Community Dynamics of the Benthic Marine Algae in Hakampo, the Western Coast of Korea

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Abstract - Benthic marine algal community of Hakampo in the western coast of Korea was investigated qualitatively and quantitatively. Seasonal assessments of species composition, biomass, dominant species in biomass and vertical distributional pattern were carried out from spring to winter. A total of 121 species was identified; 6 blue-green, 18 green, 16 brown, 81 red algae. In three sites investigated, 96 species were collected at Bunjeomdo, 75 at Maoe, and 57 at Doranggol, respectively. *Dermocarpa* sp. and *Acrochaetium microscopicum* were collected for the first time in Korea through this investigation. Dominant species in specific proportions of biomass were *Sargassum thunbergii, Gloiopeltis furcata, Corallina* spp., *Symphyocladia latiuscula* and *Monostroma nitidum*. Seasonal fluctuations of mean biomass were 31.59-427.69 g dry wt · m^{-2} at Bunjeomdo and 20.98-473.48 g dry wt · m^{-2} at Maoe, respectively, which were comparatively high in the western coast of Korea. Vertical distribution in intertidal zones was *Gloiopeltis furcata-Gloiopeltis furcata* and *Corallina* spp.-*Corallina* spp. and *Sargassum thunbergii.*

Key words : benthic marine algae, community structure, vertical distribution

INTRODUCTION

There have been many studies on benthic marine algae of Korea after Kang (1966). In particular, studies on benthic algal ecology began in earnest after the 1980s, and diverse ecological methods started being used in the analysis of community structure. Among these methodologies, the use of multivariation analysis, such as direct gradient analysis, classification and ordination, became the beginning of benthic algal community structure and phycogeographical character of Korea being analyzed through statistical method (Kim 1983; Lee *et al.* 1985; Sohn 1987; Park and Kim 1990; Yoo 2003a). Yoo (1994) even attempted to analyze the environmental factors effecting the seasonal variation of benthic algal community with regression analysis.

After Kang (1966) reported 140 species of benthic marine algae at the Western Sea of the Korean peninsula, studies were conducted in 92 areas (Lee 1973; Lee and Lee 1982; Lee *et al.* 1985; Kim *et al.* 1995; Lee *et al.* 1997), and a total of 401 species have been reported ever since (Lee and Kang 2001; K. Yoo 2003). On the other hand, coastal development that increased along with the rapid growth in Korean economy after the 1970s, not only decreased the habitats of benthic marine algae, but also gave negative effects to the growth and distribution of benthic marine organisms and also environment of habitats (Lee *et al.* 1994; Jung *et al.*

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1995; Lee *et al.* 1996; Yoo 2003b). In order to accurately analyze the effects of such change in surrounding environments on the growth of benthic algal community, it is necessary to gather accurate information on the algal flora and community structure, before getting information on the environmental change. In addition, as periodic research provides long-term and continuous data, the effect of environmental change can be analyzed. Such materials provides important basic data for biodiversity study and ecological restoration, which are being noted at present.

This study was conducted to contribute to characteristic analysis and geographical distribution of benthic marine algae of the Western Sea, by grasping the community dynamics, by means of conducting quantitative and qualitative research on algal community according to each season, at Hakampo located at the northern area of Taean peninsula. Since the results of this study was derived before the construction of Taean Power Plant, the study will provide valuable data in studying the variations of algal diversity and community in the future.

MATERIALS AND METHODS

1. Algal flora

Four seasonal assessments (February, May, July and October 1987) of benthic marine algal flora were conducted at Bunjeomdo, Maoe, and Doranggol near Hakampo beach (Wonbuk-myeon, Taean-gun, Chungcheongnam-do) where Taean Power Plant will be built (Fig. 1). Samples were fixated with 10% formalin-seawater, then transported to the laboratory. The fixed samples were washed with fresh water, then identified with a microscope (Nikon E600).

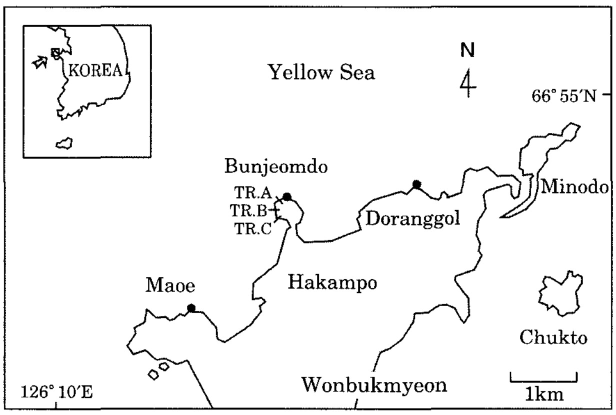

Fig. 1. A map of study area showing the location of sampling sites (●).

2. Biomass

For the study, the investigation site was defined as upper, middle and lower layer at Bunjeomdo and Maoe, and the five quadrats (0.5 × 0.5 m) were set on a random basis and then all the samples in each quadrat were transported to the laboratory after being fixed by 10% formaline-seawater. Then all the samples were washed by fresh water and classified by each kinds and were dried in the drying oven for 48 hr. at 105°C to be desiccated. Then they were measured by chemical balance up to 0.01 g and then it was converted into m^2.

3. Analysis of community structure

The study of vertical distribution of community at each tidal level was conducted in three transects (A-C) at the Hakampo beach. Three areas with geographical variation were selected in this sites, and line transect was installed and quadrats (0.5 × 0.5 m) with interval of 0.5 m were placed, to study the frequency and coverage rate according to each kind of algal species (Fig. 2).

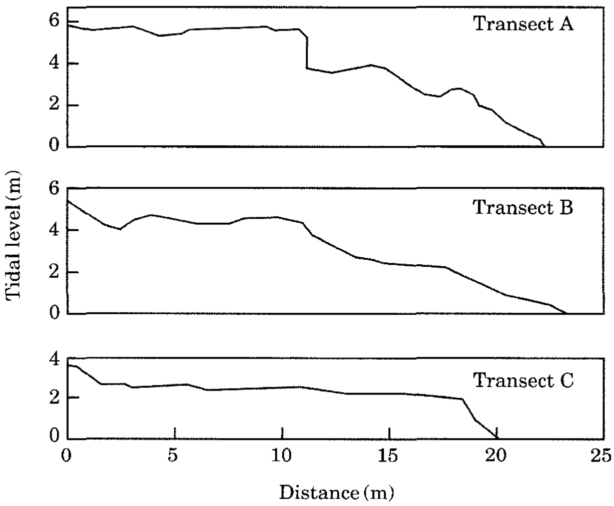

Fig. 2. The vertical profiles of intertidal rocky shore along the line transects (Tr. A-C) at Bunjeomdo, Hakampo.

The amounts of dominant and subdominant species were summed according to the kinds. If the cumulative summation was more than 50%, they were considered as dominant species. And if it was more than 75%, it was considered as subdominant species (Saito and Atobe 1970).

RESULTS

1. Algal flora

As a result, the marine algae identified from the area were 121 species; 6 blue-green, 18 green, 16 brown, 81 red algae. Among these, *Dermocarpa* sp. and *Acrochaetium microscopium* were collected in Korea through this investigation for the first time. Above all, for the Family Dermocarpaceae which the *Dermocarpa* sp. belongs to, only 2 species of genus *Entophysalis* have been reported.

For the algal flora according to each sites, the followings hold true; 96 species in Bunjeomdo (5 blue-greens, 12 greens, 13 browns, and 96 red algae), 75 species in Maoe (11 greens, 12 browns, and 52 red algae), 57 species in Doranggol (2 blue-greens, 6 greens, 10 browns, and 39 red algae). As it is, Bunjeomdo had the highest number of algal species. According to the season, 71 species in summer was the highest rate, 65 species in autumn, 57 species in winter, and 55 species in spring (Table 1 and Appendix 1).

In the three sites studied, the species that appeared throughout the year are as follows: *Sargassum thunbergii, Corallina pilulifera* and *Ahnfeltiopsis flabelliformis*. The species that appeared throughout the year in every zone are as follows; in Bunjeomdo, *Ulva pertusa, Gelidium amansii, Gelidium divaricatum, Pterocladia capillacea, Gracilaria verrucosa, Chondrus ocellatus, Acrosorium yendoi*, and *Symphyocladia latiuscula* and in Maoe, *Enteromorpha compressa, U. pertussa, Corallina officinalis*, and *Symphyocladia latiuscula* and in Doranggol, *U. pertusa* and *C. officinalis*.

Table 1. The number of marine algal species observed at Hakampo (abbreviations for division: Cya, Cyanophyta; Chl, Chlorophyta; Pha, Phaeophyta; Rho, Rhodophyta)

Sites	Season	Division				Sum
		Cya	Chl	Pha	Rho	
Bunjeomdo	Spring	–	6	7	22	35
	Summer	4	4	8	36	53
	Autumn	4	7	5	41	57
	Winter	1	5	7	43	56
	Cum*	5	12	13	66	96
Maoe	Spring	–	4	8	24	36
	Summer	–	5	6	27	36
	Autumn	–	4	4	26	34
	Winter	–	2	5	15	22
	Cum*	–	11	12	52	75
Doranggol	Spring	–	2	5	12	19
	Summer	1	5	4	21	33
	Autumn	1	2	4	23	30
	Cum*	2	6	10	39	57
Total	Spring	–	9	10	36	55
	Summer	5	8	12	46	71
	Autumn	4	8	6	47	65
	Winter	1	5	7	44	57
	Cum*	6	18	16	81	121

Cum*: Cumulative number of species.

2. Community structure

The mean biomass measured for g dry wt · m^{-2} in each zone are as follows. In Bunjeomdo, the mean biomass was 63.33 g. According to each season, the followings hold true: 427.70 g in spring, 51.97 g in summer, 65.19 g in autumn, and 31.59 g in winter. These patterns show that the fluctuation pattern was the highest in spring and was decreased in winter. The mean biomass in terms of the species are as follows. 66.33 g for *Sargassum thunbergii* which was the 44% of total biomass, which had the largest biomass in spring and smallest in summer. 33.00 g for *Gloiopelties furcata* which was 23% of total biomass which was the largest in the spring and smallest in the autumn. 14.33 g for *Corallina* spp. which was 10% of total biomass. 11.26 g for *Symphyocladia latiuscula*, which was the highest with 44.69 g in spring and was less than 1 g in the other seasons. For *S. latiuscula* and *Monstroma nitidum*, the vegetation was the richest in spring (Table 2).

In Maoe, the mean biomass was 171.10 g. According to each season, 473.48 g in spring, 20.98 g in summer, 61.27 g in autumn, and 128.69 g in winter. The mean biomass according to the species are as follows. 74.10 g for *Corallina* spp. which was 43% of total biomass and

Table 2. Mean biomass value for marine algal species per m² collected at Bunjeomdo of Hakampo. Species which had a total biomass in less than 0.05 g were removed from the list (Sp: Spring, Su: Summer, Au: Autumn, Wi: Winter)

(unit: g-dry wt · m^{-2})

Species / Seasons	Sp	Su	Au	Wi	Mean
Sargassum thunbergii	205.95	0.04	31.07	16.27	63.33
Gloiopeltis furcata	109.44	22.14	–	0.43	33.00
Corallina spp.	1.81	26.93	21.49	7.10	14.33
Symphyocladia latiuscula	44.69	0.33	–	0.03	11.26
Monostroma nitidum	44.05	–	–	–	11.01
Scytosiphon lomentaria	9.01	0.04	–	1.55	2.65
Ceramium kondoi	4.86	0.02	–	1.46	1.59
Gelidium amansii	–	–	6.28	–	1.57
Sargassum horneri	–	–	0.12	4.08	1.05
Dumontia simplex	3.67	–	–	0.40	1.02
Ulva sp.	0.11	0.27	1.55	–	0.48
Pterocladia capillacea	–	–	1.55	0.15	0.43
Porphyra spp.	1.53	–	–	–	0.38
Monostroma grevillei	1.48	–	–	–	0.37
Ahnfeltiopsis flabelliformis	–	–	1.21	0.12	0.33
Chondria dasyphylla	–	1.05	–	–	0.26
Launrecia intermedia	–	–	1.04	–	0.26
Sphacelaria sp.	0.76	0.15	–	–	0.23
Polysiphonia sp.	0.30	0.27	–	–	0.14
Leathesia difformis	–	0.34	–	–	0.09
Chondrus ocellatus	–	–	0.29	–	0.07
Chondria crassicaulis	–	0.14	0.13	–	0.07
Codium fragile	–	–	0.21	–	0.05
Sum	427.69	51.97	65.19	31.59	144.11

the biomass was the highest in spring and lowest in summer. 66.26 g for *G. furcata* which was 9% of total biomass and the biomass was the highest in spring and no information is available for autumn. 22.90 g for *Sargassum thunbergii* which was 13% of the total biomass and the biomass for the rest species were below 2.00 g (Table 3).

The rates of biomass in sampling sites according to the algal division are as follows; in Bunjeomdo, 8% (11.92 g) for Chlorophyta, 47% (67.38 g) for Phaeophyta, 45% (64.81 g) for Rhodophyta, in Maoe, 0.6% (0.99 g) for Chlorophyta, 14% (24.50 g) for Phaeophyta, 85% (145.61 g) for Rhodophyta. So, the rates for Maoe show somewhat different structure from Bunjeomdo's.

3. Vertical distribution

The changes of vertical distribution of algal community in each transect according to season are as shown

Table 3. Mean biomass value for marine algal species per m² collected at Maoe of Hakampo

(unit: g-dry wt · m^{-2})

Species / Seasons	Sp	Su	Au	Wi	Mean
Corallina spp.	180.59	0.69	47.37	67.76	74.10
Gloiopeltis furcata	253.78	7.54	–	3.73	66.26
Sargassum thunbergii	32.44	–	9.33	49.89	22.92
Sphacelaria sp.	–	–	–	6.22	1.56
Ahnfeltiopsis flabeliformis	3.32	2.09	0.67	–	1.52
Gelidium amansii	2.12	3.01	0.06	–	1.30
Ceramium kondoi	0.76	3.76	–	–	1.13
Ulva sp.	–	1.93	1.77	0.03	0.93
Chondria crassicaulis	–	–	0.99	–	0.25
Acrosorium yendoi	–	–	0.10	0.67	0.19
Symphyocladia latiuscula	–	0.35	0.01	0.05	0.10
Gelidium vagum	0.39	–	–	–	0.10
Caulacanthus ustulatus	–	0.37	–	–	0.09
Gelidium divaricatum	–	0.23	0.14	–	0.09
Gracilaria verrucosa	–	0.36	–	–	0.09
Polysiphonia sp.	–	0.32	–	–	0.08
Camphylaephora crassa	–	0.17	–	0.11	0.07
Chondrus ocellatus	–	–	0.27	–	0.07
Dumontia simplex	0.05	–	–	0.21	0.07
Codium fragile	–	–	0.24	–	0.06
Grateloupia turuturu	–	–	0.19	–	0.05
Sum	473.48	20.98	61.27	128.69	171.10

in Fig. 3. In spring, for the case of transect A, *Sphacelaria rigidula* was rarely observed at the upper intertidal zone (450–600 cm), and there was high coverage of *Scytosiphon lomentaria* with 40% of coverage. *Gloiopeltis furcata* had 40% to 70% of dominant vegetation at the upper and middle intertidal zone (250–450 cm). In lower intertidal zone, *Corallina* spp., *Dumontia simplex* and *Sargassum thunbergii* each presented 1% to 30% in the range of coverage. For the transect B, *G. furcata* was distributed in upper and middle intertidal zone and *D. simplex* and *Corallina* spp. were distributed in middle and lower intertidal zone. In particular, *Corallina* spp. had high coverage rate of 30% to 90% in lower intertidal zone. In summer, for the transect A, *S. rigidula* and *S. lomentaria* were hardly found where they were dominant species in spring. In the range of 270 cm to 430 cm, *G. furcata* had 30% to 80% of coverage rate and below the range of 270 cm, *Corallina* spp. and *S. thunbergii* had 1% to 50%. And transect B, in the range of 360 cm to 470 cm, *G. furcata* had high coverage rate and in the middle and lower intertidal zone, *Corallina* spp. had high coverage rate relatively. In autumn for

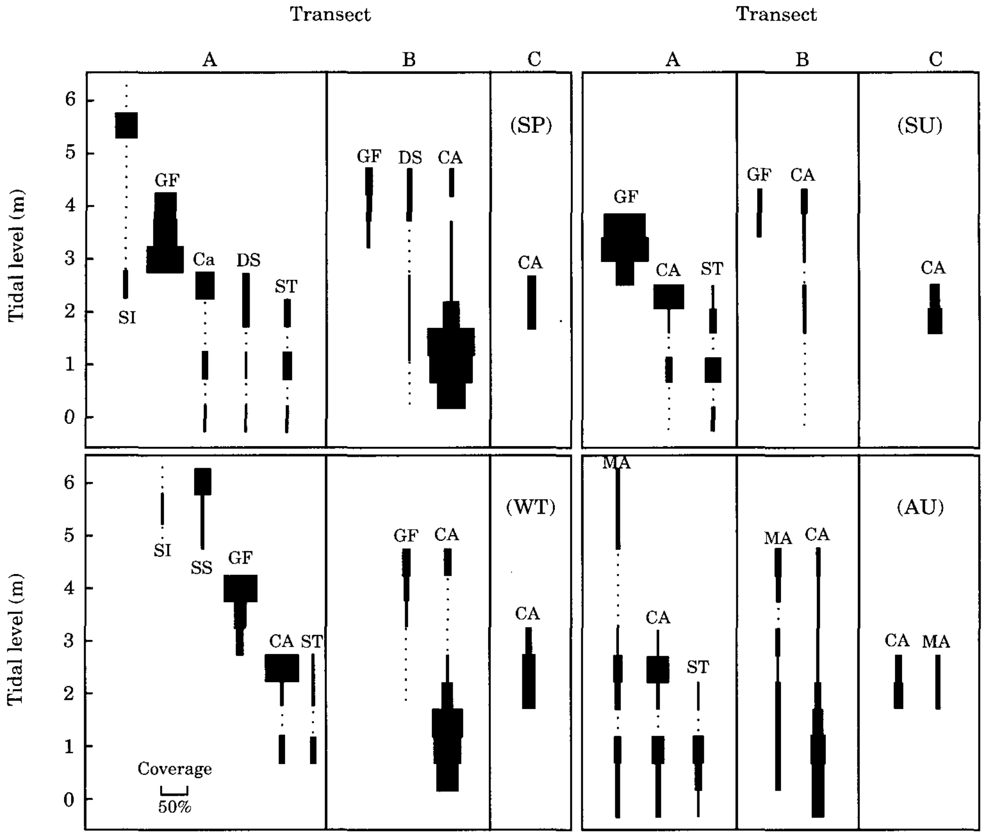

Fig. 3. The algal zonation of representative species in coverage along the line transects (A–C) at Bunjeomdo of Hakampo (SP: Spring, SU: Summer, AU: Autumn, WT: Winter, CA: *Corallina* spp., DS: *Dumnotia simplex*, GF: *Gloiopeltis furcata*, SI: *Scytosiphon lomentaria*, SS: *Sphacelaria* sp., ST: *Sargassum thunbergii*).

the case of transect A, because *G. furcata* from the high zone disappeared, the coverage could not be measured. *Corallina* spp. had 10% to 70% of coverage in the middle and lower intertidal zone. In the lower intertidal zone, *Corallina* spp. and *S. thunbergii* had 1% to 20% of coverage rate. In the transect B, *Corallina* spp. was mildly dispersed in the middle and lower zone. In the lower zone, *Corallina* spp. had 10% to 25% of coverage. In winter, for the transect A, in the upper zone, *S. rididula* and *S. lomentaria* had 50% to 30% of coverage rate and in both upper and middle intertidal zone, *G. furcata* had 15–60% of coverage and in the range of 70 cm to 270 cm, *Corallina* spp. and *S. thunbergii* had coverage rate of 1–60%. In the transect B, the *G. furcata* had abundant vegetation in upper and middle intertidal zone and *Corallina* spp. was also abundant in the middle and lower intertidal zone. Especially, in the range of lower zone, *Collarina* spp. was found to be the dominant species.

The biomass composition in each division according to each layer of intertidal zone is as follows. In Bunjeomdo, Rhodophyta occupied 98% of the upper intertidal zone in spring, Phaeophyta had 96% in the middle intertidal zone and Chlorophyta had 49% in the lower zone and also Rhodophyta had 51% in the lower zone. These results were due to the fact that *Gloiopeltis furcata* was in the upper intertidal zone, *Sargassum thunbergii* in the middle, and *Monostroma nitidum* and *Symphyocladia latiuscula* in the lower were dominant species. In summer, Rhotophyta had the rates of 99%, 99%, 54% in upper, middle and lower zone and Phaeophyta had 37% in the lower zone. And this interprets that *G. furcata* was dominant in the upper zone, *G. furcata* and *Corallina* spp. were dominant species in the middle intertidal zone and *Corallina* spp. and *S. thunbergii* were dominant in the lower zone. In autumn, Phaeophyta and

Rhodophyta had each biomass rate of 67% and 39% in the middle and lower intertidal zone, Phaophyta had 26% and Phodophyta had 67% of biomass rate and *Corallina* spp. and *S. thunbergii* were the dominant species in the middle and lower intertidal zone. In winter, in the upper zone, *Scytosiphon lomentaria* of Phaeophyta had 46% of biomass and *Ceramium kondoi* of Rhodophyta had 54% of biomass. The rate of Phaeophyta and Rhodophyta were 63% and 37% in the middle zone, and 76% and 2% in the lower zone.

In Maoe, in spring, Rhodophyta was dominant species in the upper and middle intertidal zone and Phaeophyta had 47% of biomass and Rhodophyta had 54% of biomass in the lower zone. In summer, in the lower zone, Chlorophyta had 39% of biomass and Rhdophyta had 60% of biomass and in the upper and middle zone, the vegetation patterns were the almost same with spring's. In autumn, in the upper zone, Rhdophyta was dominant and in the middle zone, Phaeophyta had 39% of biomass and Rhodophyta 62% of biomass and in the lower zone, *Corallina* spp. of Rhodophyta had 94% of biomass.

In winter, in the upper intertidal zone, Phaeophyta had 77% and Rhodophyta had 23% of biomass. And in the middle and lower intertidal zone, *Corallina* spp. was the dominant species. In this study, from the observation of biomass, *S. thunbergii*, *G. furcata* and *Corallina* spp. were the dominant species and *S. latiuscula* and *Monostroma nitidum* were added to be the dominant species in the spring. The vertical distribution pattern from the coverage is that in the upper intertidal zone, *Gloiopeltis furcata*, in middle zone, *Gloiopeltis furcata* and *Corallina* spp. and in lower zone, *Corallina* spp. and *Sargassm thungergii* were the dominant species in the distribution pattern.

DISCUSSION

In the Korean Western Sea, because of the turbidity and the difference in tidal level, vegetation is relatively poor compared to the other coasts. However, in this area (Park and Kim 1990; Kim *et al.* 1995), the community structure is very unique. There have been many studies about marine vegetation so far, but hardly before, the study in change of vegetation according to the seasonal change had been presented (Yoo and Kim 1990; Kim and Yoo 1992; Lee *et al.* 1997; Yoo 2003a).

The site of this study, Hakampo beach, has more diverse algae than any other coasts of the Western Sea, as the northernmost tip of the Taean Ocean National Park (Park and Kim 1990; Lee *et al.* 1997). In this study, 6 species of Cyanophyta, 18 species of Chlorophyta, 16 species of Phaeophyta and 81 species of Rhodophyta were observed, which totalled 121 species. And also the total of 103 species in Gyeonggi Bay (Lee and Lee 1981), the total of 104 species in Garolim Bay (Lee and Lee 1982), and the total of 84 species in Padori area (Lee *et al.* 1997), the total of 100 species in Shapsido Island (Yoon and Boo 1991) and the total of 68 species in Yeonggwang were observed (Kim and Yoo 1992). It has resulted from the fact that Taean peninsula, the site of study, has high transparency than any other areas of the Western Sea, even as to be designated as Taean Ocean National Park.

In Hakampo, the range of biomass was 20.98–427.69 g · m^{-2} and the mean biomass was 157.61 g. Comparing with other areas of the Western Sea, in Garolim Bay, the biomass was 9.40 g to 81.20 g and the mean biomass was 33.50 g (Lee and Lee 1982). In Anmyendo Island, the range was 228.30 g to 233.60 g and the mean biomass was 230.95 g (Lee *et al.* 1985). In Padori area, the range was 183.00 g to 468.00 g and the mean biomass was 276.00 g (Lee *et al.* 1997). In Muchangpo, the range was 44.55 g to 201.19 g and the mean biomass was 90.43 g, and in Maryangri the range was 19.57 g to 134.76 g and the mean biomass was 72.73 g (Yoo and Kim 1990), and in Yeonggwang, the range was 12.67–103.66 g and the mean biomass was 72.55 g (Kim and Yoo 1992). With this, it can be seen that the algal biomass of Taean Peninsula is abundant compared to other areas of the Western Sea, with the exception of Anmyeondo. As the line transect of 10 cm by 10 cm has rather high value compared with 50 cm by 50 cm, as shown in various reports on the Western Sea, it is presumed that there will be some problems in comparing these results directly (Lee and Lee 1982; Lee *et al.* 1985; Lee *et al.* 1997). With this reason, Yoo (2003a) asserted making a methodological guide line on the analysis of algal community.

Benthic marine algae in intertidal zone is extensively influenced by the biological factors such as intra- and inter-species competition and grazing and by the physical factors such as wave action, tide and current (Dring 1991). While Kim and Lee (1985) studied the vertical distribution of algal species in the upper, middle and lower intertidal zone in Muchangpo, they found that vegetation distribution is largely controlled by *Gloiopeltis furcata-Gelidium divaricatum, Silvetia siliquosa -Corallina pilulifera*. And the dominant species was *Sargassum thunbergii*. Also Lee *et al.* (1997) studied that the Padori area was controlled by *G. furcata-S. thunbergii, Corallina pilulifera, Acrosorium yendoi-Ulva pertusa, Chondrus ocellatus*. In this area, for the vertical distribution, *G. furcata* was dominant in upper zone and *G. furcata* and *Corallina* spp. were dominant in middle zone and *Corallina* spp. and *S. thunbergii* were dominant in lower zone. However, in previous studies, *G. furcata*, *Enteromorpha linza, Bangia atropurpurea, Chaetomorpha moniligera-C. pilulifera, Chondria crassicaulis-Hizikia fusiformis, Sargasum yezoense* and *S. thunbergii* were the dominant species in each zone of eastern coast of Korea (Lee 1991). For Southern part of the Sea, Sohn (1983) reported that *G. divaricatum, Enteromorpha linza-C. crassicaulis, U. pertusa, Scytosiphon lomentaria-Sargassum sagamianum, Undaria pinnatifida* and *S. thunbergii* were the dominant species in each zone. For Gwangyang Bay, Song (1986) reported that *G. divaricatum, Ulva conglobata, E. compressa-S. thunbergii, Ectocarpus arctus-U. pertusa, Corallina* spp., *C. crassicaulis* and *U. pinnatifida* were the dominant species in each zone. For this reason, we have concluded that in western coast of Korea, for the upper zone where there are great compression, the community pattern were similiar with the other seas but for the middle and lower zone, the patterns were widely different. It can be seen that the benthic marine algae of the Western Sea has similar community structure with other sea areas at the upper intertidal zone where there is serious emersion stress, but the characteristic of community structure gets evidently different as it goes to the middle and lower zones.

The reduction of algal diversity and change in community structure of the Korean coast are recently being assumed to be caused by global warming and the increase of terrigenous pollutant at the coasts (Yoo 2003b), but there is a lack in continuous research material that can back this up. Accordingly, regular research with the same method is urgently needed, in order to accurately study the change of biological community at specific areas. In addition, in order to understand the change of surrounding biological community according to the construction and operation of coastal industrial zones, research material derived before the change in habitation is very important. With this, this study will provide important material that can evaluate the effects construction and operation of coastal power plant have on the diversity and structure of algal community.

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Appendix 1. The list of marine benthic algae in Hakampo, west coast of Korea (B, Bunjeomdo; M, Maoe; D, Doranggol)

Division \ Sites \ Seasons	Spring			Summer			Autumn			Winter	
	B	M	D	B	M	D	B	M	D	B	M
CYANOPHYA											
**Dermocarpa* sp.						+					
Hydrocoleum cantharidosmum				+						+	
Lyngbya lutea				+			+				
Microcoleus chthonoplastes				+			+				
Oscillatoria bonnemaisonii							+				
Calothrix confervicola				+			+		+		
CHLOROPHYTA											
Monostroma grevillei	+										
Monostroma nitidum	+	+									
Blidingia minima					+						
Enteromorpha comprssa		+	+	+	+	+	+	+		+	+
Enteromorpha crinita		+									
Enteromorpha intestinalis					+						
Enteromorpha linza	+			+	+	+	+				
Enteromorpha prolifera						+					
Ulva conglobata	+									+	
Ulva lactuca		+									
Ulva pertusa	+		+	+	+	+	+	+	+	+	+
Chaetomorpha aerea										+	
Cladophora gracilis							+				
Cladophora stimpsonii						+	+	+			
Cladophora sp.	+						+				
Bryopsis plumosa								+	+		
Codium adhaerens										+	
Codium fragile				+			+	+			
PHAEOPHYTA											
Ectocarpus sp.						+					
Ralfsia verrucosa	+	+	+	+			+				
Ralfsia sp.		+									
Sphacelaria radiata										+	
Sphacelaria rigidula	+		+	+						+	
Sphacelaria yamadae					+	+	+		+		
Sphacelaria sp.	+	+								+	+
Dictyota dichotoma					+						
Leathesia difformis				+	+	+					
Colpomenia sinuosa		+		+			+	+	+		
Myelophycus simplex	+		+	+	+						
Scytosiphon lomentaria	+	+	+	+						+	+
Undaria pinnatifida		+		+	+			+		+	+
Silvetia siliquosa				+							
Sargassum horneri	+	+					+	+	+	+	+
Sargassum thunbergii	+	+	+	+	+	+	+	+	+	+	+
RHODOPHYTA											
Stylonema alsidii		+				+	+				
Porphyra crassa		+									
Porphyra seriata	+									+	
Porphyra tenera			+								
**Acrochaetium microscopicum*						+					
Auduinella sp.							+			+	
Alatocladia modesta		+					+	+		+	
Corallina officinalis	+	+	+	+	+		+	+	+	+	+

Appendix 1. Continued

Division \ Sites \ Seasons	Spring			Summer			Autumn			Winter	
	B	M	D	B	M	D	B	M	D	B	M
Corallina pilulifera	+	+	+	+	+	+	+	+	+	+	+
Hydrolithon sargassi										+	
Jania ungulata			+							+	
Lithophyllum okamurae	+	+				+	+		+	+	
Lithophyllum yendoi				+			+			+	
Pneophyllum zostericolum	+	+					+	+	+	+	+
Titanoderma canescens								+		+	
Titanoderma tumidulum				+	+	+	+		+	+	
Yamadaea melobesioides			+								
Gelidium amansii	+	+		+	+	+	+	+		+	
Gelidium divaricatum	+			+	+	+	+	+	+	+	
Gelidium pusillum										+	
Gelidium vagum		+		+		+				+	+
Pterocladia capillacea	+			+		+	+	+	+	+	
Hildenbrandtia rubra										+	
Bonnemaisonia hamifera							+	+	+		
Caulacanthus ustulatus	+	+		+	+	+	+		+		
Dumontia simplex	+	+	+	+	+	+				+	+
Gloiopeltis furcata	+	+		+	+	+				+	+
Chondracanthus intermedia						+				+	
Chondracanthus tenella	+										
Chondrus ocellatus	+	+		+	+	+	+	+	+	+	
Gloiosiphonia capillaris				+	+						
Hypnea saidana				+	+	+					
Callophyllis rhynchocarpa								+			
Tsengia nakamurae								+	+		
Ahnfeltiopsis flabelliformis	+	+	+	+	+	+	+	+	+	+	+
Carpopeltis affinis		+									+
Grateloupia acuminata										+	
Grateloupia divaricata							+		+		
Grateloupia filicina									+		
Grateloupia prolongata							+			+	
Grateloupia sparsa				+				+		+	
Grateloupia turuturu				+	+		+	+	+		
Grateloupia sp.										+	
Gracilaria textorii										+	
Gracilaria verrucosa	+	+		+	+		+			+	
Plocamium telfairiae		+		+			+	+			
Champia parvula				+			+	+			
Lomentaria hakodatensis				+	+						
Chrysymenia wrightii				+	+						
Antithamnion nipponicum							+	+			
Callithamnion callophyllidicola										+	
Campylaephora crassa	+				+		+			+	+
Campylaephora hypnaeoides				+							
Ceramium boydenii				+	+	+	+	+	+		
Ceramium japonicum					+		+			+	
Ceramium kondoi	+	+	+	+						+	+
Ceramium tenerrimum					+						
Pterothamnion plumosa							+				
Pterothamnion yezoense							+				
Dasya sessilis				+	+		+				
Dasya villosa							+	+	+		
Heterosiphonia japonica							+	+		+	
Heterosiphonia pulchra				+			+	+			

Appendix 1. Continued

Division \ Sites \ Seasons	Spring			Summer			Autumn			Winter	
	B	M	D	B	M	D	B	M	D	B	M
Acrosorium polyneurum				+			+				
Acrosorium uncinatum	+						+		+	+	
Acrosorium yendoi	+			+	+		+	+	+	+	+
Myriogramme crozieri										+	
Branchiogrossum ciliatum							+	+			
Chondria crassicaulis		+	+	+	+		+	+	+	+	
Chondria dasyphylla				+							
Laurencia intermedia							+			+	+
Laurencia obtusa					+						
Laurencia okamurae				+	+					+	+
Laurencia venusta	+						+			+	
Neorhodomela aculeata		+		+		+	+		+	+	
Polysiphonia decumbens		+									
Polysiphonia japonica				+		+			+		
Polysiphonia morrowii	+	+	+	+	+	+				+	+
Polysiphonia sphaerocarpa						+					
Polysiphonia yendoi	+										
Symphyocladia latiuscula	+	+	+	+	+		+	+	+	+	+

* : new to Korea