***Alien Invasion: the spread of* Caulerpa taxifolia *in Australian waters***

The eradication or control of introduced marine pests will represent one of the greatest challenges of this century. Indeed, hundreds of introduced marine species are already present in Australian waters. Marine pests pose such a challenge because by the time they are discovered they are usually well established and almost impossible to remove. Their impacts have been likened to Russian roulette — often the impacts are minor, but occasionally the results are devastating. These issues have been brought into sharp focus by the arrival on our shores of one of the world s most successful marine invaders — *Caulerpa taxifolia*. This green seaweed belongs to a family of largely tropical marine species. Its spectacular appearance, hardy disposition and profuse growth unfortunately make this species particularly popular with aquarists. An apparent escapee from aquaria at the Oceanographic Museum in Monaco has led to the spread of this species across the Mediterranean. It now occurs in five countries and covers an estimated 50,000 hectares of sea floor. Biologists have been battling this Mediterranean invader for almost 20 years without success.

*Caulerpa taxifolia* was discovered in southern Australian waters in 2000. Its presence has now been confirmed in 7 locations within NSW (http://www.fisheries.nsw.gov.au /closures/general/caulerpa%20(15-6-01).htm). The profuse growth achieved at some sites of infestation e.g. Lake Macquarie and Lake Conjola, has led biologists to suggest that it has been growing and spreading in the shallow coastal lakes of NSW for some years. Disturbingly, as I write this, *C. taxifolia* has now been recorded growing in a marina in South Australia and may also have been there for several years. Genetic data, based on DNA sequencing, are being used to disentangle the history of invasions by *C. taxifolia* in southern Australia. The picture is muddy at this stage as the data currently point to a

number of independent introductions. Although unexpected, the presence of more than one genetic form in NSW is not inconceivable, but more data are required before this can be confirmed. It seems likely that infestations are the result of dumping the contents of aquaria into shallow coastal sites with subsequent dissemination to other locations via commercial or recreational activities such as boating and fishing. In an ironic twist, *C. taxifolia* is in fact a native of north Queensland and the invasive Mediterranean form may well have originated from northern Australian waters. It has been suggested that this tropical species subsequently developed a tolerance to cold water after a few generations in European aquaria prior to its appearance in temperate Australia, perhaps via the aquarium trade.

*Caulerpa taxifolia* is already modifying shallow lagoonal habitats in NSW, despite it relatively recent arrival. In some locations it has covered extensive areas and grows as a thick monoculture. The runner-like stolons elongate across sandy or muddy substrata, while the pinnate (fern-like) fronds extend into the water column shading marine plants such as seagrass and smothering other organisms. The biomass of these infestations can be extraordinary with the wet mass of the alga sometimes exceeding 5 kg $m^{-2}$. In addition, *Caulerpa taxifolia* propagates asexually. That is, when fragments break off they can disperse, reattach and form a new infestation away from the original population. The tiniest fragments are capable of growth and hence *Caulerpa taxifolia* represents a real challenge to control. Manual or mechanical removal of the pest is likely to simply further its spread. Furthermore, this alga is hardy and the fronds are capable of surviving out of water for a period of time — such as on the nets of commercial fishers or the anchor lockers of recreational fishermen. It is believed that these may be important vectors for the dispersal of this pest.

NSW Fisheries, in collaboration with research groups at several NSW Universities, are seeking means to reduce the spread of this pest and investigate how it may be controlled. Currently NSW Fisheries are restricting recreational boating and access by commercial fishers to known infestations of *C. taxifolia*. They are also providing wash-down stations in heavily infested sites to ensure that fragments are not inadvertently spread. At present, the most promising means of control is the addition of salt to stands of the alga. The application of a thick layer of salt blankets the alga and delivers a fatal osmotic spike before going into solution. *Caulerpa taxifolia* appears to be particularly sensitive to osmotic shock as it possesses an unusual cell structure — a non-compartmentalised multinucleate organisation where a single connected thallus that can be several metres long is akin to a single cell. It is hoped that following the application of salt, other organisms in the assemblage including those beneath the surface of the sediment won t be affected, but this will require careful experimentation to confirm. Our experiments at the University of Wollongong confirm that several large and common herbivores, particularly large molluscs and common sea urchins will consume extracts of the alga in feeding trials. These trials entail feeding palatable agar discs containing solvent or aqueous extracts of the alga to a range of invertebrate herbivores and comparing the amount of treated discs eaten to discs lacking the extract. Unfortunately those species which do appear to readily consume *C. taxifolia* in the feeding assays will generally avoid it if other algae are available. An additional avenue that we are investigating is the use of specialist herbivores as a potential biological control. Specialist herbivorous insects have been used as successful bio-control agents in some invasive terrestrial plants. Small, saccoglossan molluscs are specialist feeders on *Caulerpa* spp. Their suctorial mouthparts draw the intercellular fluid, much like aphids in terrestrial systems. They are common and apparently important herbivores on

the related *Caulerpa filiformis,* reaching high densities at certain times of the year on this alga. Their ability to consume *C. taxifolia* is currently under investigation.

Finally, it should be noted that *Caulerpa taxifolia* does not lend itself to classroom activities because of its invasive habit, indeed it is an offence to possess it without the appropriate scientific permits. Nevertheless you can play a role in battling this invader. Should you find an alga which you believe might be *Caulerpa taxifolia*, visit the NSW fisheries Website (http://www.fisheries.nsw.gov.au/conservation/pests/caulerpa.htm) for a picture of this species, then report where and when you saw it. In southern Australia the only species that *C. taxifolia* can be confused with is *C. scalpelliformis* and indeed distinguishing between them is best left to experts.

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***Suggested further reading***

Jacobs WP (1994) Caulerpa. *Scientific American* 271: 66-71.

Meinesz A (1999) *Killer Algae: the true tale of a biological invasion*. University of Chicago Press, London, Pp. 360.

http://swr.ucsd.edu/hcd/caulerpa.htm
http://www.pbs.org/saf/1204/features/caluerpa.htm
http://www.caulerpa.org (in French)
http://crimp.marine.csiro.au/marine_pest_infosheets.html
http://www.sigmaxi.org/amsci/articles/01articles/vroom.html