

OBSERVATIONS ON ALGAL FLORAS CLOSE TO TWO SEWERAGE OUTLETS

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ABSTRACT

May, V. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, New South Wales, Australia 2000) 1985. Observations on algal floras close to two sewerage outlets. *Cunninghamia* 1(3), 385-394. The algae present in the general area of planned sewerage outlets at an ocean (Ulladulla) and an estuarine (Plantation Point) headland, both south of Sydney, were recorded and changes in the floras and in the abundance of individual species were observed over a period of three to five years after the installation of the sewerage pipes. Species numbers declined after sewage began flowing, there were some floristic changes, and certain taxa showed changes in abundance. The same few species, namely *Gelidium pusillum*, *Ralfsia* sp. and *Ulva lactuca*, became important near both outlets, thriving on both sides and in the main part of the sewage flow. Both the extent and the degree of change caused by the sewage were greater at Ulladulla where the volume of sewage discharged was greater and its pre-treatment less thorough.

INTRODUCTION

Relatively little is known of changes induced in algal floras subjected to the influence of sewage. For Britain, Edwards (1972, 1975) reports only minor effects caused by sewage pollution, while in both Europe and America, Golubic (1970), Waite & Mitchell (1972), Littler & Murray (1975) and Murray & Littler (1977) report very great changes. Generally, the overall richness of the flora is reduced, and relatively few species increase in abundance. In the only previous local study, Borowitzka (1972) measured species diversity of intertidal macro-algae at three sites in the Sydney region that differed in levels of pollution from sewage. He showed that there was a decrease in the total number of algal species and in algal species diversity associated with a sewer outfall.

The proposed siting of sewerage outlets at Ulladulla and Plantation Point (Jervis Bay), some 200 km south of Sydney, stimulated the present studies of the macro-algae. The general intertidal flora of these headlands is described by May (1981). The observations reported now began before the sewerage works were installed and continued for three to five years. Species present in the intertidal zone near the outlet pipes were recorded and changes in the flora and in the abundance of individual species after the installation of the sewerage outfalls documented.

The study sites

Both study sites lie on the warm temperate east coast of Australia, in southern New South Wales. Ulladulla (35° 21'S, 150° 29'E) is some 40 km south of Plantation Point (35° 04'S, 150° 42'E; May, 1981). In each case, the general area selected for the outlet was a small natural indentation in the rock platform, 16 m wide at Ulladulla and 10 m wide at Plantation Point. The Ulladulla outlet is subject to extremely heavy seas, especially when southerly winds occur, while the outlet at Plantation Point, within Jervis Bay, is relatively wave-sheltered. The sewerage outlet pipe in each case was installed with the bottom of the pipe discharging near the interface of the tidal and sub-tidal zones. The sewage discharged contains low volume domestic effluent, after secondary treatment at Ulladulla and tertiary treatment at Plantation Point; the volume discharged is greater at Ulladulla (Table 1).

TABLE 1
Characteristics of sewage effluents*

Item	Ulladulla	Plantation Point
Treatment	Secondary	Tertiary
Average dry weather flow	$> 3 \times 10^6$ L/day	$0.6-1.0 \times 10^6$ L/day
Average biological oxygen deficiency (day 5)	$20-40 \times 10^{-3}$ g/L	$5-10 \times 10^{-3}$ g/L
Average non-filterable residue	$20-30 \times 10^{-3}$ g/L	$10-20 \times 10^{-3}$ g/L
Average pH	7.0-7.4	7.9-8.4

*Information supplied by Shoalhaven City Council, Nowra.

METHODS

The algal flora at the Ulladulla site was surveyed at monthly intervals between January 1974 and June 1979. The sewerage outlet was installed and functioning by September 1975. The study at Plantation Point started in March 1976 and continued until June 1979. Sewage began flowing from the outlet there in August 1976.

The areas below the vertical edge of the rock platforms and extending out as far as could be reached and/or seen at low tide were studied, a distance of about 16 m at Ulladulla, and about 6 m at Plantation Point. In both cases the overall vertical drop in the area of observation was just over one metre.

The species present were noted and their abundance assessed as "rare", "occasional", "common" or "very common". Observations were not possible at times because of the roughness of the sea or the timing of the low tides. Illness interrupted collecting during the 1976-77 period. Thus, at Ulladulla, there were 11 sets of records in 1974 (between January and December, 10 in 1975-76 (July-June), seven in 1977-78 (July-June) and eight in 1978-79 (July-June). The observations were made at Plantation Point on four dates in 1976 (between March and August), seven during 1977-78 (July-June) and nine during 1978-79 (July-June).

Between May 1978 (about 30 months after the commencement of sewage discharge) and June 1979 at Ulladulla, monthly records were kept of the relative proximity of various algae to the outlet pipe. The algal species were listed in order of occurrence from nearest the mouth of the sewerage outlet to some distance away. The sequence of algae nearest the outlet at Plantation Point was examined in the same way, regular observations being made from July 1978 (23 months after the outlet was opened) to June 1979.

Voucher specimens of all algae collected are lodged at the National Herbarium of New South Wales, Royal Botanic Gardens, Sydney (NSW). In the case of a common variable plant such as *Ulva lactuca*, detailed taxonomic study may indicate that a name covers a cluster of species. It is impossible to determine species within the Ectocarpales complex if the material is immature or infertile, so all records are grouped together in the tables under the "complex" name. All of the algae mentioned in the paper occur generally in the area of the respective headlands.

RESULTS

Algae occurring in the general area of the outlet at Ulladulla

Records of presence and of changes in abundance of the 37 species noted in the general area of the outlet at Ulladulla are given in Table 2. Following the opening of the sewerage outlet in September 1975 there was a decrease (from 31 to between 26

TABLE 2
Species recorded from the general area of the sewerage outlet at Ulladulla

Species	Changes in abundance			Periods of occurrence				
	Increase	No change	Decrease	1974	75-6	76-7	77-8	78-9
<i>Acrotylus australis</i> J. Ag.	—	x	—	x	x	x	x	x
<i>Bangia fuscopurpurea</i> (Dillw.) Lyngb.	x	—	—	—	x	—	x	x
<i>Calothrix crustacea</i> Schousb. & Thuret	—	x	—	—	x	—	—	—
<i>Centroceras clavulatum</i> (C. Ag.) Mont.	—	—	x	x	—	—	—	—
<i>Ceramium</i> sp.	—	—	x	x	x	—	—	—
<i>Chaetomorpha aerea</i> (Dillw.) Kuetz.	x	—	—	—	—	—	x	x
<i>Chondria</i> sp.	—	x	—	x	x	x	x	x
<i>Cladophora repens</i> (J. Ag.) Harv. <i>Codium cuneatum</i> S. & G.	—	—	x	x	—	—	—	—
<i>Corallina</i> sp.	—	x	—	x	x	x	x	x
<i>Corallina officinalis</i> L.	—	x	—	x	x	x	x	x
<i>Dictyota dichotoma</i> (Huds.) Lamour	—	x	—	—	—	x	—	—
Encrusting red calcareous alga	—	x	—	x	x	x	x	x
<i>Endarachne binghamiae</i> J. Ag. <i>Enteromorpha intestinalis</i> (L.) Link.	x	—	—	—	x	—	x	x
<i>Gelidium pusillum</i> (Stackh.) Le Jol.	—	x	—	x	x	x	x	x
<i>Gigartina aculeifera</i> Zan.	—	x	—	x	x	x	x	x
<i>Griffithsia monilis</i> Harv.	—	—	x	x	—	—	—	—
<i>Helminthocladia dotyi</i> Wom.	—	—	x	x	—	—	—	—
<i>Hildenbrandtia</i> sp.	—	x	—	x	x	x	x	x
<i>Jania</i> sp.	—	x	—	x	—	—	—	—
<i>Laurencia brongniartii</i> J. Ag. <i>Laurencia filiformis</i> (C. Ag.) Mont.	—	—	x	x	x	x	x	x
<i>Lophosiphonia reptabunda</i> (Suhr.) Cribb	—	x	—	—	x	—	—	—
<i>Nemalion multifidum</i> (W. & M.) J. Ag.	—	—	x	x	x	—	—	—
<i>Padina fraseri</i> (Grev.) Grev. <i>Phyllospora comosa</i> (Labill.) C. Ag.	—	—	x	x	x	—	—	—
<i>Plocamium cartilagineum</i> (L.) Dixon	—	—	x	x	—	—	—	—
<i>Porphyra columbina</i> Mont.	x	—	—	x	x	x	x	x
<i>Pterocladia capillacea</i> (Gmel.) Born. & Thur.	—	x	—	x	x	x	x	x
<i>Ralfsia</i> sp.	x	—	—	x	x	x	x	x
<i>Rhodomenia australis</i> (Sond.) Harv.	—	—	x	x	—	—	—	—
<i>Sargassum lophocarpum</i> J. Ag.	—	—	x	x	x	x	x	x
<i>Sargassum ?neurophorum</i> J. Ag. <i>Splachnidium rugosum</i> (L.) Grev. <i>Ulva lactuca</i> L.	—	x	—	x	x	x	x	x
<i>Wrangelia plumosa</i> Harv.	—	x	—	x	x	x	x	x
TOTALS	5	15	17	31	26	19	22	21

and 19) in the total number of species recorded in any one year. Of the 31 species recorded in 1974, nine did not occur after the installation of the sewerage outlet (*Centroceras clavulatum*, *Cladophora repens*, *Codium cuneatum*, *Griffithsia monilis*, *Helminthocladia dotyi*, *Jania* sp., *Padina fraseri*, *Plocamium cartilagineum* and *Rhodomenia australis*) and a further three of the 31 were not recorded after the 1975-76 period (*Ceramium* sp., *Nemalion multifidum* and *Phyllospora comosa*). *Splachnidium rugosum* was present less often during the later years.

TABLE 3
Algae occurring nearest the sewerage outlet at Ulladulla*

Species	Frequency of occurrence (10 observation dates)		
	LHS	Centre	RHS
<i>Gelidium pusillum</i>	6	5	3
<i>Ralfsia</i> sp.	4	3	5
<i>Ulva lactuca</i>	5	2	7
<i>Corallina officinalis</i>	5	—	10
<i>Acrotylus australis</i>	1	—	3
<i>Chondria</i> sp.	1	—	5
Encrusting red calcareous alga	4	—	3
<i>Gigartina aculeifera</i> [†]	7	—	3
<i>Pterocladia capillacea</i>	3	—	5
<i>Hildenbrandtia</i> sp.	1	1	1
<i>Laurencia filiformis</i>	2	—	—
<i>Sargassum lophocarpum</i>	1	—	—

*Species are listed in order of occurrence from nearest the mouth of the outlet.

[†]Found growing on *Pyura*.

Two species (*Bangia fuscopurpurea* and *Enteromorpha intestinalis*) appeared soon after the sewerage outlet was functional and remained throughout the period of study, whilst another, *Chaetomorpha aerea*, appeared later. Some species, including *Calothrix crustacea*, *Dictyota dichotoma* and *Lophosiphonia reptabunda*, appeared only in one year.

Eighteen species occurred throughout the study period; 12 of these showed no obvious change in abundance, while four others (*Endarachne binghamiae*, *Laurencia brongniartii*, *L. filiformis* and *Sargassum lophocarpum*) decreased in abundance and two (*Ralfsia* sp. and *Porphyra columbina*) increased.

Thus, the total number of species recorded in any one year decreased following the installation of the sewerage outlet, and also, of those species that occurred in two or more years, eight decreased in abundance whilst five increased.

Algae occurring nearest the sewerage outlet at Ulladulla

Table 3 gives the frequency of occurrence of species found closest to the outlet pipe between May 1978 (30 months after sewage started flowing) and June 1979. They are listed in order of occurrence from nearest the mouth of the outlet to some distance (1 to 2 m) away. Only 12 of the 37 species recorded in the general area have been observed close to the outlet. Nine of these occur commonly and three are less frequent; all must be considered tolerant of sewage effluent.

The three species found nearest to the sewerage outlet (*Gelidium pusillum*, *Ralfsia* sp. and *Ulva lactuca*) grew on both sides and also in the central area, receiving the full effect of the outfall. While *Ulva lactuca* was common on much of the headland prior to the installation of the outlet and retained its position near the outlet pipe throughout the period of study, *Ralfsia* sp. increased in abundance and *Gelidium pusillum* did not appear there until October 1978, but by June 1979 was the dominant plant nearest the outlet. Six other species occurred commonly on both sides of the outfall but not in the central area, and three others were recorded as infrequent (Table 3).

Algae occurring in the general area of the outlet at Plantation Point

Table 4 lists the 35 species noted in the area of the sewerage outlet at Plantation Point and the changes in their abundance over time. Too few collections were made

TABLE 4
Species recorded from the general area of the sewerage outlet at Plantation Point

Species	Changes in abundance			Periods of occurrence		
	Increase	No change	Decrease	1976	77-8	78-9
<i>Amphiroa anceps</i> (Lamour.) Decne.	x	—	—	—	x	x
<i>Audouinella purpurea</i> (Lightft.) Woelk.	—	(x)	—	—	(x)*	—
<i>Ceramium</i> sp.	—	—	x	x	—	(x)
<i>Champia</i> sp. (as recorded May <i>et al.</i> 1978)	—	x	—	x	x	x
<i>Cladophora repens</i> (J. Ag.) Harv.	—	x	—	x	x	x
<i>Codium lucasii</i> Setchell	—	x	—	x	(x)	x
<i>Colpomenia sinuosa</i> (Roth.) Derb. & Sol.	—	x	—	x	x	x
<i>Corallina officinalis</i> L.	—	x	—	x	x	x
<i>Cystophora moniliformis</i> (Esper.) Wom. & Niz.	—	x	—	—	x	—
<i>Dictyota dichotoma</i> (Huds.) Lamour.	—	x	—	—	x	—
<i>Ecklonia radiata</i> (C. Ag.) J. Ag.	—	x	—	x	x	x
Ectocarpales complex	—	—	x	x	x	—
Encrusting red calcareous alga (as May, 1981)	—	x	—	x	x	x
<i>Enteromorpha intestinalis</i> (L.) Link.	—	x	—	x	x	x
<i>Gelidium pusillum</i> (Stackh.) Le Jol.	—	x	—	x	x	x
<i>Griffithsia monilis</i> Harv.	—	—	x	x	—	—
<i>Hildenbrandtia</i> sp.	x	—	—	—	x	x
<i>Hormosira banksii</i> (Turn.) Decne.	—	x	—	x	x	x
<i>Laurencia filiformis</i> (C. Ag.) Mont.	—	x	—	x	x	x
<i>Lobophora variegata</i> (Lamour.) Wom.	—	x	—	x	x	x
<i>Lophosiphonia reptabunda</i> (Suhr.) Cribb	—	—	x	x	—	—
<i>Martensia elegans</i> Hering	x	—	—	—	—	x
<i>Microcoleus lyngbyaceus</i> (Kuetz.) Crouan	—	(x)	—	—	—	(x)
<i>Padina fraseri</i> (Grev.) Grev.	—	x	—	x	x	x
<i>Petrospongium rugosum</i> (Ok.) S. & G.	—	x	—	—	x	—
<i>Phyllospora comosa</i> (Labill.) C. Ag.	—	(x)	—	—	—	(x)
<i>Polysiphonia</i> sp. (as recorded May <i>et al.</i> 1978)	—	—	x	x	—	—
<i>Porphyra columbina</i> Mont.	x	—	—	—	(x)	x
<i>Ralfsia</i> sp.	x	—	—	—	x	x
<i>Sargassum lophocarpum</i> J. Ag.	—	x	—	x	x	x
<i>Scytosiphon lomentaria</i> (Lyngb.) C. Ag.	x	—	—	—	—	x
<i>Sphacelaria tribuloides</i> Menegh.	—	—	x	x	(x)	—
<i>Styopodium zonale</i> (Lamour.) Pap.	—	(x)	—	—	(x)	—
<i>Ulva lactuca</i> L.	x	—	—	—	x	x
<i>Zonaria turneriana</i> J. Ag.	—	x	—	x	x	x
TOTALS	7	18+(4)	6	21	22+(5)	22+(3)

* (X) = recorded outside of comparative period (March–August).

in 1976, before the opening of the outlet, to justify a comparison between the number of species occurring in each year. However, since pre-installation data are available for the autumn and winter months (March to August) of 1976, comparisons can be made for this period for each year: the resulting figures indicate that species numbers are almost constant (21, 22 and 22 respectively).

Some species, including *Griffithsia monilis*, *Lophosiphonia reptabunda* and *Polysiphonia* sp., were not recorded after the opening of the sewerage outlet, whilst others disappeared later (*Ectocarpales* complex and *Sphacelaria tribuloides*) or were less often present (*Ceramium* sp.). Others were noted for the first time after the sewage began flowing and either increased in abundance (*Amphiroa anceps*,

Hildenbrandtia sp., *Porphyra columbina*, *Ralfsia* sp. and *Ulva lactuca*) or were recorded during one year only (*Cystophora moniliformis*, *Dictyota dichotoma*, *Petrospongium rugosum* in 1977-78; *Martensia elegans* and *Scytosiphon lomentaria* in 1978-79). Four taxa were noted only outside the periods of comparison (Table 4). Fifteen species occurred in all three years and did not change in abundance over that period.

Thus, the number of species recorded did not change greatly following the installation of the sewerage outlet and, although there were some floristic changes, the relative abundance of most of the taxa did not change.

Algae occurring nearest the sewerage outlet at Plantation Point

Table 5 gives the frequency of occurrence of species closest to the outlet pipe between July 1978 and June 1979 at Plantation Point. Seventeen of the 35 species recorded in the general area have been observed close to the outlet.

Six species occurred on both sides of the outlet and also in the central area, receiving the full effect of the outfall. Of these, *Corallina officinalis* was always present and abundant. *Enteromorpha intestinalis* was very common but somewhat seasonal in occurrence, while *Gelidium pusillum* and *Ulva lactuca* were less often present. *Ralfsia* sp. and an encrusting red calcareous alga became more common towards the end of the observation period.

Three species (*Colpomenia sinuosa*, *Laurencia filiformis* and *Sargassum* sp.) were recorded from both sides of the outfall but did not occur in the central area; *Sargassum* sp. was the most common of these. A further eight species were noted as occasionally present close to the outlet (Table 5).

DISCUSSION

Effects of sewage

Comparison of the data from Ulladulla and Plantation Point suggests that the sewage has had a much greater effect on the algal flora at Ulladulla. The total number of species found in the general area of the outlet has been reduced rapidly and there have been considerable changes in individual species abundance at Ulladulla that are not shown to the same extent at Plantation Point.

Of the six species at Plantation Point recorded as receiving the full effect of the sewage outfall, only three were found in a similar position at Ulladulla (*Gelidium pusillum*, *Ralfsia* sp. and *Ulva lactuca*), although two others were present on both sides of the outlet there (*Corallina officinalis* and the encrusting red calcareous alga; Tables 3 and 5). At Plantation Point, *Ralfsia* sp. and the encrusting red calcareous alga are increasing in abundance, whilst at Ulladulla, *Gelidium pusillum* has become dominant. It seems likely that these differences represent a time-dependent adjustment to the effect of sewage, since the sewerage outlet has been functioning for a shorter period at Plantation Point than at Ulladulla.

Changes in the floras near the outlet pipes are not simple variations from year to year or from season to season. For example, *Gelidium pusillum* progressively decreased in frequency on both headlands between 1973 and 1979 (May, 1981) but became important near both sewerage outlets during the same period. Seasonal increases were shown by *Enteromorpha intestinalis* at both headlands and by *Ralfsia* sp. at Plantation Point, but changes were negligible in *Gelidium pusillum*, *Corallina officinalis*, *Ulva lactuca* and the encrusting red calcareous alga. Changes in season

TABLE 5
Algae occurring nearest the sewerage outlet at Plantation Point*

Species	Frequency of occurrence (9 observation dates)		
	LHS	Centre	RHS
<i>Corallina officinalis</i>	9	6	9
Encrusting red calcareous alga	5	1	3
<i>Enteromorpha intestinalis</i>	4	2	3
<i>Gelidium pusillum</i>	1	1	1
<i>Ralfsia</i> sp.	2	2	5
<i>Ulva lactuca</i>	2	1	1
<i>Amphiroa anceps</i>	3	—	—
<i>Colpomenia sinuosa</i>	1	—	3
<i>Laurencia filiformis</i>	2	—	2
<i>Sargassum</i> sp.	6	—	9
<i>Zonaria turneriana</i>	3	—	—
<i>Cladophora repens</i>	2	—	—
<i>Codium lucasii</i>	1	—	—
<i>Hildenbrandtia</i> sp.	1	—	—
<i>Hormosira banksii</i>	1	—	—
<i>Martensia elegans</i>	—	—	1
<i>Microcoleus lyngbyaceus</i>	—	1	—

*Species are listed in order of occurrence from nearest the mouth of the outlet.

had little or no effect on the distribution and abundance of the species nearest the sewerage outfall.

The greater effect of the sewage at Ulladulla compared with that at Plantation Point correlates with the marked difference in the amount and type of sewage present. The sewage at Plantation Point received tertiary treatment, compared with only secondary at Ulladulla, and the average dry-weather flow, the non-filterable residue and the biological oxygen demand were lower at Plantation Point than at Ulladulla (Table 1).

At Ulladulla the number of species present decreased rapidly soon after the sewage began flowing and there were further reductions within 12 months of the outlet becoming functional. Also, a number of species decreased in abundance over time, whilst some others increased. The changes in abundance of some species, at least, appear to be due to the effects of the sewage, as their abundance rating was unchanged in areas not affected by sewage over the same period (May, 1981). At Plantation Point there were comparatively few losses immediately after the sewage began and even less later. Thus, even though the effluent would generally be more aerated and more readily dispersed by water movement at Ulladulla (due to its position on an ocean rock platform) the effect of the sewage was much more obvious there. It seems that the amount and type of sewage discharged was more significant than the nature of the outfall site.

Comparison with other studies

Edwards (1972) reported a small effect of sewage within an estuary and he later stated (Edwards, 1975) that general pollution had little effect on species diversity on open coasts where there is good water circulation. While this may apply for areas some distance away from the outlet, the reduction in numbers of species and the changes in abundance in certain taxa near the sewerage outlet recorded here are more in accord with the results of Golubic (1970). For the Mediterranean coast he reported that, while the numbers of species decreased with organic pollution, the number of individuals of the remaining species increased until only two became

dominant (species of *Ulva* and *Hypnea*) and later even these disappeared. His work on the Adriatic coast (Golubic, 1970) showed that increased pollution led to increased amounts of *Ulva lactuca* and *Codium tomentosum*. Elsewhere, Waite & Mitchell (1972) reported that fertilization by sewage can lead to a diverse flora of an estuary being reduced to a single dominant, *Ulva*, and Ranwell (1972) noted that extensive growths of *Enteromorpha* occurred where sewage accumulated. Littler & Murray (1975) reported that a Californian area subjected to low-volume domestic sewage was dominated by "blue-green algae" and by *Gelidium pusillum*, *Ulva californica* and small *Pterocladia capillacea*. In a later paper, the species recorded as most abundant "in the upper- and mid-littoral [zones] of the outfall region" were "blue-green algae", Ectocarpaceae, colonial diatoms, *Ulva californica* and *Gelidium pusillum* (Murray & Littler, 1977).

The importance of *Corallina officinalis* in the present study is in accord with Kindig's (1977) comment on the remarkable dominance of coralline algae in areas of high sewage concentration and in contrast to that of Brown *et al.* (1977) who found that the growth of coralline algae was "significantly inhibited by a medium enriched with orthophosphate"; the level of enrichment was probably the significant difference.

Borowitzka (1972) listed *Enteromorpha* spp. and *Chaetomorpha aerea* as the two taxa dominant near the sewerage outlets at North Head, Sydney, and a further seven species as present in the general vicinity of the outlets (*Ulva* sp., *Corallina* sp., *Petalonia (Ilea) fascia*, *Jania* sp., *Pterocladia pinnata*, *Porphyra columbina* and *Centroceras clavulatum*). All of these except *Petalonia* are recorded in the general area of the ocean outlet at Ulladulla, but the dominant species (*Gelidium pusillum*, *Ralfsia* sp. and *Ulva lactuca*) differ, and of the others, only *Corallina officinalis* and *Pterocladia capillacea* are important close to the outlet pipes (Table 3). The differences may be linked with the length of time the sewerage outlet has been operating or with the high levels of detergents present in the sewage released at Sydney compared with the southern site, but further investigation of the differences are needed.

CONCLUSIONS

This study has examined the changes occurring in algal floras and in the abundance of individual algal species subjected to the influence of sewage over a period of five years at an ocean headland, Ulladulla, and three years at an estuarine headland, Plantation Point, both on the South Coast of New South Wales.

At Ulladulla there was a marked and rapid decrease in the total number of species recorded in any one year in the general area of the outlet and also some changes in floristics and in abundance (both decreases and increases) of certain species. At Plantation Point some similar changes were noted but these were less marked.

Close to the sewerage outlets at each site there was a great decrease in species numbers and in each case a few species became abundant, growing on both sides and in the main path of the sewage flow. Three species, *Gelidium pusillum*, *Ralfsia* sp. and *Ulva lactuca*, occur in these conditions at both outlets, despite one outlet being oceanic and the other estuarine. Two other species, *Corallina officinalis* and an encrusting red calcareous alga, are also found in the immediate vicinity of the outlets at each site.

The reduced number of species in the general area and the lower number of species dominant nearest to the sewerage outlet at Ulladulla compared with Plantation Point suggest that the effects of the sewage are much greater at Ulladulla. It is considered that the volume of sewage discharged and the nature of the pre-treatment of the effluent are important factors and are more significant than is the nature of the outlet site. The longer period that the sewerage outlet at Ulladulla has been functioning compared with that at Plantation Point may also be important.

Comparisons with other studies indicate that only a few genera, and often the same few, are important at sites affected by sewage (*Corallina*, *Codium*, *Enteromorpha*, *Ulva*, *Gelidium* and *Pterocladia*) and in some cases even the same species, such as *Ulva lactuca* and *Gelidium pusillum*; they indicate the widespread nature of the tolerance to sewage amongst diverse groups of algae.

Other observations suggest that the effects noted until now within a short distance of the sewerage outlets are likely to extend further after a longer period of influence.

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