Cochlodinium

Cochlodinium polykrikoides is such a very small phytoplankton that it is invisible without a microscope. *Cochlodinium polykrikoides* is well known as one of the most harmful red tide causative organisms, which sometimes causes mass mortality of fish.
We will just call *"Cochlodinium"* hereafter in this pamphlet instead of *"Cochlodinium polykrikoides"* in order to make explanations as easy and simple as possible.

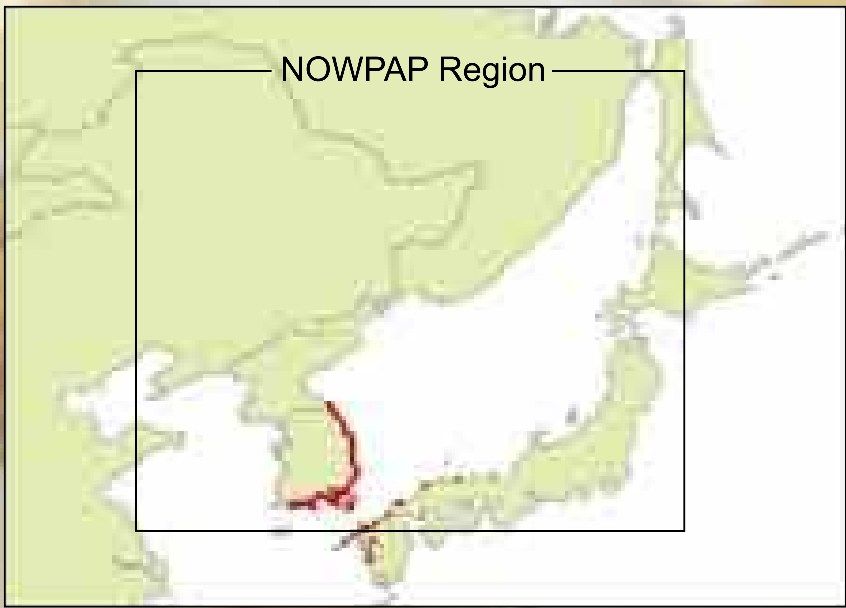
NOWPAP CEARAC

UNEP Regional Seas

This figure is a single cell of *Cochlodinium polykrikoides,* and it is about 5,000 times as big as a real size of this species.

Cochlodinium in the NOWPAP Region

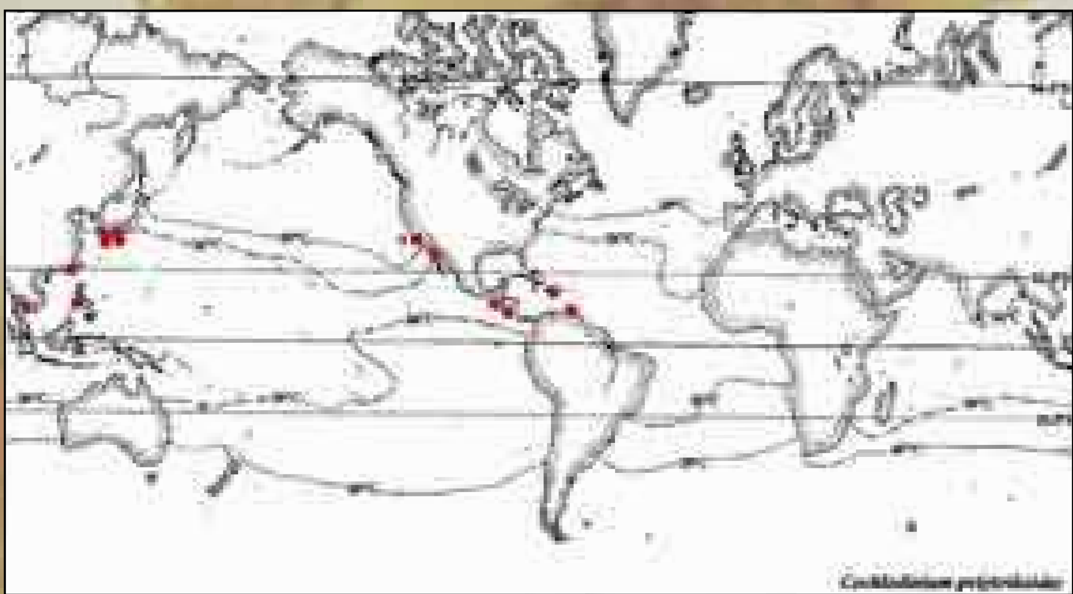
Red tides of *Cochlodinium* have occurred along the coastal areas of Japan and Korea in the NOWPAP Region and given severe damage to fisheries of these countries.



Affected areas of *Cochlodinium* red tides occurred in the NOWPAP Region (See red dots)

Cochlodinium around the World

Cochlodinium has been found not only in the NOWPAP Region but in temperate and tropical waters of the Northern Hemisphere.



World map of *Cochlodinium* red tides
(Red dots show occurrence of *Cochlodinium*)

Damage by *Cochlodinium*

Some red tides of *Cochlodinium* have given damage to marine resources. When red tides occur, fish in open water usually swim away to safe areas, however, fish in aquaculture cages cannot swim out of the threat and are easily harmed. About US$7.2 million worth of fishery damage was recorded in Japanese waters in the NOWPAP Region from 1998 to 2004. Korean fishery loss in the same period by *Cochlodinium* red tides was estimated as US$38.1 million.

Damage to aquaculture by *Cochlodinium*

Cochlodinium red tides (dark area) observed from an aircraft

Color of *Cochlodinium* red tides in high cell density

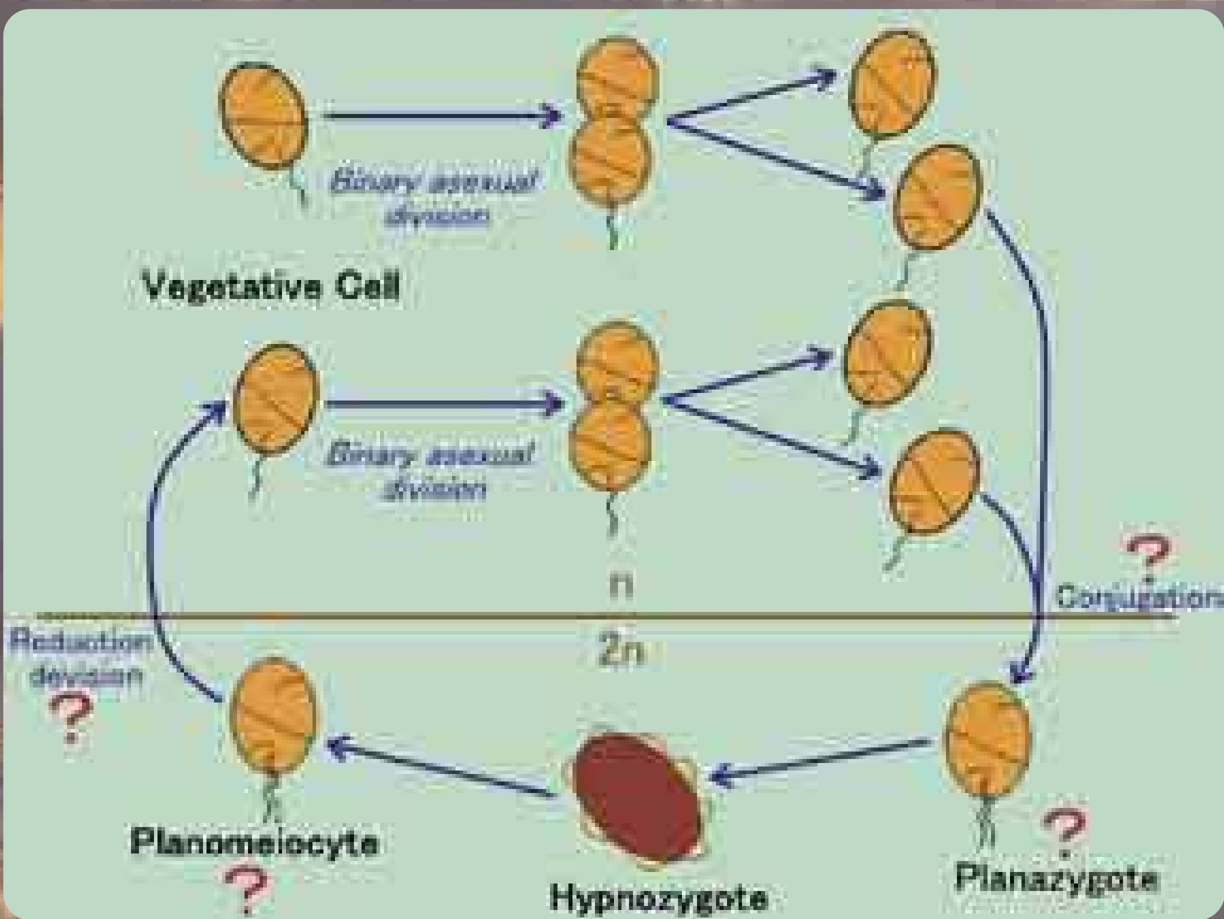
Pictures are provided by courtesy of National Fisheries Research & Development Institute (NFRDI)

Cochlodinium: Member of Dinoflagellate

Cochlodinium is an unicellular marine plankton belonging to dinoflagellate. Dinoflagellate is a unicellular alga with two dissimilar flagella. A half of dinoflagellate species are photosynthetic, and the others phagocytic. Dinoflagellate includes many species that cause red tides and shellfish poisoning.

Life Cycle of *Cochlodinium*

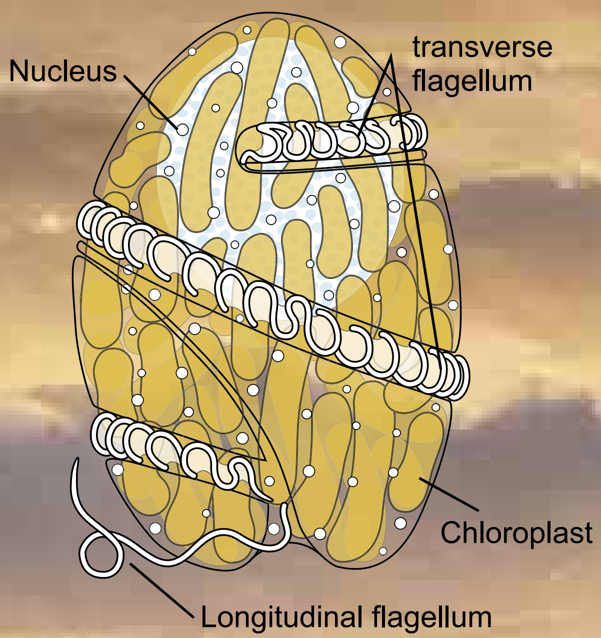
In fact, a life cycle of *Cochlodinium* has not been completely understood. Its putative life cycle is shown in the below figure.



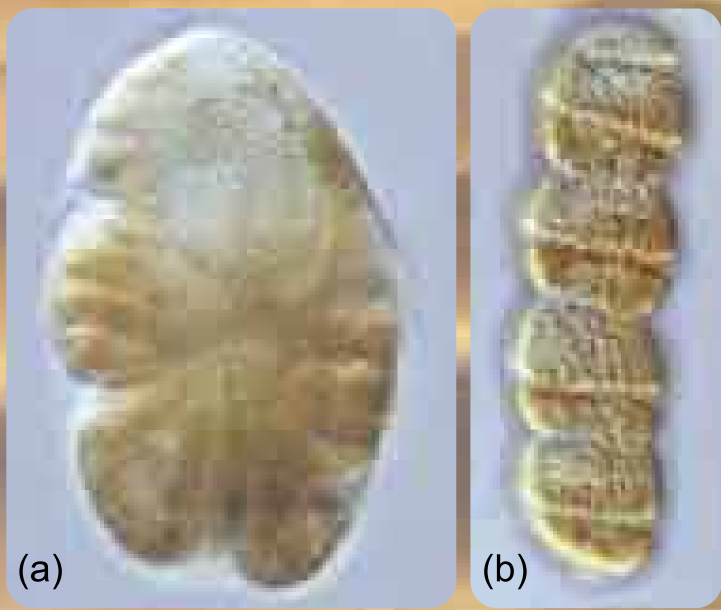
Putative life cycle of *Cochlodinium*
(“ ? ” is unclear or partially clear stages in its life cycle)

Shape of *Cochlodinium*

A cell of *Cochlodinium* is ellipsoidal, length 30-40 μm in length and 20-30 μm in width. Both single and chained cells are observed. These chained cells are formed when cells do not separate at the time of cell division.



Structure of a cell of *Cochlodinium*



Light microscope pictures of Cochlodinium
(a) Single cell (b) Chained cells
(by courtesy of Dr. Matsuoka (Nagasaki Univ.))

Cochlodinium strangulatum

The genus *Cochlodinium* has about 40 species, and most of them resemble *Cochlodinium polykrikoides.*

Electron microscope pictures of a chain of *Cochlodinium*

(by courtesy of Dr. Takayama (□iroshima Pref. □isheries □ MarineTechnology Center))

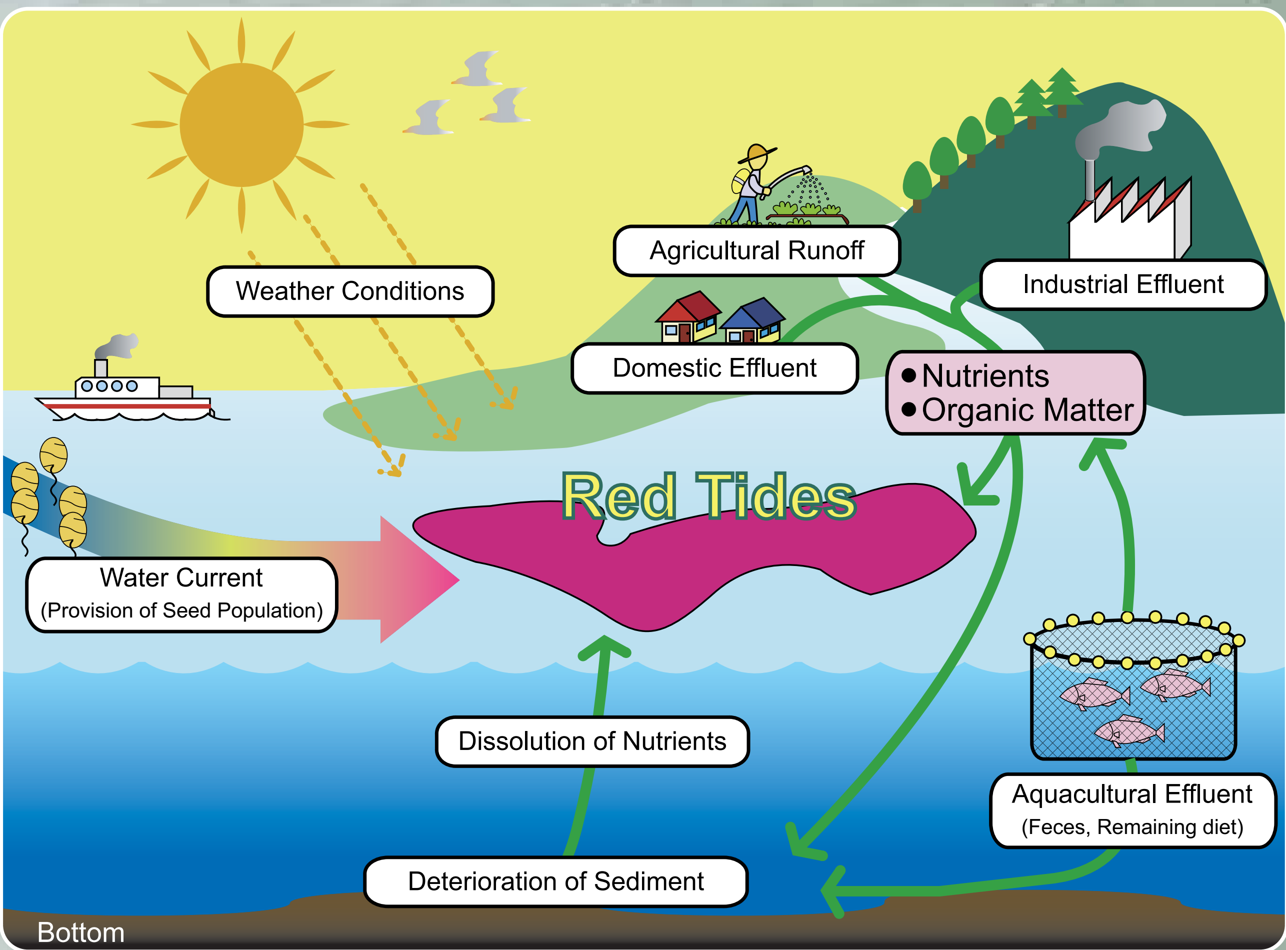
Occurrence mechanism of *Cochlodinium* red tide

It is highly speculated that a warm current such as Kuroshio and eutrophic coastal waters play an important role in the initiation and subsequent development of red tides of *Cochlodinium*.

The mechanism and triggering factors of the initiation and development into dense harmful bloom have been actively studied cooperatively among NOWPAP scientists.

Warm water current brings seed population of *Cochlodinium*. Deterioration of the marine environment is also considered to be one of the possible causes of expansion of areas and prolongation of period, as is observed in other red tide causative phytoplankton.

Phytoplankton usually increase in coastal areas and inner bays where large amount of nutrients are available through inflow of river water which contains domestic waste or industrial discharged water, and through elution from the bottom sediments which contain a lot of amount of organic substances. Once environmental conditions (i.e. water temperature, salinity and day time length) become optimum, growth of phytoplankton accelerates considerably, which causes red tides in the end.



Schematic diagram of red tide occurrence mechanism

Optimum condition of *Cochlodinium* growth

★ In the natural environment
Cochlodinium occurs mainly from June to October. Especially, *Cochlodinium* forms red tides from July to August. Optimum conditions for blooming are salinity 32 to 34 and water temperature 25 to 28 ℃.

★ In the culture condition in laboratory
In laboratory condition, *Cochlodinium* grows under water temperature 10 to 30 ℃, salinity 16 to 36 and light intensity 30 to 230 $\mu mol/m^2/sec$. The optimum condition for the growth is water temperature 21 to 26 ℃, salinity 30 to 36 and light intensity exceeding 90 $\mu mol/m^2/sec$.

Countermeasure against *Cochlodinium* red tide

To protect aquaculture against red tides, some of countermeasures have been taken such as suspension of feed supply, submergence of fish cages to deep water, evacuation of fish cage, and clay dispersion.
Especially yellow clay dispersion is quite common in Korea. Clay is sprinkled with water to red tide area to break red tide cells and make flocculants. Those flocculants sink with the broken cells to the sea bottom. Thereafter red tides disappear by the reduction of the planktonic cells, and then fishes are saved from harmful substances excreted from the cells.


Pictures of yellow clay sprinkling in Korea (by courtesy of NFRDI)

NOWPAP

The Northwest Pacific Action Plan (NOWPAP) was adopted in September 1994 as a part of the Regional Seas Programme of the United Nations Environment Programme (UNEP). The overall goal of NOWPAP is "the wise use, development and management of the marine and coastal environment so as to obtain the utmost long-term benefits for the human populations of the region, while securing the region's sustainability for future generations." China, Japan, Korea, and Russia currently participate in NOWPAP. More information is available in NOWPAP Website (http://www.nowpap.org).

NOWPAP CEARAC

The Special Monitoring & Coastal Environmental Assessment Regional Activity Centre (CEARAC) is one of the four Regional Activity Centres (RACs) to coordinate activities relevant to specific components of NOWPAP. CEARAC was founded in 1999 and is hosted by the Northwest Pacific Region Environmental Cooperation Center (NPEC), which was established in 1998 in Toyama, Japan, under the auspices of the Ministry of the Environment. Main activities of CEARAC include monitoring and assessment of Harmful Algal Blooms (HAB) under Working Group 3 (WG3) and developing new monitoring tools using Remote Sensing under Working Group 4 (WG4).

WG3 organized Cochlodinium Corresponding Group (CCG) so as to make a set of information on *Cochlodinium* for the public. One of the main CCG activities is to construct *Cochlodinium* Homepage. Another one is to make this pamphlet. If you need more information about *Cochlodinium* in the NOWPAP Region, please visit *Cochlodinium* Homepage (https://cearac.nowpap.org/cochlo-web/en/).

CEARAC and WG3 would like to express special thanks to Dr. Kazumi Matsuoka (Nagasaki University) and Dr. Haruyoshi Takayama (Hiroshima Pref. Fisheries & Marine Technology Center) for their contribution to this pamphlet.

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