Eradicating and preventing the spread of the invasive alga *Caulerpa taxifolia* in NSW

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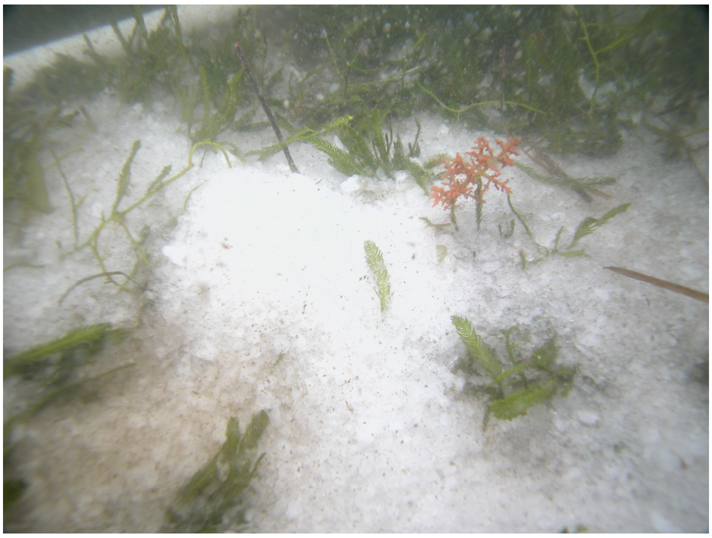

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

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EXECUTIVE SUMMARY

This joint project between NSW Fisheries and the University of Wollongong had 3 objectives:

1 To investigate patterns of dispersal, recruitment and growth of the invasive alga *Caulerpa taxifolia* and provide information on spread within NSW estuaries
2 To investigate the vectors that may transfer *C. taxifolia* to new locations
3 To develop environmentally benign ways of removing *C. taxifolia* which might eventually lead to its elimination from whole sites or regions

The research undertaken to address these objectives provided a good understanding of the population ecology of *C. taxifolia* in NSW estuaries, allowed the evaluation of several control techniques and underpinned the development of a 'Control Plan for *Caulerpa taxifolia* in NSW' based on a preliminary assessment of risks. The control plan can be found at http://www.fisheries.nsw.gov.au/thr/species/fn-caulerpa.htm

To date, *C. taxifolia* has been found in 9 separate locations. All are estuaries or sheltered embayments and the seaweed has not yet been found on exposed coasts. It occurs in water 0.5–10 metres deep. *C. taxifolia* is capable of growing extremely quickly; stolons can extend by up to 13 mm per day in optimal conditions. Vegetative growth is the primary means by which the alga has invaded these NSW waterways, covering over a total of 4-8 km^2 by mid 2004. *C. taxifolia* reproduces asexually through a process of fragmentation, dispersal and eventual anchoring of drifting fragments which are negatively buoyant and move across the seafloor in bottom currents. Large numbers of fragments were found within existing beds of *C. taxifolia*, and experiments showed that they could be trapped within seagrass beds or other structures on the seafloor. Once trapped, even small fragments can attach to the seafloor and grow into new plants. Infestations of *C. taxifolia* in NSW range from sparse distributions of scattered runners to dense beds 40 cm thick. Several other marine organisms may occur within beds of *C. taxifolia*, but most herbivorous species avoid eating it. Only two species of opisthobranch molluscs appear to readily feed on it.

A boat-mounted mapping system was developed to document the extent and spread of *C. taxifolia* in NSW waterways. A procedure whereby all known infestations are comprehensively mapped twice a year, in mid summer and in mid winter, has now been implemented. This mapping has accurately documented the continued spread of *C. taxifolia* in most of the estuaries where it occurred at the start of the project. Large-scale die-offs, however, occur in shallow water (0.5–2 m) in most waterways in NSW during winter and this was particularly evident after heavy rainfall. This die-back may be a consequence of decreased temperature, decreased salinity, increased turbidity or some combination of these.

There are several natural vectors that aid the fragmentation and translocation of *C. taxifolia*; storms, and the increased wave action associated with them, were found to be particularly important. These vectors become increasingly significant as the amount of *C. taxifolia* at a site expands, and they probably overshadow human-mediated vectors when infestations cover large areas such as in Lake Conjola and Botany Bay. Commercial activities on waterways infested by *C. taxifolia* such as commercial fishing, aquaculture, dredging or the building/maintenance of foreshore structures such as wharves, jetties or boat ramps can potentially cause increased fragmentation. Most such activities are now banned or strictly controlled at sites with *C. taxifolia*. Many human leisure activities may also generate, trap and transport fragments of *C. taxifolia*, including passive pursuits such as swimming, diving and more active pursuits such as boating, water skiing, anchoring or recreational fishing. These were investigated in an Honours project at the University of Wollongong and the results reproduced here. Abundances of fragments were higher in areas of human use, and experiments showed that boat anchors, in particular, were readily able to remove significant amounts of the seaweed from beds of *C. taxifolia*. Additional experiments showed that fragments caught this way could survive for 1-2 days out of water in conditions that mimicked the anchor well on a small boat and might constitute a major risk for transferral to other waterways.

Removing *C. taxifolia* by either hand-picking or using underwater suction devices was found to be effective for very small patches at shallow sites with sandy bottoms and good underwater visibility. Many of the infested waterways in NSW, however, are muddy and often turbid, making detection of all plants difficult and increasing the risk of accidentally releasing fragments. A scoping exercise was done for using a commercial dredging vessel to remove large areas of the seaweed, but the logistics proved too difficult. Experiments with various types of smothering materials, particularly jute matting, were also reasonably effective at killing most *C. taxifolia* in small-scale trials. Their use for areas larger than a few hundred square metres, however, created more difficulties than they provided solutions.

The use of osmotic shock showed the most promise in preliminary trials. The addition of a layer of salt directly onto the plants killed them within hours. Trials using salt delivered from a specially designed punt were very successful at scales of several hundred square metres, but results of larger scale salting were mixed. For example, single applications of salt to numerous outbreaks at one location resulted in the apparent removal of almost 5200 m^2 of *C. taxifolia*, whereas repeated salting of a 3000 m^2 infestation at another site led to a considerable reduction in the density of *C. taxifolia*, but no overall change to the extent of the infestation. Salt rapidly dissolves in seawater and therefore has little residual impact on the marine environment. Although salt may kill other marine organisms directly covered by it, experiments showed that the seagrass, *Zostera marina*, and invertebrate infauna which often co-occur with *C. taxifolia*, recover after 6 months if salt is applied at 50 kg salt per square metre. The use of this salting technique has now been adopted as a major component of the NSW *Caulerpa* Control Plan for the targeted control of new outbreaks or high risk infestations.

Because there is now more *C. taxifolia* in NSW waterways than can be effectively treated with salt, eradication does not seem feasible at this time. It is hoped, however, that the control procedures outlined in this report and in the NSW *Caulerpa* Control Plan will prevent the spread of the alga to locations where it is not currently found. A better understanding of the biology and patch dynamics of *C. taxifolia* will also assist in minimizing its impact on native biodiversity and the sustainable use of marine resources in NSW estuaries.