Marine Biosecurity

Hidden potential for harmful algal blooms in our ports and harbours

Two-cell and eight-cell chains of the harmful dinoflagellate *Gymnodinium catenatum*.

Hoe Chang, Graeme Inglis, and Rob Stewart explain how tiny dinoflagellates can hang around to cause big problems.

Lying in wait

- Dinoflagellates are free-swimming microalgae; most species are harmless but some produce toxins.
- They are fundamental to the marine food chain but can also be responsible for harmful algal blooms.
- A survey has identified six species considered harmful or potentially harmful in the sediments of ports and harbours around New Zealand.

Too small to see with the naked eye, dinoflagellates nonetheless play a big role in the New Zealand coastal ecosystem, and some species can seriously affect commercial and recreational use of the coasts. To their credit, dinoflagellates are important primary producers and, along with other microalgae, they form the basis of marine food webs. However, dinoflagellates have a dark side as well. They make up a disproportionately large number of microalgae that are known to be toxic. When conditions are right for rapid growth, dinoflagellates of harmful origins can build up to form algal blooms. Toxins produced by these blooms can cause mass mortalities of other marine life, or render seafood poisonous to humans.

Tiny free-swimmers

Dinoflagellates are single-cell, microscopic algae ranging in size from 0.02 to 0.15 mm (about 50 of the smaller ones would fit on this bullet point •). Some dinoflagellate species form chains of cells, with chain-length varying from 2 to as many as 64 cells. Unlike diatoms – free-floating single-cell algae which drift passively in the sea – dinoflagellates are free-swimming, or motile, powered by two swimming hairs called flagella. There are two different forms of dinoflagellates: the 'armoured' form is covered by a wall of cellulose plates, known as a theca, while cells of the other form are naked and lack any theca or cell wall.

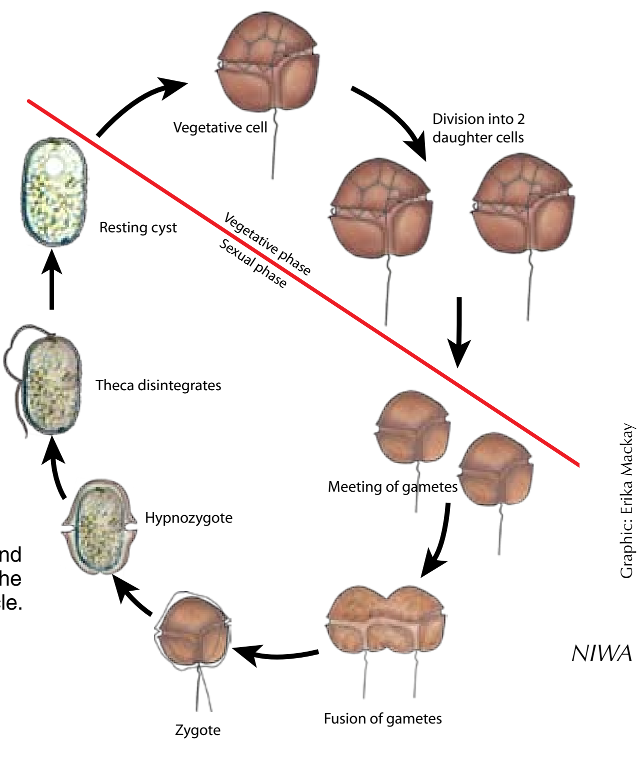
Life cycle of a dinoflagellate

Dinoflagellate life cycles vary somewhat, depending on the species. Usually, the life cycle combines a vegetative phase and a sexual phase. In the vegetative phase, most cells remain motile while dividing into two daughter cells. In the sexual phase, two reproductive cells (gametes) produced by individual vegetative cells fuse to form a cell called a zygote (which looks like a vegetative cell with two trailing flagella). In the case of armoured species, the theca thickens and the cell becomes either warty-looking or spiny. At this stage it is referred to as a hypnozygote. For some species, the hypnozygote usually remains dormant for a period of time before the theca disintegrates, revealing a form called a resting cyst. Finally, the resting cyst germinates and becomes a motile vegetative cell; for other species the hynpzygote germinates directly into vegetative cells, and the cycle begins again.

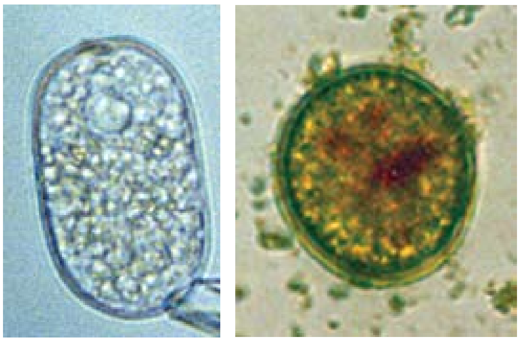
There are over 2000 species of living marine dinoflagellates; just over 80 of these (less than 4%) are known to produce resting cysts as part of their sexual life cycle. These cysts are formed near the sea surface and then settle to the seabed, where they can remain viable for a long time; thus, cysts found in seabed sediments can provide a record of species in the area. Fossilised dinoflagellate cysts from as far back as 230 million years ago have been identified in sediments.

Toxic dinoflagellate cysts

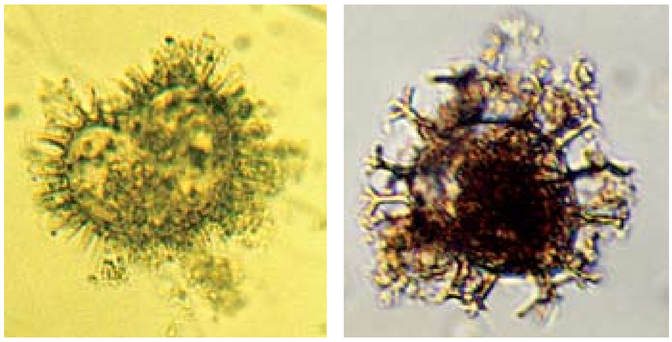
Like their motile form, most resting cysts are quite harmless, and only cysts produced by a few harmful species are known to contain toxins. The most common toxic dinoflagellate cysts found in coastal waters of New Zealand belong to species that are known to produce paralytic shellfish poison (PSP). These toxins can be accumulated by filter feeders such as shellfish and then poison any unlucky humans at the end of the food chain.



The vegetative phase and the sexual phase of the dinoflagellate life cycle.



Resting cysts of the harmful dinoflagellates *Alexandrium tamarense* (*left*) and *Alexandrium minutum*.



Photos: Hoe Chang

Spiny resting cysts of the harmless dinoflatellates *Protoperidinium conicum* (*left*) and *Gonyaulax scrippsae*.

Resting cysts usually form in adverse conditions, for example, when nutrients are depleted or temperatures drop below optimum for the motile phase. Most of these dormant cysts are deposited in the sediment and remain hidden in the seabed throughout winter. In late winter and early spring, strong mixing driven by winds and tides re-introduces resting cysts from a virtually dark environment into the light-bathed surface waters, where they germinate to form new motile cells. Coupled with stronger light and plentiful nutrients available in spring, some of these new motile cells may multiply to form massive blooms. Thus, dinoflagellate cysts hidden in the seabed – particularly those of toxic species – can be a source of harmful algal outbreaks.

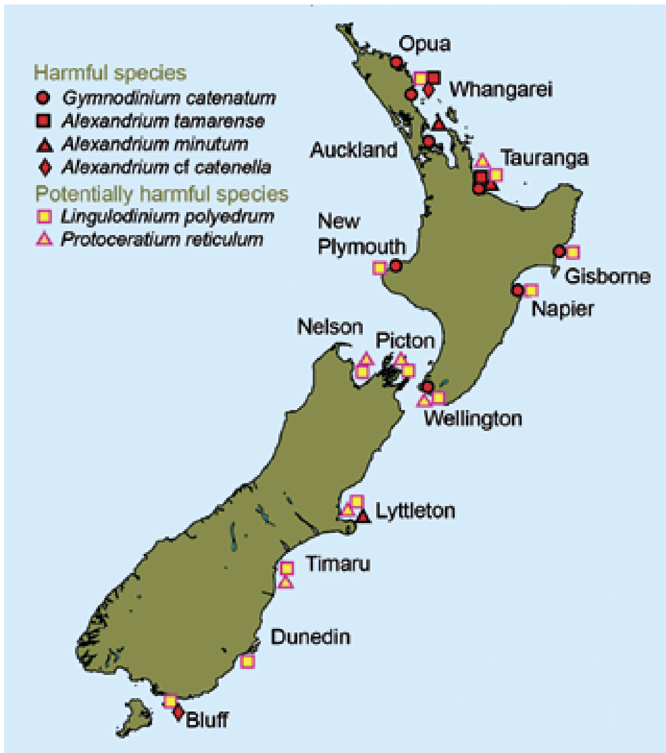
Dinoflagellates in our ports and harbours

Thanks to global transport of cysts and algae in the ballast water of ships, toxic dinoflagellate cysts may now be more widespread than in the past. Also, toxic blooms may be occurring more often because of increased human inputs of nutrients into coastal waters and due to global warming.

How has this affected New Zealand's ports and harbours? From 2001 to 2004 NIWA scientists collected more than 170 surface sediment samples from 16 shipping ports and marinas throughout New Zealand and analysed the sediments for dinoflagellate cysts. This work was part of a national programme of baseline surveys for native and non-native marine species in New Zealand ports commissioned by MAF Biosecurity New Zealand. From these 170 samples we identified 22 distinct cyst types. Four of these are known to be from harmful species (including *Gymnodinium catenatum* and *Alexandrium minutum*) and another two are from potentially harmful species.

Cysts of *G. catenatum* were confined mainly to North Island ports and harbours, coinciding with areas where very widespread blooms were reported in 2000. Cysts of *Alexandrium* species were more common in northeastern ports, in areas where blooms of the same species were previously reported.

We don't know to what extent the New Zealand dinoflagellate flora is indigenous. There is evidence of links to Australia, particularly for *G. catenatum* and *A. minutum*. But studies using radioactive lead to date *G. catenatum* cysts from New Zealand's northwest coast have shown that this species has been there since 1937, while similar studies in Tasmania showed a later date of 1972. Thus, it seems unlikely that *G. catenatum* was introduced by ballast waters from Australia to New Zealand. W&A



Six harmful or potentially harmful dinoflagellate species found in a survey of New Zealand ports and harbours, 2001–04.

Further reading

Chang, F.H.; Anderson, D.M.; Kulis, D.M.; Till, D.G. (1997). Toxin production of *Alexadrium minutum* (Dinophyceae) from the Bay of Plenty, New Zealand. *Toxicon 35*: 394–409.

Chang, H.; Richardson, K.; Uddstrom, M.; Pinkerton, M. (2005). Eye in the sky: tracking harmful algal blooms with satellite remote sensing. *Water & Atmosphere 13(2)*: 14–15.

Dr Hoe Chang's studies include harmful algal blooms and impacts on human health and marine ecosystems, and Rob Stewart works with benthic fisheries and ecology; they are based at NIWA in Wellington. Dr Graeme Inglis focuses on biosecurity of New Zealand's ports and harbours and is based at NIWA in Christchurch.

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