

Phylogeny and geographical distribution of *Cochlodinium polykrikoides* population (Gymnodiniales, Dinophyceae) collected from Japanese and Korean coasts



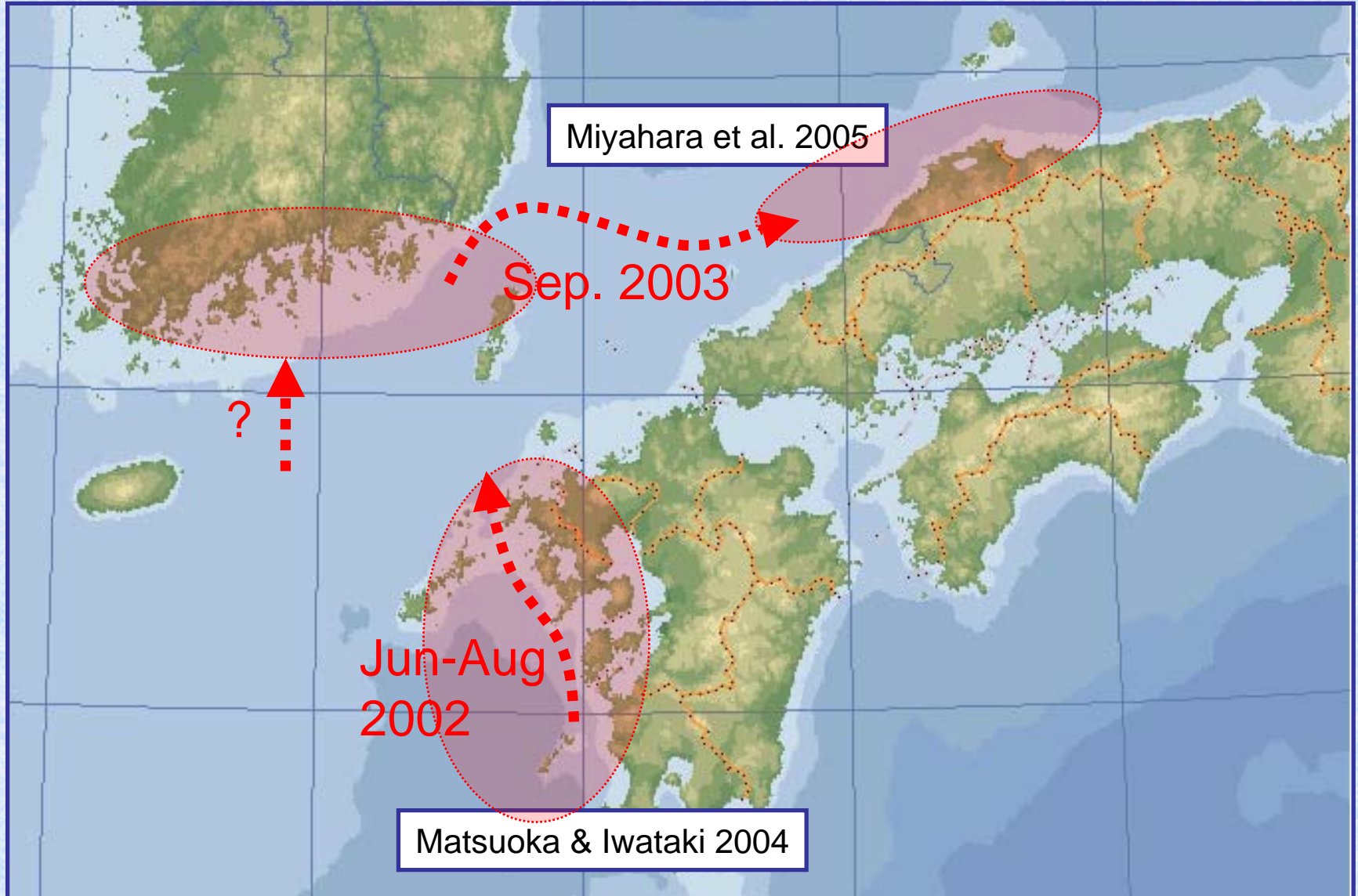
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Occurrences of *C. polykrikoides* in Japan and Korea

Red tides of *C. polykrikoides* have continuously occurred along coastal waters, does this imply that the Japanese and Korean population are identical?

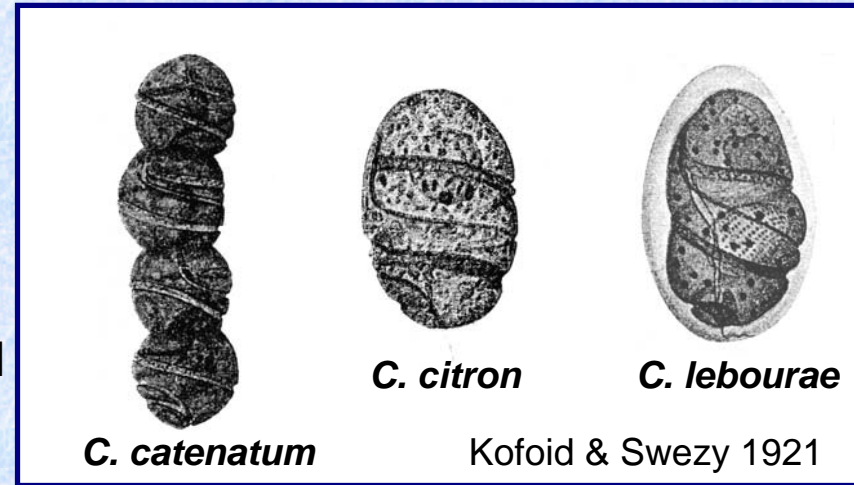


The genus *Cochlodinium*

The genus *Cochlodinium* has been established by Schütt (1894), circumscribing unarmored dinoflagellates possessing the cingulum encircling the cell >1.5 times (Kofoid & Swezy 1921).

Unarmored dinoflagellates have been classified based mainly on the position and torsion of the cingulum, however, this classification was incongruent with phylogenetic relationship based on recent molecular analyses.

Cochlodinium is still classified based on characteristics of the cingulum, because their phylogenetic relationships have not been examined.



Objectives

To clarify the phylogenetic positions of *Cochlodinium* species among dinoflagellates.

To distinguish populations of a harmful red tide forming species *C. polykrikoides*, and investigate distributions of each *C. polykrikoides* population.

Materials and Methods

Morphology

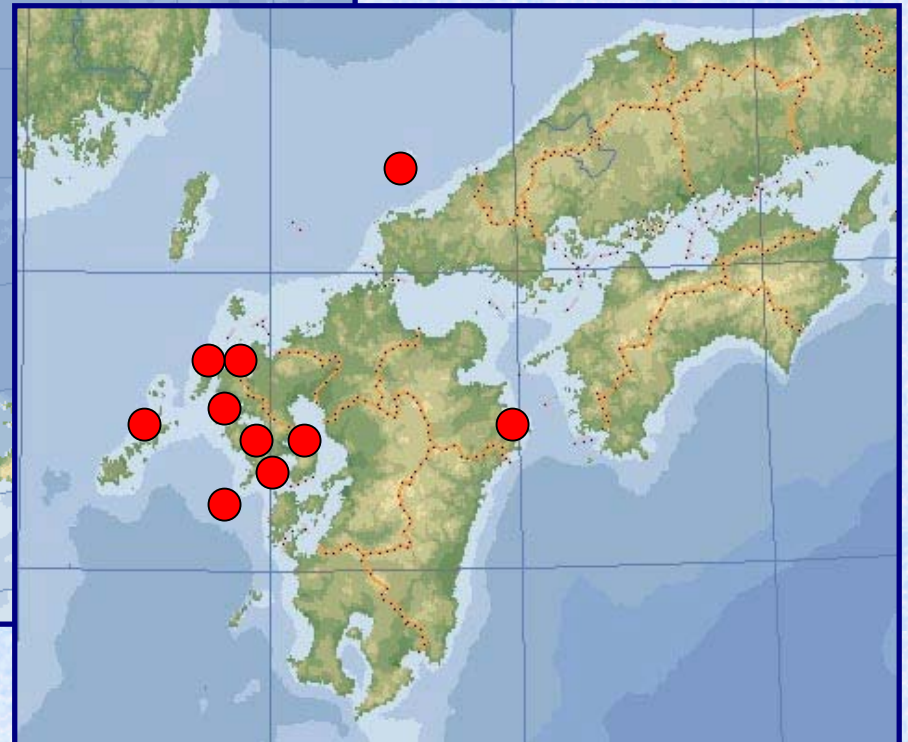
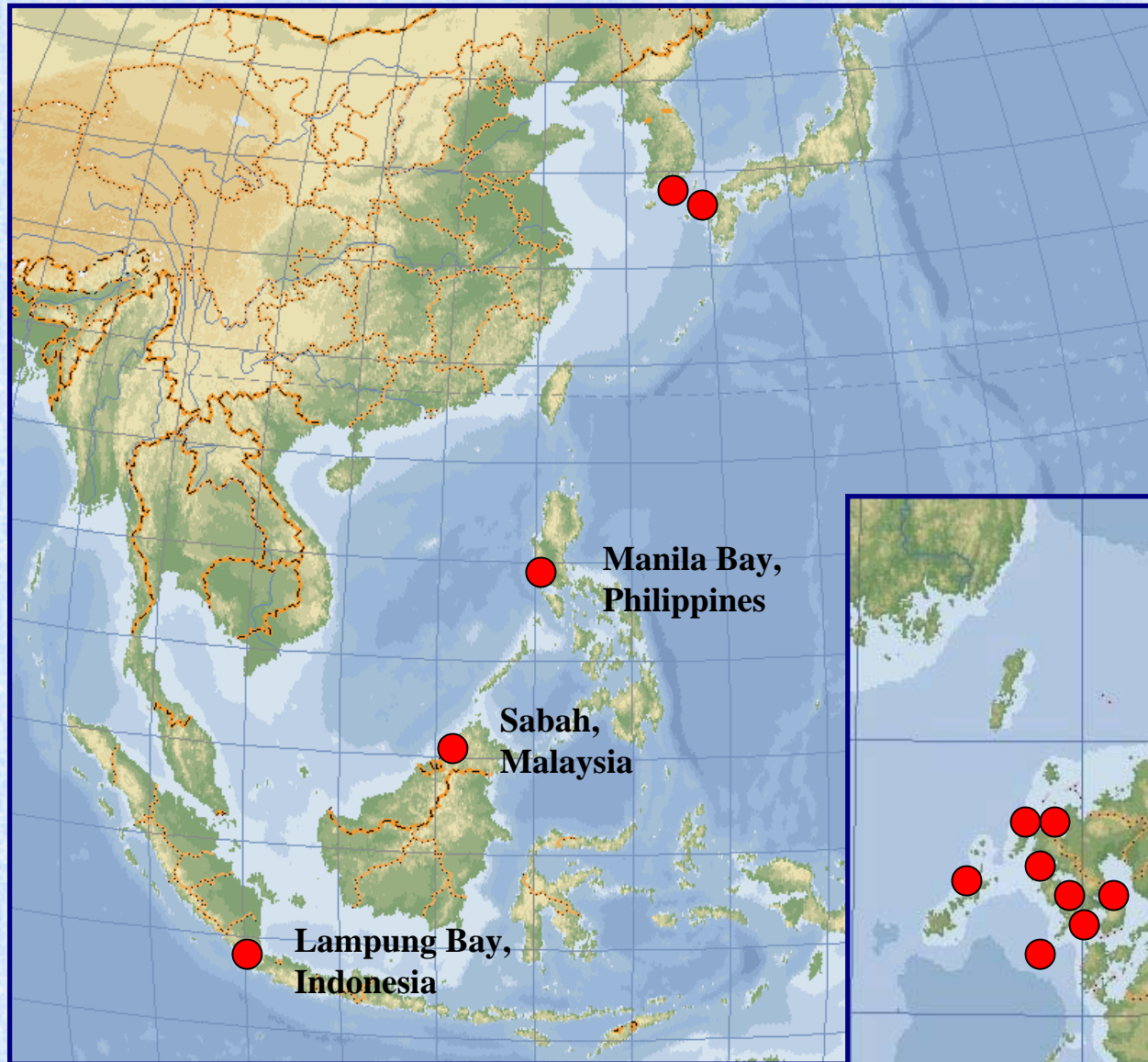
Light and fluorescence microscopy

Molecular phylogeny

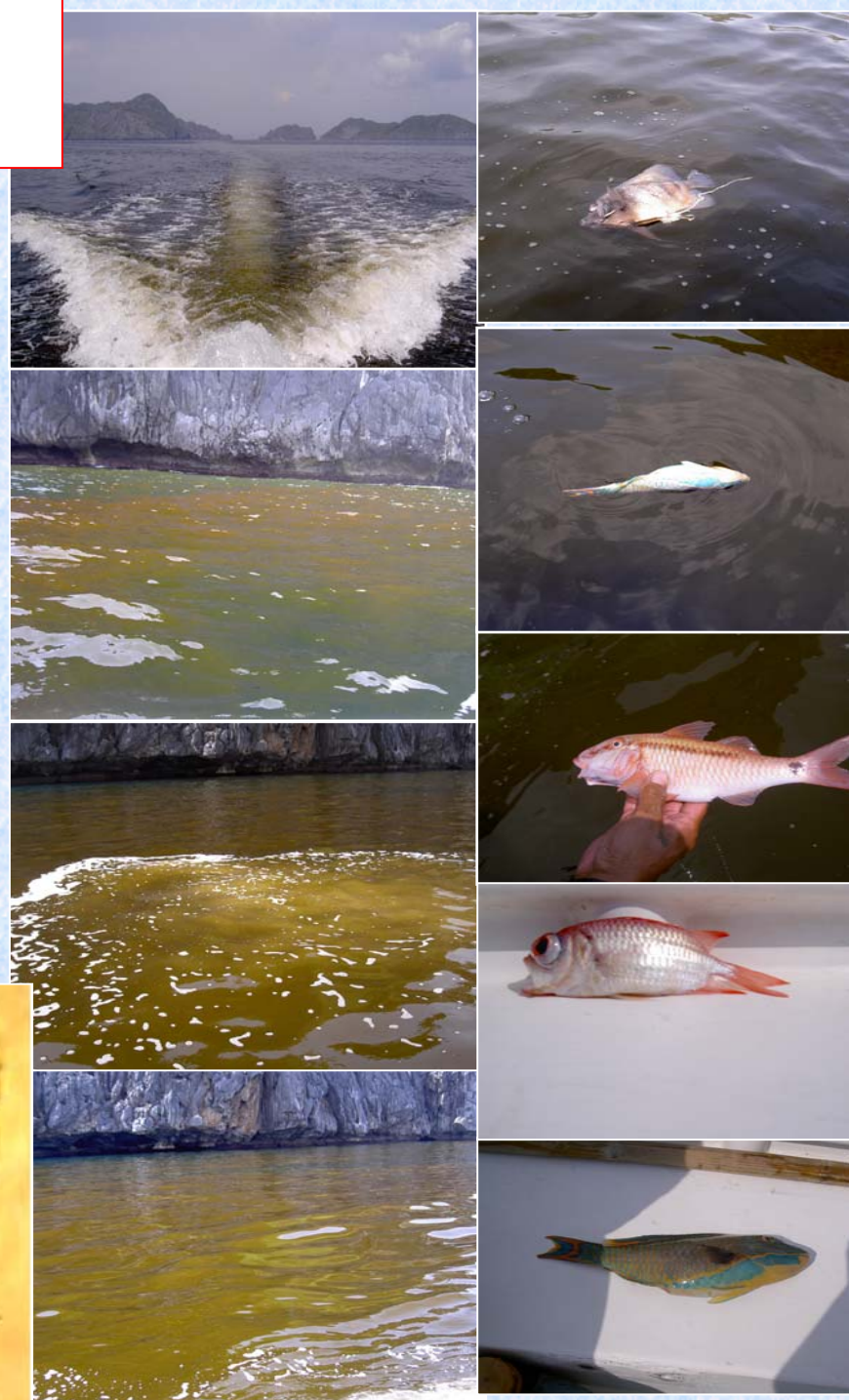
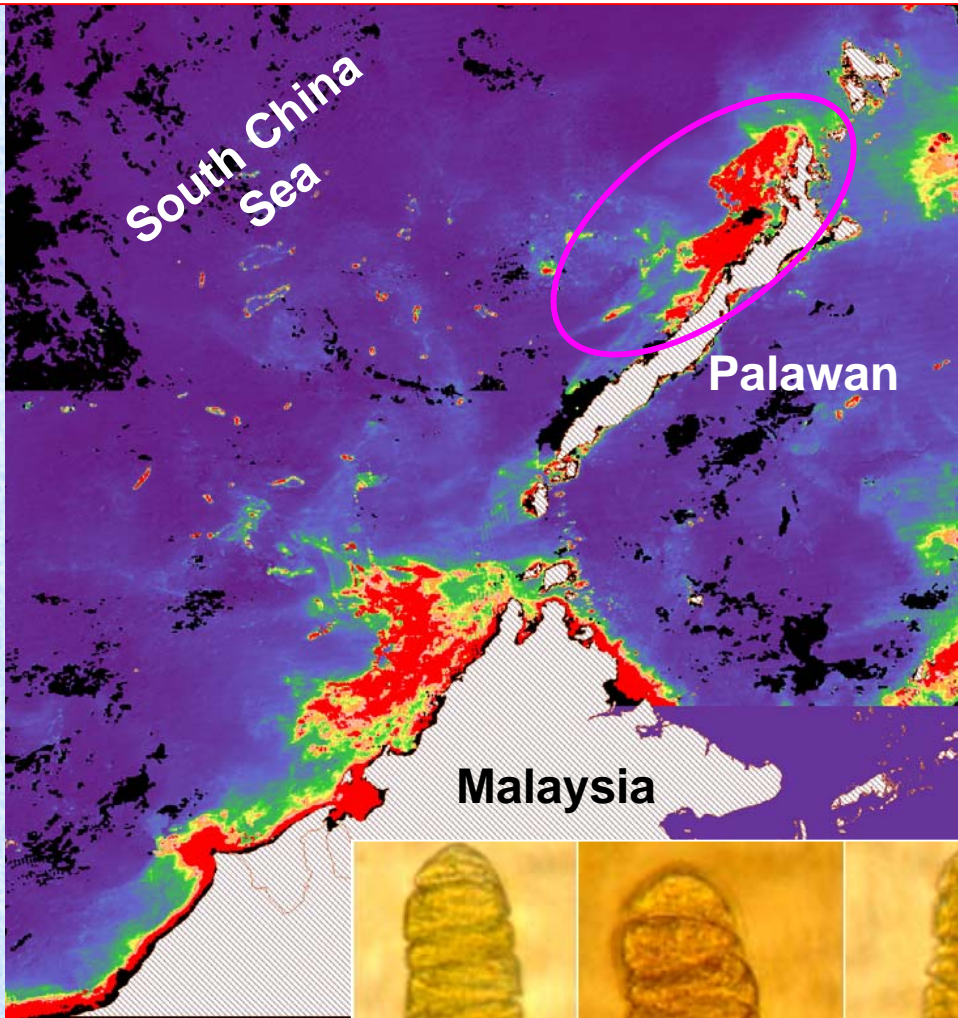
SSU rDNA

LSU rDNA (D1-D3)

Trees constructed by weighted NJ method



Red tide occurred in Malaysian, Brunei and Philippine waters



Cochlodinium sp.

Three *Cochlodinium* species

Three morphotypes assigned to the genus *Cochlodinium*, with the cingulum encircling the cell more than 1.5 times, have so far been observed and analyzed rDNAs.

C. convolutum



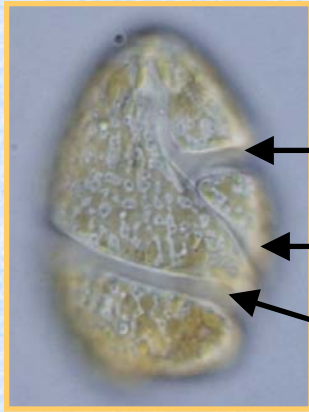
C. polykrikoides



***Cochlodinium* sp.**



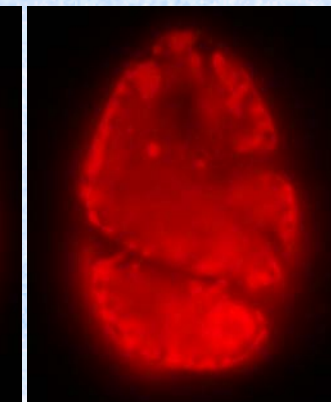
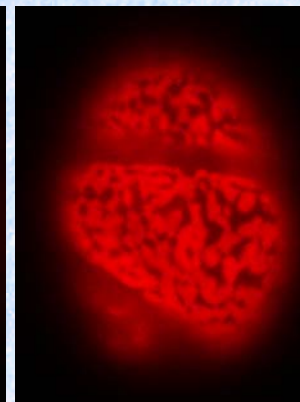
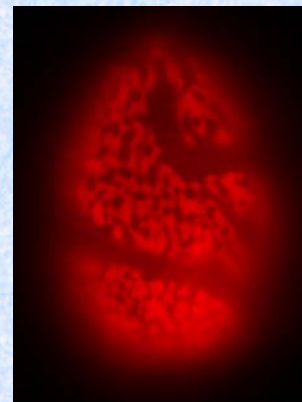
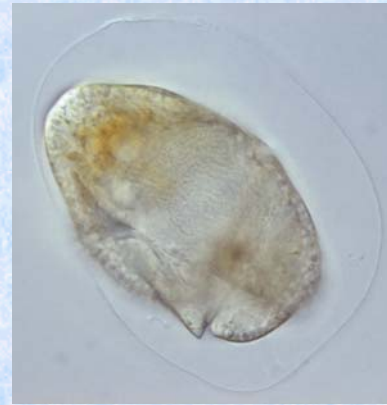
Cochlodinium convolutum



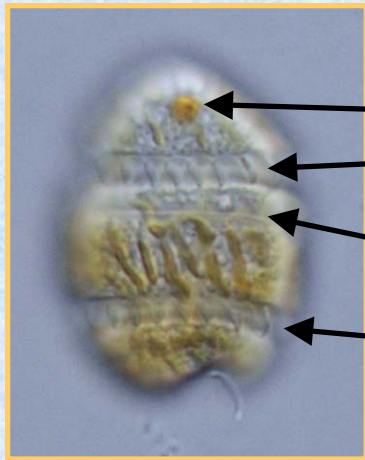
Cingulum

Sulcus

Cingulum



Cochlodinium polykrikoides

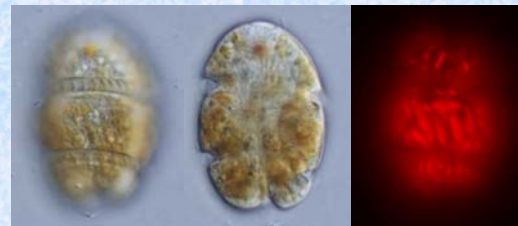


Eye spot
Cingulum
Sulcus
Cingulum

Single cell



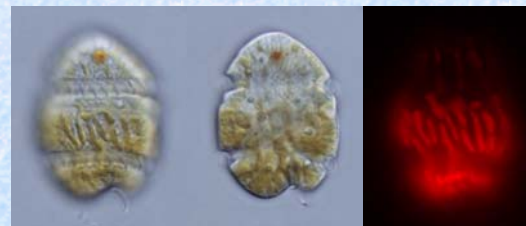
August 1999, Imari Bay, Japan



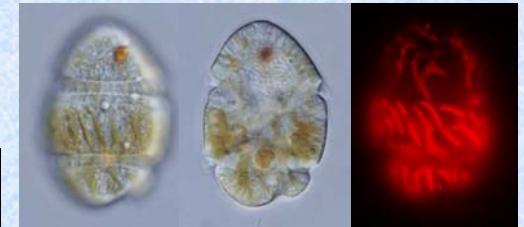
January 2004, Sabah, Malaysia



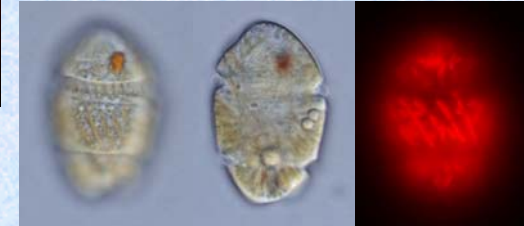
October 2003, Usuka Bay, Japan



August 2003, Mishima Is, Japan



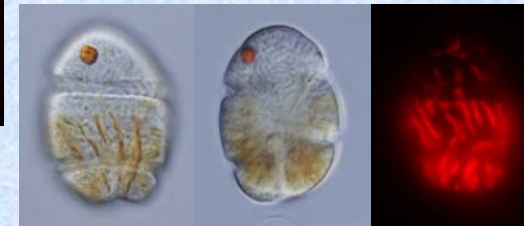
August 2002, Kamigoto, Japan



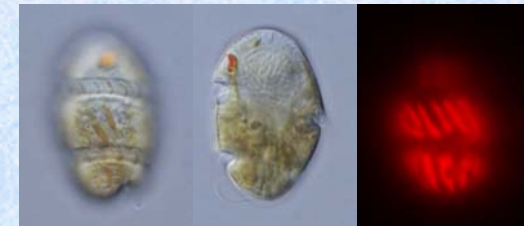
June 2003, Shikamachi, Japan



July 2003, Tachibana Bay, Japan



May 2004, Inokushi Bay, Japan



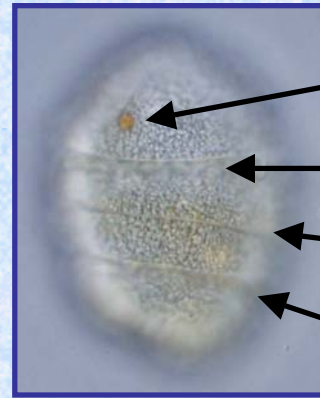
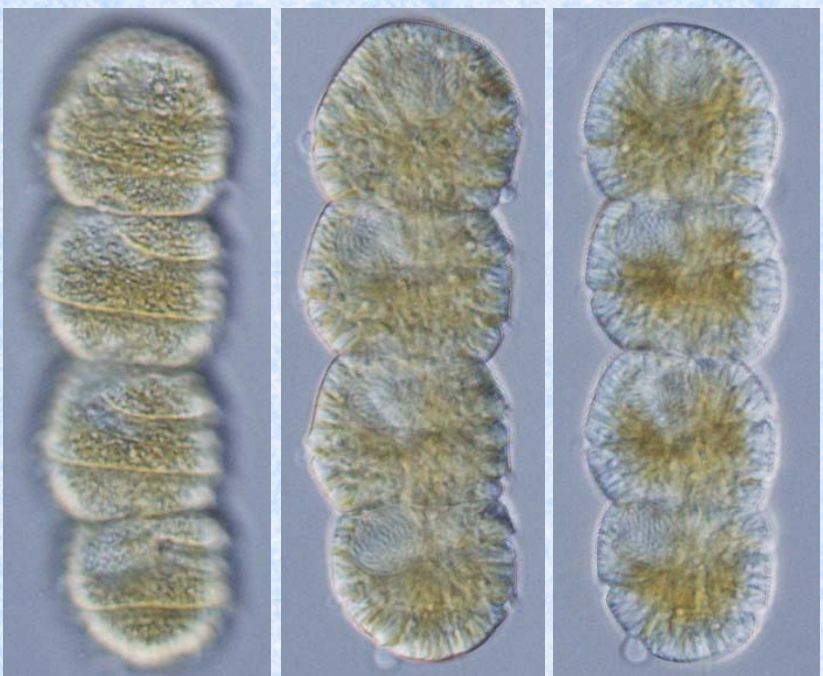
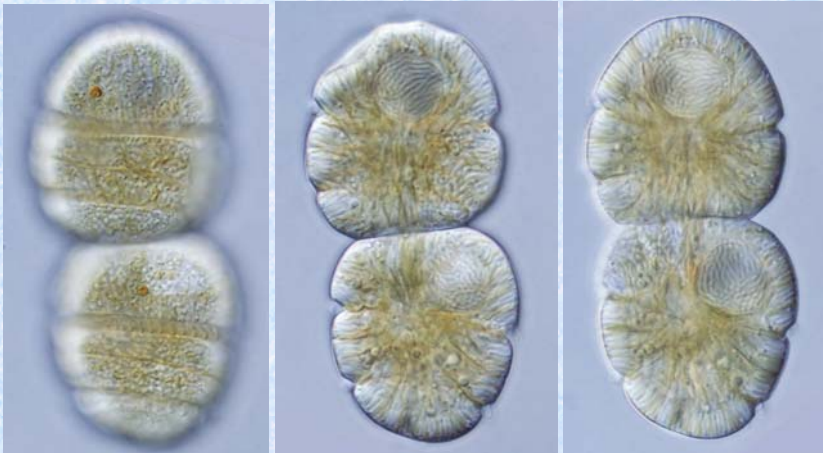
August 2003, Isahaya Bay, Japan

Chain-forming cell



Cochlodinium sp.

Resembling *C. polykrikoides*, but different in the position of the sulcus and chloroplasts.

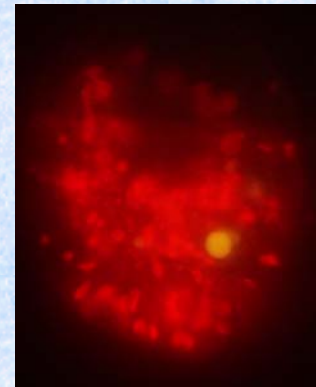
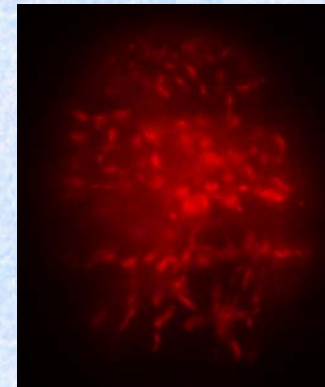
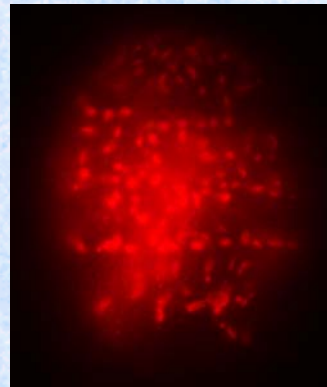
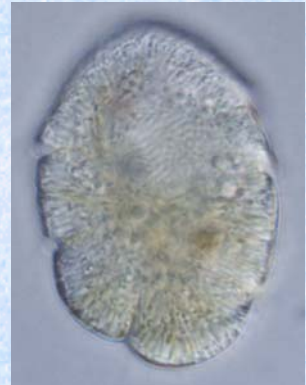
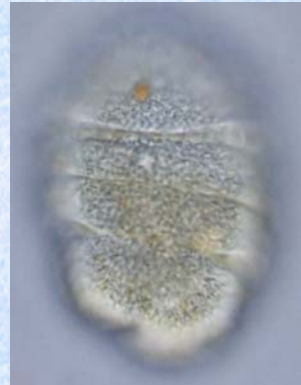


Eye spot

Cingulum

Sulcus

Cingulum

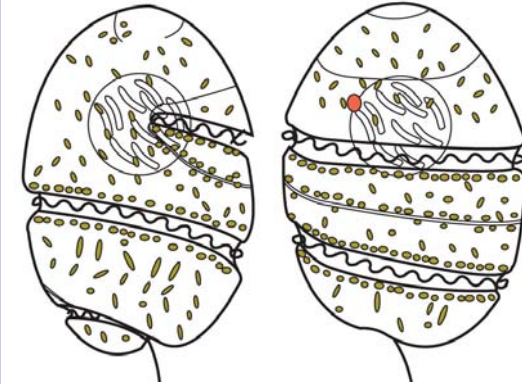
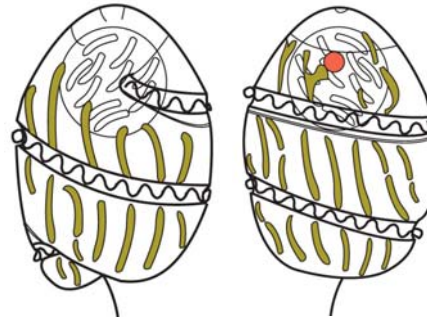


Morphological characters of *Cochlodinium* spp.

C. convolutum

C. polykrikoides

Cochlodinium sp.



Length

ca. 60-70 μm

ca. 30-40 μm

ca. 45-50 μm

Eye spot

Absent

Dorsal, epicone

Dorsal, epicone

Cingulum

ca. 1.5 times

ca. twice

ca. twice

Sulcus

Deeper

Shallow, immediately below the cingulum

Shallow, intermediate of the cingulum

Nucleus

Rectangular

Spherical, anterior

Spherical, anterior

Chloroplast

Reticulate (?)

Rod-like, aligned longitudinally

Granulate

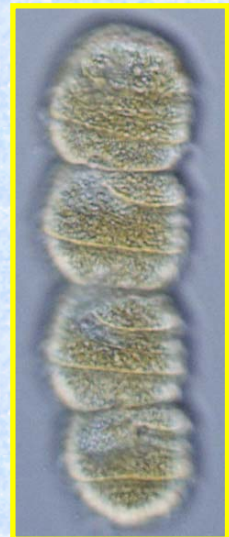
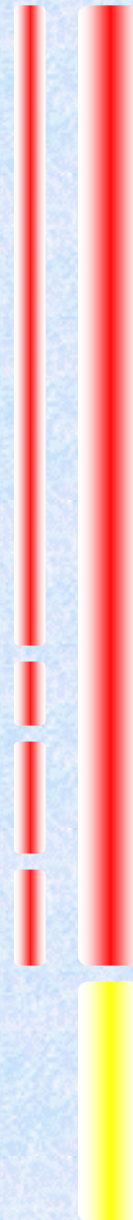
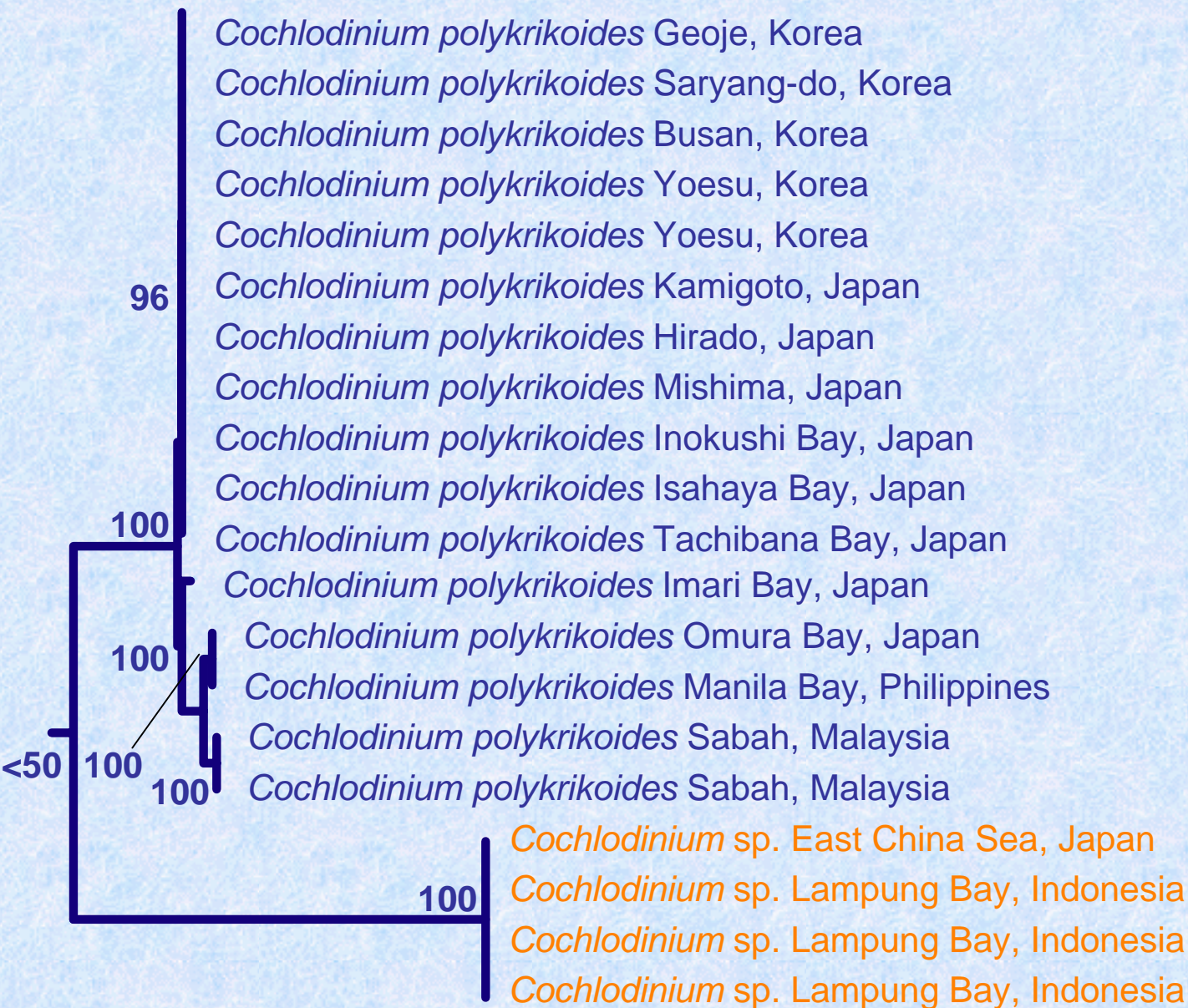
Others

Forming hyaline cyst

Cell-chains (<16 cells)

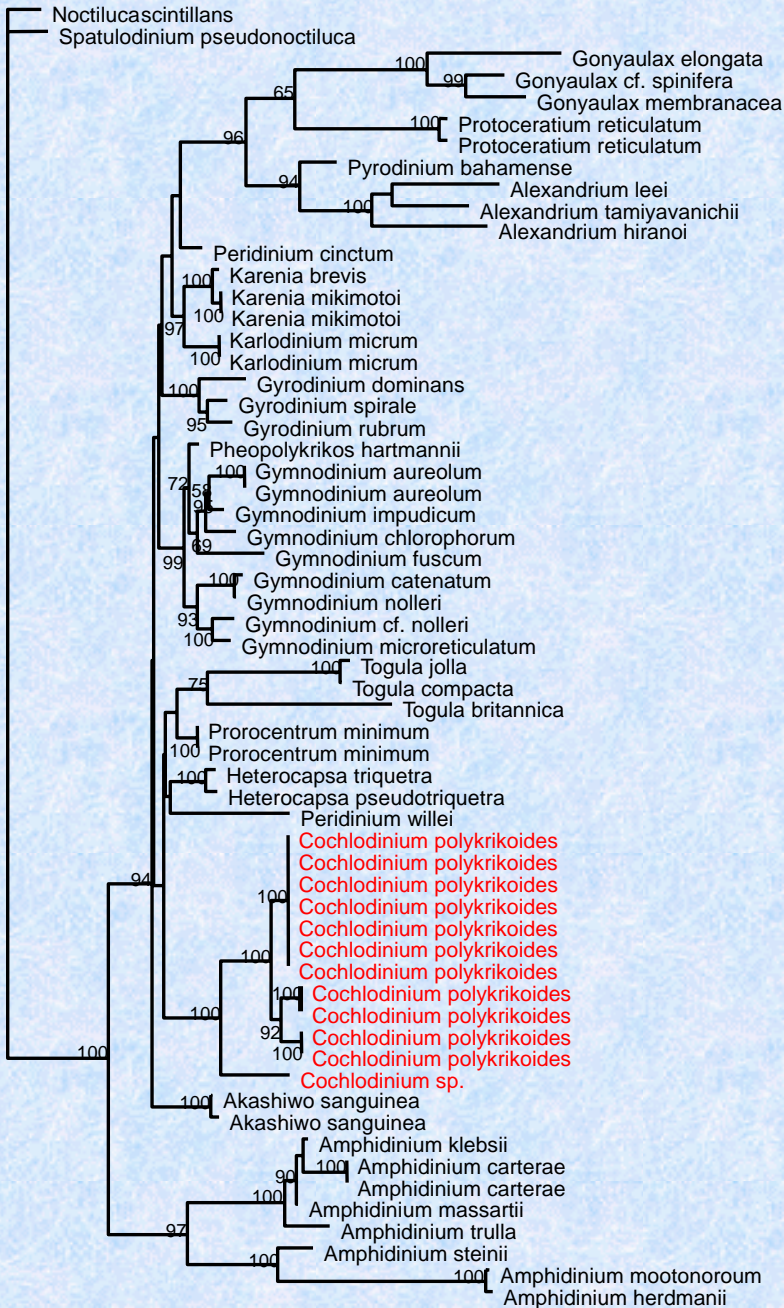
Cell-chains (<4 cells)

Phylogenetic relationship in *C. polykrikoides* (SSU rDNA)



Phylogeny of *Cochlodinium* (LSU rDNA, D1-D3)

Gamma weighted NJ tree, Substitution model: Tamura & Nei (1993),
Proportion of invariable site: 0.1580, Shape parameter: 0.7286



Karenia + Karlodinium

Gyrodinium sensu stricto

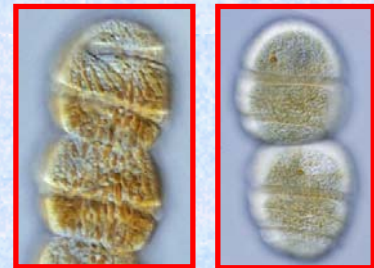
Gymnodinium sensu stricto

Togula

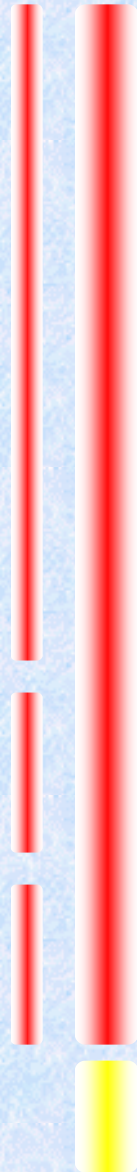
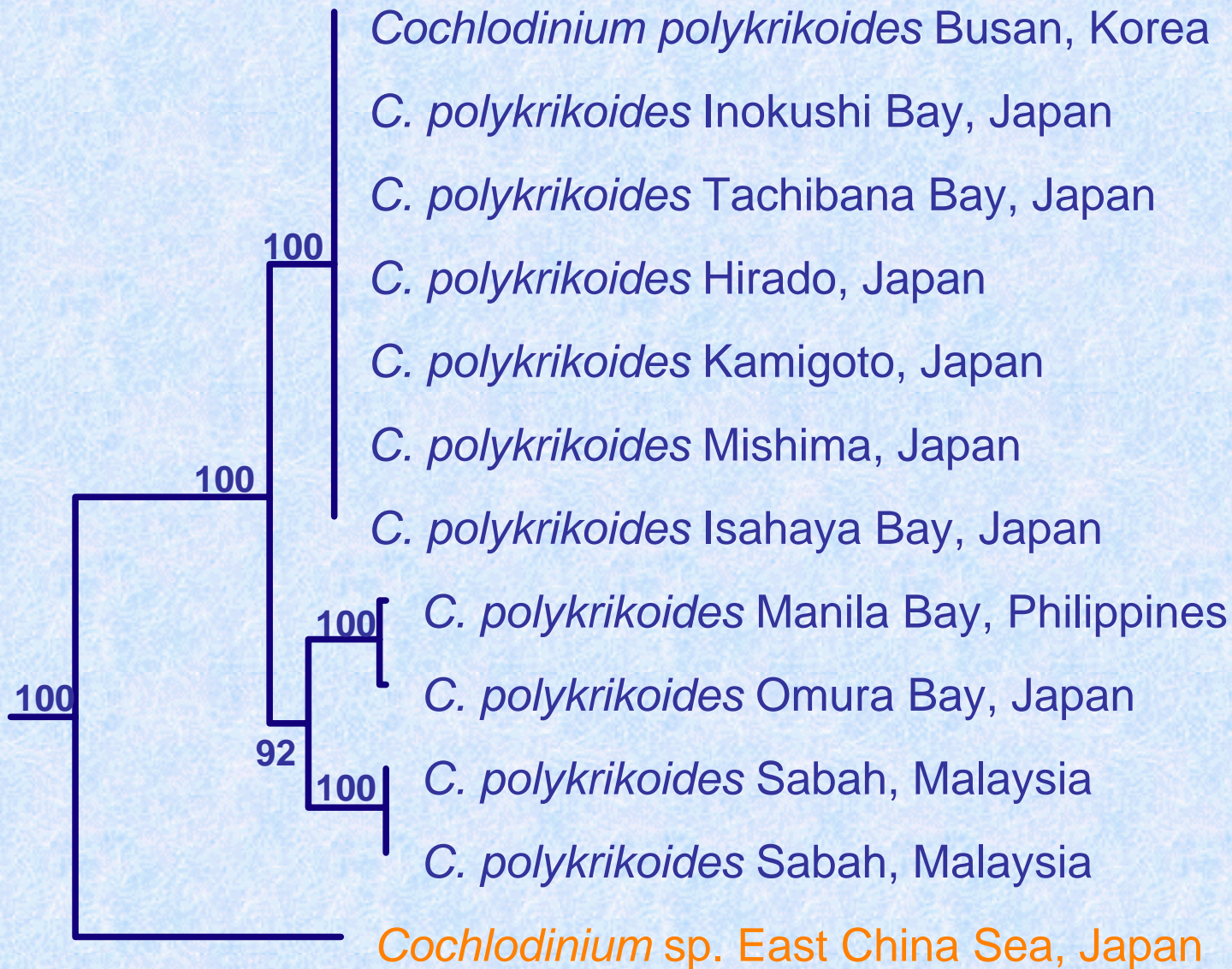
Cochlodinium polykrikoides
Cochlodinium sp.

Akashiwo sanguinea

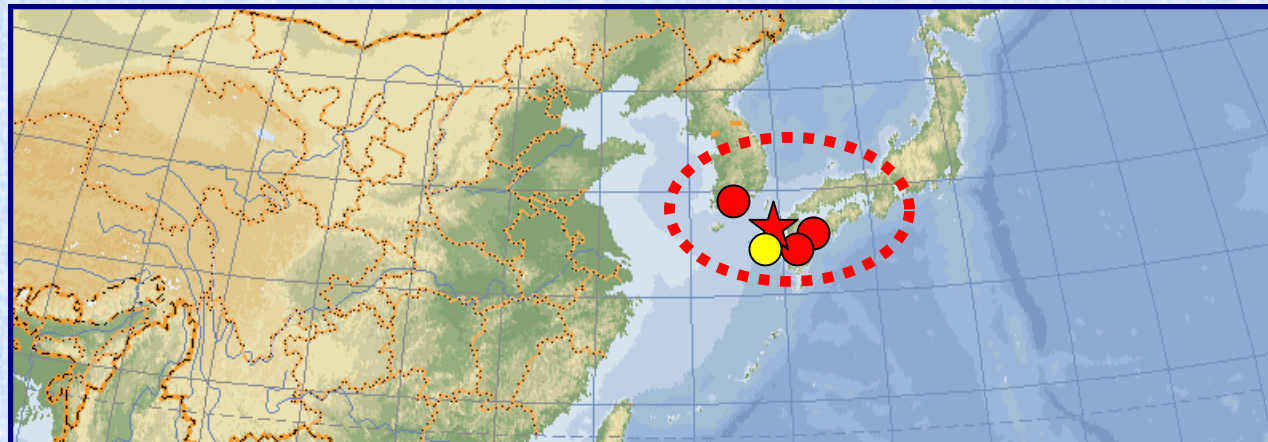
Amphidinium



Phylogenetic relationship in *C. polykrikoides* (LSU rDNA)



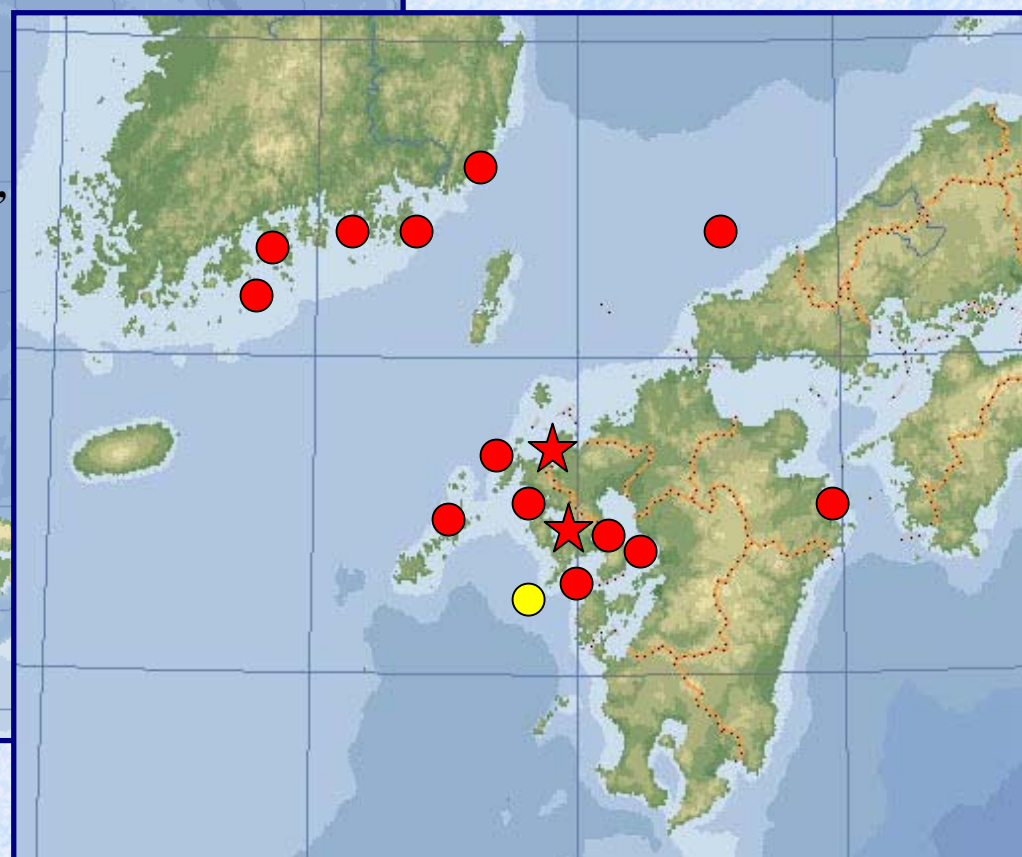
Distribution of *C. polykrikoides* population



C. polykrikoides



Cochlodinium sp.



C. polykrikoides

- Japan, Korea
- ★ Other sequences

Summary

Taxonomy and phylogeny of Cochlodinium

- *Cochlodinium convolutum* could be distinguished from other chain-forming *Cochlodinium* species based on, 1) shape of nucleus, 2) the deeper sulcus, and 3) formation of hyaline cyst; molecular data also indicates phylogenetic separation among them.
- *Cochlodinium* sp. is superficially similar to *C. polykrikoides*, but they could be distinguished by 1) cell size, 2) position of the sulcus, and 3) shape of chloroplast; their affinity was supported by molecular phylogeny.

Population and distribution of C. polykrikoides in southeastern Asia

- Majority of *C. polykrikoides* red tides occurred in Japanese and Korean coasts are derived from the same population; it could be distinguished from other populations distributed in SE Asia.
- SE Asian populations of *C. polykrikoides* scarcely exist in Japanese coastal waters.

Acknowledgements

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Thank you

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