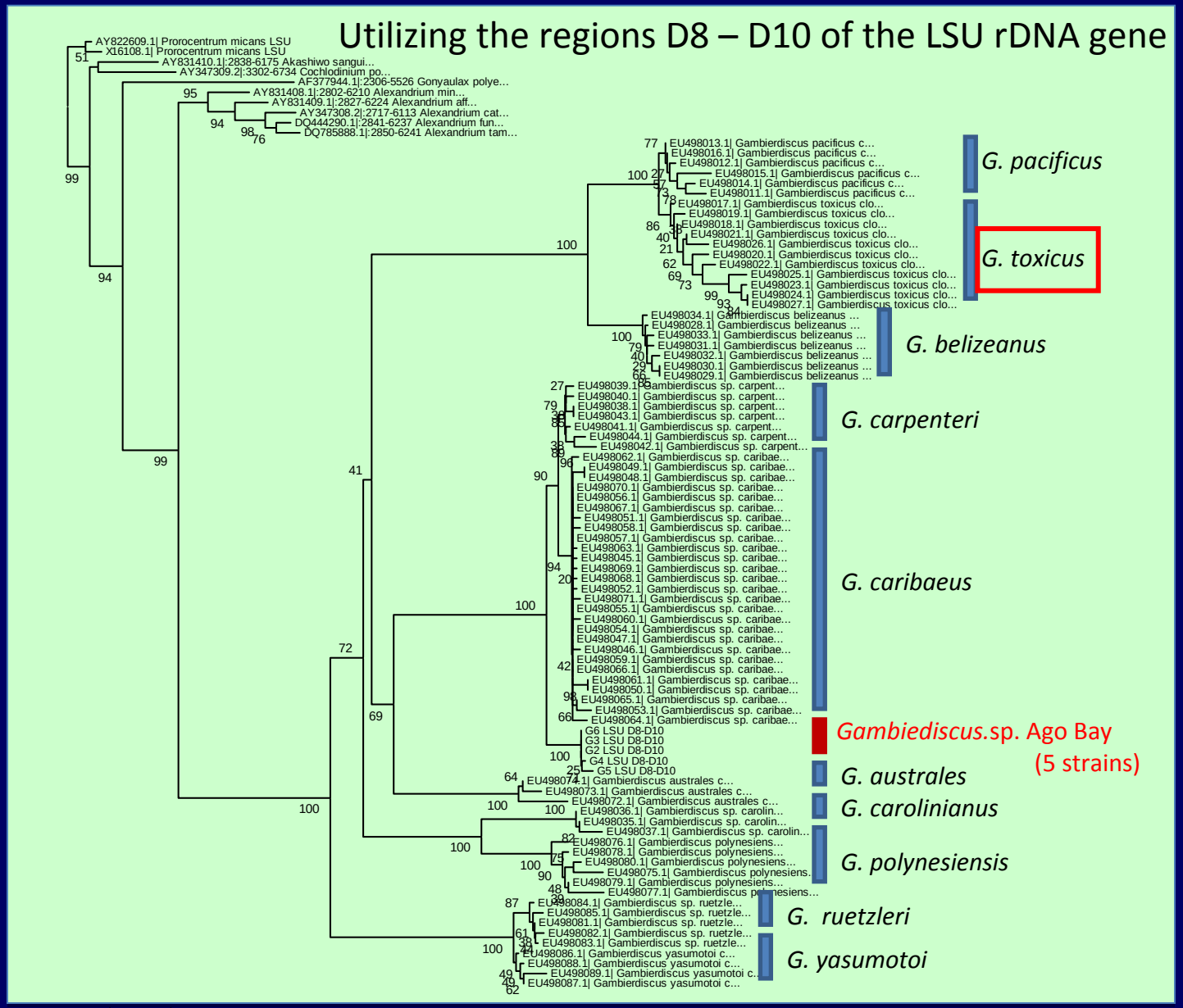
Fig. 10. A dichotomous tree detailing the morphometrics (cell size, shape and plate structure) used to distinguish the various *Gambierdiscus* species.

Fig. 10 in Litaker *et al.* (2009): *Phycologia*



Scal bars: 10 µm

Result of phylogenetic analysis (NJ)



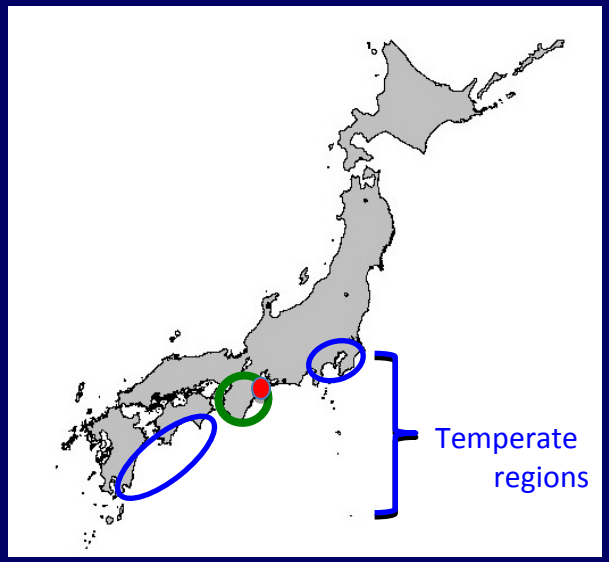
Aim of this study

To evaluate future risk of CFP in temperate regions, it is necessary to understand the population dynamics of *Gambierdiscus* sp.

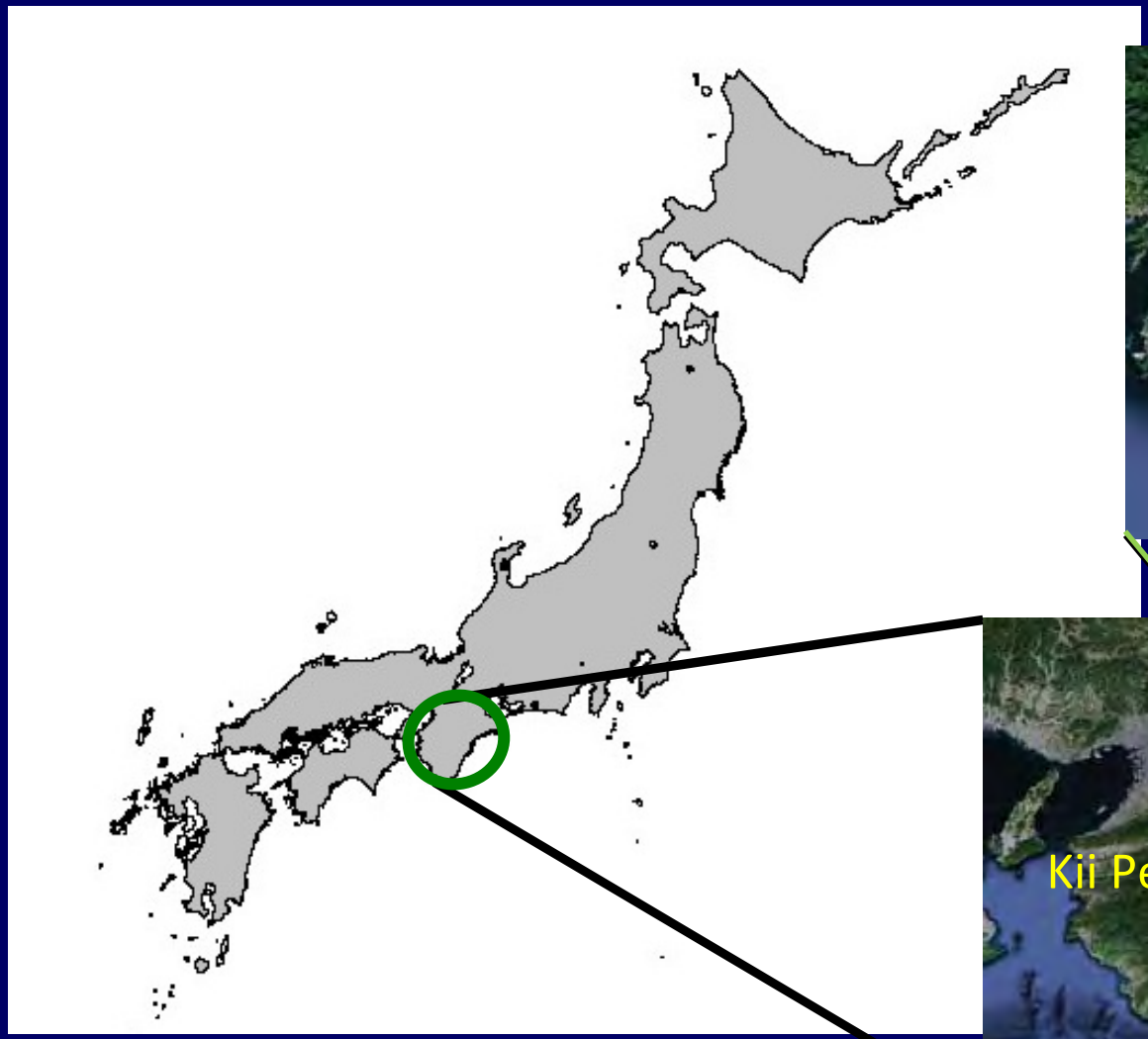
But no ecological studies on *Gambierdiscus* have yet been done in temperate regions…..

This study aimed to reveal the seasonal change in abundance of *Gambierdisucs* sp. in Ago Bay.

In addition, the effect of temperature on the growth of *Gambiediscus* sp. isolated from the bay was also investigated in this study.



Study site



Seaweed bed

Field works

Depth: 1－3m

Sampling period: November 2008 － March 2011
(once a month or more in warmer seasons)

Various macroalgal species were collected by snorkeling and sealed within plastic bags while underwater.

Examples of macloalgae collected

Chlorophyceae

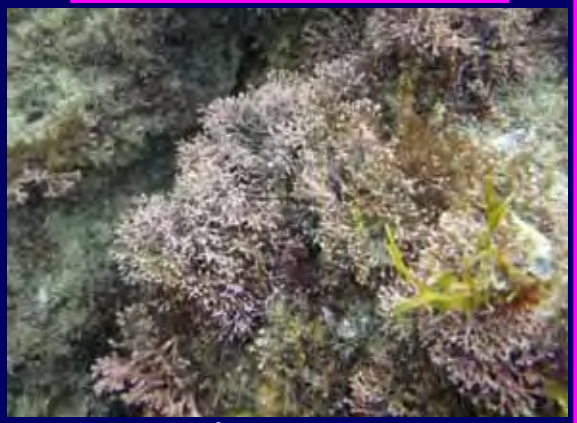
Codium fragile

Phaeophyceae

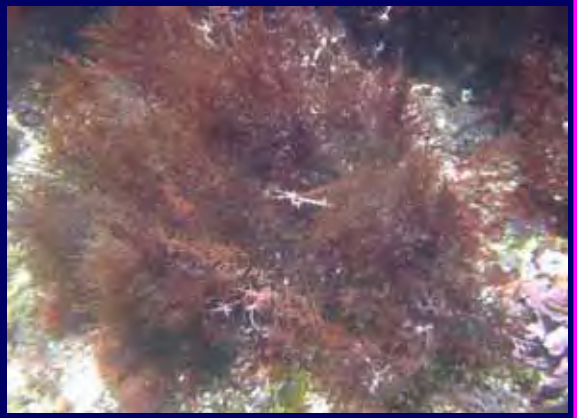
Padinaarborescens

Sargassumthunbergii

Phodophyceae

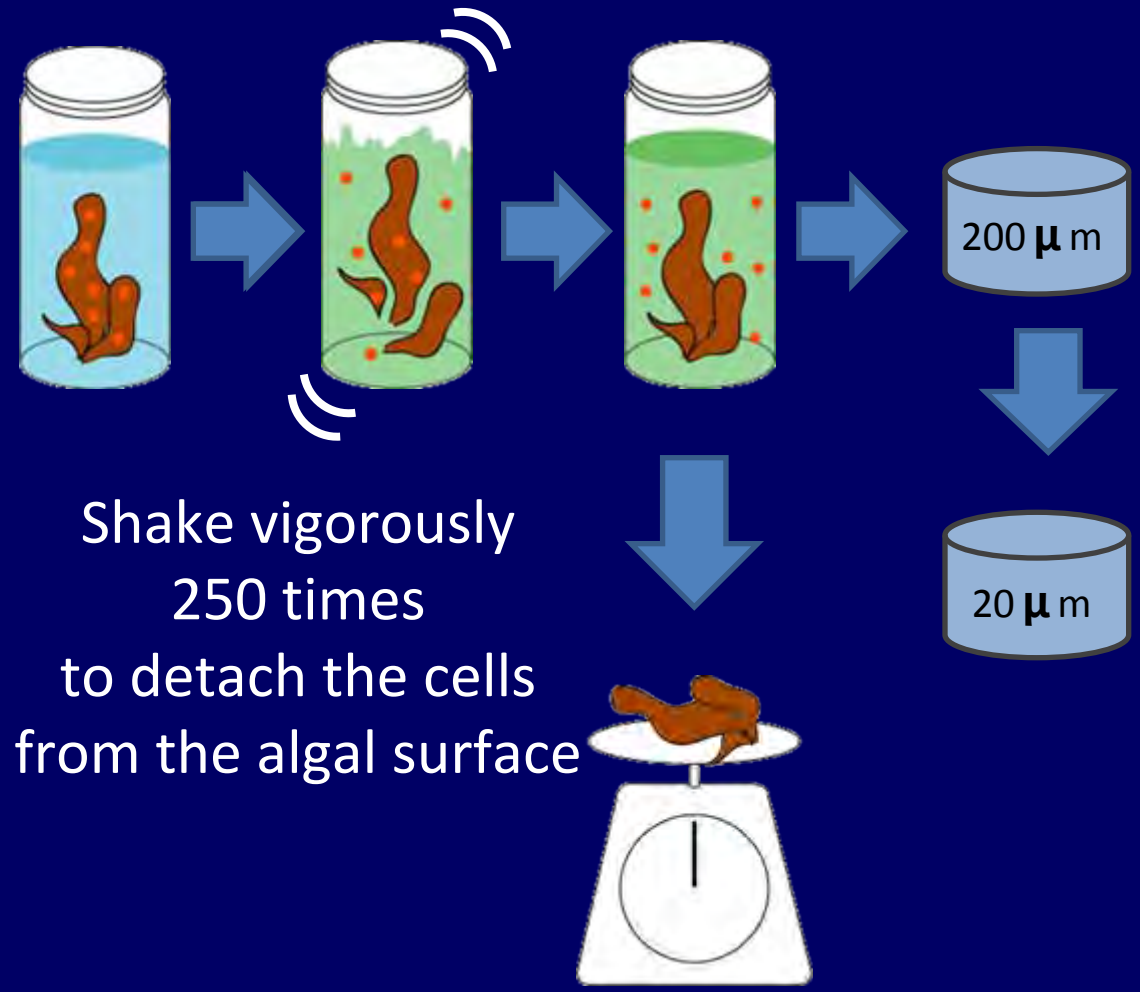


Amphiroazonata



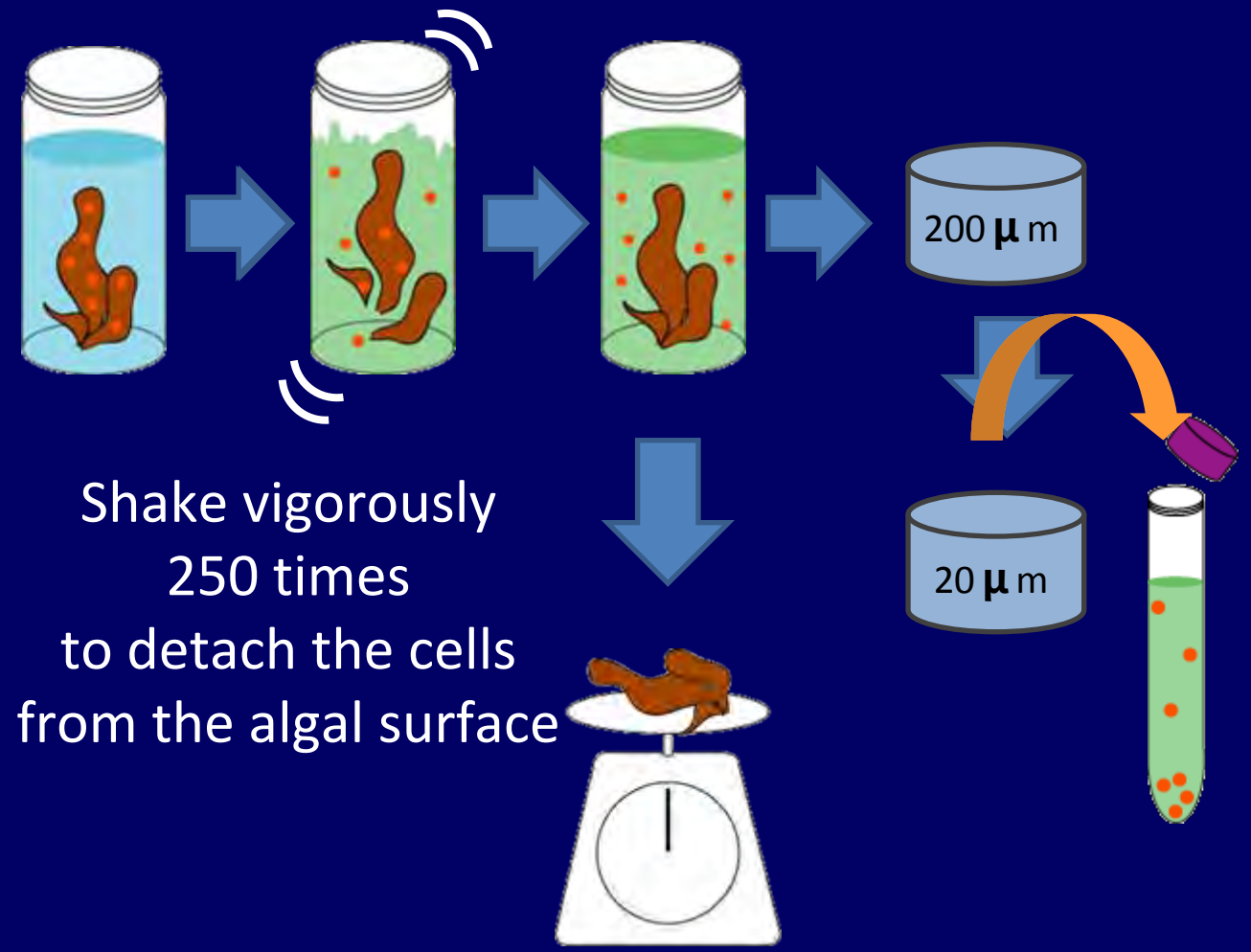
Gelidiumelegans

Procedure to quantify *Gambierdiscus* sp.



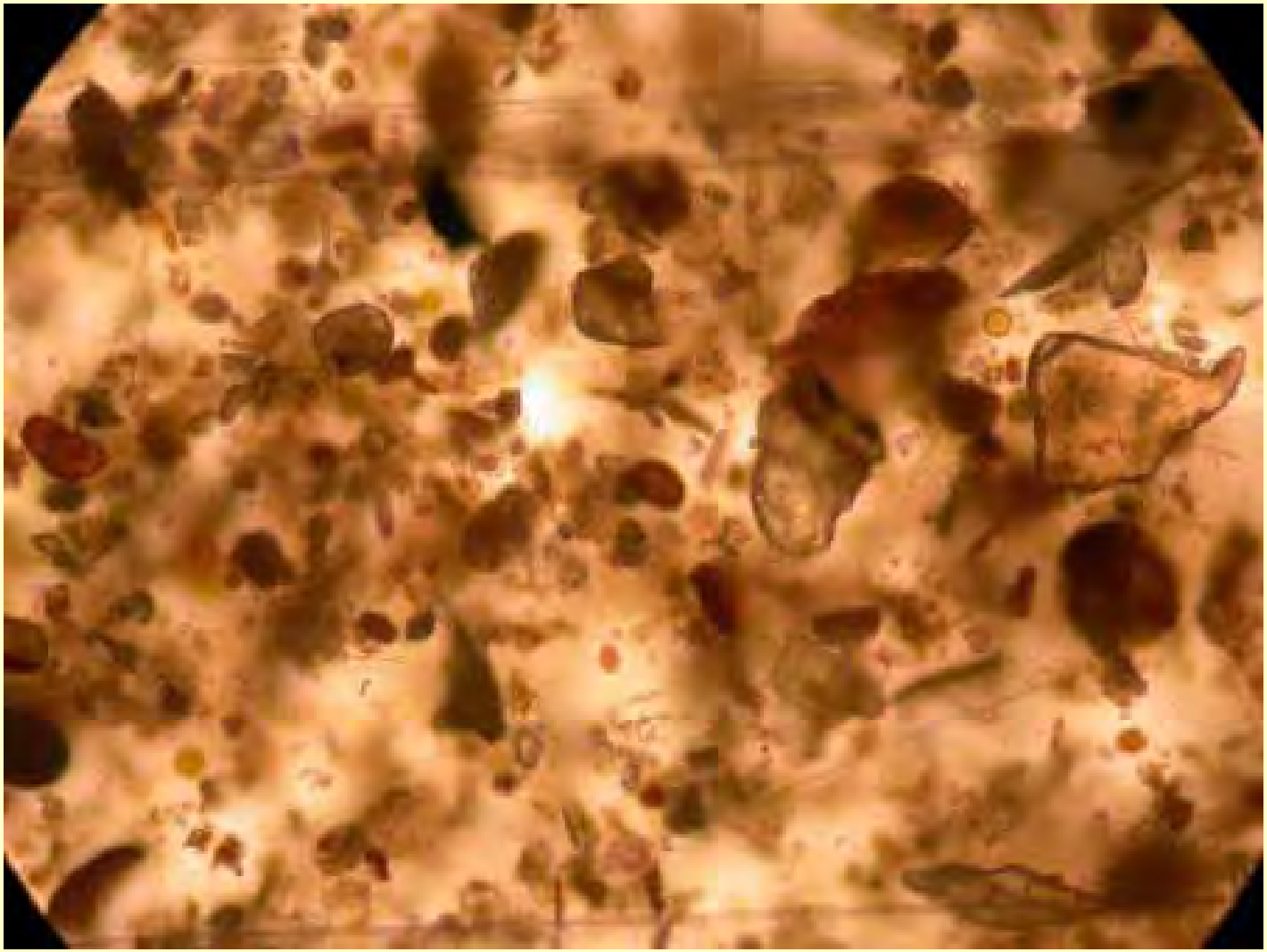
Shake vigorously
250 times
to detach the cells
from the algal surface

Procedure to quantify *Gambierdiscus* sp.

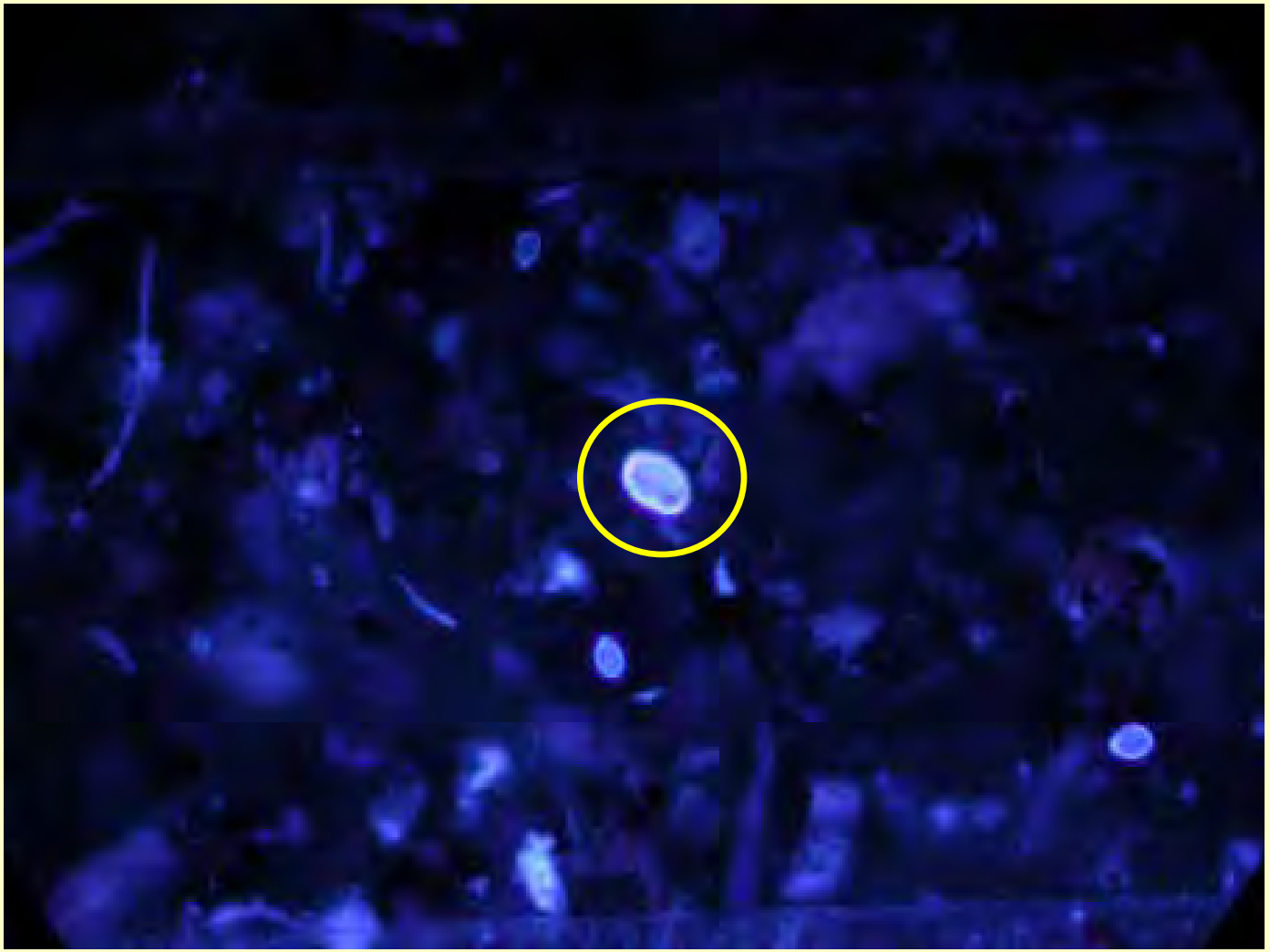


Shake vigorously
250 times
to detach the cells
from the algal surface

Preserved in 15 mL of 1 %
formalin-filtered seawater



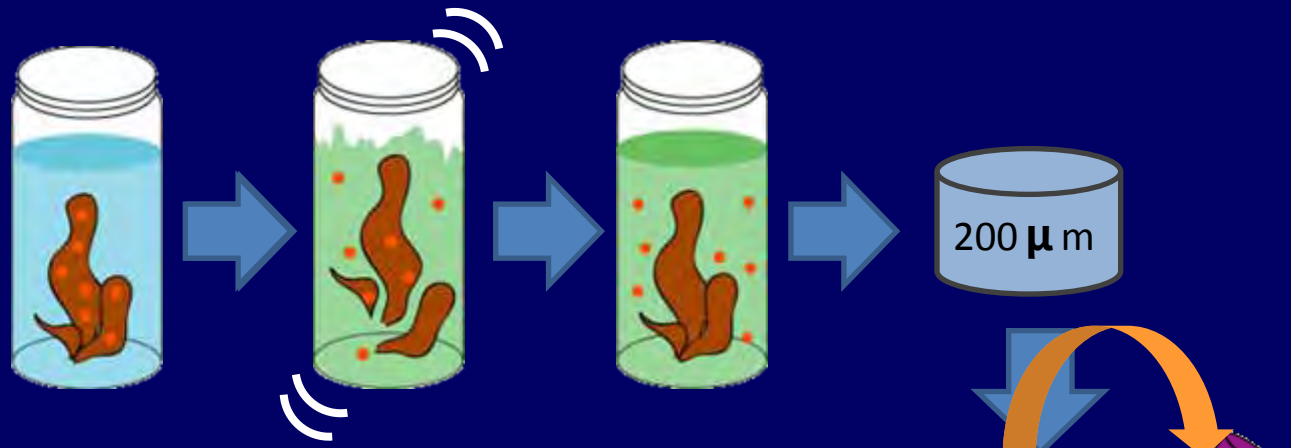
Under the light microscope



Under the epifluorescent microscope

The cells were stained with calcofluor.

Procedure to quantify *Gambierdiscus* sp.



Shake vigorously
250 times
to detach the cells
from the algal surface

15 mL of 1 % formalin-filtered seawater

Calcofluor staining

Cell counting

The abundance was expressed in cells g^{-1} alga wet weight

Growth experiments

Effects of temperature on the growth

Experimental conditions

Temperature：10, 15, 20, 25, 30 , 32, 35 ℃

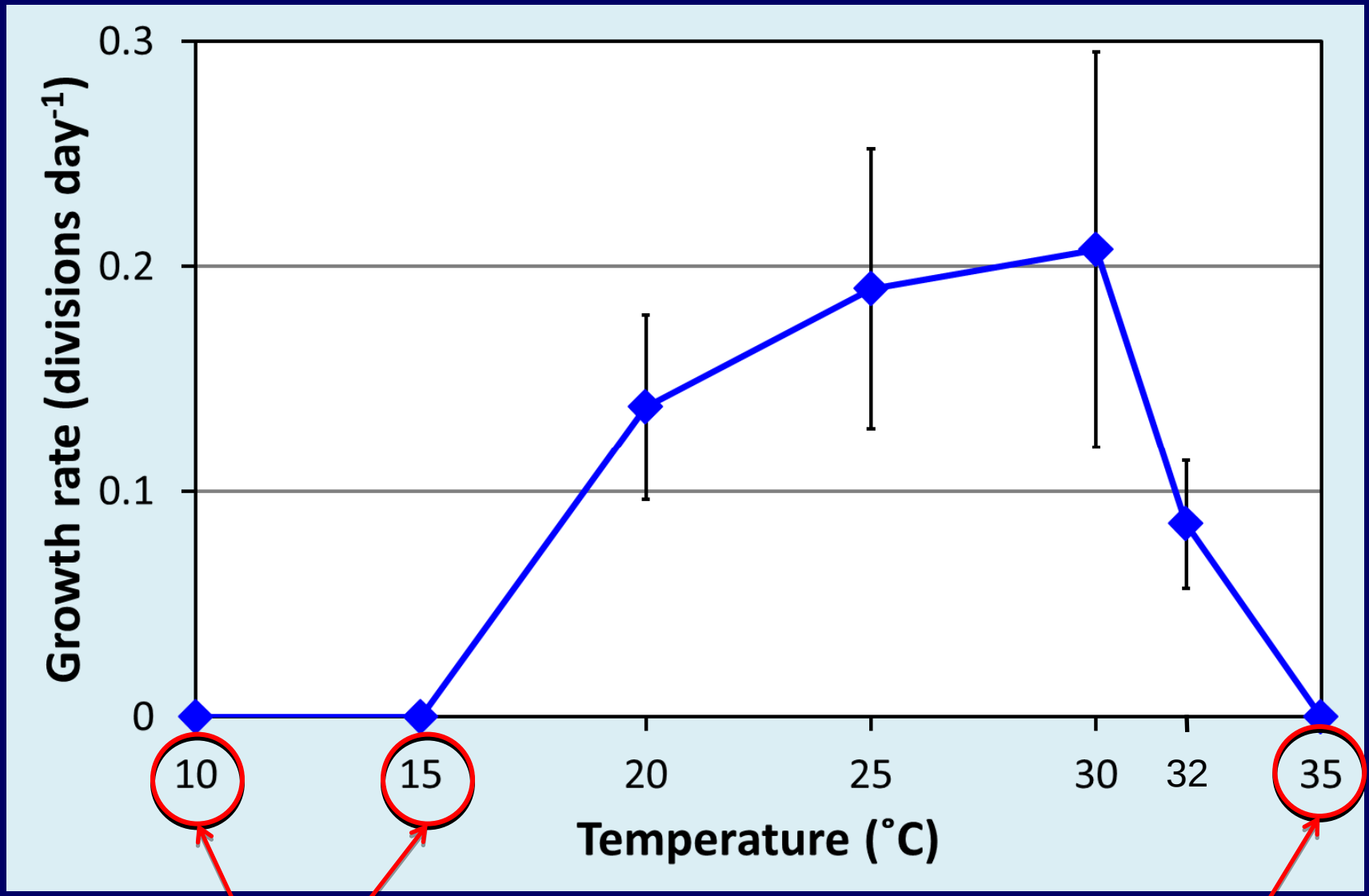
Medium：f/2

Light intensity：150 μmol m^{-2} s^{-1}

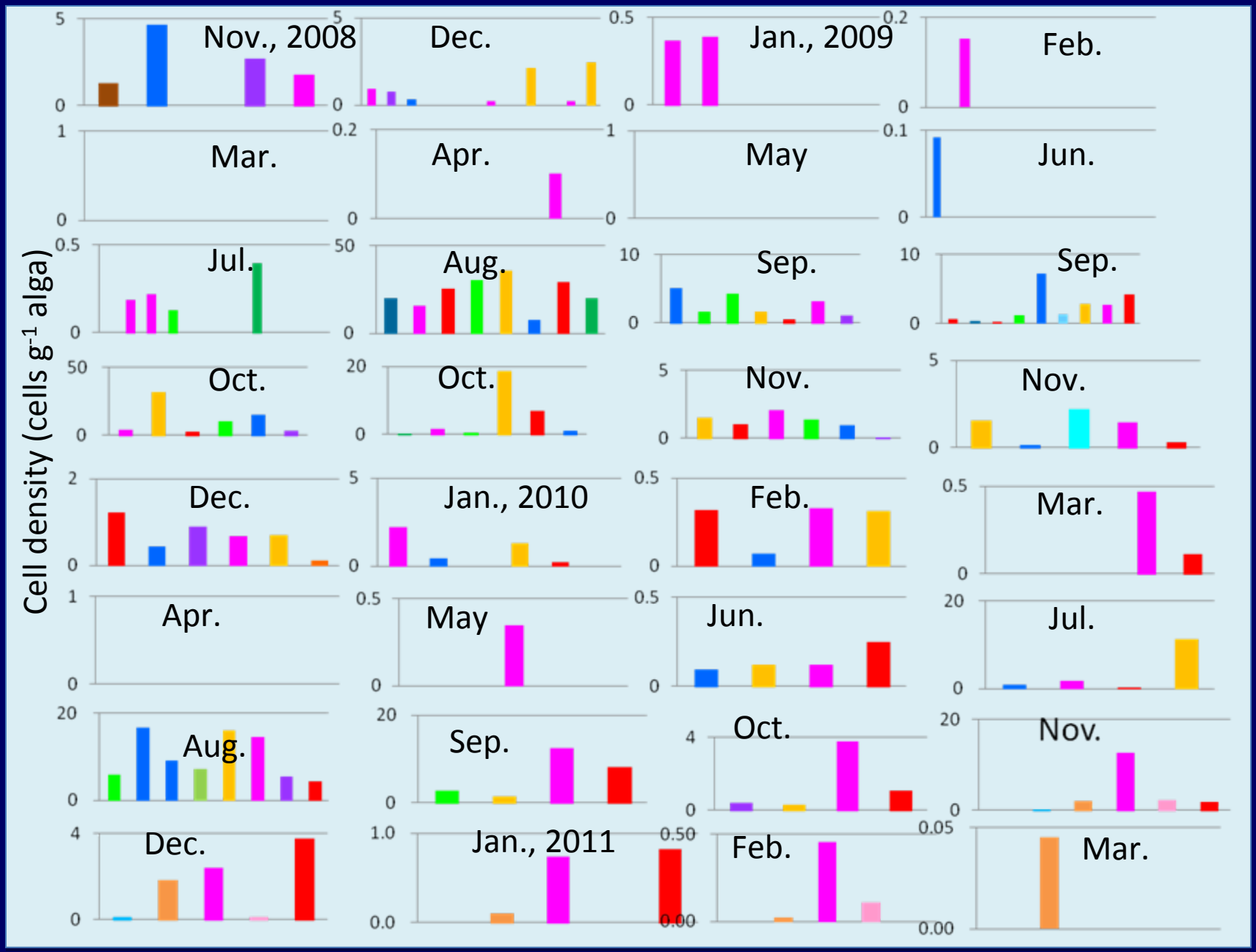
Photo cycle：12h：12h

Growth rate (divisions day^{-1}) was calculated.

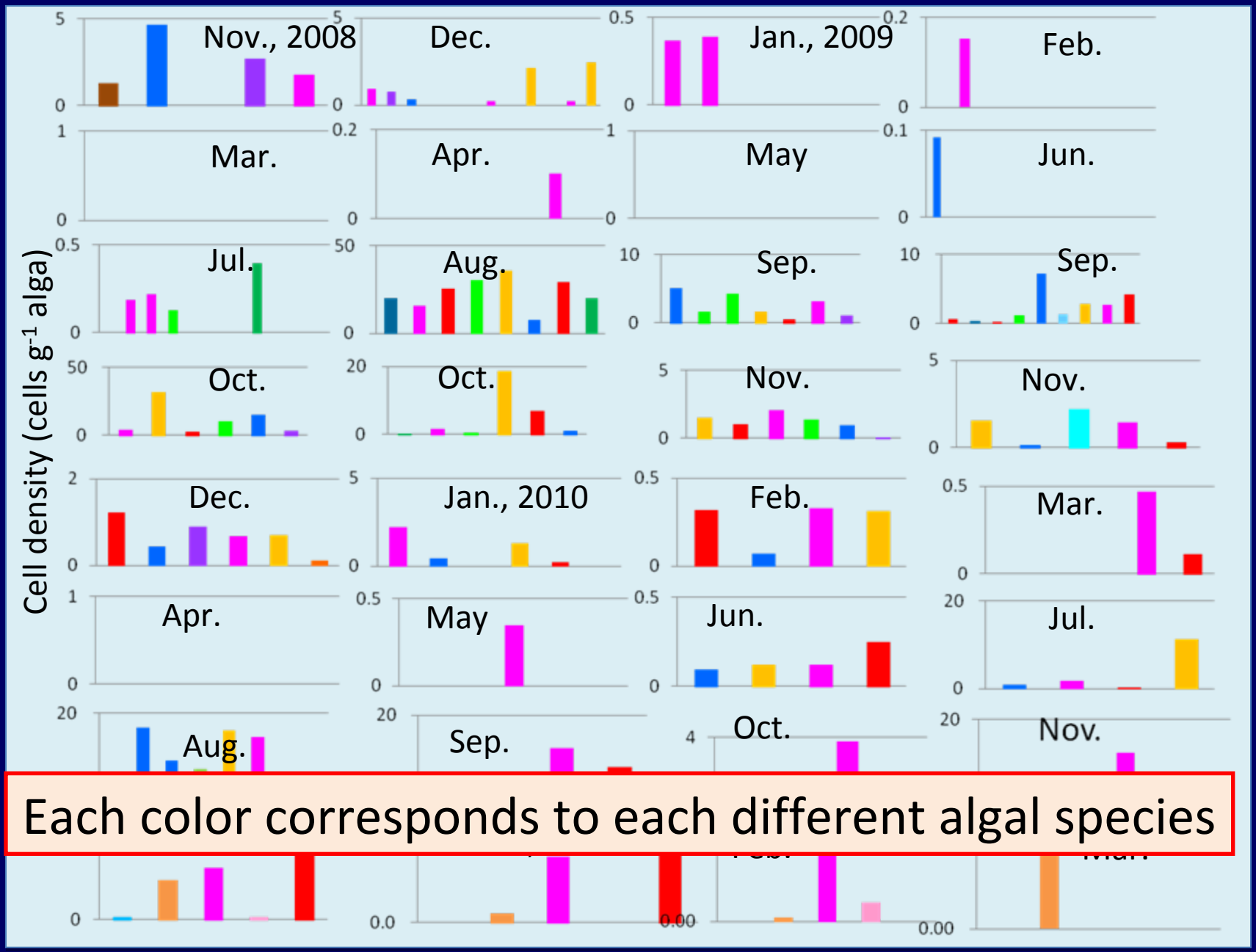
Effect of temperature on the growth



Cell densities of *Gambierdiscus* sp. attached to each different macroalga

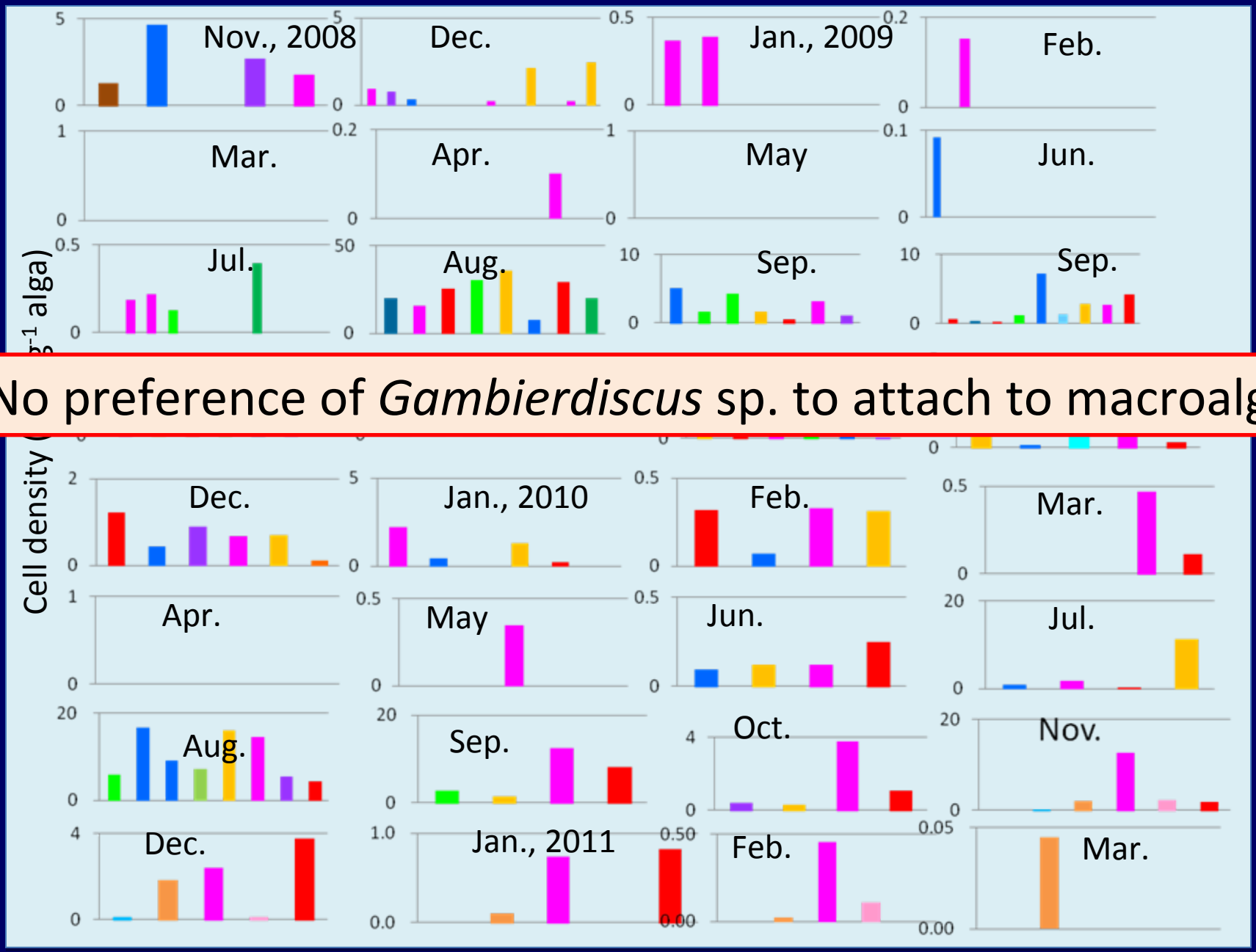


Cell densities of *Gambierdiscus* sp. attached to each different macroalga



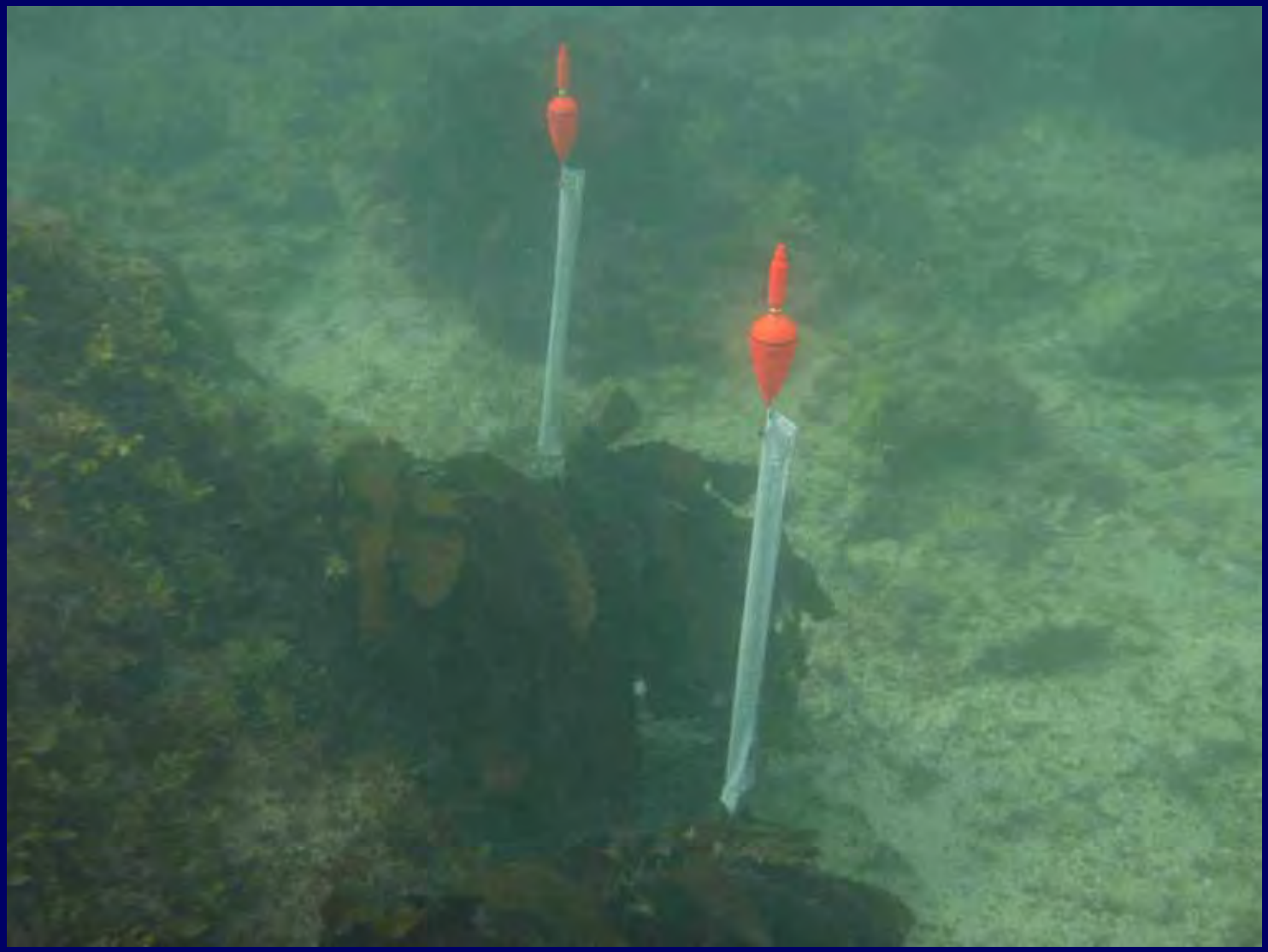
Each color corresponds to each different algal species

Cell densities of *Gambierdiscus* sp. attached to each different macroalga



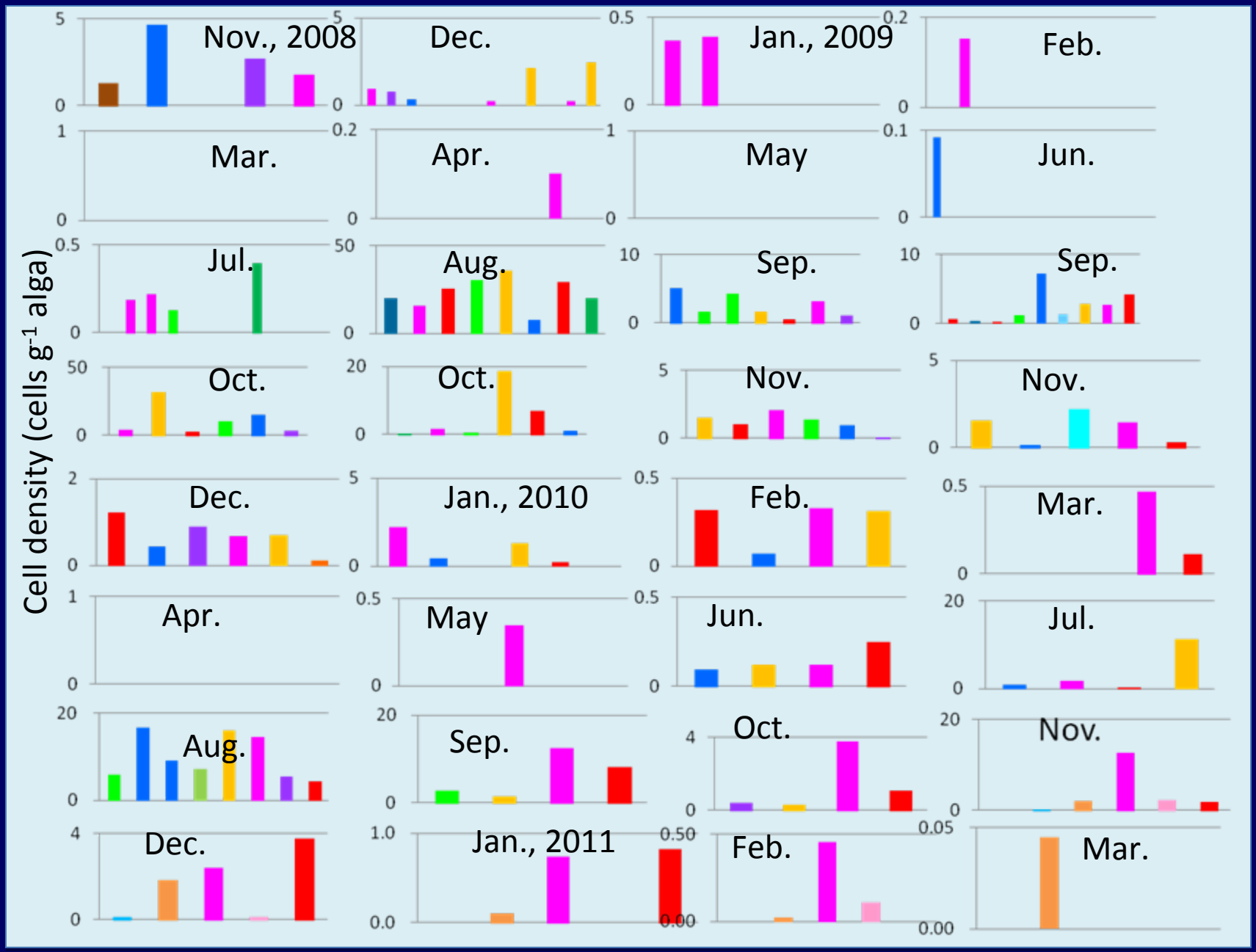
No preference of *Gambierdiscus* sp. to attach to macroalga

Artificial seaweed experiment

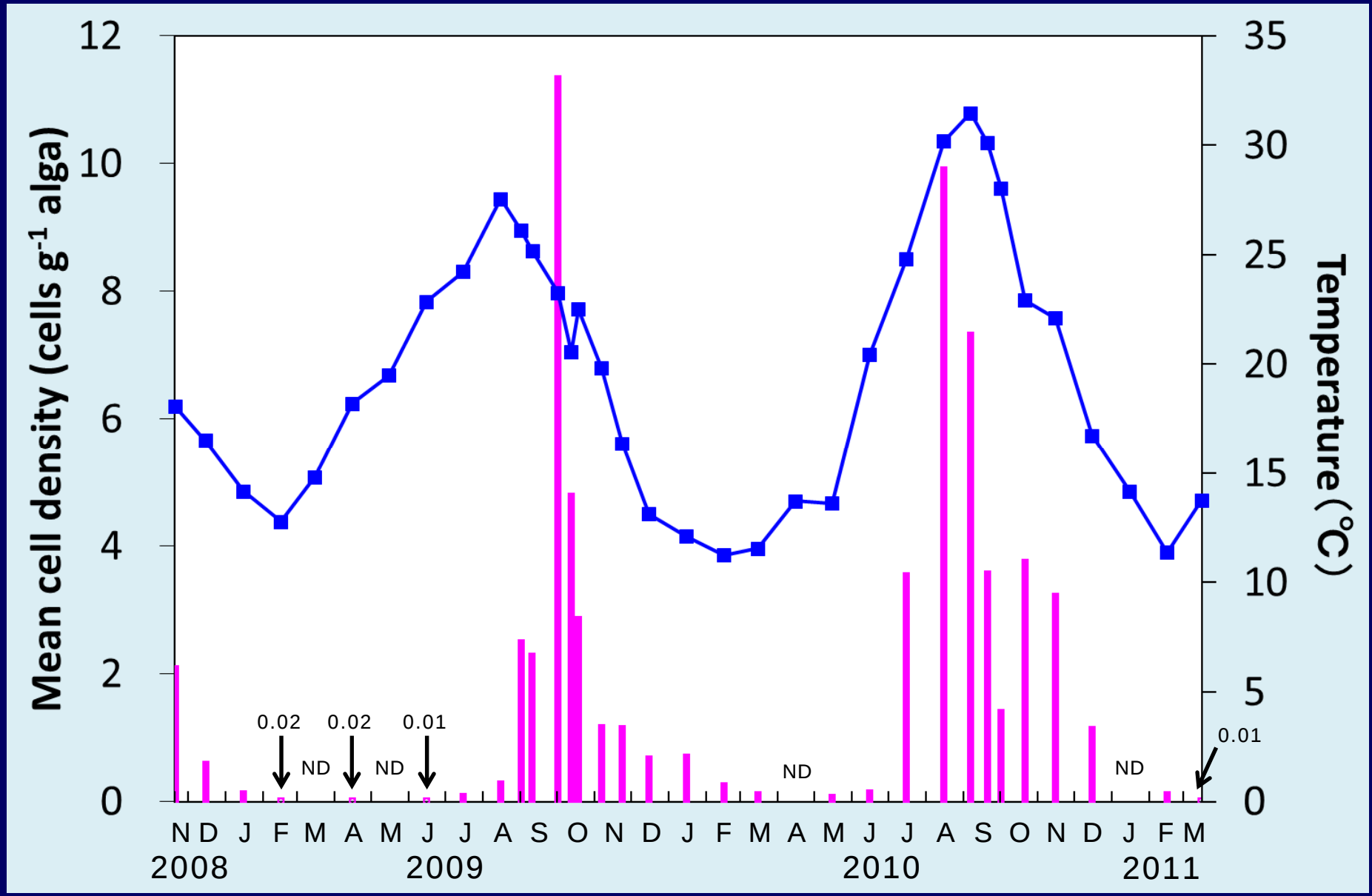


Cloth (Cotton: 65%, Chemical fiber: 35%)

Cell densities of *Gambierdiscus* sp. attached to each different macroalga

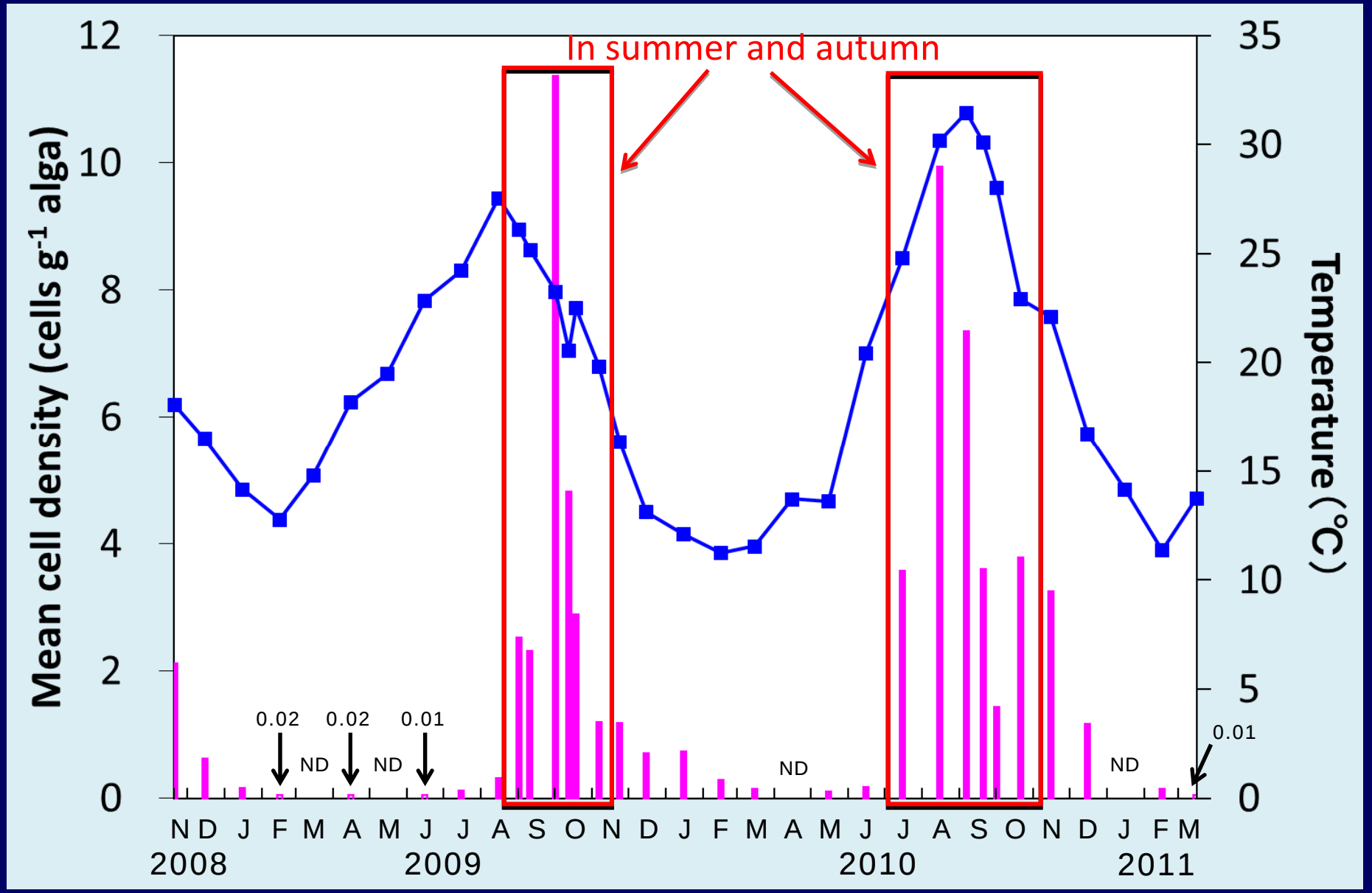


Seasonal change in mean abundance of *Gambierdiscus* sp. attached to the macroalgae



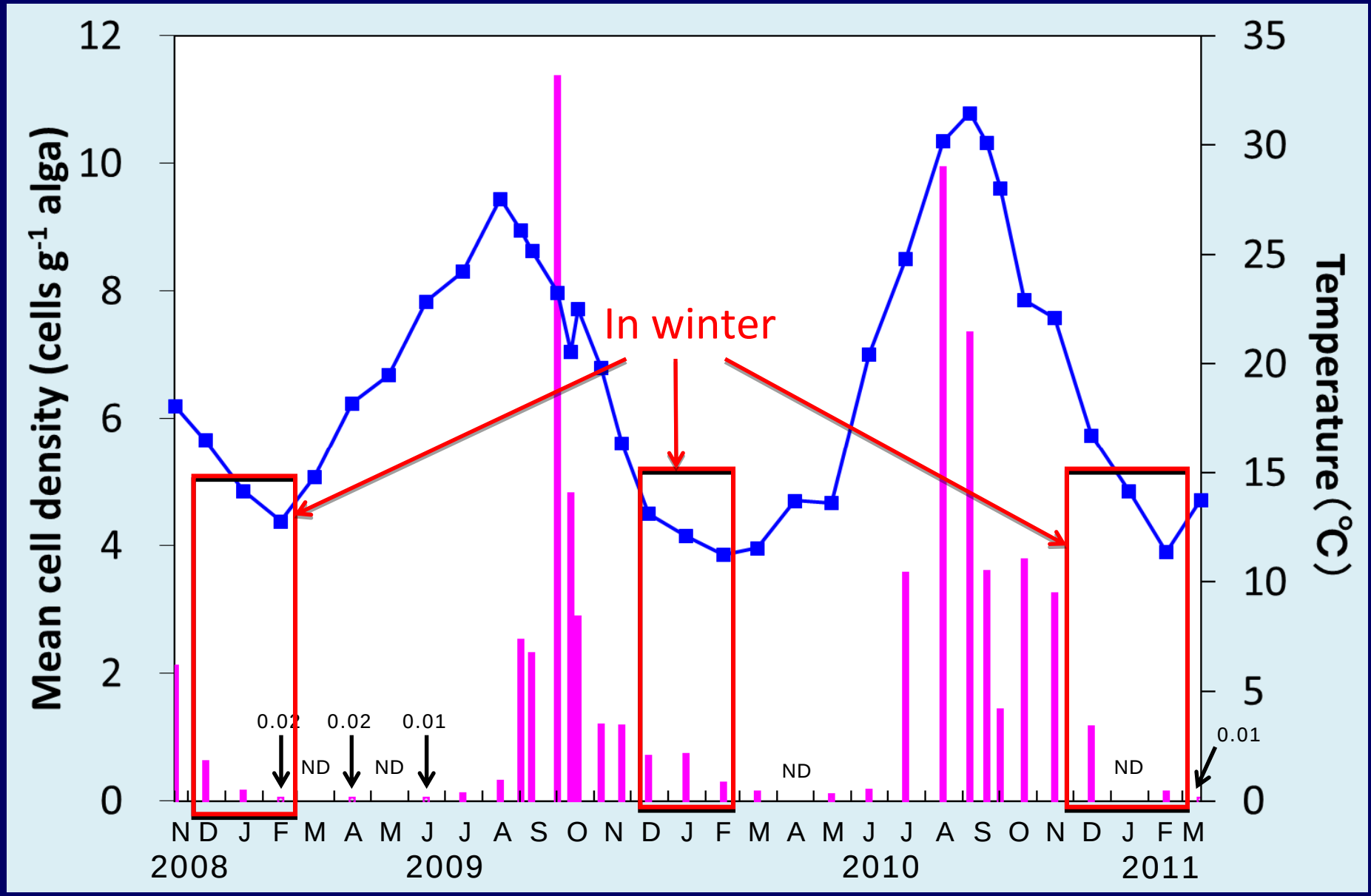
ND: Not detected

Seasonal change in mean abundance of *Gambierdiscus* sp. attached to the macroalgae



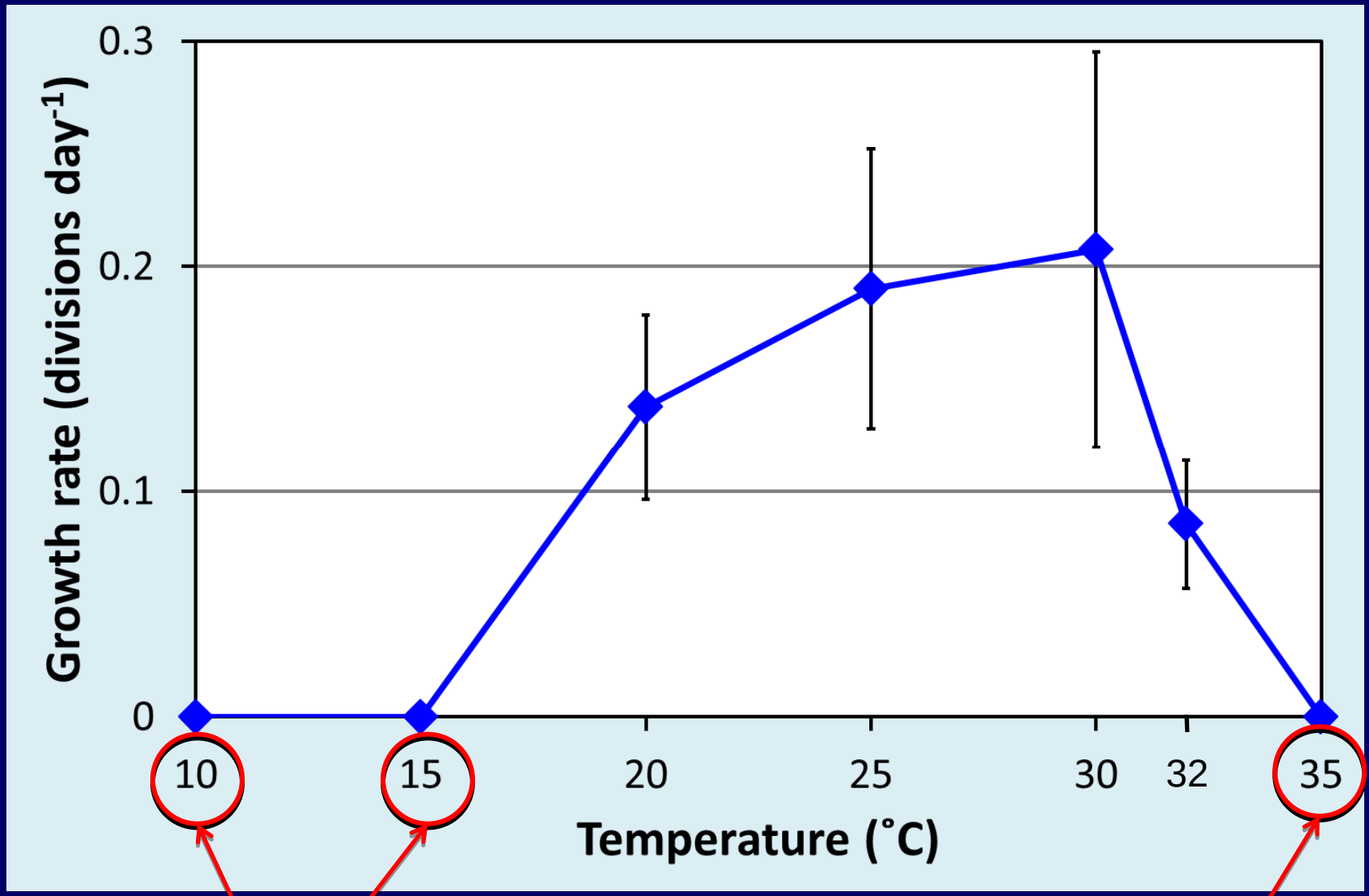
ND: Not detected

Seasonal change in mean abundance of *Gambierdiscus* sp. attached to the macroalgae

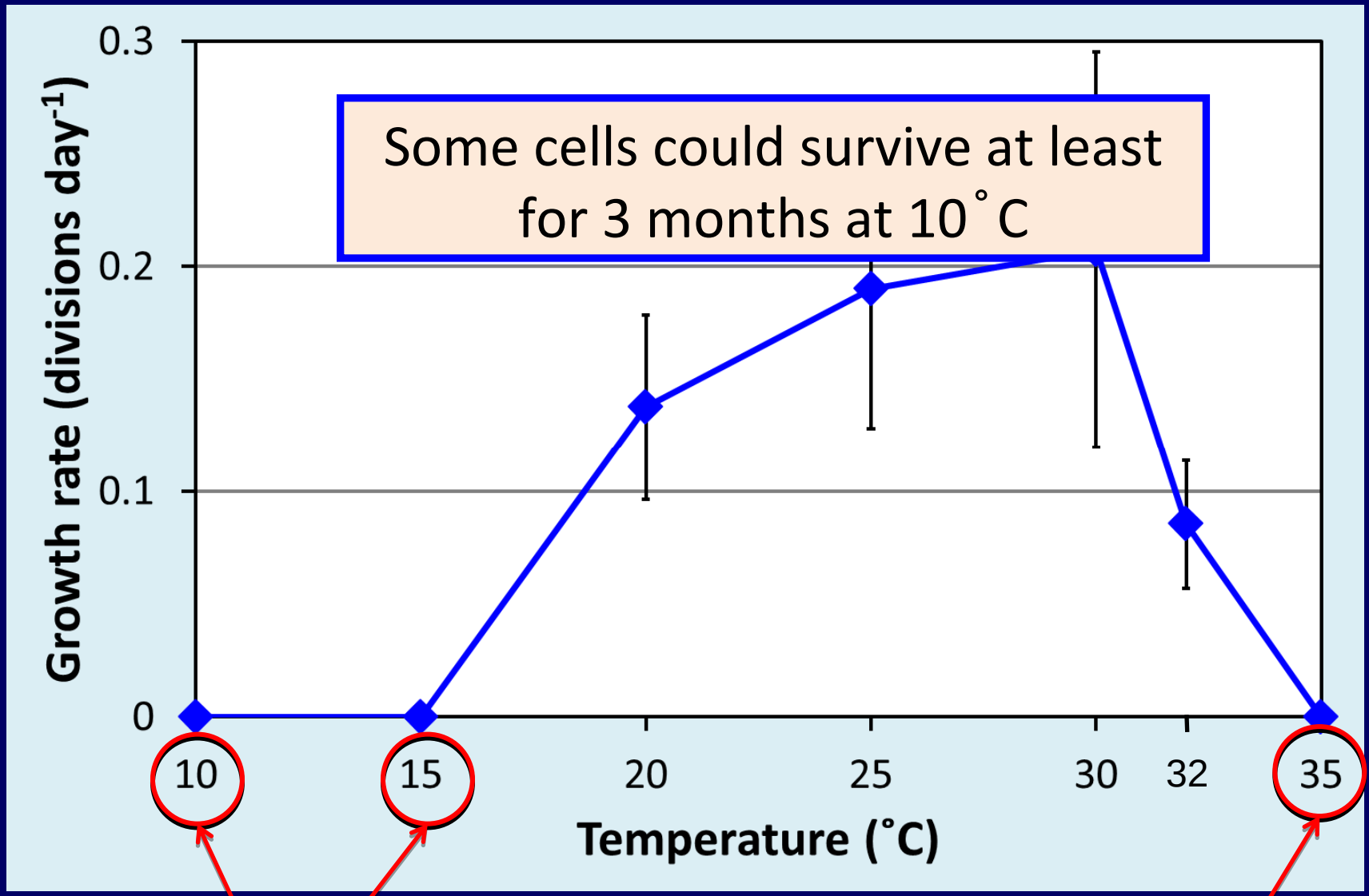


ND: Not detected

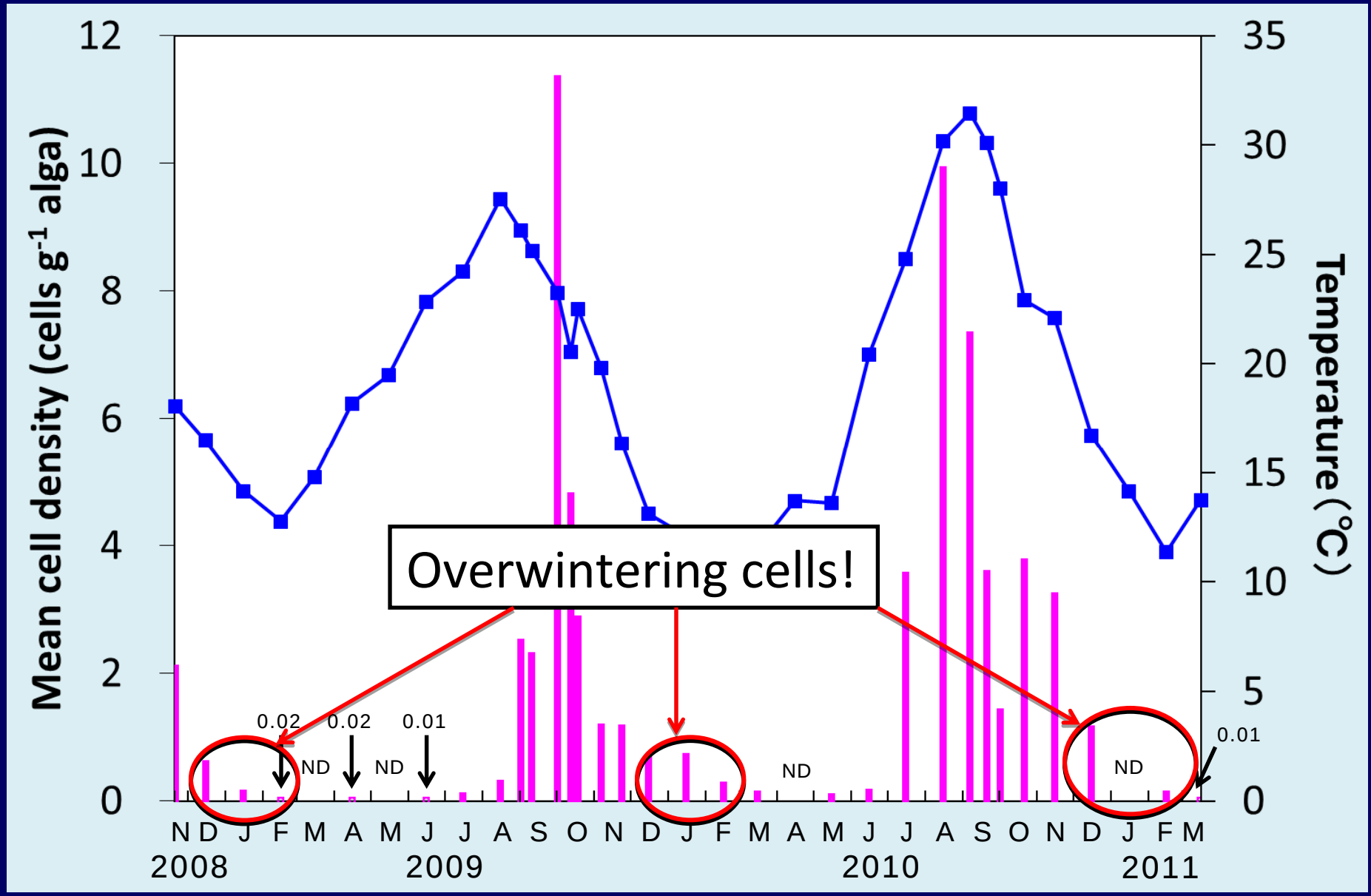
Effect of temperature on the growth



Effect of temperature on the growth



Seasonal change in mean abundance of *Gambierdiscus* sp. attached to the macroalgae



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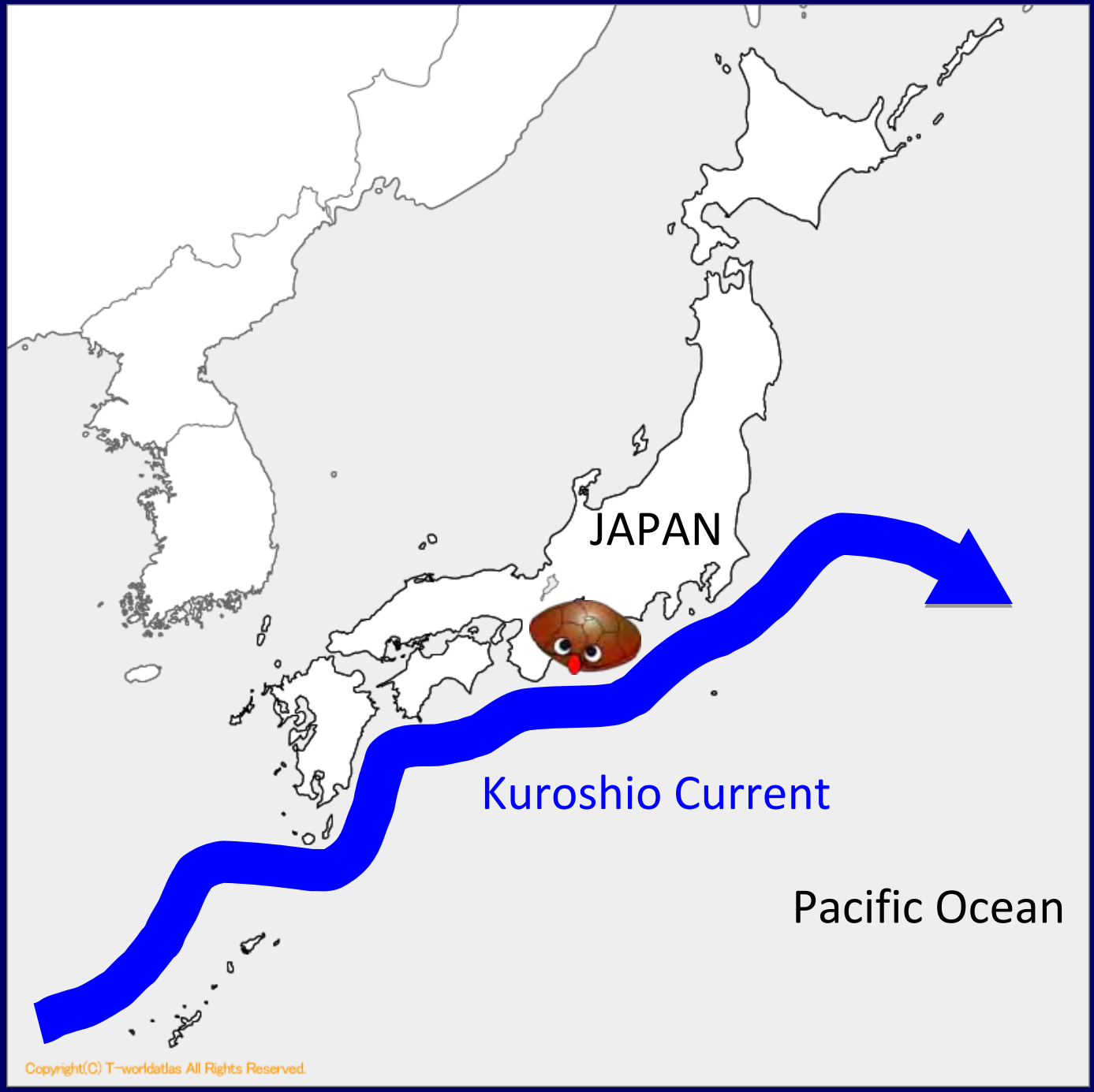
JAPAN
Kuroshio Current
Pacific Ocean
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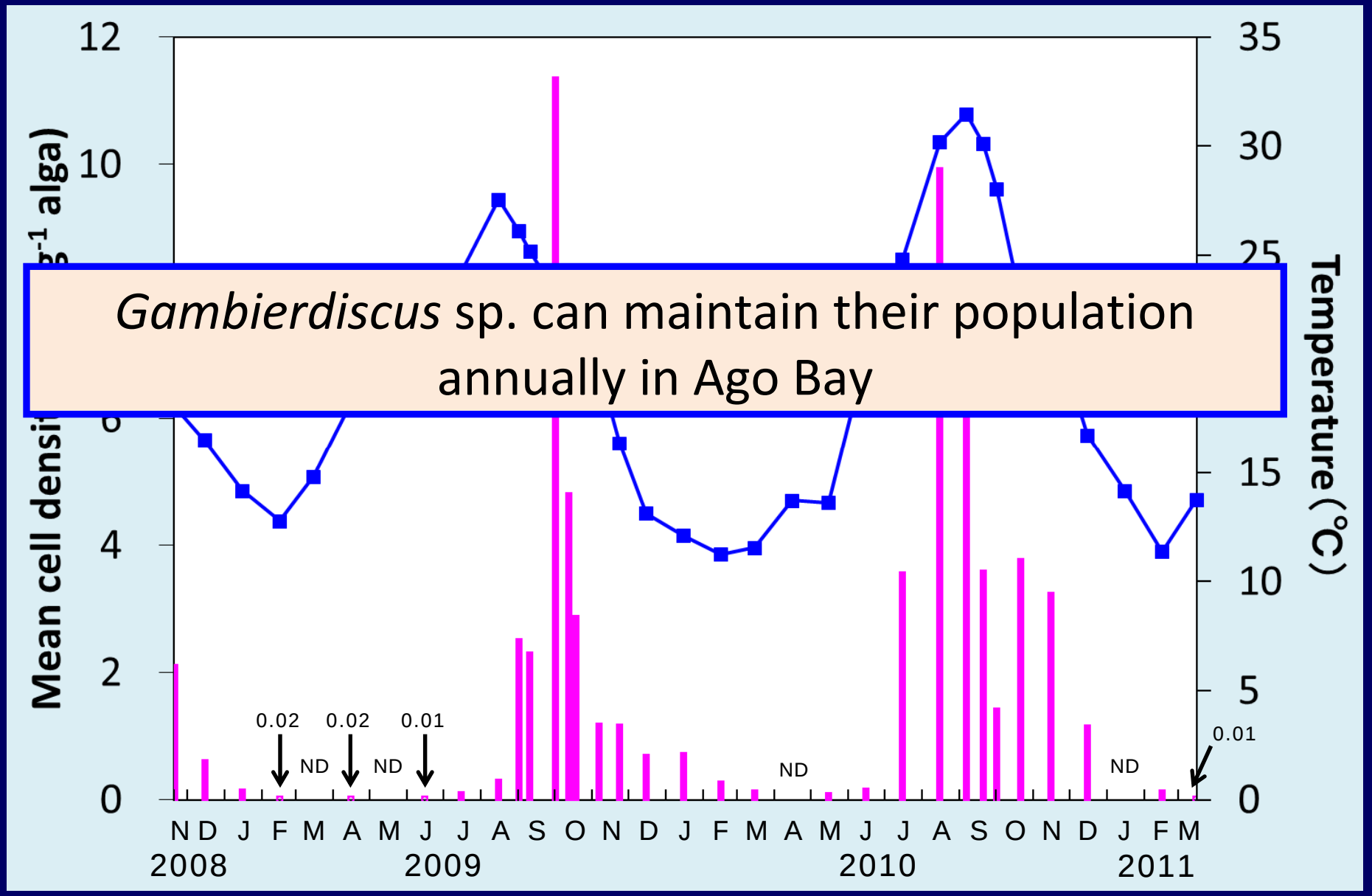
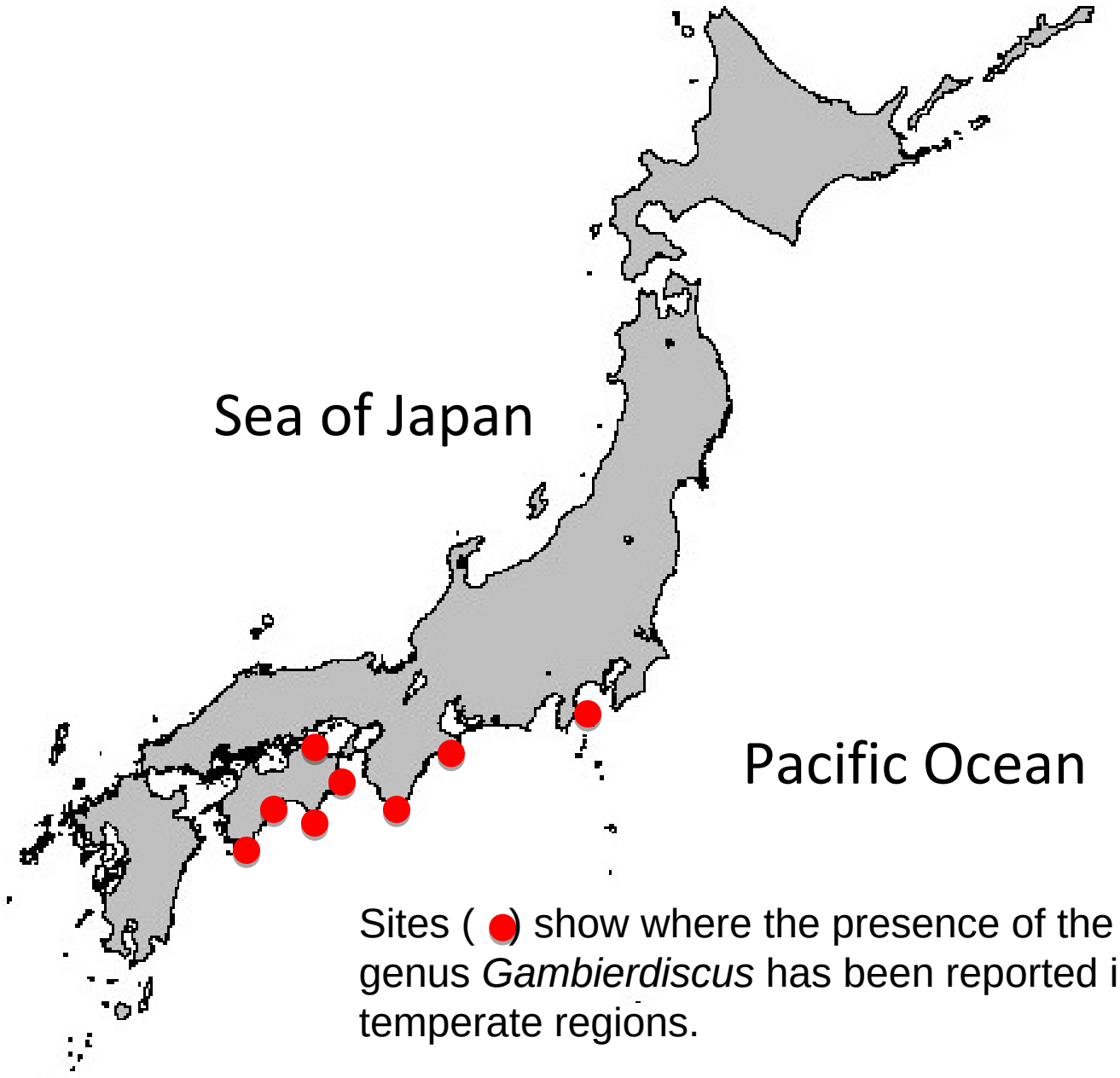
Seasonal change in mean abundance of *Gambierdiscus* sp. attached to the macroalgae



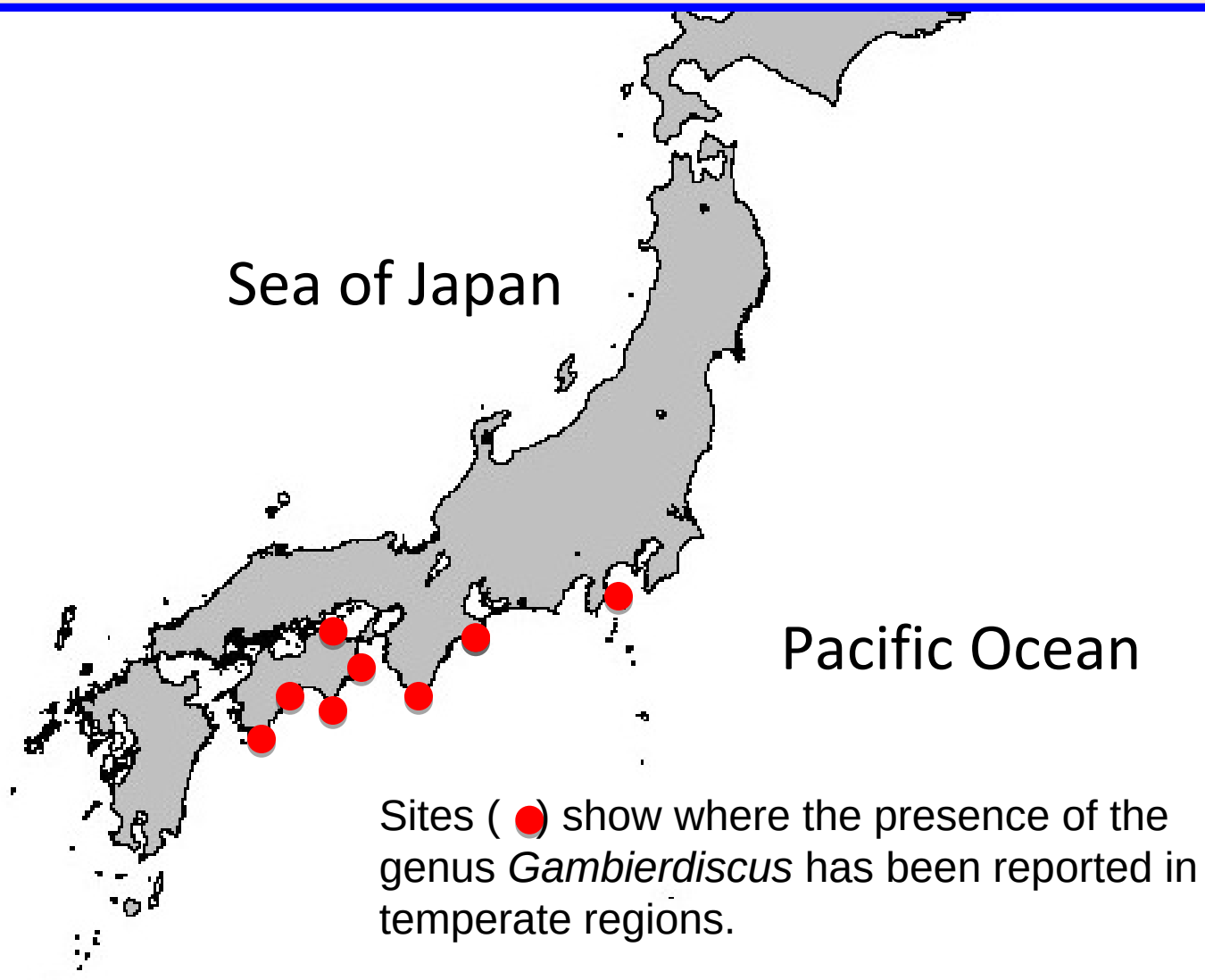
Gambierdiscus sp. can maintain their population annually in Ago Bay

ND: Not detected



Sites (●) show where the presence of the genus *Gambierdiscus* has been reported in temperate regions.

No reports of the presence of *Gambierdiscus* from the coast in Sea of Japan



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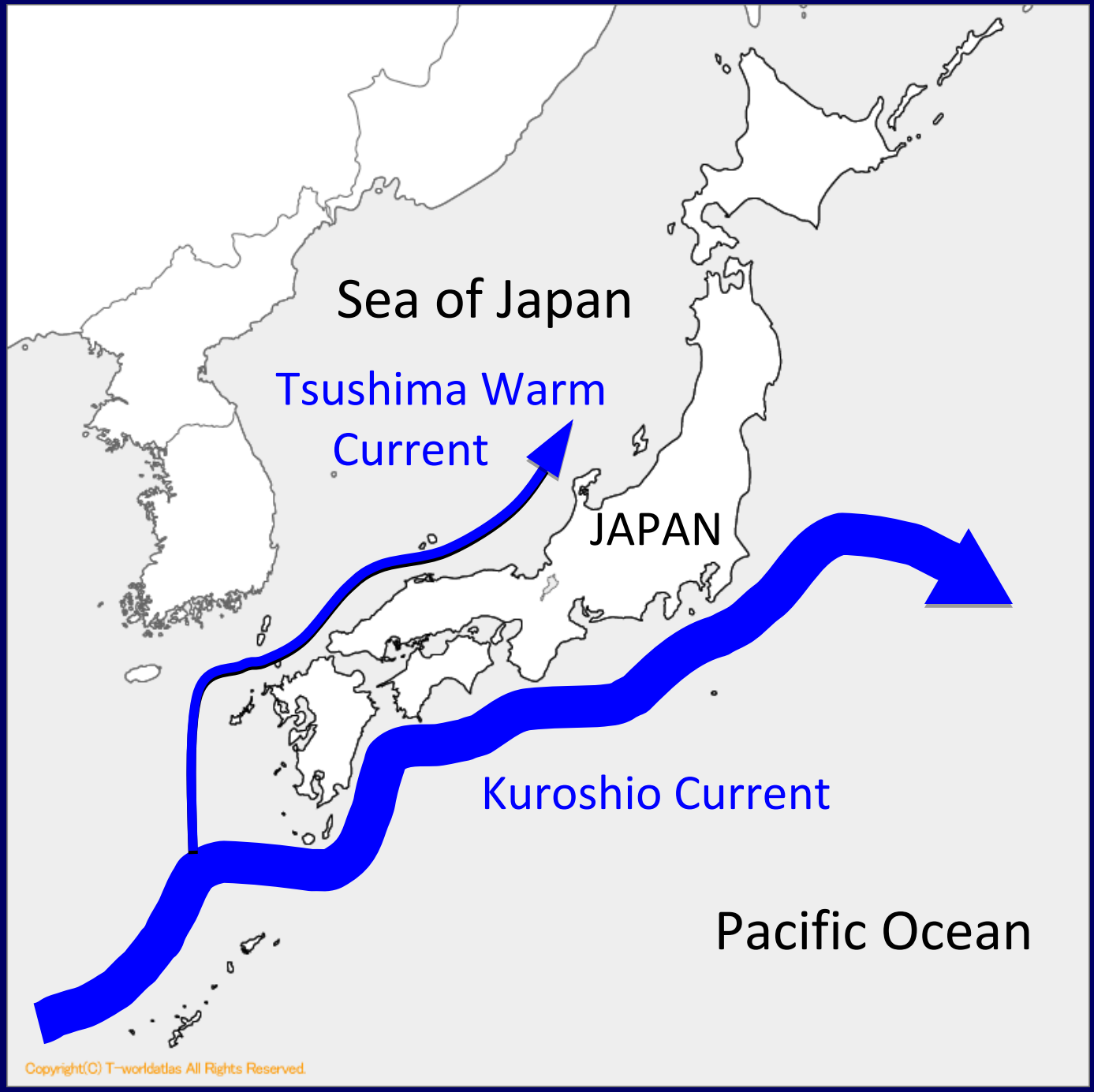
Sea of Japan
Tsushima Warm Current
JAPAN
Kuroshio Current
Pacific Ocean
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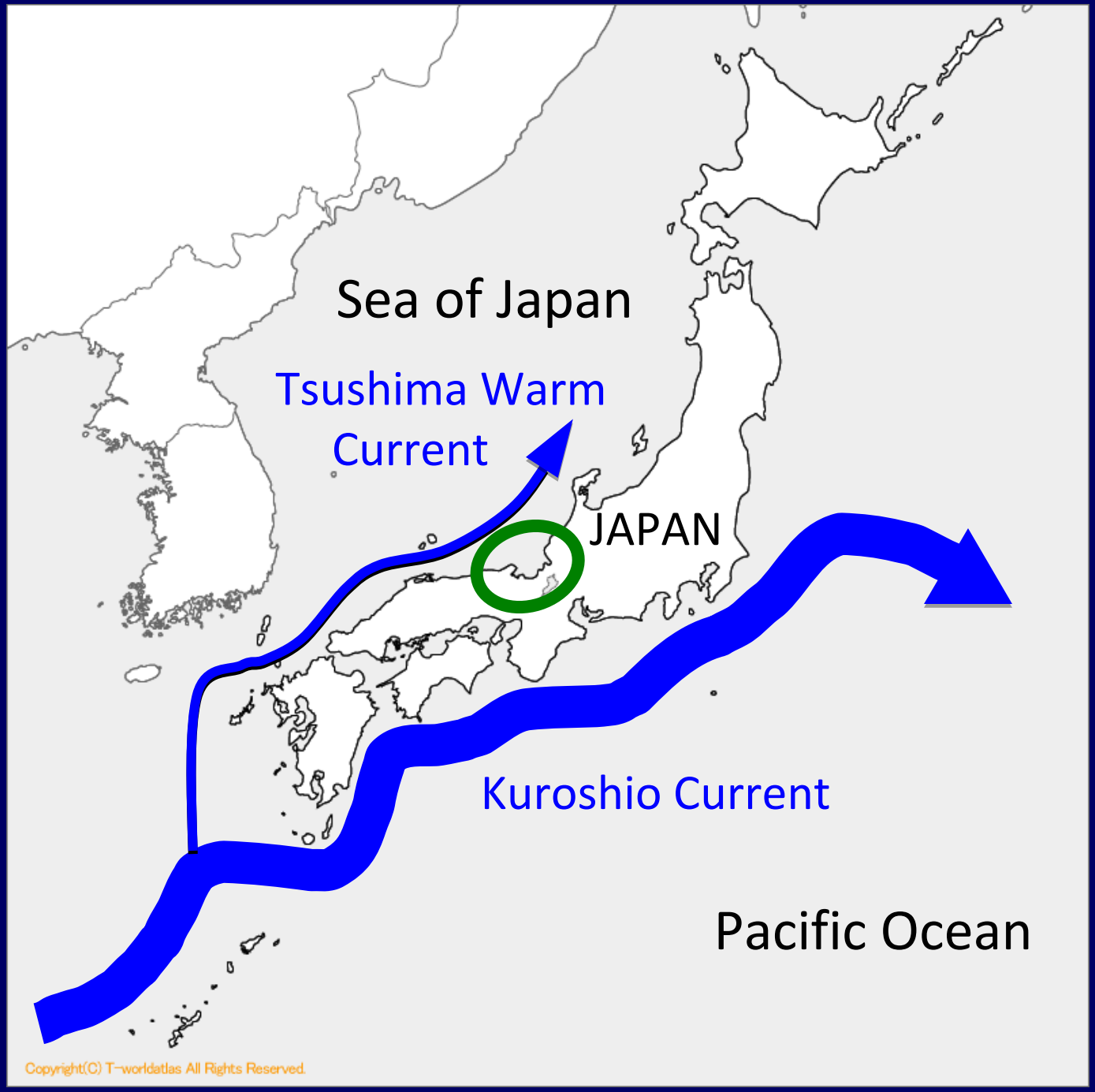
Sea of Japan
Tsushima Warm Current
JAPAN
Kuroshio Current
Pacific Ocean
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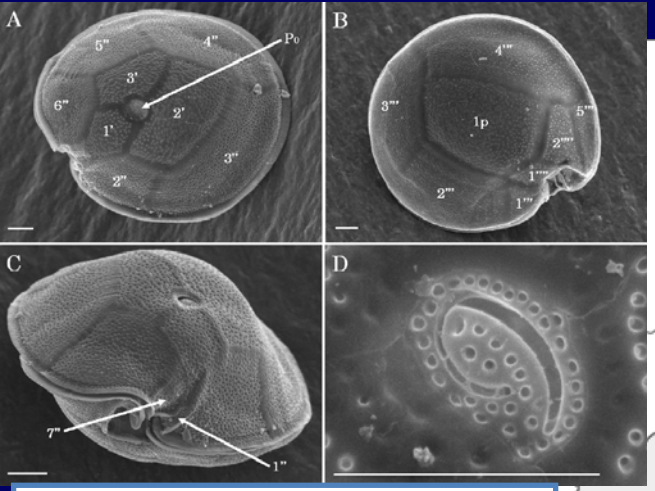

Hatayama et al. 2011:
Nippon Suisan Gakkaishi

Sea of Japan

Tsushima Warm Current

JAPAN

Kuroshio Current

Gambierdiscus sp. was found in Wakasa Bay.

Pacific Ocean

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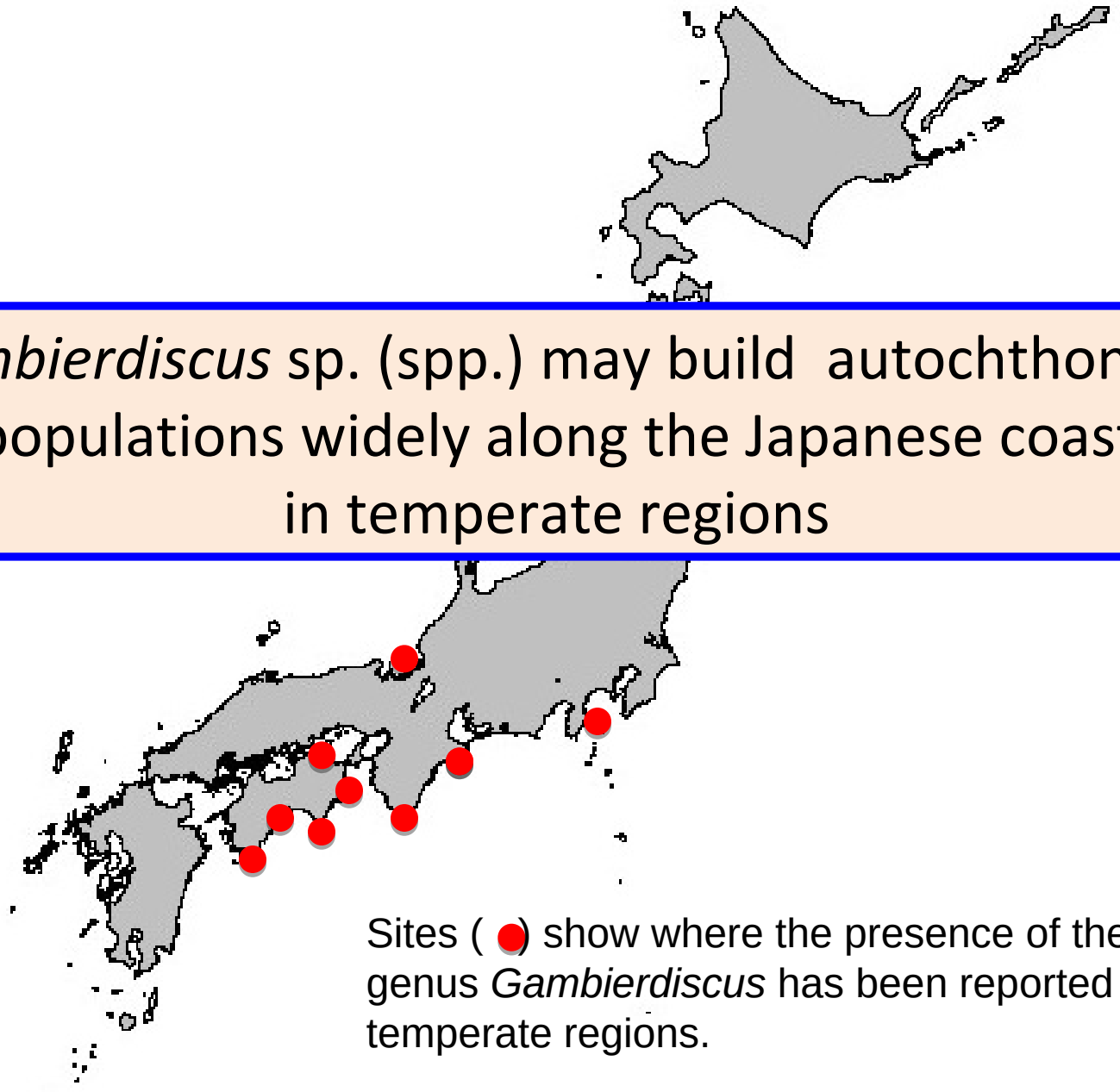
Gambierdiscus sp. (spp.) may build autochthonous populations widely along the Japanese coast in temperate regions



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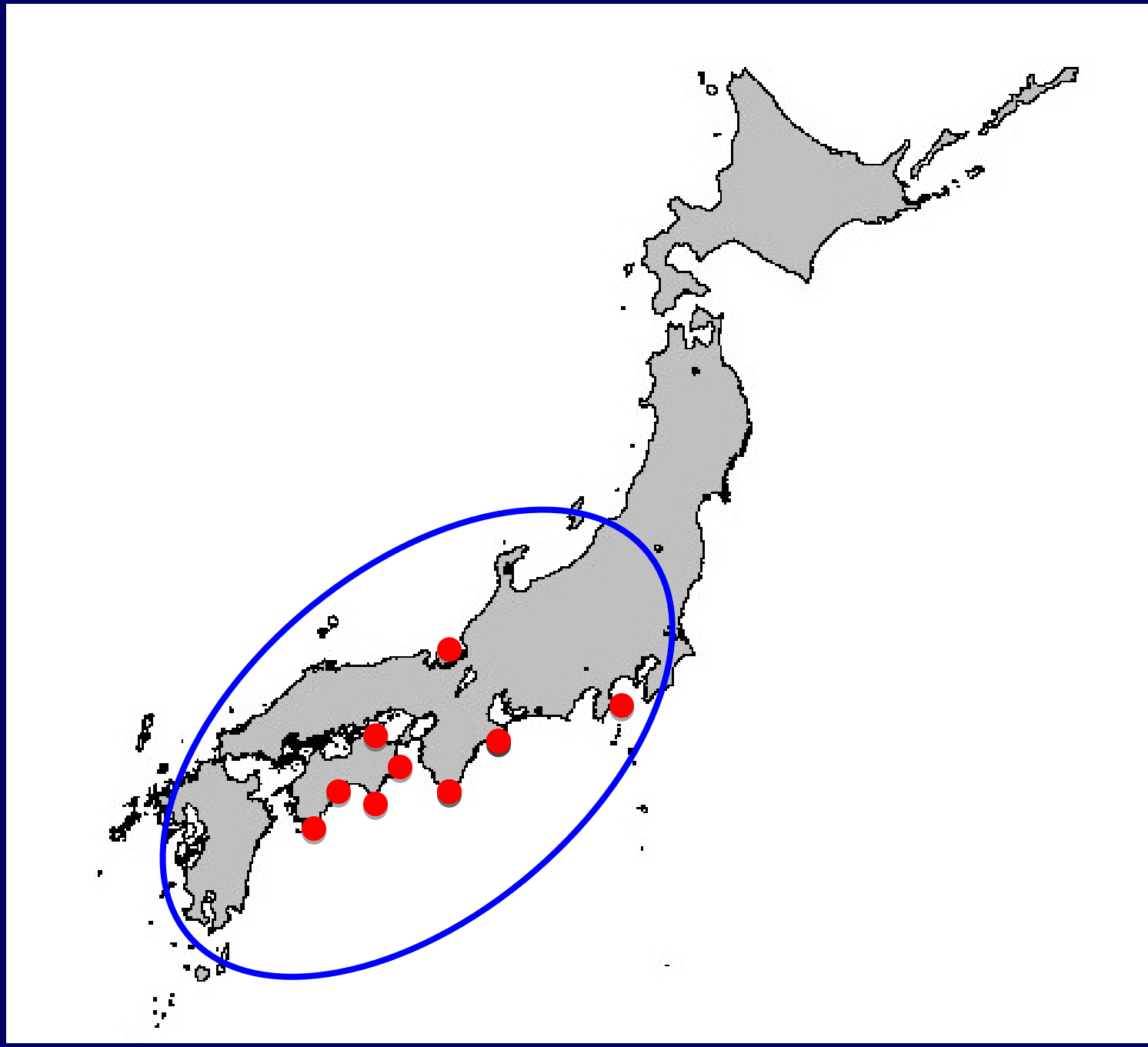
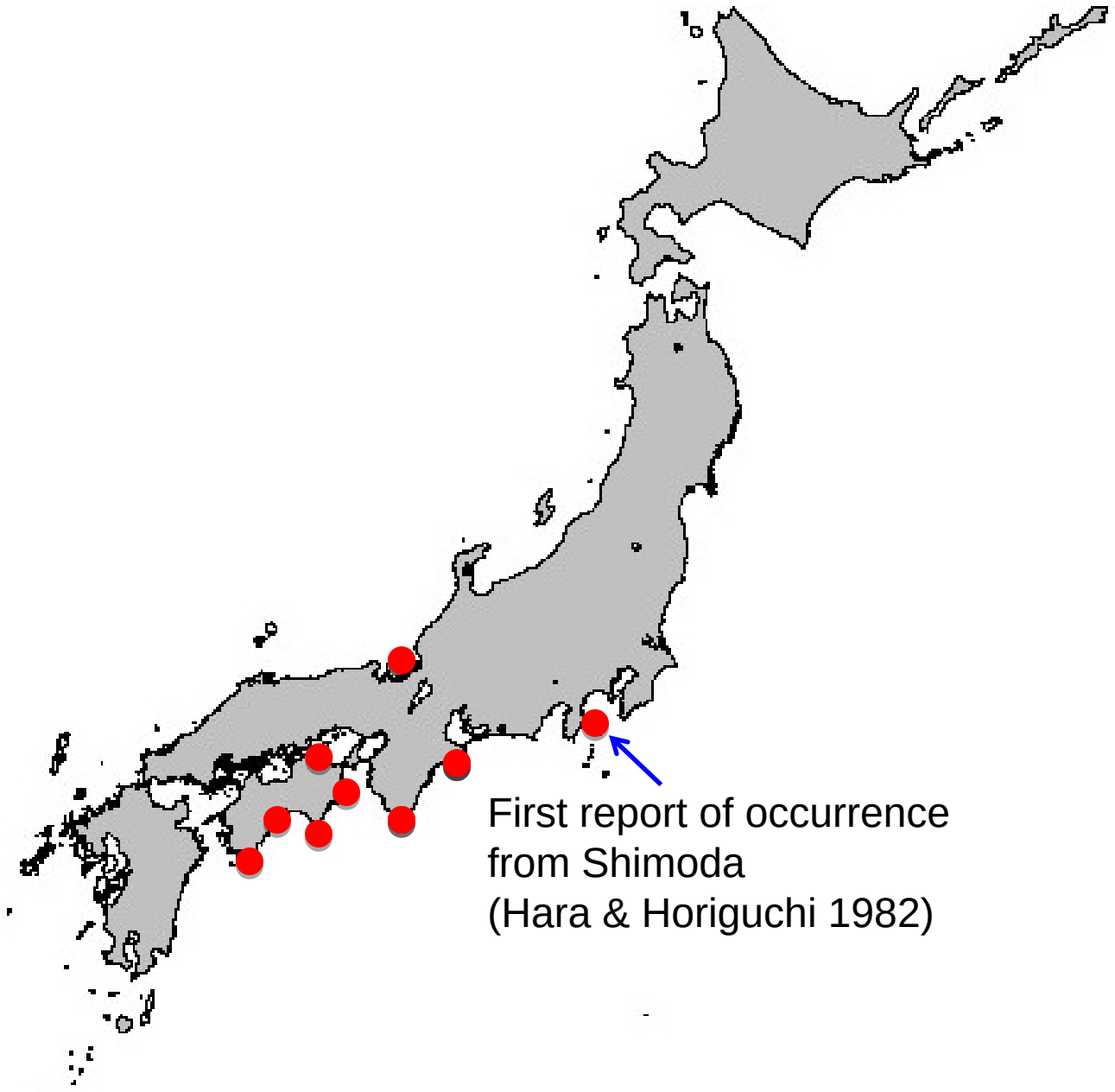
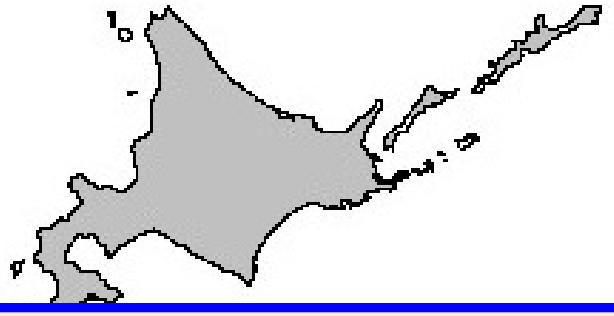
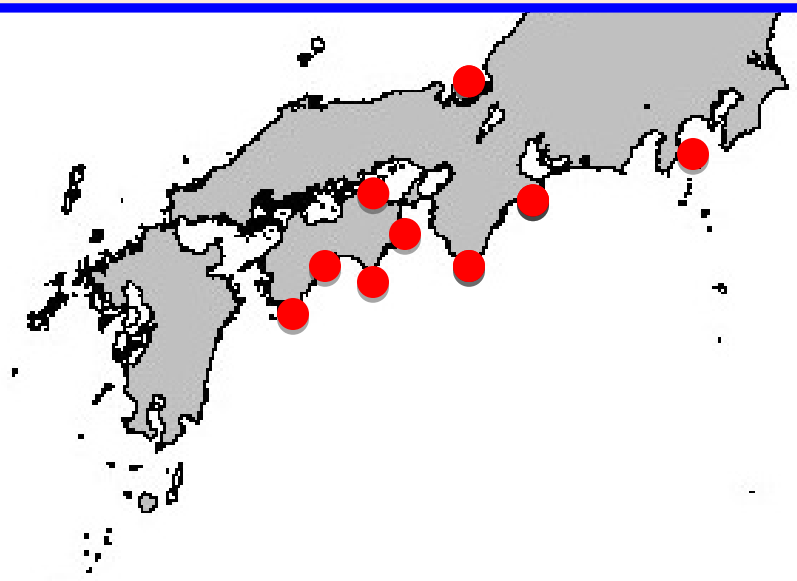



First report of occurrence
from Shimoda
(Hara & Horiguchi 1982)



Increase of water temperature would induce *Gambierdiscus* sp. (spp.) to build larger populations in temperate regions and also spread their distribution toward north



Maximum cell density of *Gambiediscus* sp. in Ago Bay

Sargassum thunbergii (**Phaeophyceae)**

Octber 1st, 2009

32 cells g^{-1} alga

Gambierdiscus spp. abundance in other regions

Regions	Maximum cell density (cells g^{-1})	References
Hawai (USA)	823	Shimizu et al. 1982
Florida (USA)	8,191	Bomber et al. 1989
Virgin Islands（Puerto Rico）	75,793	Carlson and Tindall 1985
Mayotte（Mozambique channel）	60,463	Turquett et. al. 2001
Queensland（Australia）	2,180	Gillespie et al. 1985
Great Barrier Reef (Australia）	250	Heil et al. 1998
Tahiti（French Polynesia）	10,880	Chinain et al. 1999
JAPAN		
Ago Bay, Mie	32	This study

Gambierdiscus spp. abundance in other regions

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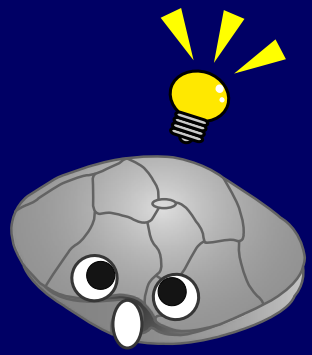
Mayotte (Mozambique channel)	60,463	Turquett et. al. 2001
Queensland (Australia)	2,180	Gillespie et al. 1985

The maximum cell density in Ago Bay is comparable to those recorded in Okinawa Islands located in subtropical part of Japan, where CFP have often been reported.

JAPAN		
Ago Bay, Mie	32	This study
Kerama Islands, Okinawa	51	Koike et al. 1991
Nago, Okinawa	10	Ishikawa, unpublished.

NOW



Further studies on ecology and physiology, including toxicology, of *Gambierdiscus* sp. are certainly needed to evaluate future risk of CFP, even in temperate waters of Japan.