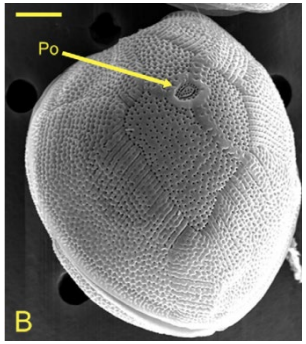
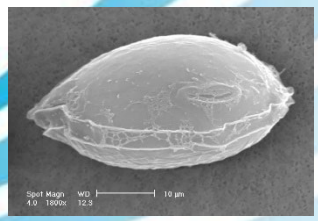
Distributional characteristics of BenthicHAB in Korean coastal waters and East Asian area

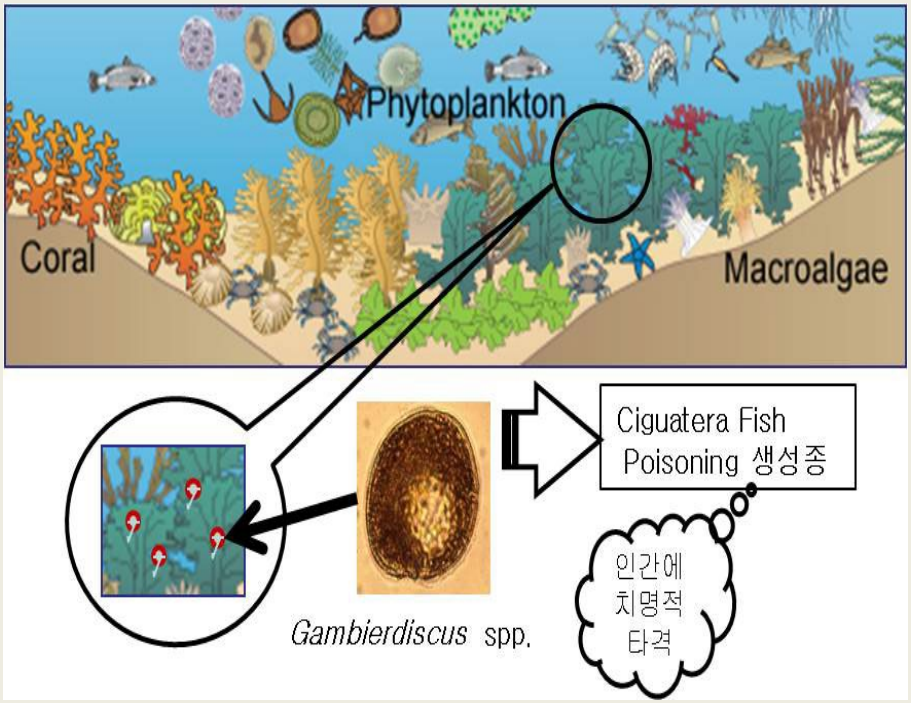


Korea Institute of Ocean Science & Technology

SEUNG HO BAEK



-General Background For Benthic HABs-



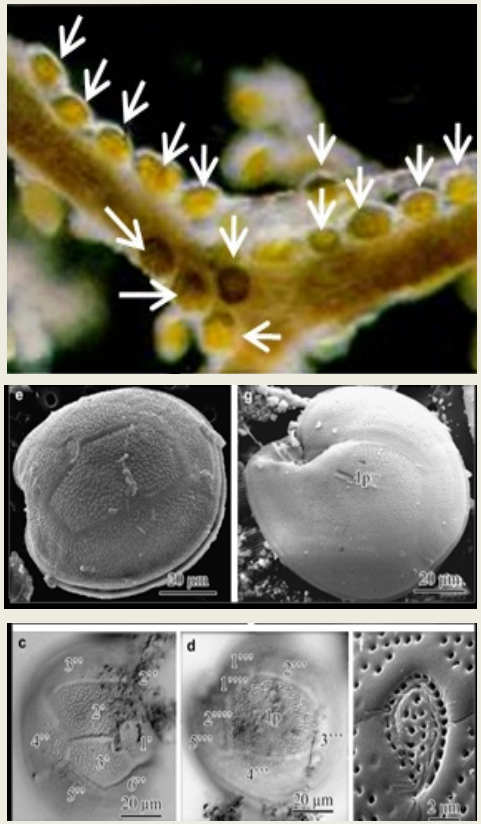
➢ **These benthic-dinoflagellates live on the surface of macroalgae.**

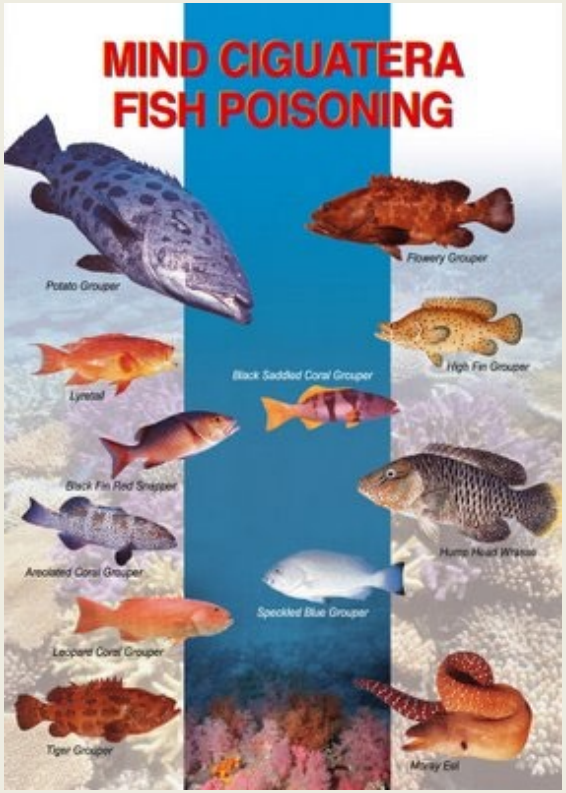
➢ **The primary toxins associated with CFP are ciguatoxins (CTXs), produced by benthic/epiphytic dinoflagellate of the genus *Gambierdiscus*; moreover, other benthic species(e.g. *Ostreopsis, Coolia*) are also known to be CFP or palytoxicosis.**

➢ ***Gambierdiscus*, *Ostreopsis*, *Coolia*, *Prorocentrum*, and *Amphidinium* are known to be benthic dinoflagellates.**

➢ **Most of the benthic dinoflagellates(HABs) are harmful to humans as well as to marine organisms.**

-General Background For Benthic HABs-

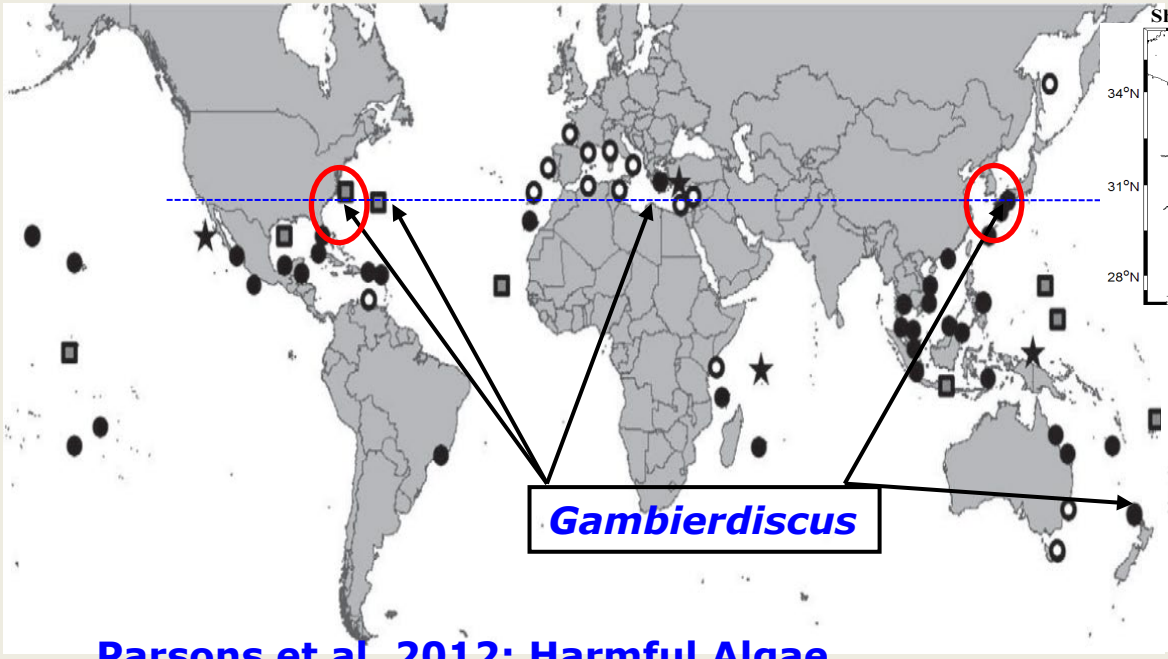


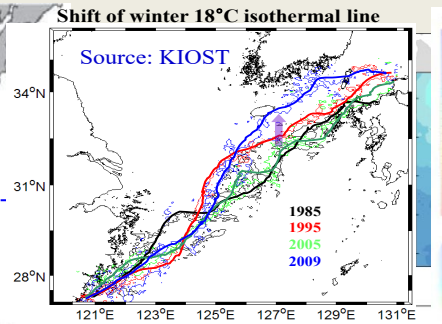


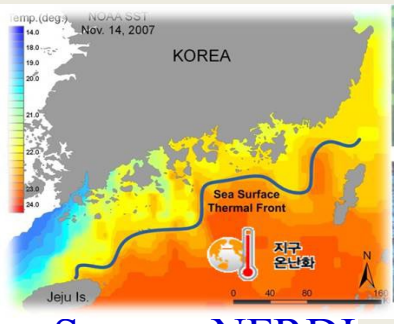
➢ **Ciguatera fish poisoning (CFP) is associated with seafood consumption worldwide(25,000-500,000/ year)**

➢ **The Intergovernmental Panel on Harmful Algal Blooms (IPHAB) under IOC of UNESCO (2013) noted "the potential global increase in CFP… due to climate change, coastal development, and globalised seafood trade" and recommended /improved ciguatera research.**

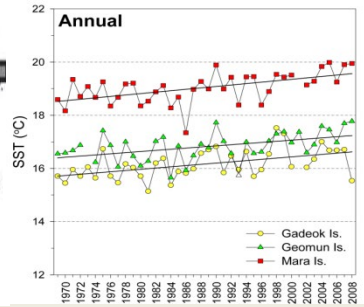
-Statement of Problem-

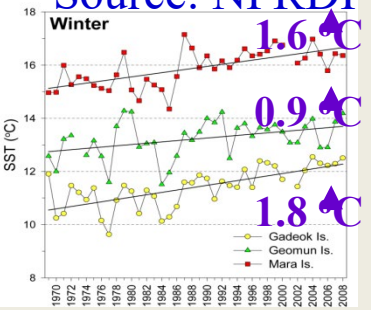






Source: NFRDI



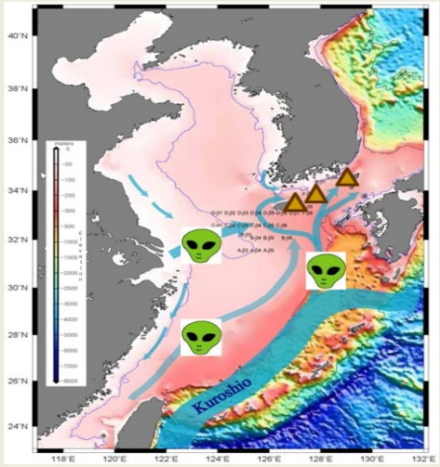


Parsons et al. 2012; Harmful Algae

➢ **These dinoflagellates are known to be present in tropical or subtropical regions (Steidinger and Tangen 1997), but some species also live in the warm waters of temperate regions.**

Ex.1. In case study of KOREA and U.S, several tropical species was recently detected in the Pacific and Atlantic zone (over 30' latitude) that it may have caused by warm water current, namely Kuroshiwo and Mexico.

Ex.2. The invasion of several tropical species into temperate waters can be a signal of global warming.



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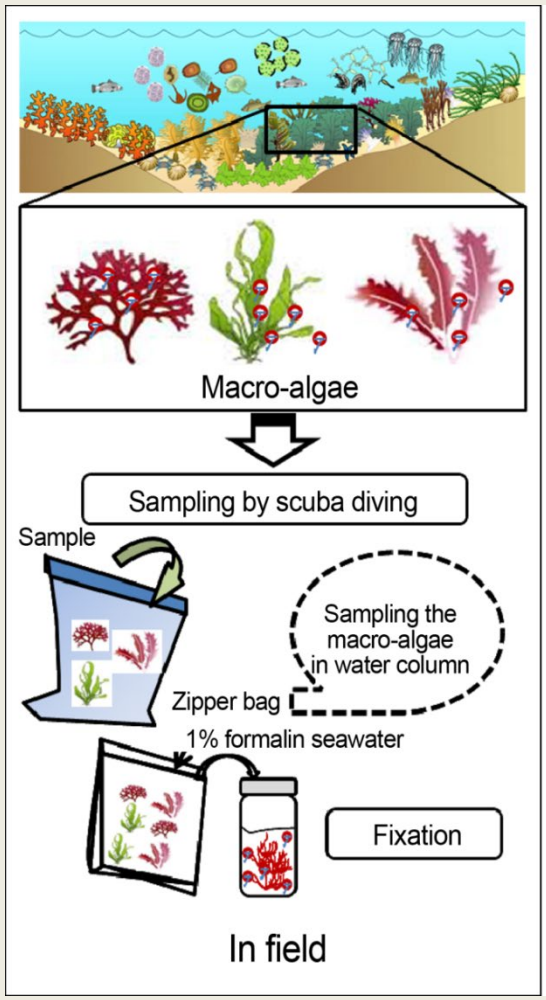

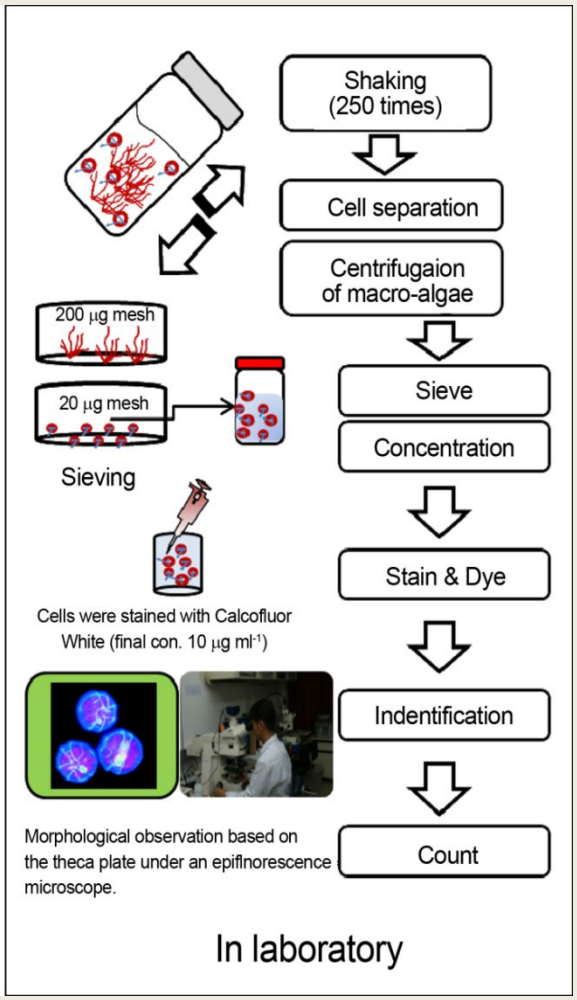

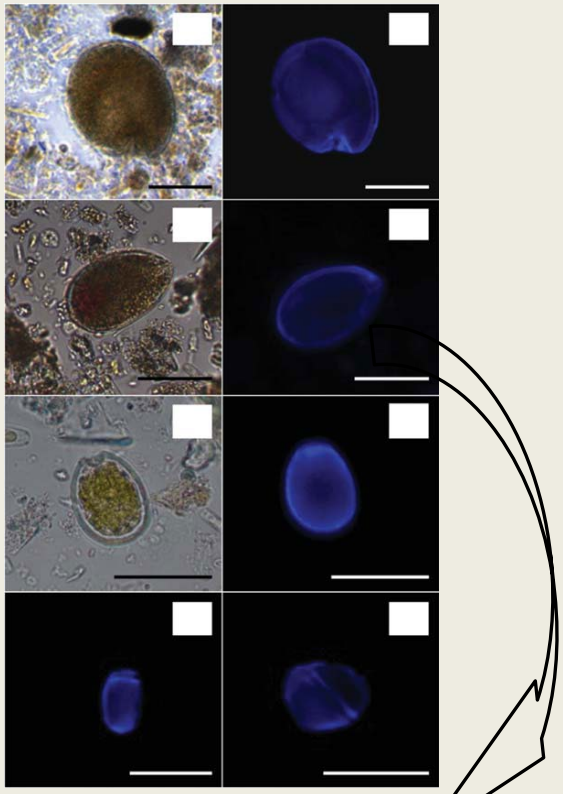

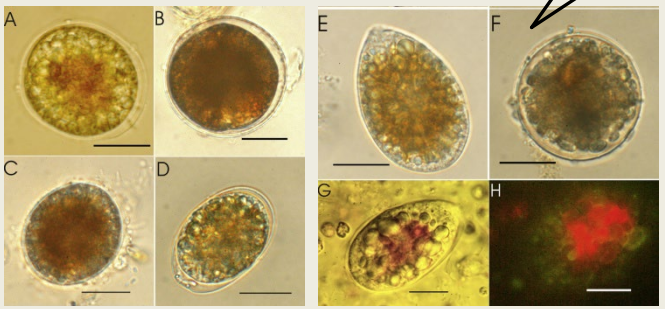

LM :Identification of genus level- OK
Identification is not easy

-Case study in Korea in 2009-

Ocean Sci. J. (2011) 46(3):205-209
http://dx.doi.org/10.1007/s12601-011-0016-9

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Ocean Science Journal

Note

Abundance of Epiphytic Dinoflagellates from Coastal Waters off Jeju Island, Korea During Autumn 2009

Hyung Seop Kim[1], Wonho Yih[2*], Jong Hyeok Kim[2], Geumog Myung[3], and Hae Jin Jeong[4]

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[3]*Western Branch, Korea Fisheries Resources Agency, Kunsan 573-030, Korea*
[4]*School of Earth and Environmental Sciences, College of Natural Sciences, Seoul National University, Seoul 151-747, Korea*

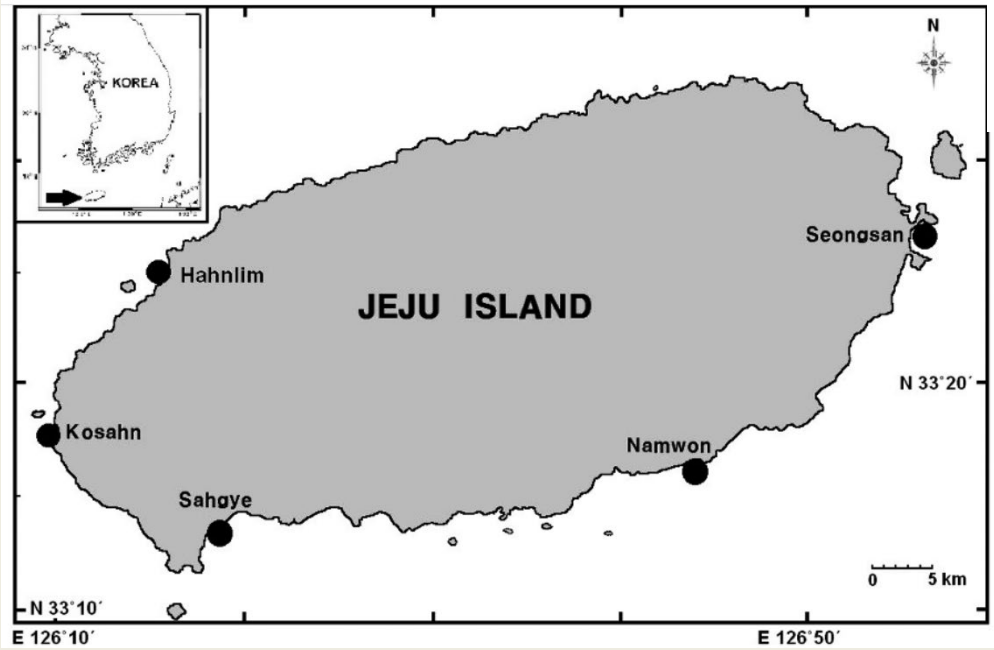

Table 2. The abundance (cells/g wet weight) of the epiphytic dinoflagellates *Amphidinium* spp., *Coolia* spp., *Gambierdiscus* spp., *Ostreopsis* spp., *Prorocentrum* spp. on diverse macroalgae collected from 5 stations along the coasts of Jeju Island, Korea on October 31-November 1, 2009

	Macroalgae\Epiphytes	*Amphidinium*	*Coolia*	*Gambierdiscus*	*Ostreopsis*	*Prorocentrum*
Chlorophyta	*Cladophora wrightiana*	0–15	0	39	758	0
	Ulva pertusa	0	0–237	500	342	29–53
	Cladophoropsis herpestica	0	0	173	231	0
	Derbesia sp.	0	0	1,595	8,660	0
	Codium fragile	0	0	0	0	0
Phaeophyta	*Dictyopteris prolifera*	0	0	60	164	0
	Ecklonia caba	0	0–33	17–53	5–69	8
	Dictyota okamurae	0	0	1,000	185	0
	Sargassum siliquastrum	0	0	–	121	0
	Sargassum sp.	0–10	0–121	343	434	30
	Dictyopteris divaricata	0–37	0	13–200	87–216	12
	Chordaria flagelliformis	0–121	0–339	1,770	364	97
	Zonaria diesingiana	0	0	111	44–94	0
	Padina arborescens	0–137	0–652	789	583	171
	Colpomenia sinuosa	0–68	0	136	545	0
	Dictyopteris undulata	0	0	62	–	0
Rhodophyta	*Plocamium cartilagineum*	0	0	255	255	0
	Pterocladiella capillacea	0	0	1,599	837	0
	Lithothamnion sp.	0	0	25	–	0
	Martensia sp.	0–406	0–710	4,871	3,349	304
	Gelidium amansii	0	0	229–426	78–688	233
	Corallina sp.	0	0	33–993	28–307	33
	Chondrus ocellatus	0	0–47	63	267	0
	Plocamium telfairiae	0	0	406–1477	50–966	0

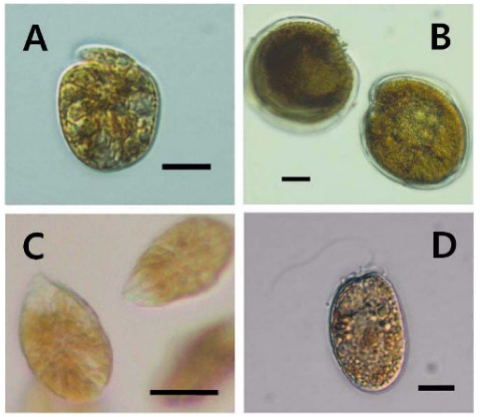

Fig. 2. Epiphytic dinoflagellates observed in this study. (A) *Amphidinium* sp. bar = 10 um. (B) *Gambierdiscus* sp. bar = 20 μm. (C) *Ostreopsis* sp. bar = 20 μm. (D) *Prorocentrum* sp. bar = 10 μm

-Case study in Korea in 2012-

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Ocean and Polar Research

March 2012

Occurrence of the Toxic Benthic Dinoflagellate *Gambierdiscus* spp. in the Uninhabited Baekdo Islands off Southern Coast and Seopsom Island in the Vicinity of Seogwipo, Jeju Province, Korea

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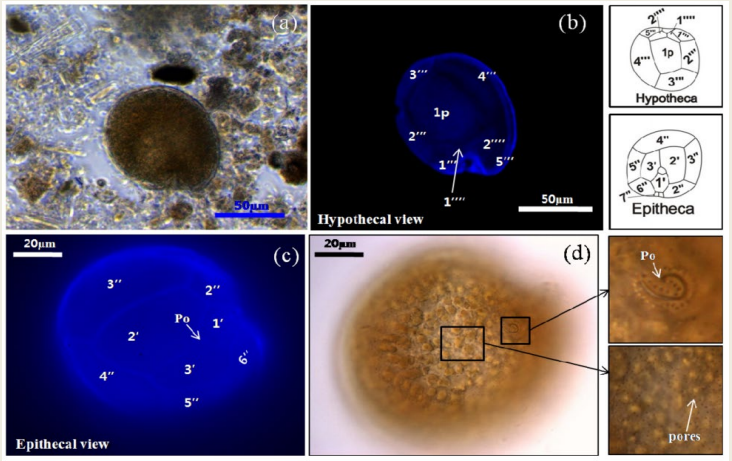
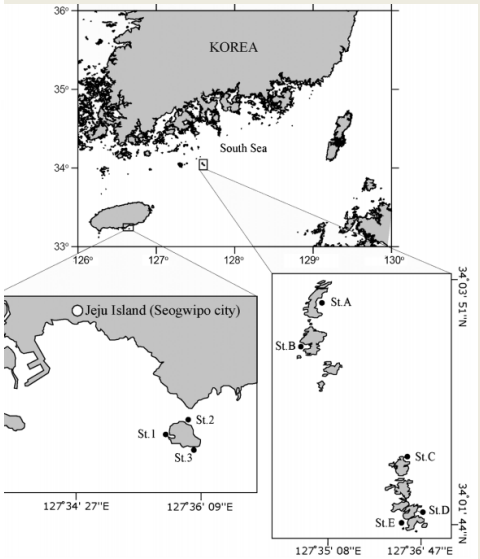
Geoje 656-830, Korea

Abstract : *Gambierdiscus toxicus*, Adachi et. Fukuyo, is a benthic ciguatoxin-producing armored dinoflagellate, often attached to macroalgae. This organism is the primary causative agent of ciguatera fish poisoning which occurs in tropical and subtropical regions. However, regardless of the fact that the population of *Gambierdiscus* spp. has expanded to such temperate areas from sub-trophic and trophic areas, monitoring of *G. toxicus* has been lacking in the Korean coastal waters of temperate areas. This study was performed at the uninhabited Baekdo Islands off the southern coast of Korea and at Seopsom Island in the vicinity of Seogwipo, Jeju Province during April and May, 2011. Cell densities of *Gambierdiscus* spp. on macroalgae at Baekdo and Jeju Island ranged from zero to 56.4 cells g^{-1}. Maximum density was recorded on the brown alga *Cladophora japonica* at St. 3 of Jeju Island. In particular, the cell densities of *Gambierdiscus* spp. were influenced by the substrate characteristics of macroalgae. In the future, the continuous monitoring of toxic benthic dinoflagellate is necessary to predict and prevent ciguatera poisoning in Korean coastal waters.





1. Map of the sampling site at Baekdo and Jeju Island

Table 2. List of macroalgae, wet weight, and cell density of *Gambierdiscus* spp. attached to macroalgae collected in May, 2008, at Jeju Island, Korea

Site	Macro-algae species	Wet weight (g)	*Gambierdiscus* spp. (Cells g^{-1})
St.1	*Sargassum horneri*	237.2	0
	Ecklonia cava	291.5	0.54
	Undaria pinnatifida	156.3	0
	Gelidium amansii	39.6	10.27
St.2	*Sargassum horneri*	96.3	0.86
	Ecklonia cava	65.4	0
	Undaria pinnatifida	128.6	1.38
	Padina arborescens	22.2	8.19
	Dictyopteris prolifera	70.4	1.21
	Ulva pertusa	39.2	8.15
St.3	*Sargassum horneri*	87.5	0
	Ecklonia cava	66.2	0
	Cladophora japonica	15.0	56.37
	Grateloupia angusta	30.8	23.95
	Dendronephthya castanea	174.4	0

Table 1. List of macroalgae, wet weight, and cell density of *Gambierdiscus* spp. attached to macroalgae collected during April, 2008, at Baekdo in South Sea, Korea

Site	Macro-algae species	Wet weight (g)	*Gambierdiscus* spp. (Cells g^{-1})
St.A	*Sargassum honeri*	108.6	1.33
	Eklonia cava	169.3	0.64
	Undaria pinnatifida	94.7	0
	Gracilaria textorii	34.5	2.70
	Grateloupia angusta	75.4	0
St.B	*Sargassum honeri*	23.6	0
	Eklonia cava	32.8	0
	Undaria pinnatifida	29.8	0
	Gracilaria textorii	14.1	0
St.C	*Sargassum honeri*	28.6	0
	Eklonia cava	42.1	0
	Undaria pinnatifida	25.4	3.68
	Gracilaria textorii	15.2	6.07
St.D	*Eklonia cava*	36.1	0
	Undaria pinnatifida	19.7	0
	Gracilaria textorii	10.8	0
	Grateloupia angusta	33.7	12.59
	Plocamium telfairiae	7.2	0
	Amphiroa anceps	37.0	19.93
	Dictyota okamurae	23.2	0
	Acinetospora crinita	5.3	0
	Pachymeniopsis elliptica	10.2	0
St.E	*Sargassum honeri*	18.8	0
	Ecklonia cava	28.9	0
	Undaria pinnatifida	10.9	9.81
	Gracilaria textorii	24.3	0

-Case study in Korea in 2012-

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First Report for Appearance and Distribution Patterns of the Epiphytic Dinoflagellates in the Korean Peninsula

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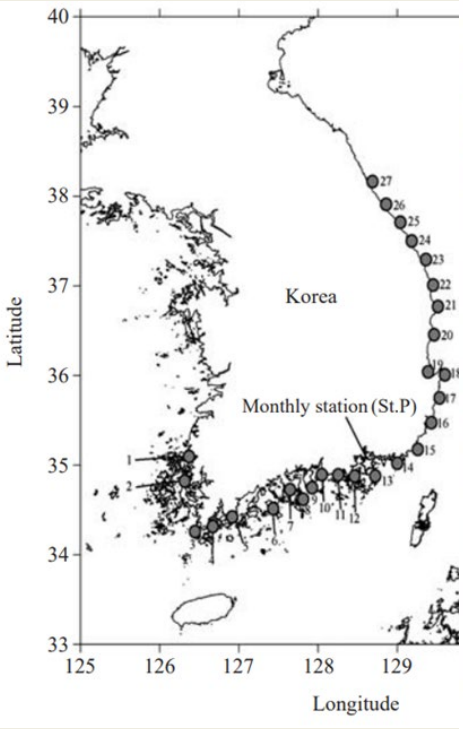
Abstract - **Genus of *Gambierdiscus, Ostrepsis, Prorocentrum, Coolia* and *Amphidinium* are epiphytic ciguatoxin-producing armored dinoflagellate, often attached on macroalgae. These organisms are the primary causative agent of ciguatera fish poisoning which occurs in tropical and subtropical regions. However, regardless of the fact that population of epiphytic dinoflagellates have expanded to such temperate areas from sub-trophic and trophic areas, monitoring of the epiphytic dinoflagellates was greatly lacked in coastal water of Korean Peninsula. This study was performed in the Korean Peninsula in November, 2011. Cell densities of *Gambierdiscus* spp. on macroalgae ranged from zero to 10 cells g^{-1} and the maximum density was recorded at St.18 (Pohang guryongpo). The abundance of *Ostreopsis* spp. was highest on macro-algaes *Chondrus ocellatus, Lomentaria catenata* and *Plocamium telfairiae* (140 cells g^{-1}). The maximum abundance of *Prorocentrum, Coolia* and *Amphidinium* were 52, 3 and 1 cells g^{-1}, respectively. Of these, *Prorocentrum lima* was observed at most stations of East Sea. Therefore, our results suggest that the epiphytic armored dinoflagellates may have adapted to Korean coastal water of temperate areas (i.e., East Sea) and those abundances may be related to the macroalgal species.**

Key words : epiphytic dinoflagellate, macroalgae, the Korean Peninsula, Ciguatera

-Case study in Korea in 2012-



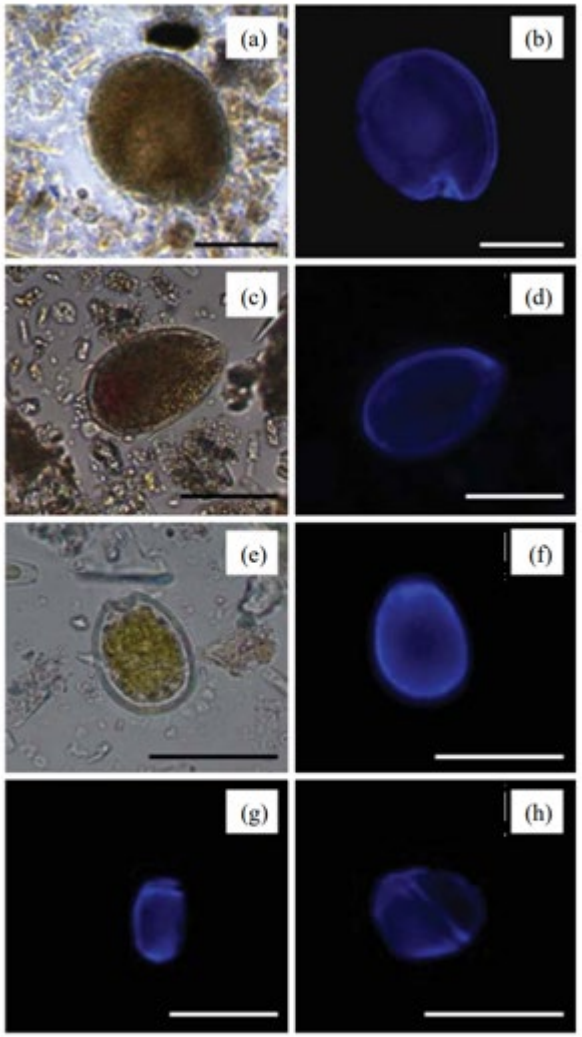
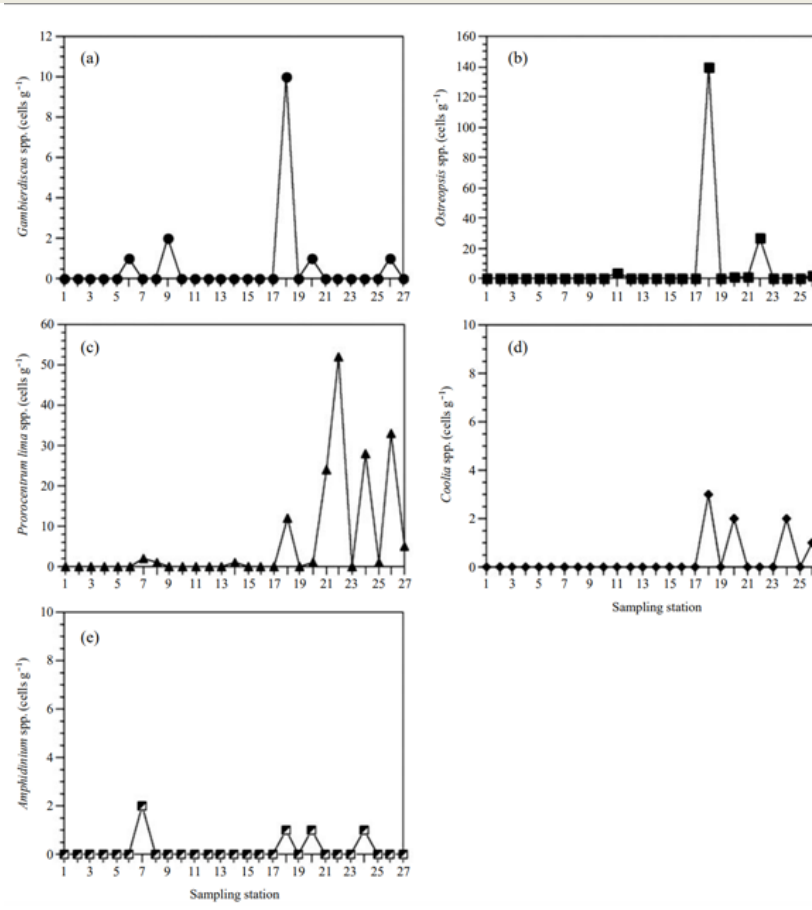


Fig. 3. Cell morphology of ephiphytic dinoflagellates in light and epifluorescent observation; a-b: *Gambierdiscus* sp., c-d: *Ostreopis* sp., e-f: *Prorocentrum lima*, g: *Ampidinium* sp., h: *Coolia* sp.



-Case study in Korea in 2020-

Harmful Algae 96 (2020) 101820

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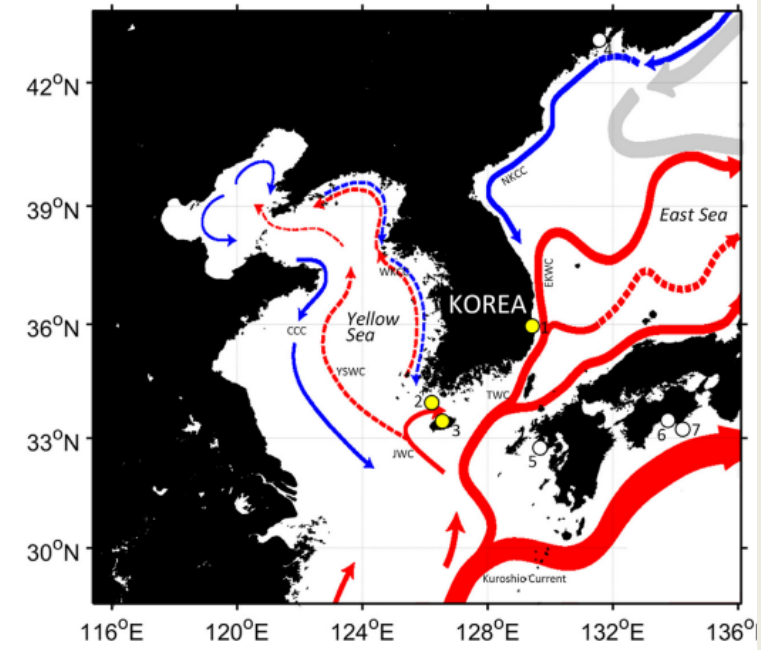
journal homepage: www.elsevier.com/locate/hal

Original Article

Distribution and genetic diversity of the toxic benthic dinoflagellate genus *Ostreopsis* in Korea

Bora Lee, Myung Gil Park*



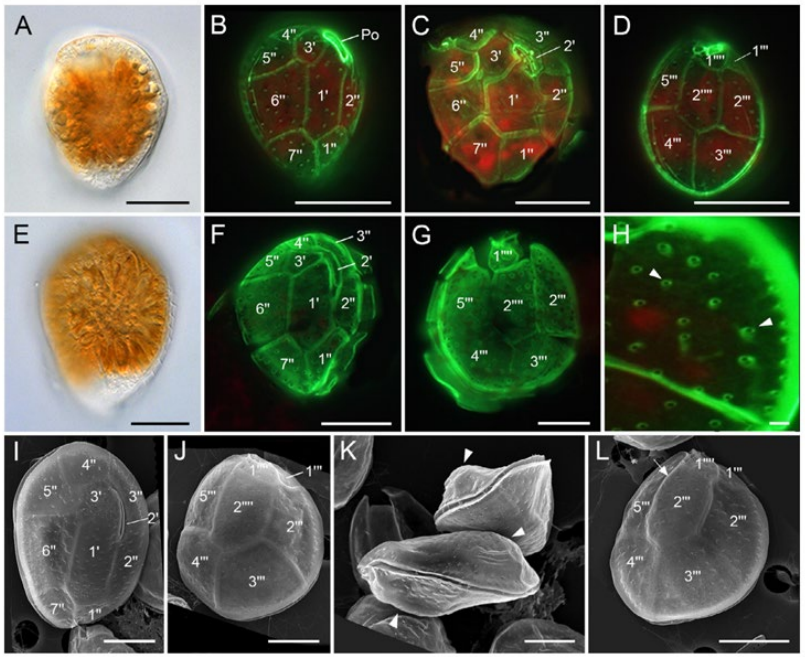


Fig. 2. Light and epifluorescence and scanning electron micrographs of *Ostreopsis* sp. 1 (A-D) and *Ostreopsis* sp. 6 (E-L) from Korea. (A) Live *Ostreopsis* sp. 1 cell in apical view. (B-C) Epithecal plates in epifluorescence after staining with Direct Yellow 96. Note the red autofluorescence by chloroplasts. (D) Hypotheca in epifluorescence. Red autofluorescence by chloroplasts is also shown together. (E) Live *Ostreopsis* sp. 6 cell in apical view. (F) Epithecal plates in epifluorescence. (G) Hypotheca in epifluorescence. (H) Detail of the thecal surface with one type of thecal pores (indicated by arrowheads). (I) SEM micrograph of *Ostreopsis* sp. 6 in apical view. (J) SEM micrograph of *Ostreopsis* sp. 6 in antapical view. (K) Lateral view showing undulated cingulum and asymmetrically biconvex shape (indicated by arrowheads). (L) Antapical view showing the convex plate (indicated by arrow). All scale bars are 20 μm, except for one in (H), where scale bar is 5 μm. Po = apical pore. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

ribosomal DNA (rDNA) sequences from partial nuclear LSU D8-D10, 5.8S, and ITS regions were determined for 169 isolates of Ostreopsis species collected from three coastal sites (i.e., Jeju Island, Chuja Island, and Pohang) within Korea

-Case study in Korea in 2020-

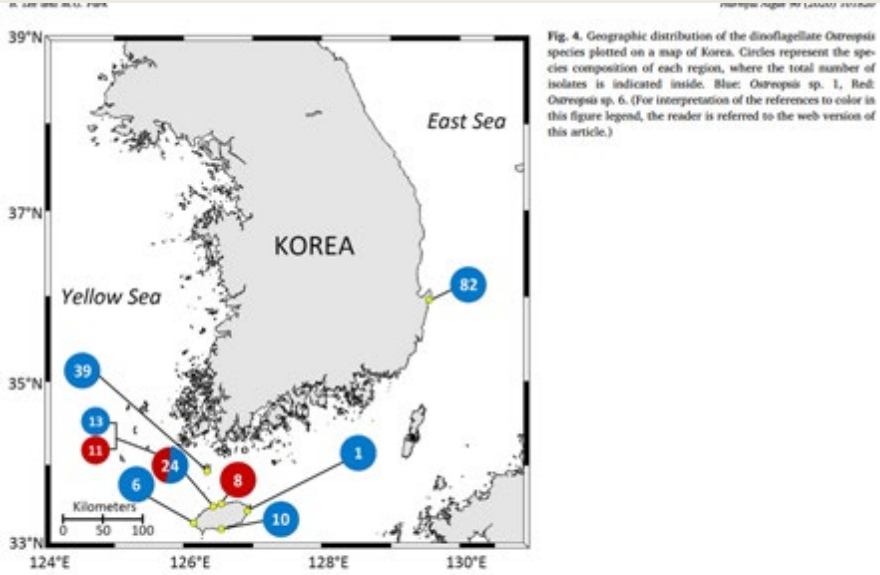


Fig. 4. Geographic distribution of the dinoflagellate *Ostreopsis* species plotted on a map of Korea. Circles represent the species composition of each region, where the total number of isolates is indicated inside. Blue: *Ostreopsis* sp. 1, Red: *Ostreopsis* sp. 6. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

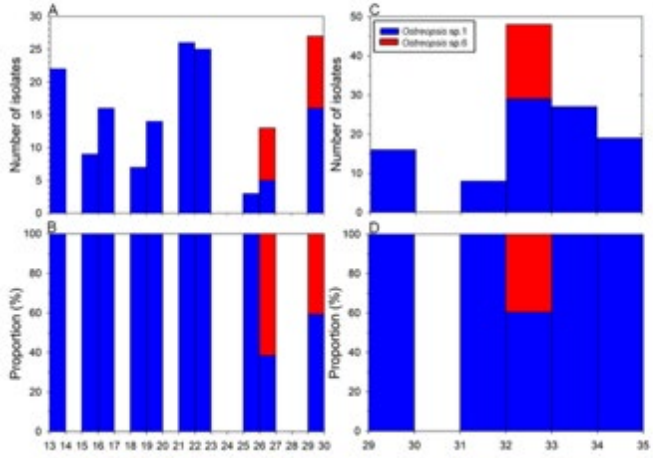
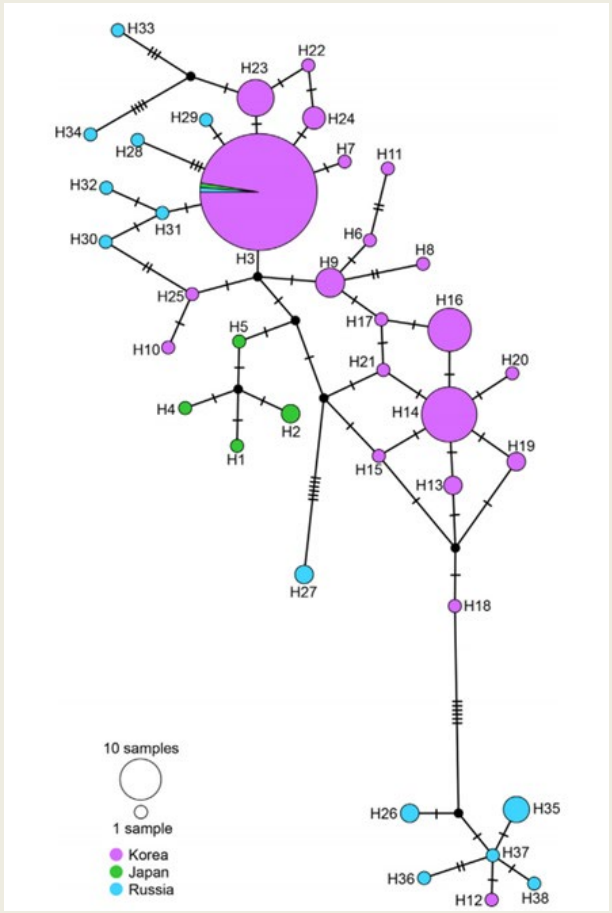


Fig. 5. The occurrence of the *Ostreopsis* species as functions of in situ water temperature (A, B) and salinity (C, D). Absolute number (A, C) and proportion (B, D) of *Ostreopsis* isolates. Blue: *Ostreopsis* sp. 1, Red: *Ostreopsis* sp. 6. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

The results from this study provide a basis for a better understanding of the distribution and genetic structure of the Asian Ostreopsis sp. 1 populations



The haplotype network of the dinoflagellate Ostreopsis sp. 1 based on ITS sequences. Circles size is proportional to the number of isolates having that haplotype. Circles color indicates each region. Small black closed circles in- dicate missing haplotypes.

-Case study in Korea-

Review

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Open Access

Benthic dinoflagellates in Korean waters

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[2]*School of Earth and Environmental Sciences, College of Natural Sciences, Seoul National University, Seoul 08826, Korea*
[3]*Research Institute of Oceanography, Seoul National University, Seoul 08826, Korea*

Table 5. Comparison of the maximum abundances (MA, cells g^{-1} wet weight) of benthic dinoflagellates in the genera *Amphidinium*, *Coolia*, *Gambierdiscus*, *Ostreopsis*, and *Prorocentrum* reported from the waters of temperate and subtropical-temperate regions

Species	Location	MA	Reference
Coolia spp.	Jeju Island, Korea	710	Kim et al. (2011)
	South-East Sea, Korea	3	Baek (2012*a*)
C. monotis	North Aegean Sea, Greece	16,000	Aligizaki and Nikolaidis (2006)
	NW Mediterranean Sea	**143,000**	Vila et al. (2001)
Gambierdiscus spp.	Back Islands, Korea	20	Baek (2012*b*)
	Jeju Island, Korea	56	Baek (2012*b*)
	Jeju Island, Korea	4,870	Kim et al. (2011)
	South-East Sea, Korea	10	Baek (2012*a*)
	New South Wales, Australia	**8,255**	Kohli et al. (2014)
G. toxicus	Knight key, Florida	2,279	Bomber et al. (1989)
Ostreopsis spp.	Jeju Island, Korea	8,660	Kim et al. (2011)
	Pohang, Korea	1,588	Lee and Park (2018)
	Jeju Island, Korea	158	Kim and Seo (2019)
Ostreopsis sp.	South-East Sea, Korea	140	Baek (2012*a*)
Ostreopsis spp.	Peter the Great Bay	71,000	Selina et al. (2014)
Ostreopsis cf. *ovata*	Jeju Island, Korea	3,204	Park et al. (2020)
Ostreopsis sp.	NW Mediterranean Sea	596,000	Vila et al. (2001)
O. siamensis	Auckland, New Zealand	**1,400,000**	Shears and Ross (2009)
	Knight key, Florida	308	Bomber et al. (1989)
O. heptagona	Knight key, Florida	394	Bomber et al. (1989)
Ostreopsis spp.	North Aegean Sea, Greece	405,000	Aligizaki and Nikolaidis (2006)
Prorocentrum spp.	Jeju Island, Korea	304	Kim et al. (2011)
Prorocentrum lima	South-East Sea, Korea	52	Baek (2012*a*)
P. concavum	Knight key, Florida	133	Bomber et al. (1989)
P. mexicanum	Knight key, Florida	844	Bomber et al. (1989)
P. lima	Knight key, Florida	**1,379**	Bomber et al. (1989)
Prorocentrum spp.	Kochi, Tosa Bay, Japan	29	Nishimura et al. (2020)
	Okinawa, Nakagusuku Bay, Japan	267	Nishimura et al. (2020)
Amphidinium spp.	Jeju Island, Korea	**406**	Kim et al. (2011)
	South-East Sea, Korea	2	Baek (2012*a*)

Bold letters indicate highest maximum abundance reported for each genus.

Table 2. The abundance (cells g^{-1} wet weight) of benthic dinoflagellates (*Amphidinium* spp., *Coolia* spp., *Gambierdiscus* spp., *Ostreopsis* spp., and *Prorocentrum* spp.) living on the thalli of diverse Chlorophyta collected from the coast of Jeju Island and the southern coast of Korea

Chlorophyta	Surface types	Morphology	*Amphi-dinium*	*Coolia*	*Gambier-discus*	*Ostreopsis*	*Prorocen-trum*	Reference
Cladophora japonica	H	FI	NA	NA	56.37	NA	NA	Baek (2012*b*)
C. wrightiana	H	FI	0–22	6	39	102–758	0–6	Kim et al. (2011), Shah et al. (2013*b*)
Cladophoropsis herpestica	H	FI	0	0	173	231	0	Kim et al. (2011)
Codium fragile	H	AR	25	0	0	21	8	Kim et al. (2011), Shah et al. (2013*b*)
Derbesia sp.	S	FI	0	0	1,595	8,660	0	Kim et al. (2011)
Enteromorpha linza	S	FO	14	4	0	57	25	Shah et al. (2013*b*)
Ulva pertusa	S	FO	23	3–237	0–500	52–342	8–53	Kim et al. (2011), Baek (2012*b*), Shah et al. (2013*b*)

H, hard; FI, filamentous; NA, not available; AR, arborescent; S, slippery; FO, foliaceous.

-Case study in Korea-

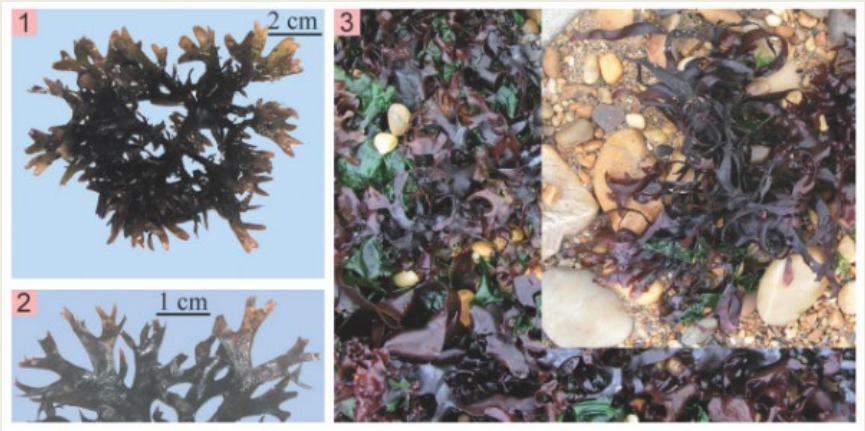
We monitored the epiphytic dinoflagellates in Korean Peninsula including Jeju Island.

In coastal water of Korean Peninsula,

Cell densities of *Gambierdiscus* spp. on macroalgae ranged from zero to 10 cells g^{-1}

The abundance of *Ostreopsis* spp. was highest on macro-algaes *Chondrus ocellatus, Lomentaria catenata* in Pohang area.

Therefore, the benthic HABs have already adapted to Korean coastal waters of temperate areas, which was dependent on macro-algal species.



Chondrus ocellatus

Lomentaria catenata

-Case study in Japan in 1991-

Nippon Suisan Gakkaishi 57(12), 2261–2264 (1991)

Distributions of Benthic Dinoflagellates in Akajima Island, Okinawa, Japan

Kazuhiko Koike,* Takashi Ishimaru,* and Masaaki Murano*

(Received July 3, 1991)

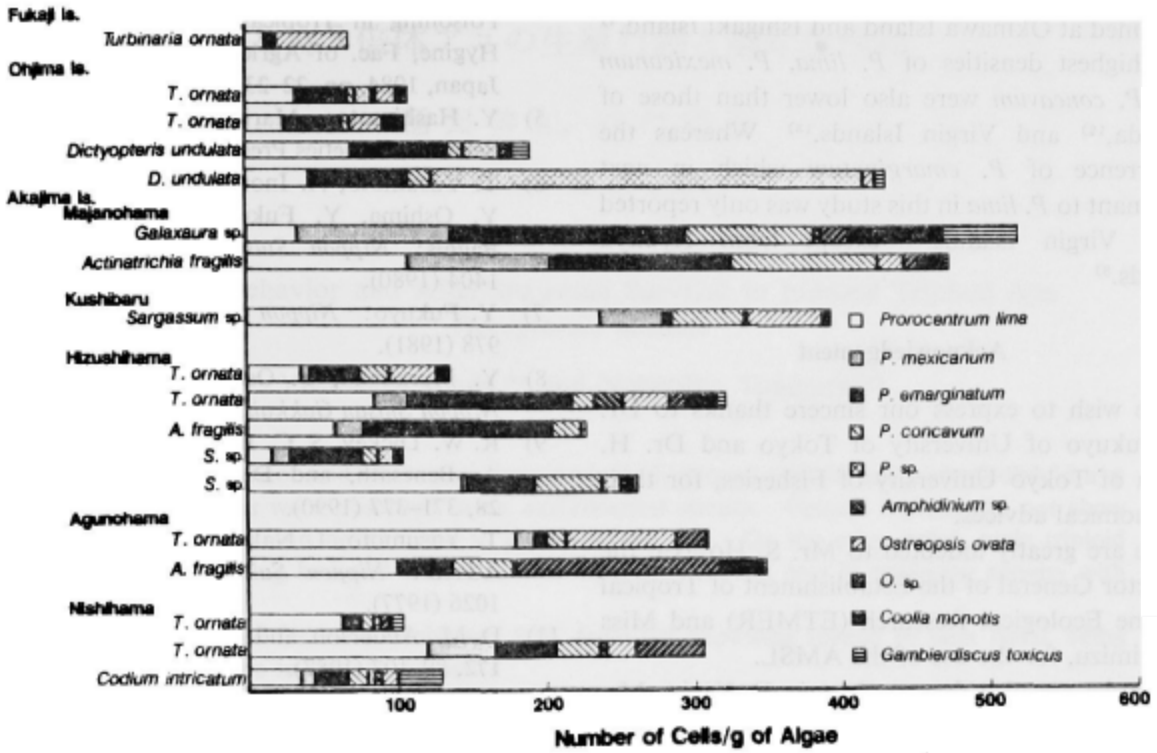


Fig. 2. Densities of the benthic dinoflagellates by locations and algal species.

Table 1. The mean densities of appearing benthic dinoflagellates

Species	Mean density (cells/g of alga)
Prorocentrum lima	75.0
mexicanum	18.3
P. emarginatum	51.0
P. concavum	30.0
P. sp.	17.1
Amphidinium sp.	1.8
Ostreopsis ovata	16.4
O. sp.	12.4
Coolia monotis	8.7
Gambierdiscus toxicus	6.7

-Case study in Japan in 2013-

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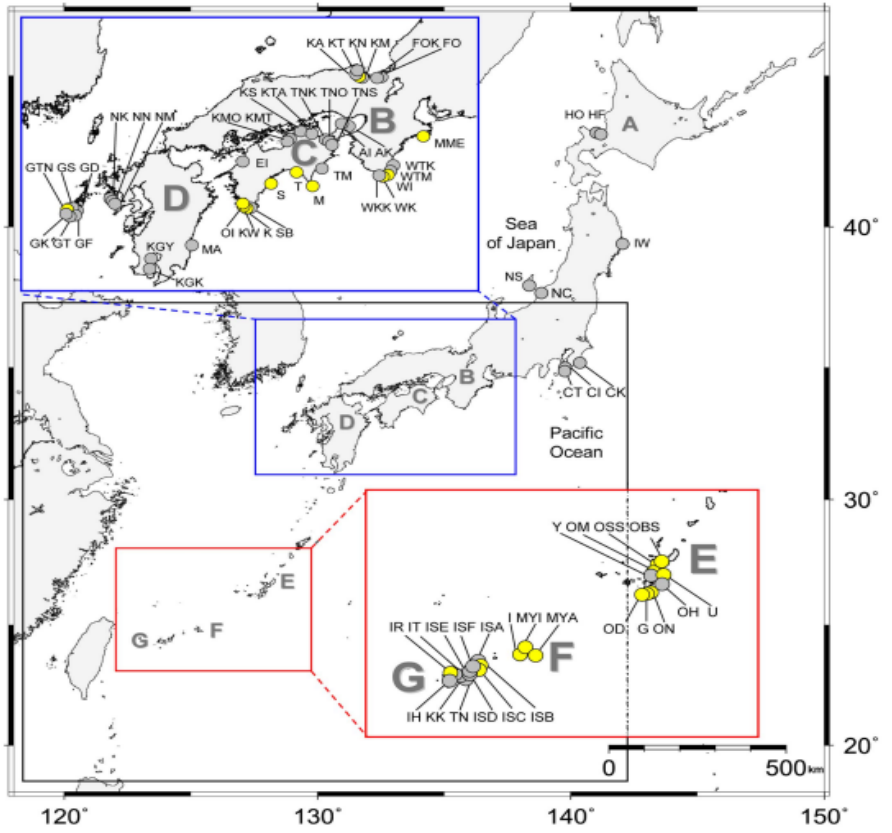
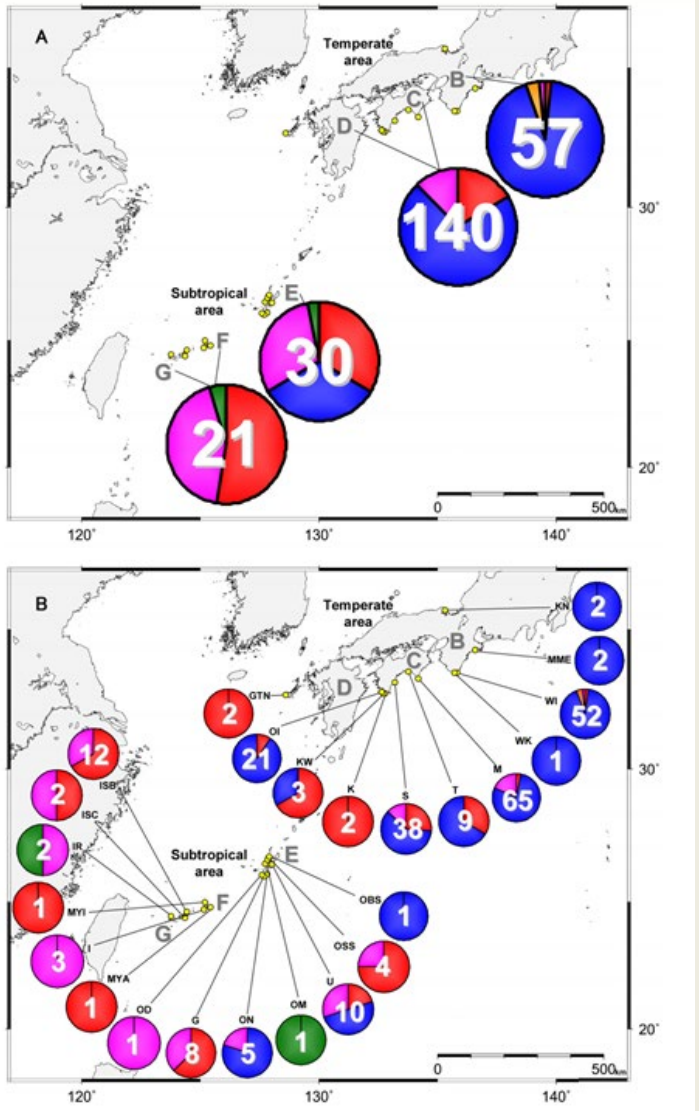
PLOS ONE

Genetic Diversity and Distribution of the Ciguatera-Causing Dinoflagellate *Gambierdiscus* spp. (Dinophyceae) in Coastal Areas of Japan

Tomohiro Nishimura[1,2], Shinya Sato[3,4], Wittaya Tawong[1,2], Hiroshi Sakanari[1], Keita Uehara[1], Md Mahfuzur Rahman Shah[5,6], Shoichiro Suda[5], Takeshi Yasumoto[7], Yohsuke Taira[8], Haruo Yamaguchi[1], Masao Adachi[1]*

1 Faculty of Agriculture, Kochi University, Nankoku, Kochi, Japan, 2 The United Graduate School of Agricultural Sciences, Matsuyama, Ehime University, Ehime, Japan, 3 Royal Botanic Garden Edinburgh, Edinburgh, United Kingdom, 4 Cardiff University, Cardiff, Wales, United Kingdom, 5 Faculty of Science, University of the Ryukyus, Nakagami District, Okinawa, Japan, 6 College of Ocean Science, Jeju National University, Jeju, South Korea, 7 National Research Institute of Fisheries Science, Yokohama, Kanagawa, Japan, 8 Okinawa Institute of Science and Technology Evolutionary Systems Biology Unit, Kunigami District, Okinawa, Japan





-Case study in Japan in 2013-

Harmful Algae 111 (2022) 102163

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

Horizontal and vertical distribution of *Gambierdiscus* spp. (Dinophyceae) including novel phylotypes in Japan identified by 18S rDNA metabarcoding

Hiroshi Funaki [a,b], Chetan Chandrakant Gaonkar [a,1], Takafumi Kataoka [c], Tomohiro Nishimura [a,2], Kouki Tanaka [d], Ippei Yanagida [e], Shouta Abe [a,3], Haruo Yamaguchi [a,b], Keizo Nagasaki [f], Masao Adachi [a,b,*]

the distributions of Gambierdiscus species/phylotypes at two depths (2–8 and 30 m)

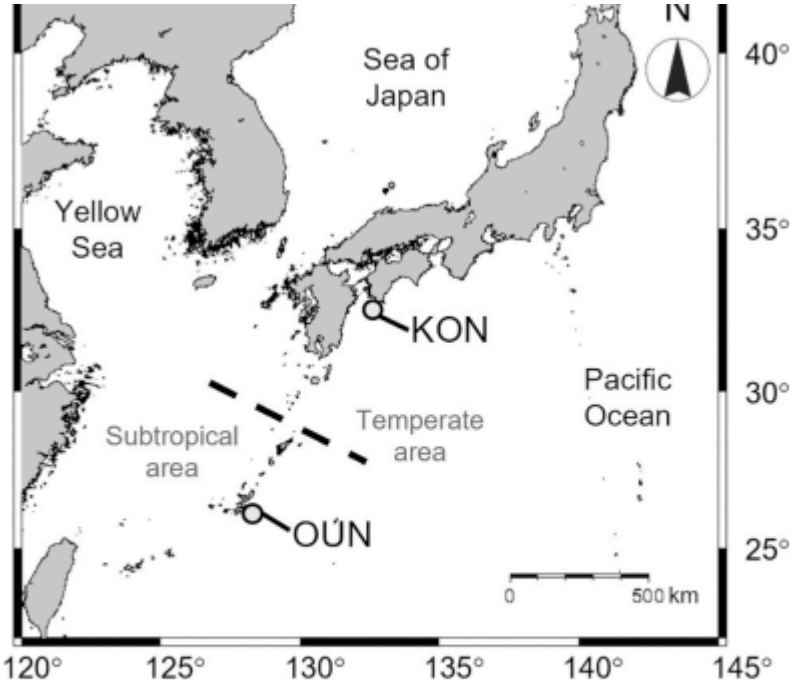


Fig. 1. Map of sampling locations. The abbreviations for the sampling sites are described as follows. KON: the coastal site of Nishidomari, Otsuki Town, Kochi Prefecture (32°46′26.4″N 132°43′27.6″E); OUN: Nakagusuku Bay, Uruma City, Okinawa Prefecture (26°14′46.8″N 127°52′59.0″E). The map of Japan and nearby seas are depicted using GMT6 (Wessel et al., 2019).

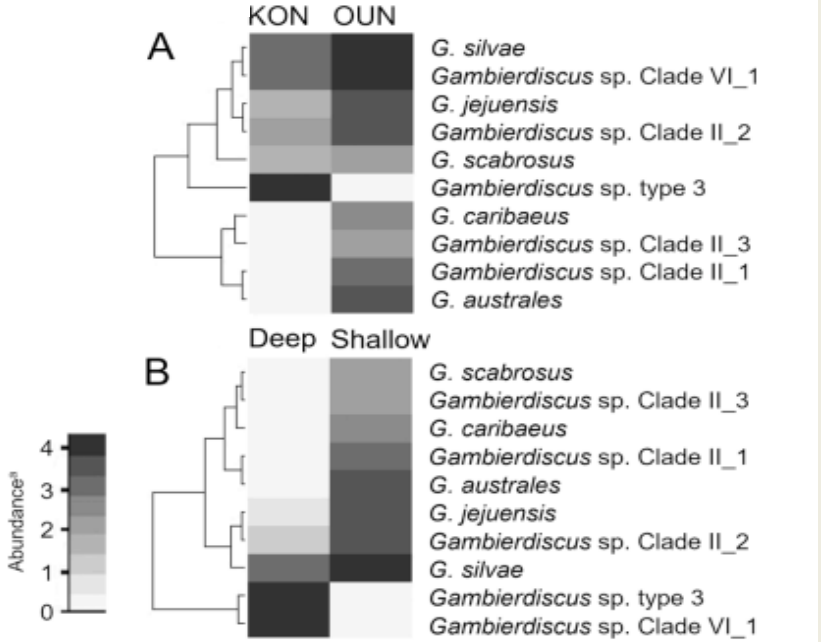


Fig. 3. Heatmaps based on the read number of ten *Gambierdiscus* species/phylotypes obtained from MiSeq sequencing under two conditions (A: sampling location, B: sampling depth). The nine gray shadings on the heatmaps are based on the total reads of each *Gambierdiscus* species/phylotype. Deep = 30 m, Shallow = 2–8 m. [a]: The total read number of each species/phylotype at each site or at each depth subjected to ordinary logarithmic transformation with the base being 10.

-Case study in China in 2018-

Marine Pollution Bulletin 158 (2020) 111313

Contents lists available at ScienceDirect

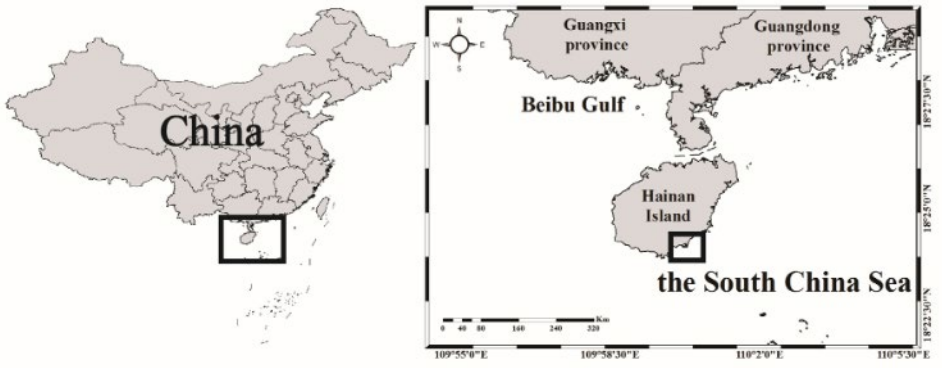
Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

The first benthic harmful dinoflagellate bloom in China: Morphology and toxicology of *Prorocentrum concavum*

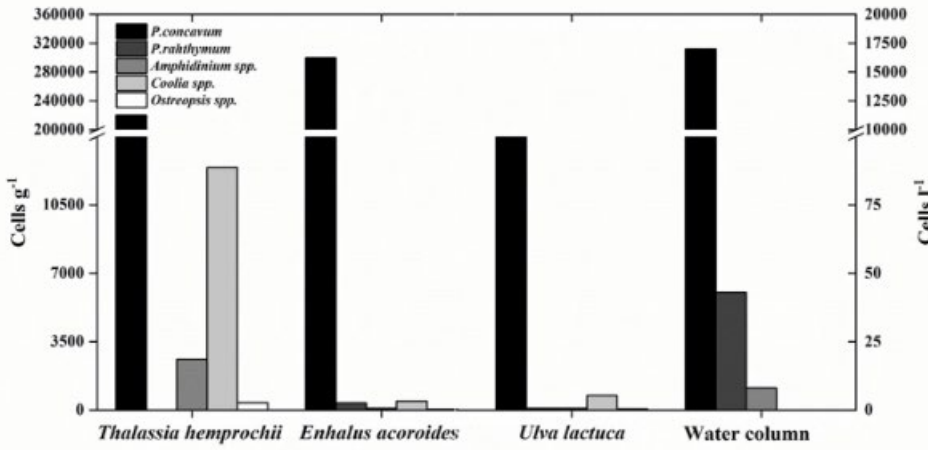
Jian Zou[a,b,1], Qun Li[a,b,1], Songhui Lu[a,b,c,*], Yuelei Dong[a,b], Heng Chen[a,b], Chengzhi Zheng[a,b], Lei Cui[a,b,*]

[a] Research Center of Harmful Algae and Marine Biology, Jinan University, Guangzhou 510632, China
[b] Key Laboratory of Eutrophication and Red Tide Prevention of Guangdong Higher Education Institutes, Jinan University, Guangzhou 510632, China
[c] Southern Marine Science and Engineering Guangdong Laboratory, Zhuhai, China



Habitat during the P. concavum bloom in Xincun Bay, South China Sea. A, B, C, and D exhibit the seagrass bed,

P. concavum had a high cell density on the surface of substrates and in water column. The bloom forming species was identified based on the morphology and phylogeny. Toxin analysis indicated that there were no detectable DSP toxin



-Case study in China in 2018-

Harmful Algae 74 (2018) 78–97

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

Phylogeny, morphology and toxicity of benthic dinoflagellates of the genus *Fukuyoa* (Goniodomataceae, Dinophyceae) from a subtropical reef ecosystem in the South China Sea

Priscilla T.Y. Leung[a,b], Meng Yan[a,b], Veronica T.T. Lam[a], Sam K.F. Yiu[a], Chia-Yun Chen[a], J. Sam Murray[c], D. Tim Harwood[c], Lesley L. Rhodes[c], Paul K.S. Lam[a,b,d,*], Tak-Cheung Wai[a,b,*]

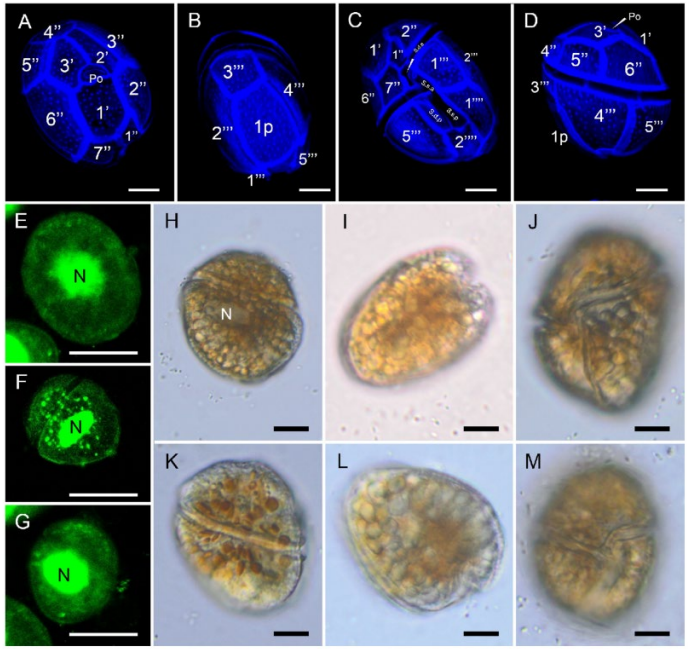
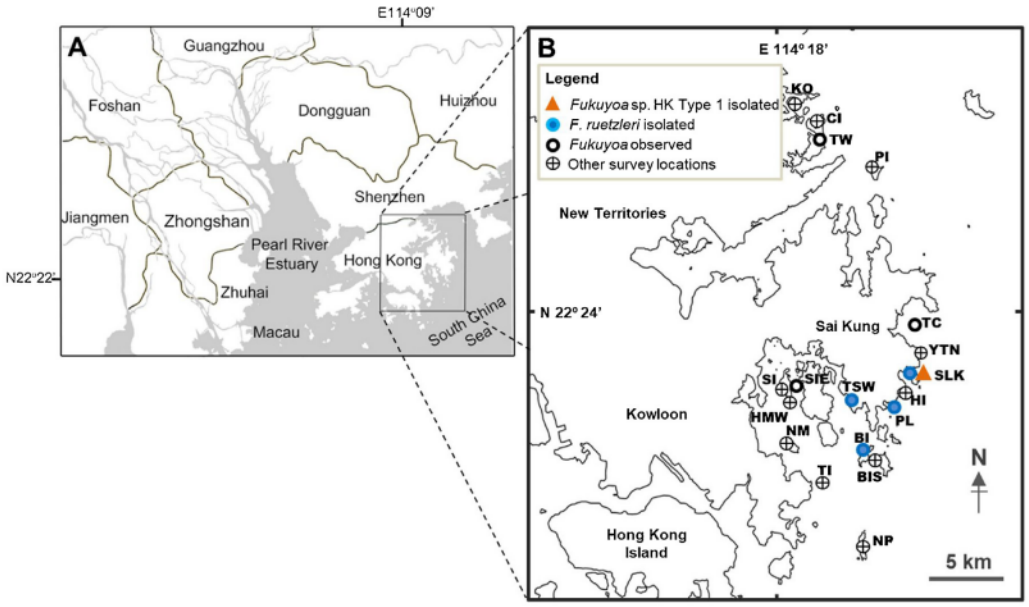


Fig. 3. Light microscopy photos of *Fukuyoa* sp. HK Type 1 (SKLMP_Ve014). (A–D) Confocal images showing the thecal plates stained with Fluorescent Brighter 28. (E–G) Nuclei stained with SYBA Green I. (H–M) Live cells in different views. Scale bar: A-D, H–M 10 μm; E-G, 30 μm. Microscope: (A–G) Leica SPE Laser Confocal Scanning Microscope (400×); (H–M) Zeiss AxioPlan 2 (400×). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



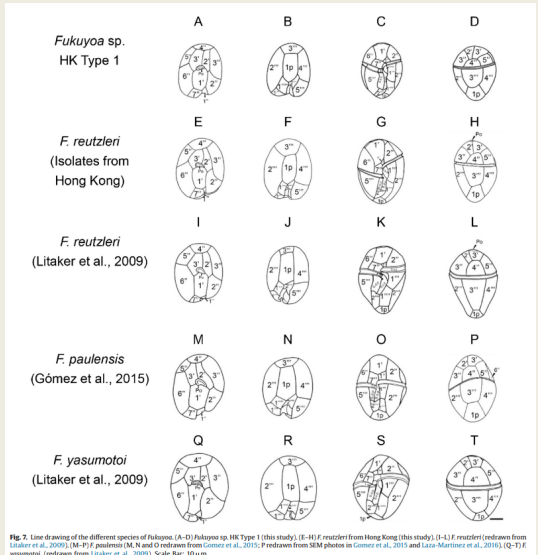


Fig. 7. Line drawing of the different species of *Fukuyoa*. (A–D) *Fukuyoa* sp. HK Type 1 (this study). (E–H) *F. reutzleri* from Hong Kong (this study). (I–L) *F. reutzleri* (redrawn from Litaker et al., 2009). (M–P) *F. paulensis* (M, N and O redrawn from Gomez et al., 2015; P redrawn from SEM photos in Gomez et al., 2015 and Laza-Martinez et al., 2016). (Q–T) *F.*

-Case study in China in 2022-

Journal of Oceanology and Limnology
Vol. 40 No. 6, P. 2120-2145, 2022
https://doi.org/10.1007/s00343-022-1322-z

Biodiversity and distribution of benthic dinoflagellates in tropical Zhongsha Islands, South China Sea*

Hang XIE[1, 3, #], Jian ZOU[1, 3, #], Chengzhi ZHENG[1, 3], Yuchen QU[1, 3], Kaixuan HUANG[1, 3, **], Songhui LÜ[1, 2, 3, **]

The paper reported the benthic dinoflagellate biodiversity and distribution characteristics of a series of tropical reefs in 20–40-m water depth in wet season in South China Sea using morphological, phylogenetic, and cell counting methods.

The abundance of benthic dinoflagellates was relatively low at 88–4 345 cells/100 cm2 on sediment and 10–91 cells/g on macroalgae.

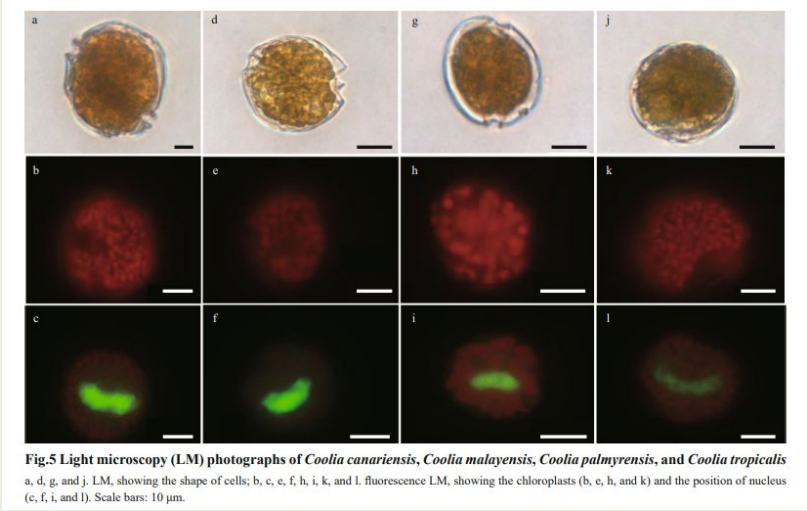


Fig.5 Light microscopy (LM) photographs of *Coolia canariensis*, *Coolia malayensis*, *Coolia palmyrensis*, and *Coolia tropicalis*
a, d, g, and j. LM, showing the shape of cells; b, e, e, f, h, i, k, and l. fluorescence LM, showing the chloroplasts (b, e, h, and k) and the position of nucleus (e, f, i, and l). Scale bars: 10 μm.

-Case study in China in 2022-

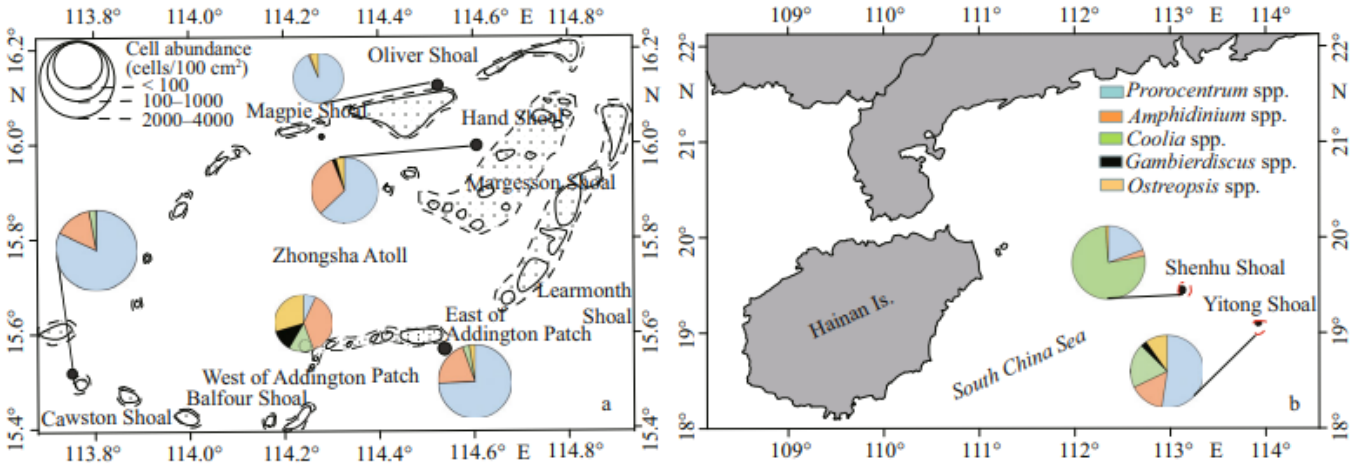


Fig.14 The cell abundances (cells/100 cm²) of five benthic dinoflagellates on sediment in Zhongsha Great Atoll (a), Yitong Shoal, and Shenhu Shoal (b)

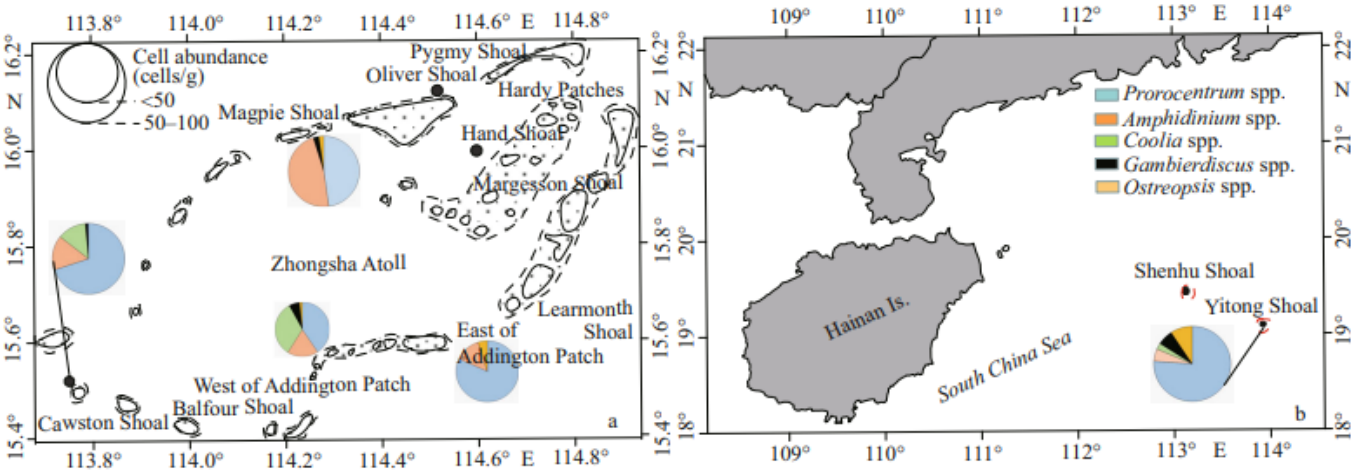


Fig.15 Cell abundances (cells/g) of five benthic dinoflagellates on macroalgae in Zhongsha Great Atoll (a), Yitong Shoal, and Shenhu Shoal (b)

Prorocentrum was dominant on macroalgae at all sites. In China, *Prorocentrum* , *Amphidinium* was widely distributed in various substrates with a high abundance.

-Summary-

The ciguatera-causing harmful benthic/epiphytic dinoflagellates bloom (HAB) is generally occurs in tropical and subtropical regions.

These benthic HABs species in temperate area related to global climate change and have been clearly established to be present in China, Korea and Japan.

The recent increase in temperature of East Asian country has allowed for the expansion of benthic dinoflagellate species into these regions.

Therefore, it is important to investigate the distribution of toxic benthic dinoflagellates and continuously monitor their abundance to prevent risks to human health. Molecular techniques may allow researchers to distinguish morphologically similar species and to monitor the abundance of toxic benthic dinoflagellates.

All of these efforts will provide a better understanding of the epiphytic and benthic dinoflagellates in world.

-Recent topic issue-

Journal of Applied Phycology
https://doi.org/10.1007/s10811-022-02804-0

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Laboratory evaluation of floating marine plastic debris as a potential vector for transportation of the harmful benthic dinoflagellate *Fukuyoa koreansis*

Young Kyun Lim[1,2] · Minji Lee[1] · Seongjin Hong[3] · Seung Ho Baek[1,2]

Received: 15 May 2022 / Revised and accepted: 13 July 2022

Abstract

MPD may provide a habitat or shelter for benthic/planktonic HAB and thereby function as a dispersal vector for this harmful epiphytic dinoflagellate

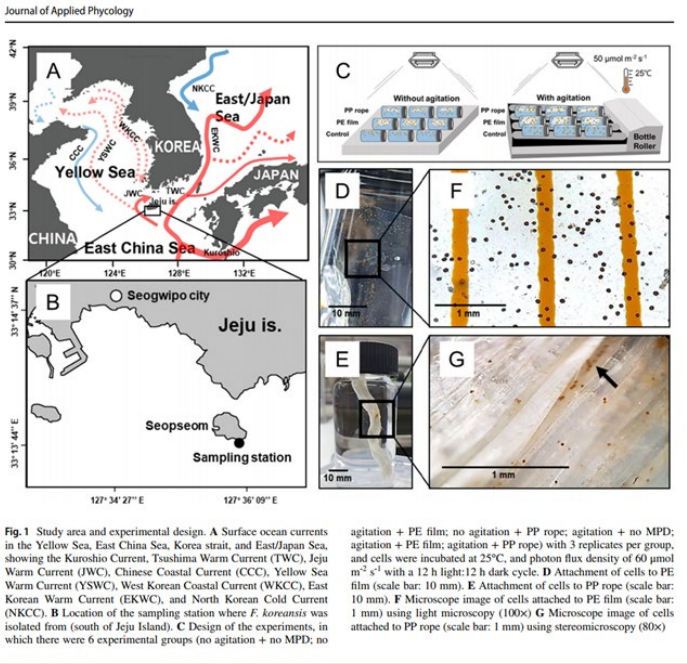

Fig. 1 Study area and experimental design. **A** Surface ocean currents in the Yellow Sea, East China Sea, Korea strait, and East/Japan Sea, showing the Kuroshio Current, Tsushima Warm Current (TWC), Jeju Warm Current (JWC), Chinese Coastal Current (CCC), Yellow Sea Warm Current (YSWC), West Korean Coastal Current (WKCC), East Korean Warm Current (EKWC), and North Korean Cold Current (NKCC). **B** Location of the sampling station where *F. koreansis* was isolated from (south of Jeju Island). **C** Design of the experiments, in which there were 6 experimental groups (no agitation + no MPD; no agitation + PE film; no agitation + PP rope; agitation + no MPD; agitation + PE film; agitation + PP rope) with 3 replicates per group, and cells were incubated at 25°C, and photon flux density of 60 µmol m^{-2} s^{-1} with a 12 h light:12 h dark cycle. **D** Attachment of cells to PE film (scale bar: 10 mm). **E** Attachment of cells to PP rope (scale bar: 10 mm). **F** Microscope image of cells attached to PE film (scale bar: 1 mm) using light microscopy (100×) **G** Microscope image of cells attached to PP rope (scale bar: 1 mm) using stereomicroscopy (80×)

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Drifting marine plastics as new ecological habitats for harmful eukaryotic microbial communities in Jeju Strait, Korea

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The harmful or toxic dinoflagellates observed on the plastic surface were *Alexandrium*, *Coolia*, *Dinophysis*, *Heterocapsa*, *Karlodinium*, *Noctiluca*, *Ostreopsis*, *Prorocentrum*, *Scrippsiella*,*and Tripos*.

2022_PICES meeting in Busan_Benthic HAB

Thank you for your attention