Bord Iascaigh Mhara
Irish Sea Fisheries Board

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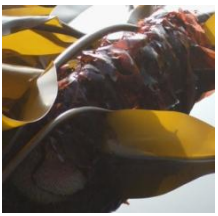

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Astrid Werner & Matthew Dring

This document is an output of the project, PBA/SW/07/001, 'Development and demonstration of viable hatchery and ongrowing methodologies for seaweed species with identified commercial potential'. This project is carried out under the Sea Change Strategy with the support of the Marine Institute and the Marine Research Sub-programme of the National Development Plan, 2007-2013.

Recommendations for optimal ongrowing and harvesting techniques for *Palmaria palmata* in different Irish sites with indications of yield

The recommendations given below are based on the result of trials carried out under the project PBA/SW/07/001 'Development and demonstration of viable hatchery and ongrowing methodologies for seaweed species with identified commercial potential'. At three hatchery sites (i.e. DOMMRS, MRI Carna Laboratories, QUB Portaferry), *Palmaria* was seeded on string and stocks were built up for ongrowth at sea. Four different open-sea aquaculture sites around Ireland were used for deployment and ongrowing of seeded material. The sites differed in exposure, water current and water temperature. The site in Strangford Lough (East coast, Irish Sea) is characterised by semi-exposure, high tidal current and lower average annual water temperature. Ard Bay and New Quay are located on the west coast of Ireland in sheltered to semi-sheltered bays with a good tidal water exchange but less current. The most sheltered aquaculture site with the least tidal current and highest average water temperatures is Roaringwater Bay (RWB) in the Southwest of Ireland.

For successful production of *Palmaria palmata* on longlines, several requirements have to be met from deployment to harvest. These are described in the following.

1. Seeded material for deployment:

High quality seeded string is essential for successful ongrowth of *Palmaria*. The density of sporelings on the string should be even over the whole length of string with 30-50 plantlets cm^{-1} prior deployment. The length of the largest sporelings should be 5-8 mm (Fig. 1). If the sporelings are too small, they are liable to be out-competed and overgrown by rapidly growing fouling algae, such as ectocarpoid algae, as was frequently observed during ongrowth trials. Sporelings of 5 mm or more seem to adapt to the change from hatchery to sea more rapidly and to resume growth in a shorter time. Consequently, following autumn/winter deployment, sporelings can reach a thallus length of about 5 cm before the almost complete cessation of growth in December. This enables growth to start again in late winter (i.e. January/February) before fouling sets in. Once a thallus length of 10 cm or more is reached, the chances of being overgrown by other algae are significantly reduced (Fig. 2). For summer deployment, it is even more critical to have an even and dense cover of *Palmaria* sporelings on the culture string, since there will be a higher abundance of opportunistic algae to settle on the string. Patchiness increases the risk of loss of crop through strong development of fouling algae and other organisms.

Fig. 1. *Palmaria* sporelings on culture string before deployment. The upper string is well seeded showing a high density (10-20 sporelings cm^{-1}) and the optimal size (5-8 mm) in comparison with the lower string.

Fig. 2. Culture string of *Palmaria* after 3 months at sea. The string is fouled by brown filamentous algae (*Ectocarpus* and similar species; arrow) and some filamentous *Ulva* species (green alga).

2. Time of deployment:

The best time for deployment at most sites is autumn (October to early December). Sporelings have the chance to grow for several weeks before growth ceases during the shortest days of the year and a drop in water temperature. In late autumn/winter, the pressure of fouling organisms is significantly reduced. Highest yields of

Palmaria were obtained from autumn deployment. When growth resumes in January/February, *Palmaria* sporelings have reached lengths of 5-10 cm and there is less chance of them being overgrown by fouling algae.

For aquaculture sites in areas where summer water temperatures exceed 15°C (i.e. the South and Southwest of Ireland), deployment is only possible in autumn/winter. Of the four aquaculture sites used for trials, only Strangford Lough permitted successful ongrowth following summer deployment, provided that the deployed material fulfilled the requirements described above.

3. Ongrowth at sea

The most critical stage for the *Palmaria* sporelings is the period immediately after deployment. The deployment of any kind of culture string provides a new substrate for the settlement of any other algal spores or organisms which are floating in the water column. Of these potential fouling organisms, fine filamentous algae (often a variety of ectocarpoid algae) are the most damaging as they develop more rapidly than the *Palmaria* sporelings and thus can overgrow and literally smother the latter. Because the filaments are so fine and all-enveloping, removal of these fouling algae is not feasible. Therefore the quality of deployed material and the timing of deployment are critical. Fouling of deployed *Palmaria* string by larger algal species generally sets in at a later stage. These larger species include the green alga *Ulva*, red algal species such as *Polysiphonia*, *Lomentaria*, *Ceramium*, and large brown algae such as *Sargassum muticum*, *Saccharina latissima* and *Saccorhiza polyschides*. Which of these species occur and when they appear will vary from site to site around Ireland. Other fouling and grazing organisms which are frequently found on the culture string and structural ropes of the longlines are sea squirts, hydrozoans and snails (Fig. 3). The deployed *Palmaria* should be monitored frequently, if possible once a month. Larger fouling algae should be removed from head ropes and nets or droppers.

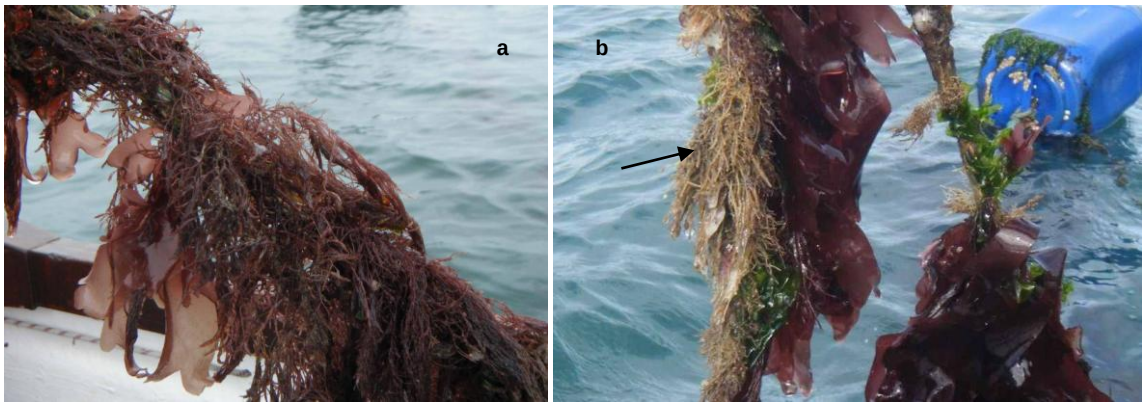

Fig. 3. a, b) Culture string of Palmaria after 4.5 months at sea. Left: The string is heavily fouled by red algae. Right: Hydrozoans (arrow) have settled on the string as well as the green alga *Ulva*.

4. Harvesting techniques and yield of Palmaria palmata

The number of harvesting trials conducted was restricted by the limited availability of harvestable crop. For various reasons (e.g. poor quality of deployed material, patchiness of *Palmaria* on culture string, heavy fouling), *Palmaria* on nets and droppers often did not grow to harvestable size or there was only a patchy distribution of harvestable plants on the culture substrate. Therefore, no trials of mechanical harvesting techniques could be attempted. All material was hand-harvested.

In order to determine the best strategy for harvesting *Palmaria* with respect to method and timing, samples from 10 cm of culture string were taken at intervals during the growing season and the potential yield estimated (see Table 1), or all large plants were removed at each harvest, allowing the remaining small plantlets, whose growth had so far been suppressed by the larger *Palmaria* individuals, to continue growing (multiple harvests, Table 2).

Table 1. Yield of *Palmaria palmata* on droppers deployed in Ard Bay and Strangford Lough.

Deployment	Location	Days at sea	Months at sea	Yield (g FW m^{-1})	Standard-deviation
Nov. 2009	Ard Bay	151	5	750	156
Oct. 2010	Strangford Lough	153	5	510	101
Oct. 2010	Strangford Lough	180	6	880	460
Nov. 2010	Strangford Lough	158	5	1190	530

Multiple harvests of one culture string (i.e. 3-4 harvests from a net or dropper at monthly intervals from early spring until early summer) have yielded the highest biomass and would be the method of choice. However, harvesting in this way is not always feasible. The prerequisite for multiple harvests is a high quality of seeded culture string, i.e. even and dense cover by *Palmaria* sporelings. At high density, the strongest sporelings grow out first and can be harvested after approx. 4 months at sea. At this stage the largest *Palmaria* fronds have not reached their mature size but the outgrowth of smaller sporelings is possible after their removal (Fig. 4). A dense cover is essential to prevent fouling organisms to overgrow *Palmaria* sporelings and to encourage growth of sporelings through intraspecific competition. Yields from multiple harvests of a net deployed in Ard Bay in 2009 and harvested in 2010 are given in Table 2. A total yield of 25 kg was obtained after three harvests of one net.

Fig 4. Growth of Palmaria on a net after 4 months at sea in Ard Bay.

Table 2. Yield from multiple harvests of *Palmaria palmata* on nets deployed in Ard Bay.

Deployment	Location	Days at sea	Months at sea	Yield (g FW m^{-1})	Total yield (kg FW)
Dec. 2009	Ard Bay	111	4	91	7.1
		147	5	150	11.7
		183	6	80	6.3

The timing of the harvest is just as critical as the timing of deployment for obtaining a high quality crop. If only one harvest is to be performed, 5 months at sea will generally provide a high quality crop with a satisfactory yield. For *Palmaria* deployed in November, for example, the best time for harvest would be in April. After 6 months at sea, the likelihood of deterioration of fronds because of grazing or high irradiance increases, and the fronds may become so heavy that they are easily dislodged from the culture string. When multiple harvests are performed, these problems are reduced because of a "rejuvenation" of the *Palmaria* crop, due to sequential outgrowth of fronds. However, the development of *Palmaria* at sea and the optimal times for harvest naturally vary from year to year depending on weather, water temperatures, and availability and vigour of fouling organisms.

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