

Distribution and biomass of epiphytic seaweeds on the kelp *Ecklonia maxima* (Osbeck) Papenfuss, and the potential effects of two kelp-harvesting methods in the Western Cape.



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## **ABSTRACT**

The demand for freshly harvested kelp, *Ecklonia maxima*, in the Western Cape, has greatly increased due to the need for fodder to supply the growing abalone industry. There is evidence suggesting that the present demand may exceed the amount of *E.maxima* available, if the traditional method of harvesting continues (cutting the whole kelp plant off, just above the holdfast). There is also evidence that, although the kelp beds recover in 2 – 3 years, and are ready for the next harvesting event, the epiphytic seaweed populations have not recovered even 5 years after harvesting. A new method of harvesting has been proposed, where the secondary blades of the *E.maxima* are cut 30cm from the primary blade. This method would increase the amount of kelp that can be harvested sustainably. This study investigated whether this new method of harvesting would have less impact on the epiphytic seaweed populations, particularly the three obligate epiphyte species; *Carpoblepharis flaccida*, *Polysiphonia virgata* and *Suhria vittata*, and whether there is pattern of distribution of epiphyte populations around the Cape Peninsula. The distribution of the epiphytes on the different portions (stipe; primary blade and first 30cm of secondary blades; rest of the secondary blades) of kelp was investigated. *E.maxima* was sampled at five sites around the Cape Peninsula, and the epiphytes on each portion were identified and weighed. All the epiphytes except *Carpoblepharis flaccida* were found predominantly on the portion of kelp that would be left after the new method of harvesting, and would therefore be unaffected. It was found that the mass of *C.flaccida* removed in the new method was not significantly different from the mass remaining; therefore a large proportion is left untouched. There was no geographic pattern of distribution of *C.flaccida* in relation to water temperature around the Cape Peninsula. The results suggest that this new method of harvesting would have little impact on the epiphyte populations, which is an added incentive for changing the method of harvesting.

**Key words:** *Ecklonia maxima*, epiphytes, *Carpoblepharis flaccida*, *Polysiphonia virgata*, *Suhria vittata*, kelp harvesting.

## INTRODUCTION

Extensive beds of the kelp, *Ecklonia maxima* (Osbeck) Papenfuss (Laminariales, Phaeophyceae), are found dominating the inshore regions of the West Coast of Southern Africa, from Papenkuilsfontein (ca. 10km west of Cape Agulhas) to north of Luderitz, Namibia (Stegenga *et al.* 1997).

For over 30 years, small quantities of fresh *E. maxima*, have been harvested from the West Coast of South Africa. However, recently there has been an increasing demand for freshly harvested kelp due to the growth of the cultured abalone industry. In fact the harvesting of kelp for abalone fodder is the fastest growing use of seaweeds in South Africa (Anderson *et al.*, in press).

Since it started in 1992, commercial abalone farming in South Africa has been greatly expanding. More and more farms are being built and these farms are growing, the current stock is estimated to be worth R150 million. The abalone are preferentially fed fresh kelp as this improves flesh taste. The figures of kelp harvests for abalone feed clearly show that this industry is a major factor causing the increasing demand for kelp. The figures are as follows, 0.2t in 1992, 0.9t in 1993, 1.6t in 1994, 2.1t in 1995, 5.2t in 1996, 6.1t in 1997, 23.3t in 1998, 215.5t in 1999 (Anderson *et al.* in press) and 2300t in 2000 (Anderson pers. comm.).

The traditional method of kelp-harvesting involves divers cutting the kelp. The structure of *Ecklonia maxima* is shown in Figure 1a. They cut all *Ecklonia maxima* plants with stipes longer than about 50cm, just above the holdfast. The plants float to the surface due to the gas-filled bladder at the top of the stipe. The holdfasts subsequently die, and the recovery of the kelp bed relies on the growth of the small plants left behind as well as the recruitment of new plants. Plants are harvested in 60m wide lanes, which are expected to be cut every 2-3 years (Levitt *et al.*, in press).

There is evidence that kelp regenerates quickly and that after harvesting, kelp biomass recovers within 2-3 years (Anderson *et al.* 1989, Anderson, pers comm.). However Marine and Coastal Management have some data suggesting that seaweed epiphyte populations associated with the kelp plants are more sensitive to harvesting. In an experimental site just north of Saldanha Bay, the biomass of the 3 common epiphytic seaweeds had not recovered within 5 years of harvesting (Anderson, pers comm.).

Levitt *et al.* (in press) also encountered problems with the harvesting of kelp for abalone fodder. Their study was done at Danger Point, on the Cape Peninsula, which is one of the main harvesting sites and is located near two of the largest abalone mariculture facilities. It was found that the estimation of fresh *E. maxima* biomass in the area is insufficient to sustain the projected abalone feed requirements. However they proposed a solution.

The sporophyte of *Ecklonia maxima* (Figure 1a) is made up of an elongated stipe, a primary blade and secondary blades produced bilaterally. These secondary blades or “fronds” as they are sometimes known are the portion fed to the abalone. Levitt *et al.* (in press) found that when the kelp's secondary blades were cut, at a distance of 20–30 cm from the base of the blades, they continued growing. Mann *et al.* (1979) showed that the growth of the secondary blades of *Ecklonia* occurs towards the base of the blades. They likened the growth to “a moving belt of tissue, adding at the base and eroding at the tip”. Levitt *et al.* (in press) ~~author~~ suggested a new method of harvesting: instead of cutting the whole kelp, one would simply cut the secondary blades off 20-30 cm from the base of the secondary blades. They found that this method produces a higher yield of frond material, specifically; long-term yields 4-5 times higher (per area of substratum) than if whole plants were cut.

Therefore they proposed this as a new method of harvesting. This method is far more productive as whole life-histories do not need to be completed between

harvests. It is also more efficient as it is only the fronds that are fed to the abalone. Using this new procedure, the required commercial yield can be achieved from much smaller areas than if whole plants are harvested.

This new method may also have important consequences for the epiphyte populations growing on the kelp plants. As explained above, the previous method eliminates the epiphyte populations and they are not fully recovered even after 5 years. Therefore if the beds are harvested every 2 years, the epiphyte populations will never recover.

This is not the only evidence that kelp harvesting severely affects the kelp's epiphytic populations. Christie *et al.* (1998) investigated the recolonisation of epiphytes onto harvested *Laminaria* beds in Norway. The *Laminaria* beds are trawled in Norway, a different method of harvesting kelp. The trawling events are limited to every 4 to 5 years. It was found that the epiphyte species composition recovered after the first 2-3 years, however the relative abundance data showed that the epiphytes did not recover before the next trawling episode. Thus it is unlikely that these populations will <sup>ever</sup> fully recover in an area subjected to repeated trawling.

The full consequences of this decline of epiphytes to the kelp bed community are unknown. The kelp plants may actually benefit from a decrease in epiphytes as the presence of these seaweeds may decrease the growth rate of their host, increase the probability of breakage and may decrease reproductive output (Luning 1990). However the kelp bed community has an abundance of intricate interactions that occur together for the successful functioning of the system. The epiphytes may play an important role in this order.

In South African kelp beds, an important example of how the epiphyte populations are vital for the community, is the significance for the hottentot fish, *Pachymetopon blochii* (Val.). Hottentot fish form a major component of the

Western Cape commercial handline catch. The hottentot fish occurs commonly in and around kelp beds and has also been identified as an important carnivore in the kelp bed community, therefore contributing to the overall functioning. Pulfrich and Griffiths (1988) studied the feeding biology of the hottentot, with an estimate of daily ration. Gut content analysis was done for a sample of hottentots to determine their diet. It was found that the hottentot was an omnivore, consuming a wide variety of algae and invertebrate prey. Of the major prey categories, the most important were amphipods, represented in 64% of the stomachs examined and contributing to 30% of the volume of the diet. It had been previously thought that hottentots accidentally ingested amphipods whilst grazing on algae.

However there was no association between the algae and the amphipods in the stomach, suggesting that hottentot selectively prey on amphipods. It is therefore apparent that amphipods are an important component of the hottentot diet. Allen and Griffiths (1981) surveyed the fauna and flora of a kelp bed community and found that 27 species of invertebrates occurred in the canopy and these organisms are mainly associated with the epiphytic algae. The densely tufted epiphytic algae provide favourable microhabitats for a variety of organisms. It is therefore clear that the epiphytic algae are of great importance in terms of the feeding biology of the hottentot. It is also significant to note that the second most important identifiable component of the hottentot's diet was algae, many being epiphytic or parasitic on the kelp plants themselves (Pulfrich and Griffiths 1988). Algae occurred in 34% of the fish and contributed to 19% of the volume, suggesting another important role of the epiphytes.

It is also interesting to note that Pulfrich and Griffith's study showed that the most noticeable trend in changing proportions of the various food categories in fish of increasing size is the progressive decline in the proportion of amphipods eaten and the corresponding increased reliance on algal browsing. This suggests that amphipods are an important part of the juvenile diet. This was confirmed by direct underwater observation of fish. Juveniles were seen occurring singly or in small groups only leaving shelter to feed for short periods. When they get big enough they can leave shelter for longer and join the foraging shoals. If there is

a shortage of epiphytic algae, the adults can browse on the other algae available. However for the juveniles this shortage of epiphytes and the subsequent shortage of amphipods may greatly affect their diet and development.

The potential effect on the hottentot is one example of the problems that may arise from decreasing the epiphyte populations. Another example of the importance of epiphytes is for the teleost, *Sarpa salpa* (Linnaeus). Hutchings (1968) showed that algae (including epiphytes) are an important component of their diet. It is impossible to quantify all the species that may be affected by a decrease in epiphytes.

The new method of harvesting only removes the distal portions of the secondary blades. If the majority of the epiphytes occur on the stipe and first 30cm of the fronds, then the populations will be less affected by the harvesting than the previous method. This will therefore have a decreased effect on the associated fauna of the plants.

Over 50 species of epiphytic algae have been reported as growing on the stipes and holdfasts of *Ecklonia maxima*. The most important are the three obligate (i.e. they do not occur anywhere else) kelp epiphytes *Suhria vittata*, *Carpoblepharis* spp., *Polysiphonia virgata* (Stegenga *et al.* 1997).

Marine and Coastal Management are trying to encourage the kelp harvesters to use the new method of cutting fronds only, resulting in increased production. However it is much easier to harvest whole kelp, take them ashore and cut off the fronds on the beach and therefore the harvesters prefer this method. If it were found that the epiphyte populations are protected by leaving the plants alive, there would be added justification for the 'fronds-only' harvesting, and it would be further encouraged.

The purpose of this study is to determine whether the new method of harvesting will have less impact on the epiphytic algae found on the kelp than the traditional method. The biomass and distribution of the different epiphytic algae was determined by dividing the kelp into three portions and weighing the epiphytes on each portion. This was used to determine the abundance of epiphytes that would be removed by fronds-only method compared to the traditional whole-cutting method.

An additional aim was to determine whether the distribution and abundance of the kelp epiphytes varied around the Cape Peninsula, given that sea water temperatures are generally higher in False Bay than on the West Coast of the Peninsula (Stegenga *et al.* 1997).

## METHODS

### **Study Sites**

Five sites around the Cape Peninsula were sampled (Figure 2): Oudekraal, Soetwater, Buffels Bay, Glencairn and Dalebrook. All support *E. Maxima* beds and are periodically exposed to strong wave action.

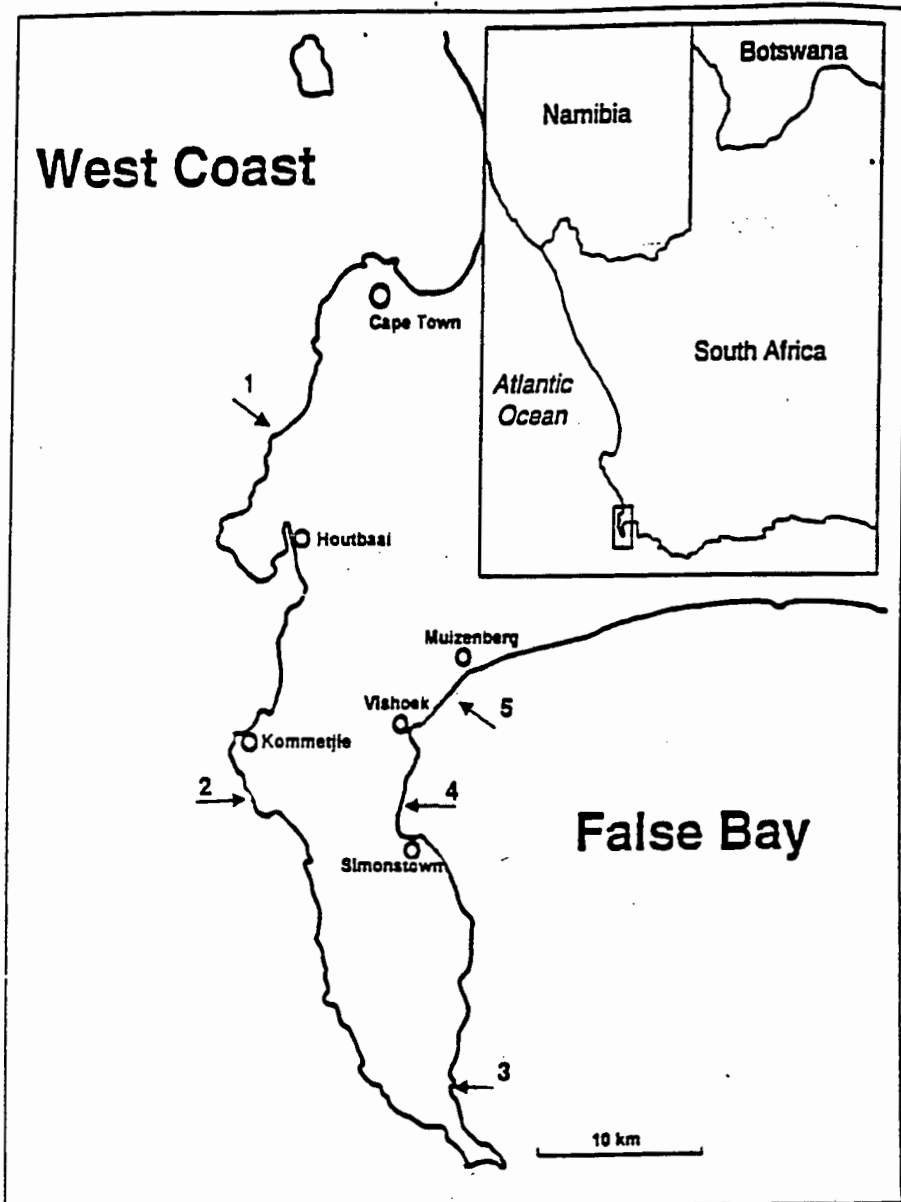


Figure 2: Map of the five different areas sampled, 1. Oudekraal, 2. Soetwater, 3. Buffels Bay, 4. Glencairn and 5. Dalebrook.

## Methods

The sampling was carried out at spring tides from April to September 2001. At each site, 10 quadrats were placed by SCUBA. Each quadrat was 1 X 1m, and they were placed at increasing depths along the kelp bed. The first quadrat was placed by selecting a typical area at about 1m depth, then all subsequent quadrats were placed at regular intervals out to the extent of the visible surface kelp.

The depth of each quadrat was measured and all the kelp plants in the quadrat with stipes longer than 0.5m were cut just above the holdfast and taken to the shore.

Each plant was cut into three parts:

1. the stipe;
2. the primary blade with the first 30cm of the secondary blades (In this analysis, this portion will be called the "basal fronds");
3. and the remaining portions of the secondary blades (in this analysis, this portion will be called the "distal fronds").

See Figure 1b for a schematic diagram and Pictures 1 & 2.

The epiphytes from each portion of the kelp were removed, identified and their mass recorded.

Each section of the plant was then measured: stipe length, stipe mass, basal frond mass, distal frond mass.

The basal fronds were additionally divided into fronds and primary blades and weighed.

The number of species of epiphytes occurring on each portion of kelp was recorded to give an idea of the species diversity of the different portions.

Thereafter, only the three dominant, obligate species of epiphytes were analysed; *Carpoblepharis flaccida*, *Polysiphonia virgata* and *Suhria vittata*. The

total mass of each of these three epiphytes was recorded per quadrat to give the mass of epiphyte per m<sup>2</sup> of substrate. This unit was used in comparisons between the portions of kelp and the different sites.

Authorities for all seaweed names are as in Stegenga *et al.* (1997).

The difference between the occurrence of these three main epiphytes on the different portions of kelp was determined using Chi-square tests. The differences between the mass of these epiphytes per m<sup>2</sup> of substrate on the different portions of kelp is presented as Box and Whisker plots.

The difference between the mass of *Carpoblepharis* per m<sup>2</sup> of substrate on the portion of kelp remaining and the portion taken in the new method of harvesting was determined with a t-test.

The difference between the proportion of *Carpoblepharis* on the basal fronds and the distal fronds was determined by using the Wilcoxon's matched pairs test. This test was performed as the proportion data was not normally distributed.

The difference in *Carpoblepharis* abundance on the different portions of kelps at the five different sites was determined using Kruskal Wallis ANOVA and the two-way ANOVA. All tests were performed in STATISTICA, and the significance values were presumed to be >0.05.

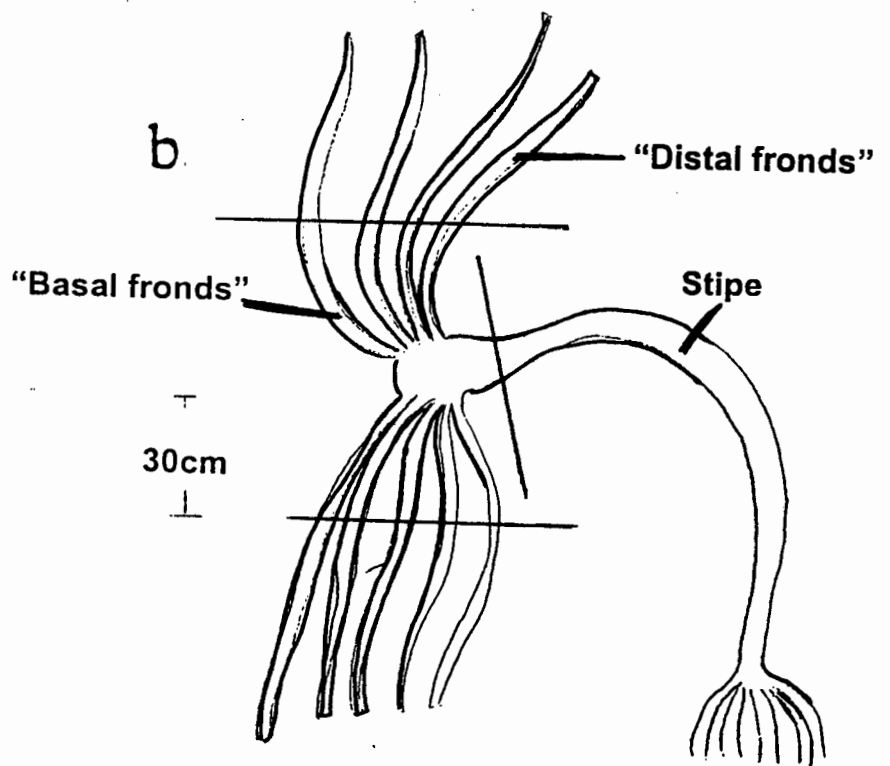
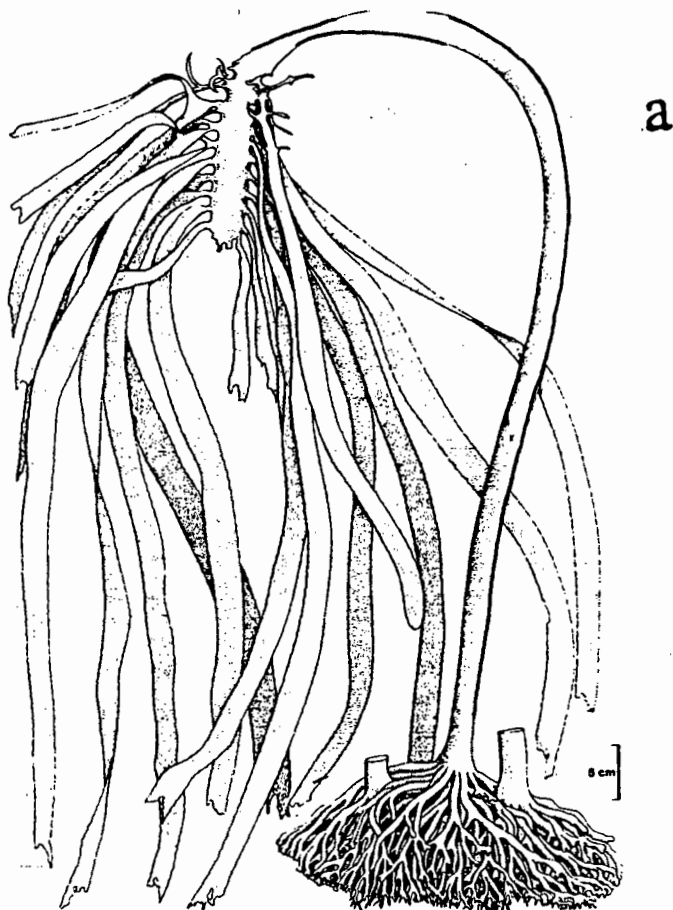


Figure 1: a) Habit of *Ecklonia maxima* sporophyte (young plant) (taken from Stegenga 1997), b) Schematic diagram of the different portions of kelp.



Pictures 1 & 2: Photographs of *Ecklonia maxima* plants that were sampled showing the different portions. (Hazel Drummond).

## RESULTS

Firstly, all the different species of epiphytes found on the different portions of kelp for all five sites were recorded to give an indication of the species richness on the different portions. This is shown in Table 1.

Table 1: The different species of epiphytes found on the different portions of kelp.

Species of epiphytes found on the stipe	Species of epiphytes found on the basal fronds	Species of epiphytes found on the distal fronds
<i>Acrosorium maculatum</i> <i>Botryocarpa prolifera</i> <i>Bryopsis</i> sp. <i>Carpoblepharis flaccida</i> <i>Desmarestia firma</i> <i>Ecklonia maxima</i> (juven) <i>Gigartina polycarpa</i> <i>Kallymenia agardhii</i> <i>Neuroglossum binderianum</i> <i>Placophora binderii</i> <i>Polysiphonia virgata</i> <i>Porphyra</i> sp. <i>Pterosiphonia</i> sp. <i>Suhria vittata</i> <i>Thamnophyllis discifigera</i> <i>Ulothrix flacca</i> <i>Ulva</i> sp. Blackening(sp.Unknown) Crustose coralline	<i>Botryocarpa prolifera</i> <i>Bryopsis</i> sp. <i>Carpoblepharis flaccida</i> <i>Centroceras clavulatum</i> <i>Neuroglossum binderianum</i> <i>Placophora binderii</i> <i>Polysiphonia virgata</i> <i>Pterosiphonia cloiophylla</i> <i>Suhria vittata</i> <i>Ulothrix flacca</i> <i>Ulva</i> sp. <i>Gigartina polycarpa</i>	<i>Carpoblepharis flaccida</i> <i>Polysiphonia virgata</i> <i>Suhria vittata</i>

The numbers of species found on different portions is shown in Figure 3. All species authorities are as in Stegenga *et al.* (1997).

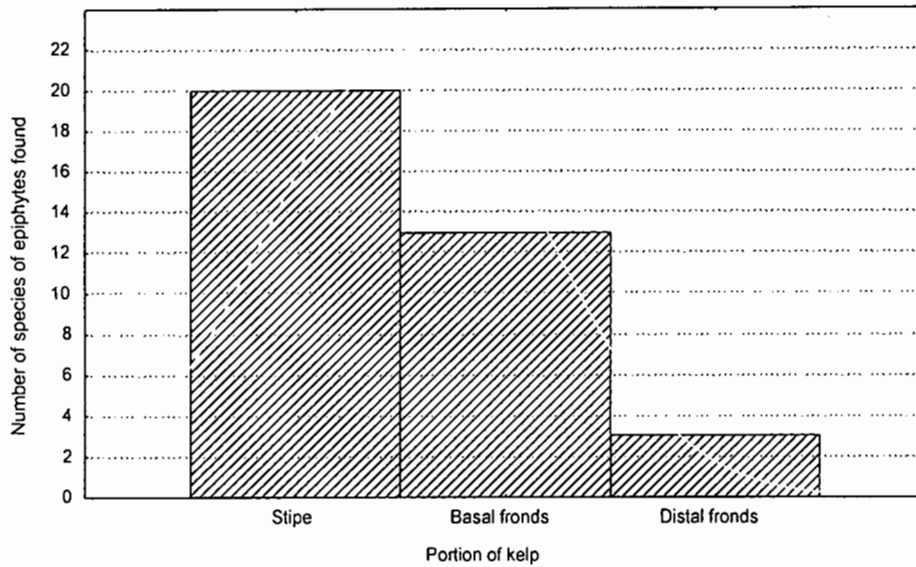


Figure 3: The total number of species found on each portion of the kelp for all sites combined

It is clear that the portion of kelp with the highest species diversity of epiphytes is the stipe. The portion with the least number of species is the distal fronds. This portion only bears the three main species of epiphytes, *Carpoblepharis flaccida*, *Polysiphonia virgata* and *Suhria vittata*.

### Distribution of the three dominant epiphytes

The only three species of epiphytes that were found to be common on all portions of the kelp were *Carpoblepharis flaccida*, *Polysiphonia virgata* and *Suhria vittata*. To determine where on the kelp these species are found, Chi-square analyses were done with the presence/absence data and the different areas of kelp.

Table 2: Two-way summary table of the presence and absence of *Polysiphonia* on the different portions of kelp for all sites. (Pearson Chi-square value = 47.57, df = 2, p= 0.00001).

	Present	Absent	Total
Stipe	28	193	221
Basal	2	219	221
Distal	1	220	221
Total	31	632	663

Table 3: Two-way summary table of the presence and absence of *Suhria* on the different portions of kelp for all sites. (Pearson Chi-square value = 61.498, df = 2, p= 0.00001).

	Present	Absent	Total
Stipe	35	186	221
Basal	3	218	221
Distal	0	221	221
Total	38	625	663

Table 4: Two-way summary table of the presence and absence of *Carpoblepharis* on the different portions of kelp for all sites. (Pearson Chi-square value = 111.69, df = 2, p= 0.00001).

	Present	Absent	Total
Stipe	16	205	221
Basal	92	129	221
Distal	117	104	221
Total	225	438	663

Tables 2,3 and 4 show that for all three species, the two variables (presence/absence and part of kelp) are not independent of one another. In other words, the distribution of epiphytes is different on different part of the kelp.

For *Polysiphonia* and *Suhria*, it is clear that most of the epiphytes are found on the stipe (Tables 2 & 3). This is confirmed by the average biomass of these epiphytes occurring per m<sup>2</sup> (Fig. 4 & 5).

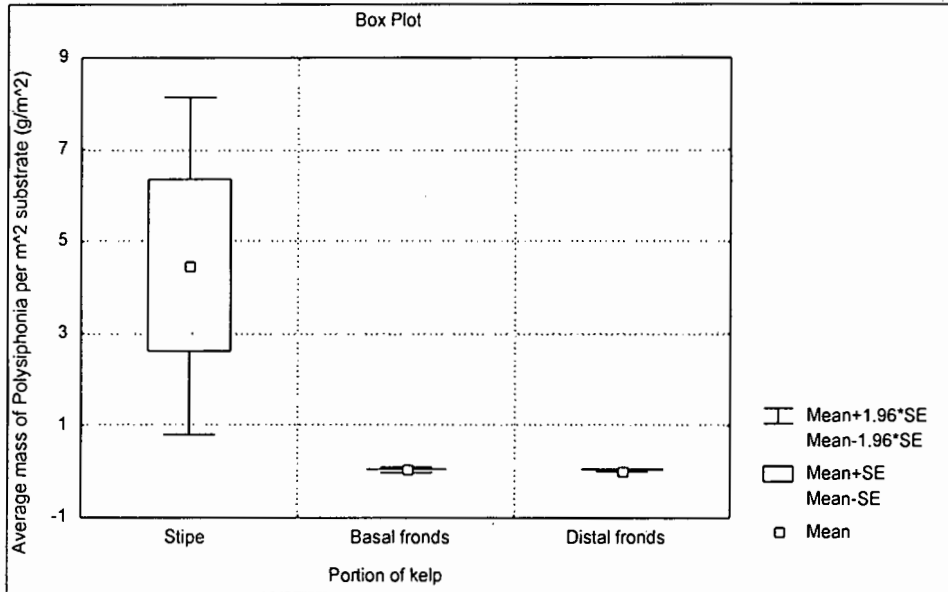


Figure 4: Box and whisker plot of the average mass of *Polysiphonia* per m<sup>2</sup> of substrate.

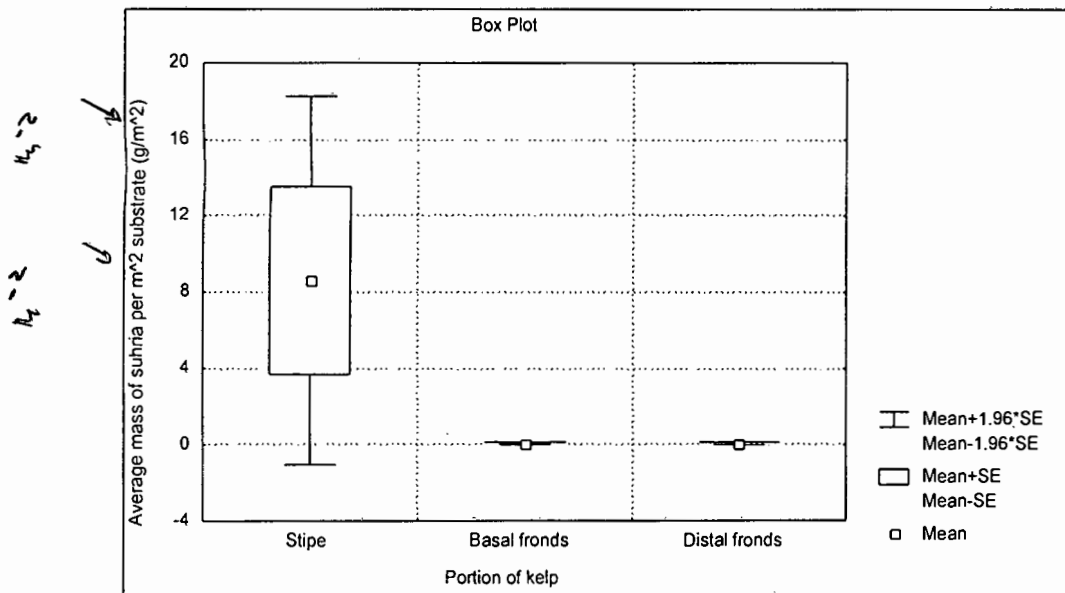


Figure 5: Box and whisker plot of the average mass of *Suhria* per m<sup>2</sup> of substrate.

However for *Carpoblepharis*, the two-way classification table (Table 4) shows that the stipe houses the minority of the epiphytes. The distal fronds have the highest occurrence of *Carpoblepharis* (Table 4), followed by the basal fronds. This is confirmed by the average biomass data (Fig. 6).

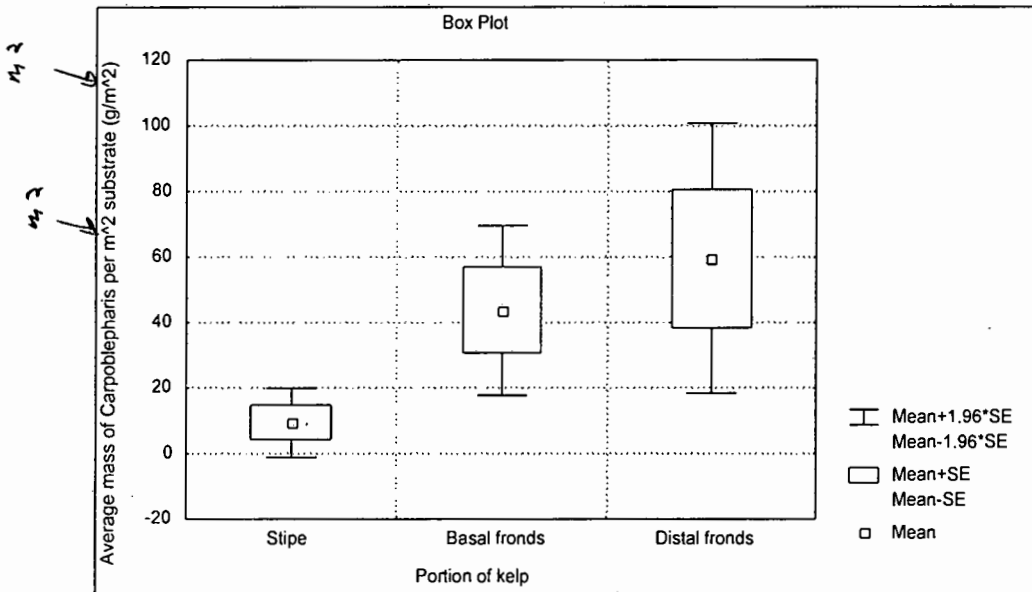


Figure 6: Box and whisker plot of the average mass of *Carpoblepharis* per m<sup>2</sup> of substrate for the different portions of kelp, for all sites.

In terms of what epiphytes will be removed when the distal fronds are harvested, it is clear that for *Polysiphonia* and *Suhria*, most will be left behind. However for *Carpoblepharis* the majority of the epiphytes are found on the distal fronds. To determine the effect of the new method of harvesting, the epiphytes occurring on the portion taken and the portion remaining must be looked at. The portion remaining is the stipe and the basal fronds together. The average mass of *Carpoblepharis* on the portion remaining and the portion taken is shown in Figure 7.

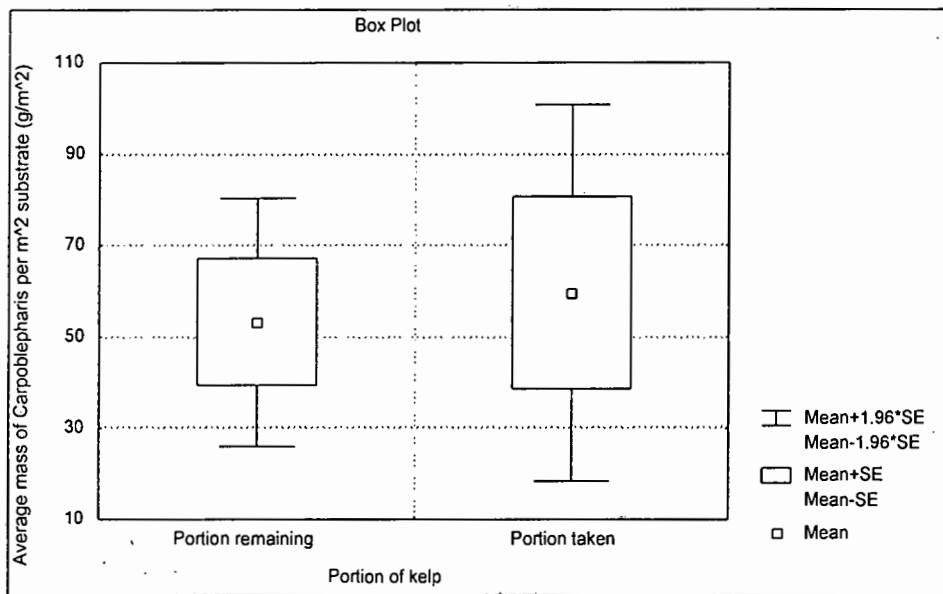


Figure 7: Box and whisker plot of the average mass of *Carpoblepharis* per m<sup>2</sup> of substrate for the portion of kelp remaining and the portion of kelp taken in the new method of harvesting.

The average biomass of *Carpoblepharis* on the portion taken and the portion remaining seem to be similar. To determine whether these values are significantly different, a t-test was performed on all the average biomasses for the five different sites. The biomasses on the two portions were not normally distributed, and therefore the data was transformed using the log (x+1) transformation. This produced a data set that was normally distributed. The variances were not significantly different, therefore the t-test was performed (Table 5)

Table 5: Results of the t-test performed on the average biomass of *Carpoblepharis* on the portion of kelp remaining and taken in the new method of harvesting per m<sup>2</sup> substrate, for the five different sites.

t	N	Df	p-level
0.0898	50	49	0.929

There is no significant difference between the average biomass of *Carpoblepharis* on the remaining portion and the taken portion of kelp in the new method of harvesting.

The kelp biomass data was used to determine the proportion of *Carpoblepharis* per g of kelp for the basal and the distal fronds. This was done by dividing the mass of

*Carpoblepharis* by the mass of kelp for each portion. For the basal fronds, only the mass of the fronds was used, not the primary blade. The next step was to find out whether there was a difference between the proportion of epiphyte per gram of kelp for the basal and the distal fronds. It is known from statistical theory that proportions from 0 to 1, form a binomial, rather than a normal, distribution (Zar 1999). A possible solution to this is to transform the data using the arcsine transformation, such that

$$P' = \arcsin \sqrt{P}$$

This transformation was carried out for the data, however the results were still not normally distributed. Therefore a non-parametric test was used.

To determine whether there is a significant difference between the proportion of *Carpoblepharis* per gram of kelp on the basal and distal fronds, the Wilcoxon's Matched Pairs test was performed. The matched pair test is used because the proportion on the basal fronds is compared to the proportion on the distal fronds of the same plant. Only the plants that had *Carpoblepharis* occurring on both the basal and the distal fronds were used, so a comparison could be made. The results are shown in Table 5.

Table 5: Results of the Wilcoxon's Matched Pairs test between the proportion of *Carpoblepharis* per gram of kelp for the basal and distal fronds.

Mean basal proportion (g epi per g kelp)	Mean distal proportion (g epi per g kelp)	Valid N	T	Z	p-level
0.055128	0.087357	69	828	1.939	0.0544

The mean proportion of *Carpoblepharis* per gram of kelp on the distal fronds is higher than the basal fronds. This difference is not significant at the 95% level, but is significant at the 90%.

## Differences in distribution of epiphytes between the sites

To determine whether there is a difference in epiphyte abundance on the different portions of kelp between the five sites, the distribution of *Carpoblepharis* was examined. The mass of *Carpoblepharis* per square metre for all the quadrats was compared for each portion.

The distribution of *Carpoblepharis* mass on the stipe was not normally distributed, and even after a  $\log(x+1)$  transformation was used, the data did not fit a normal distribution. Therefore the non-parametric Kruskal-Wallis ANOVA was used to determine whether there was a difference in abundance of *Carpoblepharis* on the stipe between the sites. The results are shown in table 6.

Table 6: The results of the Kruskal-Wallis ANOVA showing that there is a significant difference between the abundance of *Carpoblepharis* on the stipes of the plants at the five different sites.

H (4, N = 50)	P
20.659	0.0004

The results show that there is a significant difference between the abundance of *Carpoblepharis* on the stipes of the plants at the different sites. To determine which sites are different, Box and Whisker plots were drawn.

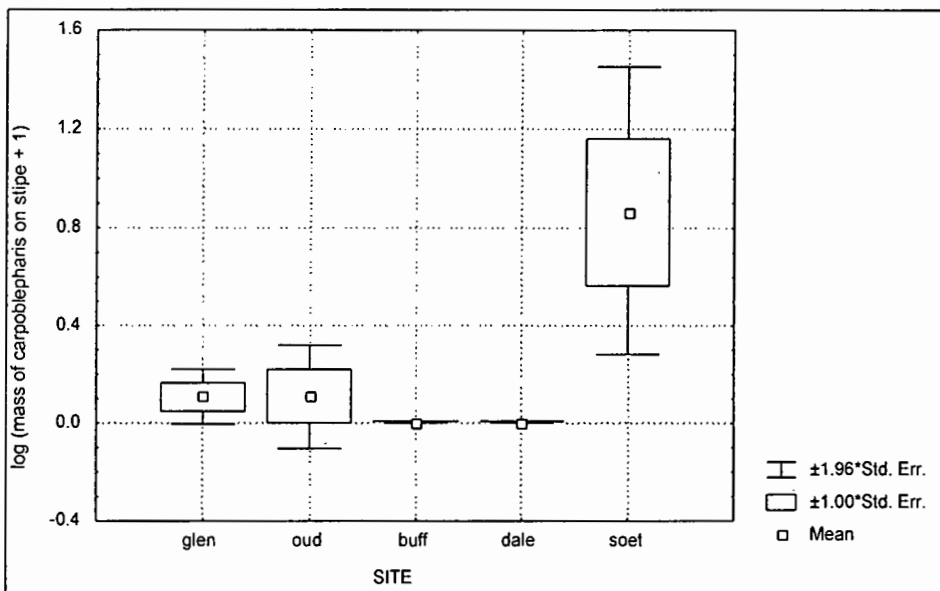


Figure 8: Box and Whisker plots of the log of the average mass of *Carpoblepharis* per  $m^2$  of substrate found on the stipes of the plants at the five different sites. The key for the sites are glen = Glencairn, oud = Oudekraal, buff = Buffels Bay, dale = Dalebrook and soet = Soetwater.

The Box and Whisker plots show that the abundance of *Carpoblepharis* at Soetwater is surprisingly high and significantly different from the others.

The data for the mass of *Carpoblepharis* per m<sup>2</sup> of substrate for the basal and distal fronds, when log transformed using log(x+1), were normally distributed. When the Levene's test of Homogeneity of Variances was performed, both sets of transformed data showed no significant difference between the variances. Therefore to determine whether there were any differences between the abundance of *Carpoblepharis* on the basal and distal fronds for the five sites, two-way ANOVAs were performed. The results of these tests are shown in table 7.

Table 7: Results of two-way ANOVAs performed on the mass of *Carpoblepharis* per m<sup>2</sup> of substrate on the basal and distal fronds for the five different sites.

Portion of kelp	N	F	P
Basal fronds	50	9.598	0.00001
Distal fronds	50	4.755	0.002

Both sets of results show that there are significant differences between the mass of *Carpoblepharis* per m<sup>2</sup> of substrate on the basal and distal fronds for the five different sites. The Scheffe test for post-hoc comparisons of means was performed for both data sets. The results showed that for the basal fronds, the mean mass of *Carpoblepharis* per m<sup>2</sup> of substrate was highest at Glencairn and that this site was significantly different to the others. This is also shown in the Box and Whisker plot.

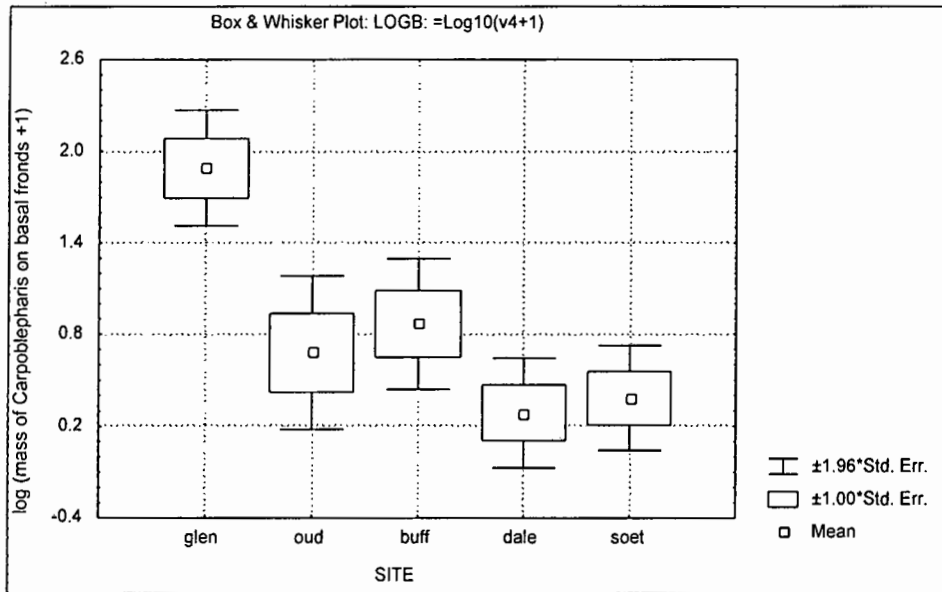


Figure 9: Box and Whisker plots of the log of the average mass of *Carpoblepharis* per m<sup>2</sup> of substrate found on the basal fronds of the plants at the five different sites. The key for the sites are glen = Glencairn, oud = Oudekraal, buff = Buffels Bay, dale = Dalebrook and soet = Soetwater

The results of the Scheffe test for post-hoc comparisons of means for the distal fronds showed that the mean mass of *Carpoblepharis* per m<sup>2</sup> of substrate on the distal fronds was significantly different between Glencairn and Oudekraal and Glencairn and Dalebrook. Once again the Box and Whisker plot shows that Glencairn has a particularly high mean mass of *Carpoblepharis* on the distal fronds. In this case, however, this mass is only significantly different to the two sites that have the lowest mean masses, Oudekraal and Glencairn.

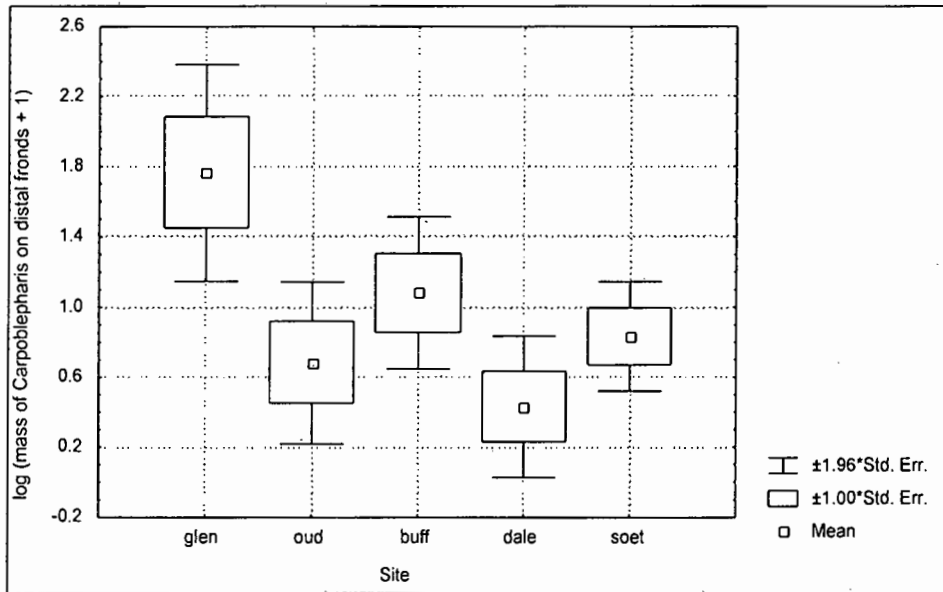


Figure 10: Box and Whisker plots of the log of the average mass of *Carpoblepharis* per m<sup>2</sup> of substrate found on the basal fronds of the plants at the five different sites. The key for the sites are glen = Glencairn, oud = Oudekraal, buff = Buffels Bay, dale = Dalebrook and soet = Soetwater

In terms of *Carpoblepharis flaccida*, the sites that seem to have a different abundance of epiphyte compared to the others are Soetwater and Glencairn. The plants at Soetwater have a particularly large mean mass of *C. flaccida* on the stipe, and the plants at Glencairn have a particularly large mass of *C. flaccida* on the basal and distal fronds.

## **DISCUSSION**

In a complex community, it is almost impossible to understand the importance of one component and how it contributes to the functioning of the system. The epiphytes of the Western Cape kelp beds play an integral part in the feeding biology of the Hottentot, an important commercial fish. However the ecological and economic significance of this case may be just one example of the importance of kelp epiphytes and their associated fauna. There may be other fish or different kinds of organisms affected. There is no doubt that epiphytes play an important role in the ecosystem.

In Norway, trawling of *Laminaria* seriously affects epiphyte populations (Christie *et al.* 1998). In South Africa, whole-plant cutting at intervals of less than 5 years would similarly cause a reductions to epiphytes.

The new “fronds-only” method has been shown to be more efficient in terms of utilising the resources. However what about the epiphytes? Will this method decrease the adverse effects on the epiphyte populations?

The new method only removes the distal portion of the secondary blades, leaving the first 30cm of the secondary blades intact. Therefore the epiphytes occurring on the stipe, the primary blade and the first 30 cm of the secondary blade will not be removed. The stipe had the highest species diversity with 20 species found. The three species of epiphytes found on the distal fronds were also found on the other areas. Therefore in terms of species, when the distal fronds are removed, no species of epiphytes are eradicated completely and there will not be the need for colonisation from other areas. The species diversity will be maintained.

Christie *et al.* (1998) found that in Norwegian *Laminaria* beds, it was the relative abundance of the epiphytes that did not recover after five years. Therefore it was also important to regard the biomass of the epiphytes. Only the biomass of the

three main epiphytes was considered, as the other species occurred in very small amounts.

Both *Polysiphonia* and *Suhria* were generally found on the stipe. The average biomass of these epiphytes on the different portions reflected this, with the majority found on the stipe. Therefore the new method of harvesting would have an insignificant impact on the populations of *Polysiphonia* and *Suhria*. The fronds would be taken and these epiphytes would be left untouched.

The distribution of *Carpoblepharis* on the kelp was different to the other epiphytes. There was a much higher biomass found on the fronds than on the stipe. However when the average mass of *Carpoblepharis* on the distal fronds (the portion that would be removed) was compared to that on the basal fronds and stipe together (the portion that would remain), it was found that there was no significant difference between the two. Therefore the new method of harvesting would leave an average mass of *Carpoblepharis* close to half of what was there beforehand. With this large proportion left behind, it would no doubt be much easier for the population to recover.

The age of the different portions must also be considered. Jennings and Steinberg (1997), in a study of the kelp *Ecklonia radiata* found that most of the variation of epiphyte distribution on the kelp plants was adequately explained by an increase in epiphyte loads on older tissue. They explained that this pattern presumably reflects either simple accumulation and growth of epiphytes over time or tissue that was higher in the water column. The height would have an effect because of both the light filtering effect that kelp canopies can have and shading of lower portions of thalli. On *Ecklonia maxima*, the mass of *Carpoblepharis* per gram of kelp for the basal fronds (younger material) was compared to that of the distal fronds (older material). It was found that the proportion found on the distal fronds was significantly higher than the proportion found on the basal fronds which supports the pattern found by Jennings and

Steinberg (1997). However *Ecklonia maxima* differs from *Ecklonia radiata* in that the younger portions are not lower in the water than the older portions. The entire frond is found near the surface. Therefore it seems likely that difference in abundance epiphytes on the different aged portions seems to be due to the simple accumulation and growth of the epiphytes. However, Russell (1983) showed that the growing tissue of kelps actively prevents epiphytic settlement. This may be a reason why there is a higher proportion of *C.flaccida* on the distal fronds. Nonetheless, after the distal fronds are removed by the new method of harvesting, and the fronds recover (grow in a belt-like fashion), the biomass of *Carpoblepharis* will increase as the portions of the fronds get older.

The distribution and biomass of epiphytes on the different areas of kelp have shown that the new method of harvesting would not only increase the efficiency of collecting kelp, but would also drastically decrease the impact of harvesting on epiphytic populations. Most of the species would be almost untouched by the harvesting including two of the main epiphytes, *Polysiphonia* and *Suhria*. The impact on the other main epiphyte, *Carpoblepharis*, would be drastically reduced with approximately half of the former population remaining after harvesting. There is also a good chance that the biomass would recover quickly as the fronds grow back.

Although water temperatures are warmer in False Bay than on the West Coast of the Cape Peninsula, and there is evidence of an increase in temperature from Buffels Bay to Kalk Bay (Bolton & Anderson 1990), the present study detected no pattern in the geographical distribution in abundance of *C.flaccida*. The abundances were mostly similar with two sites showing significantly high mean masses.

It is also important to consider the structure of the kelp forest. Christie *et al.* (1998) explained that after harvesting of *Laminaria* by dredging, the difference between the harvested and unharvested areas is that the harvested areas have a

much more homogeneous distribution. All the adults are removed together and therefore the new recruits will all start growing at the same time. The authors suggested that one of the contributing factors to the inability of the epiphytes to recover may be light. The canopy-forming plants can greatly reduce the light penetration and the new dense homogeneous kelp generation will inhibit light penetration more efficiently than the heterogeneous untrawled forest. Therefore there may not be enough light for the epiphytes to grow. The new method of harvesting would maintain the heterogeneity of the forest with older and younger plants remaining together. The kelp forest would maintain a more natural stand.

It seems that the new proposed method of harvesting would greatly influence the continuation of the epiphyte communities, which are an important component of the kelp bed. This is another incentive for the transformation from the traditional to the “fronds-only” method.

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