# A Protocol for Introducing Non-indigenous Seaweeds, *Kappaphycus* and *Eucheuma,* into a New Farming Area with Minimum Intrusive Environmental Impact

## 1. General Considerations

All marine aquaculture of both plants and animals impacts to varying degrees on the natural environment, and any decision to introduce a non-native species should be preceded by careful analysis of the socio-economic benefits and the potential adverse impact on environmental values.

The two primary environmental issues with any introduction are :

- that a foreign organism may be unknowingly introduced with the target species, and that this organism may have an impact on local environmental values such as biodiversity ;

- that the target species itself may spread and establish itself beyond farming areas, which may have an adverse impact on local environmental values.

There are three commercial carrageenan-bearing seaweeds that have a long history as the preferred species for farming: *Kappaphycus alvarezii* and *Kappaphycus striatum*, both commercially known as 'Cottonii', and *Eucheuma denticulatum* commercially known as 'Spinosum'. Within the *Kappaphycus* species there are several domesticated varieties and strains. Over the last forty years *K. alvarezii* var. *tambalang* and *K. striatum* 'Sacol' strain have been the most preferred for transplanting to numerous locations beyond S.E. Asia. The three species and their varieties have different habitat requirements and consequently require separate risk assessment. *E. denticulatum* has the greatest invasive potential as it can tolerate a wide range of environmental conditions, readily attaches itself to substrates, and is more resistant to herbivore grazing. In this respect any increase in farming *E. denticulatum* should first be explored where the species has already been introduced or occurs naturally. In contrast, the farmed varieties and strains of *Kappaphycus* have more specific habitat requirements within a narrower range of biophysical conditions. *K. alvarezii* has already been transplanted to more than twenty countries, and while few have established commercial production (Ask. 2003), in nearly all cases the introduction has been non-invasive with minimal environmental impact. Similarly, this species has for many years been transplanted throughout S. E. Asia and farmed outside of its natural distribution of Sabah, the Sulu archipelago and adjacent areas, without any invasions of the surrounding environments.

This transplanting to numerous sites without any disruptive effect is a positive indication of low risk for a new introduction. However, there are no guarantees that the specific variety will behave similarly in a new environment. It should be noted that in the last forty years there have been two reported cases where *Kappaphycus* plants have spread from the introduction sites and adversely impacted on native habitats. The following sections are aimed at mitigating the risk of *Kappaphycus* establishing itself beyond any proposed new farming area, and minimising the risk of introducing a foreign organism with the target species.

## 2. Feasibility and Risk Assessment

Any seaweed introduction should be preceded by a feasibility study that identifies potential farming sites and evaluates the risks and benefits in terms of the ecology and socio-economic environment. The study should include :

(i) confirmed support for a *Kappaphycus* farming development research programme from national and regional governments and from regulatory agencies with jurisdiction over marine activities ;
(ii) a socio-economic analysis that critically reviews the potential benefits for local communities, and includes community-based approval for any farming research ;
(iii) confirmed availability of technology and finance to support a pilot scale programme, and support in principle from either the domestic or foreign commercial sector ;
(iv) the identification of potential coastal sites with the socio-economic and biophysical environmental conditions that may support *Kappaphycus* farming, with an assessment of the space available for farm production and farming activities without conflicting with customary rights and other uses ;
(v) a baseline inventory of existing benthic species, their abundance, and habitats present at potential sites ;
(vi) analysis of the potential negative and positive impacts of introducing a particular variety/strain of *Kappaphycus* to each potential coastal site, including contingencies for mitigating the potential risk of any unwanted spread of plants beyond proposed farming sites.

## 3. Sourcing and Selecting *Kappaphycus* 'seed' stock

Only farmed *Kappaphycus* should provide the 'seed' stock for any new introduction, and consultation with processors and other producers is recommended to determine which species and variety/strain is likely to be most suitable for the proposed new locations.

Potential risks of any introduction can be minimised by:

(i) sourcing the variety/strain from the nearest geographical location where it is being farmed ;
(ii) establishing and documenting the history of the variety/strain at the source location and at prior locations ;
(iii) sourcing the variety/strain from farmed stock that has never shown any spore production over several years, and is assumed to be non-reproductive or sterile ;
(iv) rejecting any source locations where the unwanted spread of plants has been identified as a problem e.g. plants readily attach themselves to substrates or their own branches ;
(v) selecting vigorous healthy plants with strong pigmentation (colour) as providers of vegetative cuttings. Ideally the parent farm stock should be pre-selected, out planted and grown for the purpose of producing cuttings for relocation ;
(vi) obtaining cuttings from only the tops of primary axes (main branches) that are no more than 6 to 8 weeks old. The cuttings and the parent stock must be free of 'ice-ice' and epiphytes e.g. *Ceramium* and *Polysiphonia*. Cuttings showing any tip whitening, herbivore wound damage, or surface callous growth should be rejected ;
(vii) implementing quarantine procedures at either the donor location or at the recipient new location.

## 4. Quarantine Procedure

Quarantine procedures should be taken every time cuttings are transferred across international borders or transplanted domestically to a new location, to reduce the risk of introducing diseases or invasive problems.
The scale and specifics of the equipment used for maintaining cuttings in a land-based culture system will depend on the facilities available in the donor or recipient country. The reader should refer to the quarantine techniques and procedures used for seaweeds in the following countries :

Brazil (Oliveira et al. 1995 and Paula et al. 1998), Madagascar (Ask et al. 2003a), Fiji (Sulu et al. 2003).

The principal features of any quarantine system are :

(i) an area isolated from any other activities at the facility to prevent contamination from other marine organisms ;
(ii) the ability to sanitize all equipment used ;
(iii) an independent supply of filtered and/or UV sterilised seawater ;
(iv) an independent discharge system that allows for chemical treatment of wastewater.

## 5. Farming Trials and Monitoring

The literature on *Kappaphycus* farming methods and some environmental factors necessary for viable commercial production is extensive and this, along with cultivation handbooks, provide a useful starting point for understanding trial results and assessing new site potential. The monitoring of physical parameters such as temperature, salinity and water movement, over an extended period is essential. However, the best indcator of favourable biophysical conditions is the *Kappaphycus* seaweed itself. The use of *Kappaphycus* as a bio-indicator of site fertility may require monitoring personnel with experience in the commercial production of the particular variety/strain under trial.

Proximity to coastal communities with a high dependence on coastal and marine resources for subsistence and income generation is an important criterion in selecting sites. However, consideration must be given to the surrounding environment and any problems that may arise from the introduction. In this respect, it may be desirable first to initiate trials in isolated areas, such as off-shore islands, where any potential problems can be contained,.

Farming trials should not be contemplated on or in close proximity to coral reefs, turtle nesting sites, dugong habitats or other habitats with special conservation value. Similarly, trials should never be established adjacent to marine protected areas or marine parks.

A monitoring programme for pilot farming trials should include:

(i) monitoring the performance of *Kappaphycus* to regularly assess site fertility, but also to identify any potential environmental problems ;
(ii) a farmer production database to provide verifiable indicators of economic viability and social benefits ;
(iii) an impact assessment of sourcing any farming materials from the coastal environment e.g. the use of mangroves and other coastal vegetation ;
(iv) the monitoring of any programme implemented to dispose of old or redundant farming consumables e.g. rope, plastic raffia, plastic floats etc. ;
(v) the identification of any socio-economic problems e.g. issues relating to access, allocation and tenure of marine space, and the use of communal land for farming activities.

Periodic written reports should be prepared and sent to the appropriate government agencies reporting on any environmental, economic and social problems.

## 6. Recommended Responsibilities of Government Agencies

(i) Ensure that any proposed farming trials conform with existing legislation pertaining to the use of marine areas and marine resource utilisation.
(ii) Facilitate a community-based consultation process and ensure that a farming development has community approval.
(iii) Promote and support commercial sector seaweed trading as part of rural development policy objectives.

(iv) Assume, internally or through external contractors, overall responsibility for programme evaluation and environmental monitoring.

(v) Initiate plans for an exit strategy involving the clean up of any unattended free-living plants in areas that do not sustain continuous farming activity.

## 7. Key References


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