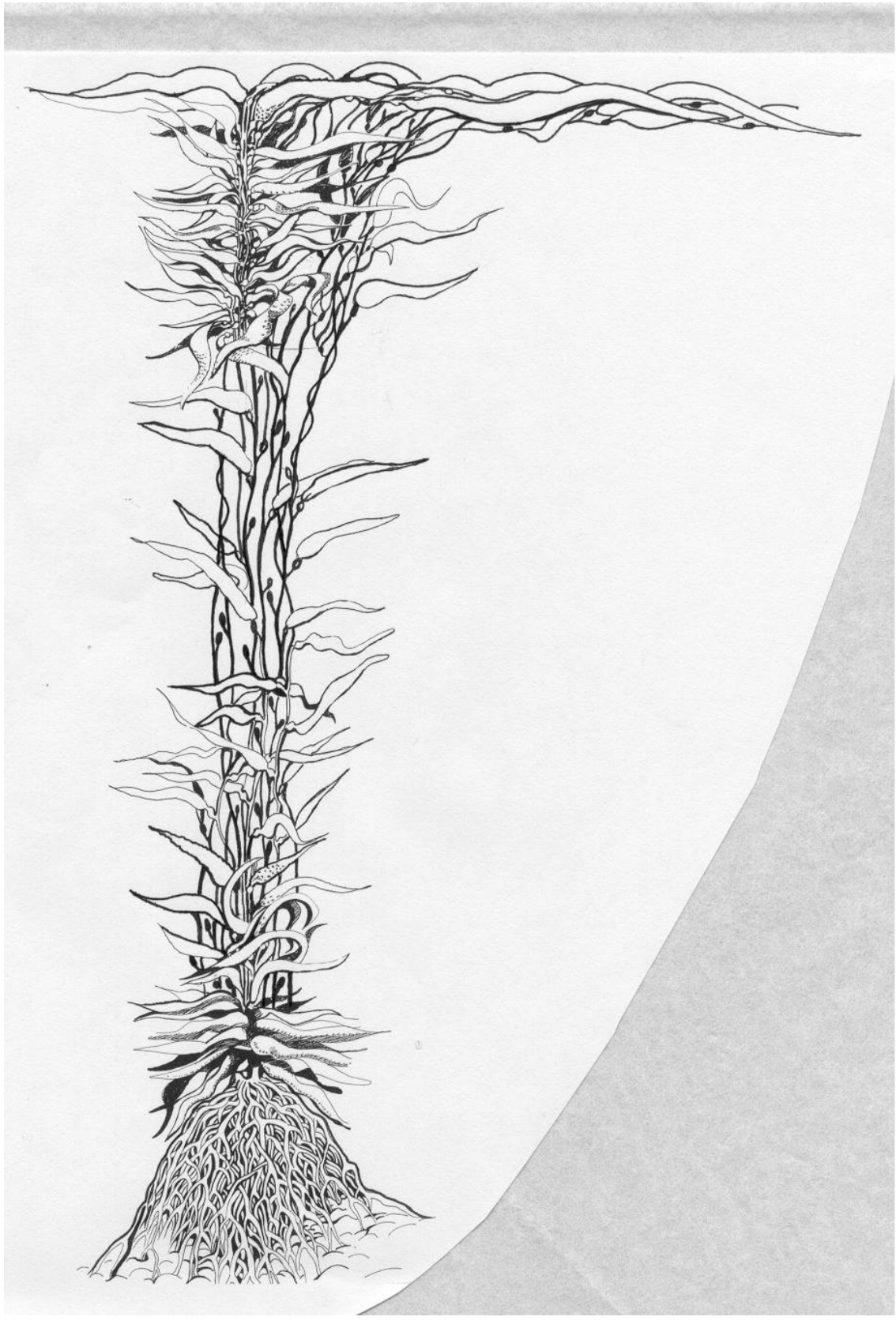

MACROCYSTIS TRANSPLANT HANDBOOK

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FOREWORD

This handbook has been put together to assist community groups interested in re-initiating *Macrocystis pyrifera* in areas where it has been abundant but is no longer found. It is hoped to inform the members of the community who are concerned about the implications the loss of habitat might have on dependent animal life including lobster, abalone and fin fish species in their areas.

Unfortunately the opportunity to enjoy the many benefits of Tasmania's String Kelp forests is becoming increasingly rare. String Kelp forests are disappearing from our coastal waters. Surveys carried out by CSIRO, the Tasmanian Department of Primary Industry and other institutions have documented the decline of *M. pyrifera* to the present. Anecdotal evidence based on observational skills and knowledge of fishers back up these surveys.

Binnalong Bay, St Helens, Bicheno, Maria Island, Fortesque Bay and Eaglehawk Neck and the Derwent Estuary are all situated on Tasmania's east coast and have all been amongst the many places where string kelp forests have thrived.

Commonly, areas formerly occupied by *M. pyrifera* are now bare urchin infested rocky substrate or they might be barren, sediment covered reefs or are are inhabited primarily by forests of less spectacular, less productive, much smaller brown algae such as *Ecklonia radiata* and *Phyllospora comosa*.

More information can be obtained regarding this project from:
SEACARE c/- at: or
BINALONG BAY COASTCARE GROUP c/- at:

MACROCYSTIS TRANSPLANT HANDBOOK

INTRODUCTION

Inside a String Kelp forest, shafts of light penetrate the blades to reveal a tremendous variety of marine life. Beautiful red seaweeds which prefer diffused light, grow in the cover of the kelp canopy. Fish and schooling invertebrates such as mysids shelter from predators. Crayfish, sea urchins, abalone and herbivores graze on attached and drift laminae. Small fish, eels, crabs, isopods, worms, sponges and others shelter in the strong anchoring holdfasts. Bryozoans and sessile organisms grow on the surface of the plants which are in turn preyed upon by organisms such as fish and nudibranchs. Lobsters feed on the sea urchins. The long fronds of the alga also trap larvae of fish species, abalone and crayfish ensuring these species recolonise close to the coast.

Charles Darwin wrote in 'The voyage of the Beagle' (1860) after observing *M. pyrifera* forests off Tierra del Fuego:

...The number of living creatures of all orders, whose existence intimately depends on the kelp, is wonderful.....I can only compare these great aquatic forests of the southern hemisphere, with the terrestrial in the intertropical regions. Yet if in any country a forest was destroyed, I do not believe nearly so many species of animals would perish as would here, from the destruction of the kelp.

PLANT DESCRIPTION, BIOLOGY AND DISTRIBUTION

Macrocystis spp. are found in cold temperate oceans with surface temperatures ranging from 0 to 20ºC, and their main distribution is circumpolar in the southern hemisphere, between 40 and 60º S longitude. They are also present in the major upwelling areas including the west coast of South Africa, the Pacific coast of South America and in North America from Baja California. *It* is a brown alga of which, worldwide, four species are recognised; *M. integrifolia*, *M. angustifolia*, *M. pyrifera* and and *M. laevis* .

LIFE CYCLE OF THE KELP

The plants produces spores formed in specialised blades, called sporophylls. The spores settle and if space and light is available develop into filamentous gametophytes which then give rise to male and female gametes producing eggs and sperm. Male and female gametes fuse giving rise to the zygote or tiny embryonic plant and thence the large plant or sporophyte with which we are familiar. Wrinkled and transparent the heart shaped blade must fight for space and light with other species and avoid being grazed on by herbivores. Sporophytes of all kelp species start out as a single blade. At an early stage it is hard to differentiate one species from another. As it grows the characteristics of each species become more obvious. When about 10 cm high the blade begins to split at the base. the bladders (floats)or vesicles appear as slight swellings at the base.

Macrocystis pyrifera - is the largest of the kelps and forms dense beds adjacent to the coast. Plants in Tasmania have been recorded to grow 5 cm. to 11 cm per day. The plants main growth time if from March to December with fastest growth in late spring and early summer. Growth rates are dependent on ocean temperature and god nutrient levels in the water.

DOCUMENTED HISTORY OF MACROCYSTIS IN TASMANIA

Most of the data available on the extent of kelp beds in Tasmania comes from surveys done in relation to assessing the commercial potential of the alga. In the 1950's, interest was directed at the Tasmanian *Macrocystis* beds as a possible alginate resource.

In 1954, a study conducted through the Commonwealth Scientific and Industry Research Organisation (CSIRO) estimated a standing crop of approximately 118,000 wet tons at one harvest per year, with a total area of approximately **120 km^2**. A company was initiated in the 1960's to harvest this alga. A survey conducted immediately prior to this company starting to harvest indicated a possible annual tonnage of 11,000 wet tons.

Whilst operating, the company realised in most areas a single harvest per year rather than three as anticipated and the maximum amount of the alga that was harvested in any one year was 9000 tons. In the late sixties and early seventies, the amounts of the alga declined, coinciding with increasing mean annual sea-water temperatures and in 1972 the company ceased harvesting as the enterprise was no longer financially viable.

In 1986 another survey was conducted for a separate company applying to harvest the alga. Estimates of the standing crop were again in the vicinity of 10-12,000 wet tons forming a total area of approximately **8 km^2**. Permission to harvest was not granted by the local Department of Fisheries.

In 1987 the quantities of *Macrocystis pyrifera* decreased dramatically, again coinciding with increasing annual mean sea-water temperatures. In 1988, the total amount of *M.pyrifera* evident on the Tasmanian coastline was reduced to less than an estimated **0.5 km^2** (pers. obs.). Since then levels of the alga have slowly increased to approximately a quarter of levels surveyed in 1986 (1998).

There is some doubt as to the authenticity of the original estimates of quantities of *M. pyrifera* made by Cribb, especially as one of the larger beds recorded by Cribb is within what is presently a large sandy bottomed bay and appears to always have been so (Chinamans Bay, Maria Island). Other areas do however have little or none where there appears to have been large quantities in the past (The Gardens, Oakhampton Bay, Stapleton Point).

Table 3. Findings of major seaweed surveys of the stocks of *Macrocystis pyrifera* on Tasmania's East coast.

Surveyor	Weed Area -Acres	Tons/ Acre	Weed Available	Cuts/ year	Yearly Harvest
Cribb (1954)	30,000	5	120,000	3	360,000
Button (1961)	1,993	4	11,143	3	33,429
Alginates 1965/72	3,000	approx. 5		1+	6,500-14,000
Sanderson/ Light(1986)	2,530	5	12,650	1 1/3	16,870

Table 4. Change in estimated quantities of *Macrocystis* based on survey reports at some select sites.

Area	Cribb 1954	Button 1961	Alginates 1965	Alginates 1965/72	Sanderson/ Light 1986
Grindstone Bay	8,240	140	80	525	nil
Southern Maria Is	4,064	150	20	55	10
Actaeon-Southport	58,116	310	not given	not given	1,970

FACTORS AFFECTING THE ALGA'S DISAPPEARANCE

A number of explanations, some involving human interference with the marine environment have been put forward for the disappearance of *M. pyrifera*. These include:

Disturbing the substrate through dredging for scallops in the 1950's.
This has resulted in the silting up of inshore reef areas that were formerly colonized by *M. pyrifera* forests. In California, germination of spores of *M. pyrifera* has been shown to be negatively affected by sediment.

Possible affects of the increasing sediment load in coastal waters
Land clearing and wood chipping results in less binding and protection for top soils which are then more susceptible to runoff. These then end up in waterways and are dumped into the sea. This results in more suspended sediment in the water column, cutting light penetration and more sediment on the inshore reefs.

Increases in boat traffic which cuts off growing fronds.
This is equivalent to harvesting which has been demonstrated to have minimal effect on healthy *M. pyrifera* beds when conducted in a controlled manner. However, when done on a continual basis and especially with beds that may be unhealthy for some reason will have a deleterious affect.

Over-fishing of rock lobster which are believed to feed on sea urchins
This has led to an increase in the herbivores, sea urchins which then feed on *M. pyrifera.* In Canada and North America, a relationship has been postulated between crayfish and urchins whereby urchin numbers are controlled by crayfish. The heavy fishing pressure on crayfish has consequently resulted in an increase in the numbers of urchins. This has then bought about an increase in urchin barrens that have resulted from increased numbers of this animal. As in California, divers in Tasmania have observed urchin climbing *M. pyrifera* plants

and pulling them down to the substrate where they are eaten. Urchin barrens are the ocean equivalent of deserts on land.

Commercial harvesting of String Kelp

A company established in the 1960's was established to harvest *M. pyrifera* for alginates. Declining levels of this alga at the time contributed to the collapse of this company in the early seventies. Levels of the alga have since approached former levels, but some areas, a number of which are close to the site of the former alginate factory, have never recovered.

The recent introduction of *Undaria pinnatifida*

(a Japanese seaweed thought to have introduced through ballast waters) which occupies a similar ecological niche to *M. pyrifera* and is thus a potential competitor. In areas where *Undaria* can form dense mono-specific stands in areas where it occurs. The plant can grow up to two meters in length and so effectively 'smother' the reef bottom. This will affect not only *M. pyrifera* but other local plants and animals in an unknown manner.

Indications of a decline in conjunction with the warming of coastal waters.

Maximum annual temperatures and salinities of eastern Tasmania's coastal waters have been rising as measured by CSIRO oceanographers since the 1940's due to more frequent incursions of the warm, nutrient depleted waters of the East Australian Current (EAC) adjacent to Tasmania's coast. In 1987, levels of *M. pyrifera* on Tasmania's east coast were at a minimum (pers obs). This coincided with very warm waters.

In California, *M. pyrifera* beds have shown to be affected by El Nino

The driving force behind the appearance of the EAC is not known but may be related to El Nino. At present it appears to be affected by the duration and intensity of the westerly winds which drive cooler waters up the east coast of Tasmania. These may tie into a 10 year cycle, the mechanism for which is not yet known. The kelp's poor health is most likely to be caused by the nutrient depleted nature of these waters than the warmth of the water.

MACROCYSTIS AS HABITAT

The presence of forests of *Macrocystis pyrifera* on the coast enhances the commercial, recreational and environmental productivity of an area. Some Tasmanian abalone and urchin divers and crayfishermen believe the beds of *Macrocystis* are better areas for production of their respective catch. The decline in levels of the alga in Tasmania may have lowered the available stocks of abalone and urchin which feed on the alga.

Macrocystis plays a role in trapping and sheltering larvae of important commercial species such as lobster and abalone. In urchin barren areas there is little to prevent eggs and larvae from being swept off the reefs. The larger seaweeds also provide important protection from predators for juvenile species. Research also needs to be conducted into plant and animal diversity in association with _Macrocystis_ stands.

forming an upper canopy over other smaller shade loving algae they increase habitat complexity and provide a refuge for a greater number of fish and invertebrate species and are possible nursery areas. The decline in Stripy Trumpeter and Real Bastard Trumpeter stocks from Tasmania's east coast may be partly attributable to the decrease in stocks of _Macrocystis_.

If the loss of *M. pyrifera* is related to an activity which is reversible such as boating traffic or fishing practises then these can be mitigated and the populations of *M. pyrifera* encouraged to return. In California kelp has been restocked despite the effects of El nino and the proliferation of sea urchin

numbers. By assisting nature to create a 'critical mass' of the species, it is hoped it can withstand the many likely causes of its decline.

THE KELP RECOVERY PROGRAM

The resilience of kelp beds to stress factors such as warmer waters can be enhanced by increasing the stock levels. Recovery of populations in years when water temperatures are lower may be influenced by recruitment difficulties. If there are no adults to recruit from then populations will not recover.

When water temperatures are lower it may be possible to re-establish *M. pyrifera* by transplanting. This has been successfully done in California in the wake of sea urchin plagues. In California Macrocystis replanting programs were done in conjunction with urchin eradication in the aftermath of El Nino in the 1980 's. This could be an ongoing program in Tasmania if the worth of these forests from an intrinsic and commercial point of view is recognised as justifying this course of action. Growing from spores is also an option but normally requires laboratory facilities.

SITE DESCRIPTIONS FOR PROJECTS CCRRENTLY UNDERWAY

For these projects, there are presently (July 1998) seven sites in the Derwent region, and three sites at Binalong Bay (see maps). These consist of donor and recipient sites and controls for each of these. Sites are comparable in depth and substrate. The control sites are used to compare the effects of transplanting with areas that have not been disturbed through this project..

Each site has been surveyed by qualified Marine Biologists

Surveys have recorded:

- percentage cover of *Macrocystis* (including the density of plants);
- percentage cover of major macroalgal species including total cover;
- density of urchins and other invertebrates and;

- number and species of fish.

Each transect has been videoed at the same time as they were surveyed.

TRANSPLANT METHODOLOGY

The total number of Macrocystis plants taken from a donor area will be less than 10% of the total population in that area at the request of the local Department of Sea Fisheries.

Volunteer divers will collect the Macrocystis plants from the donor site, from an area as described by the researchers in relation to permanent transect lines (Derwent Estuary) or mooring markers (Binalong Bay).

Transplantation of plants should take place between autumn and spring (latest early December) to give the plants the best chance of survival. Plants should consist of juveniles from 10- cm in length to mature plants with up to one-five fronds but preferably less than 2 m in length. Once gently wedged off the rocks, transplants should be taken to the surface and kept moist and cool. This may be by keeping in low densities in water filled tubs or by being kept covered with damp hessian. Ideally they should be re-planted the same day or the following day at the latest.

Plants should be gently returned to the water at transplant sites. Plants can be secured using elastic bands on bricks (see Fig 1).
Band should be not so tight that they cut through the holdfast or hapetera.

CULTURE

Culture of *Macrocystis* is an option. Young plants can be seeded on to small rocks and then dispersed from the surface into the sea. This method will be trialed. The Marine Studies Centre has expressed an interest in growing plants from spores.

METHODOLOGY FOR CULTURE

Sporophylls are harvested from mature plants. These are kept in cool seawater once bought to the surface. Spore release should be initiated in a clean cool environment. To initiate spore release, sporophyll surfaces were wiped clean and placed in a 10% solution of the antiseptic Betadine in seawater for 10 minutes to surface sterilize, rinsed in sterilized seawater, wiped clean again and left in a cool place for 1.5 hours. They were then placed in seawater (sterilized 0.5 - 1 litre containers). Spore release will be effected within 1-2 hours.

This spore solution can be used to innoculate many litres of sterilized, nutrient enriched seawater. Ideally spore densities on the bottom should be calculated to give a density of not more than approximately 1000 gametophytes per 5 x 5 cm^2 of substrate. Sea water should be exchanged approximately every two weeks. Under ideal conditions, new plants will become evident at 4 - 6 weeks.

Ideally, the seawater solution should consist of 0.2µm filtered sterilized (autoclaved) seawater, PES enriched with iodine. Heat sterilised seawater may be substituted, with ammonium phosphate (common fertiliser) added at a rate to give comparable concentrations of N and P.

For optimal growth, the seawater should be kept between 10 and 20^{o}C.

OUTCOMES

A report will be provided by the researchers after each survey detailing results. Recommendations should be given by the researchers as to the number of plants for transfer, where they are to come from and where they are to go to.

Seacare and Binalong Bay Coastcare Group will run information meetings regarding this project and co-ordinate field days where dive groups are able participate in transplantation of *Macrocystis* plants. Neither group endorses participation by any individual in similar or related activities outside of these advertised community events.

A final report will be made giving the success of the project and further follow-up options.

RELATED WEB SITE ADDRESSES

http://www.pebble-beach.com/attrct-b.html

http://www.crl.com/~hardiman/kelp.html

http://www.outerstate.com/kelp/macro.htm

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