Subtidal Marine Algal Community of Jisepo in Geoje, Korea

Choi, Chang Geun
Korea Inter-University Institute of Ocean Science, Pukyong National University

Oh, Seok Jin
Korea Inter-University Institute of Ocean Science, Pukyong National University

Kang, Ik Joon
Aquatic Biomonitoring and Environmental Laboratory, Department of Bioscience and Biotechnology, Faculty of Agriculture, Kyushu University

https://doi.org/10.5109/16112

出版情報：九州大学大学院農学研究院紀要. 54 (2), pp.339-345, 2009-10-29. Faculty of Agriculture, Kyushu University

J. Fac. Agr., Kyushu Univ., **54** (2), 339–345 (2009)

Subtidal Marine Algal Community of Jisepo in Geoje, Korea

Chang Geun CHOI[1], Seok Jin OH[1] and Ik Joon KANG*

Aquatic Biomonitoring and Environmental Laboratory, Department of Bioscience and Biotechnology,
Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan
(*Received June 30, 2009 and accepted July 13, 2009*)

The seasonal variations of the marine algal community were studied with quadrat method during June 2005 to May 2006 at subtidal zone of Jisepo at Geoje. In this area, a total of 59 marine algal species including 8 Chlorophyta, 11 Phaeophyta and 40 Rhodophyta was identified. The representative species in each study sites throughout the year are *Ulva pertusa, Codium adhaerens, C. fragile, Colpomenia sinuosa, Dictyota dichotoma, Dilophus okamurae, Sargassum horneri, Gelidium amansii, Lithophyllum okamurae, Amphiroa dilatata, Corallina pilulifera, Grateloupia elliptica, G. turuturu, Prionitis cornea, Plocamium telfairiae, Chondracanthus intermedia, Lomentaria catenata, Acrosorium polyneurum* and Melobesioidean algae. The dominant species among the representative species in importance value were *Ulva pertusa, Undaria pinnatifida, Sargassum horneri, Gelidium amansii, Prionitis cornea* and *Amphiroa dilatata*. Dry weight of total vegetation, the most luxuriant period appears in spring season and the poorest one in summer period. The total dry weight of the vegetation in spring season is very high rather than the summer season. On the basis of group–average using PRIMER, the 6 study sites were classified into two groups; two clusters emerge at the 50 level of threshold. The R/P, C/P, and (R+C)/P value were 3.63, 0.73, and 4.36, respectively.

INTRODUCTION

Studies of marine algal flora for any region have not only set out the distributional data concerning each species, but also have provided much valuable ecological information on local communities (Boo and Lee, 1986). Thus, the biogeography of benthic algal flora has been intensively investigated in recent years by using cluster analysis (van den Hoek, 1975; Choi, 2008) and ordination technique (Lawson, 1978).

A floristic study of benthic marine algae in Korean coasts was much indebted to Kang (1966). Enumeration 414 species, he divided the Korean coast into five sections considering their water temperature and other hydrological conditions: 1) Northern East Coast Section, 2) Southern East Coast Section, 3) South Coast Section, 4) West Coast Section, and 5) Jeju Island Section. According to him, our study site was included in the South Coast Section.

Since about 1980, much valuable information on subtidal macroalgae has been obtained by a direct observation with SCUBA at several places around Korean coasts (Kim and Lee, 1995). On the south coast, Sohn *et al.* (1983) investigated the subtidal algal community at Dolsan Island. Lee *et al.* (1991) reported the flora and vertical distribution of marine algae from intertidal and subtidal zone at Chongsando Island. However, knowledge of subtidal macrophyto–benthos off Korean coasts is still very limited, compared to the floristic and monographic studies (Kim and Lee, 1995).

In Korean coasts, studies on marine algal community have been conducted by using biomass, coverage and important value at mainly intertidal zone (Koh, 1990; Kim *et al.*, 1995) and a few in subtidal zones (Choi *et al.*, 2008a, b; Ko *et al.*, 2008). Because of the difficulties and limited of sampling, the seasonality of subtidal marine algae of Korea has remained largely uninvestigated. At subtidal rocky shores, marine algal community structures and distribution are related to light, water movement, which are inversely correlated to seawater depth (Neto, 2001).

In this paper the floristic composition and seasonal periodicity of marine algae were investigated through a year as a part to understand the benthic algal community in south coast of Korea. This study was carried out in the subtidal zone of a Jisepo in Geoje rocky shore, Korea.

MATERIALS AND METHODS

The collection and observation of subtidal macroalgae were carried out at 6 sites chosen as representative

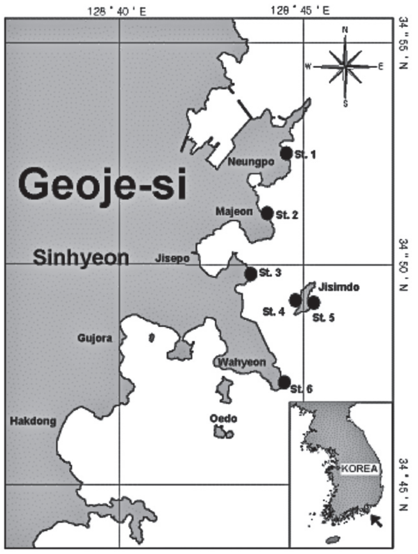

Fig. 1. Map showing the investigated localities.

[1] Korea Inter–University Institute of Ocean Science, Pukyong National University, Korea
* Corresponding author (E–mail: kangnew@agr.kyushu–u.ac.jp)

areas that were accessible by SCUBA diving during the period from June 2005 to May 2006 (Fig. 1), using a quadrat method along a vertical transect line set across the subtidal zone perpendicularly to the coastal line.

The specimens (excluding crustose forms) were scraped out the substratum using a paint–scraper and placed in numbered fine–mesh bags. All samples were preserved in 5–10% formalin–seawater solution and transferred to the laboratory for identification. The classification of taxa was followed by Kang (1968) and Lee and Kang (1986, 2001). They were washed and cleaned to sort species, and dried at 105 ˚C for 48 hours to measure dry weight per m^2. The important value of an algal species was obtained from arithmetic mean value of the relative coverage, frequency, and organic matter (Sohn *et al*., 2007). Species with coverage less than 0.1% in each quadrat were excluded from the list (Lee *et al*., 1991).

In order to analyze floristic composition value of the vegetations, C/P (Segawa, 1956), R/P (Feldmann, 1937), and (R+C)/P (Cheney, 1977) ratio were adopted. The similarity of flora was compared to group–average using PRIMER (Plymouth Routines Multivariate Ecological Research) computer package when the data consists of species presence–absence data (Clarke and Gorley, 2006).

RESULTS

A total of 59 taxa were recorded from six sites, including 8 Chlorophyta, 11 Phaeophyta and 40 Rhodophyta (Table 1). The largest number of marine algal species (38) was found at autumn and winter season. The small-

Table 1. A list of marine algal species found at Jisepo in Geoje

Species	Spring	Summer	Autumn	Winter	Total
Chlorophyta					
Enteromorpha intestinalis			+		
Ulva pertusa	+	+	+	+	
Urospora penicilliformis				+	
Cladophora japonica			+		
Cladophora sakaii		+			
Bryopsis plumose	+		+		
Codium adhaerens	+	+	+	+	
Codium fragile	+	+	+	+	
Phaeophyta					
Colpomenia sinuosa	+	+	+	+	
Undaria pinnatifida	+		+	+	
Ecklonia stolonifera		+		+	
Dictyopteris latiuscula	+			+	
Dictyopteris prolifera	+	+	+		
Dictyota dichotoma	+	+	+	+	
Dilophus okamurae	+	+	+	+	
Hizikia fusiformis		+			
Sargassum horneri	+	+	+	+	
Sargassum nigrifolium		+			
Sargassum sp.		+			
Rhodophyta					
Galaxaura falcate			+		
Gelidium amansii	+	+	+	+	
Pterocladia capillacea		+	+	+	
Lithophyllum okamurae	+	+	+	+	
Lithothamnion cystocarpioideum		+			
Amphiroa beauvoisii			+	+	
Amphiroa dilatata	+	+	+	+	
Corallina pilulifera	+	+	+	+	
Carpopeltis affinis		+		+	
Grateloupia divaricata			+		
Grateloupia elliptica	+	+	+	+	
Grateloupia filicina				+	
Grateloupia lanceolata			+		
Grateloupia prolongata			+		
Grateloupia turuturu	+	+	+	+	
Prionitis cornea	+	+	+	+	
Plocamium telfairiae	+	+	+	+	
Hypnea saidana	+		+	+	
Gracilaria textorii	+	+		+	
Chondrus ocellatus		+			
Chondracanthus intermedia	+	+	+	+	
Chondracanthus tenellus	+	+			
Rhodymenia intricate	+	+		+	
Lomentaria catenata	+	+	+	+	
Champia bifida			+	+	
Champia japonica	+				
Champia parvula		+	+	+	
Antithamnion nipponicum				+	
Ceramiopsis japonica	+	+		+	
Ceramium tenerrimum			+		
Platythamnion yezoense				+	
Acrosorium polyneurum	+	+	+	+	
Phycodrys fimbriata			+		
Heterosiphonia japonica			+		
Chonddria crassicaulis	+		+		
Laurencia okamurae	+	+		+	
Laurencia undulate	+		+		
Polysiphonia morrowii		+		+	
Symphyocladia latiuscula	+			+	
Melobesioidean algae	+	+	+	+	
Chlorophyta	4	4	6	4	8
Phaeophyta	7	9	6	7	11
Rhodophyta	22	23	26	27	40
Sum	33	36	38	38	59

est number of species (33) was found at spring season. The seasonal patterns of total numbers of species found at each site are shown in Table 2. Numbers of macroalgal species in the subtidal zone, on the whole, showed highest at St. 1 during the autumn and at St. 5 and St. 6 during the winter, minima were recorded at St. 1 in spring. St. 5 where the lowest number of species was identified, however, was an exception another season.

The numbers of species found at all four seasons were: Chlorophyta, 3; Phaeophyta, 4; Rhodophyta, 12 (Table 1). Of totally distributed species at all sites, 19 common marine algal species among 59 taxa appeared throughout the study period: *Ulva pertusa, Codium adhaerens, C. fragile, Colpomenia sinuosa, Dictyota dichotoma, Dilophus okamurae, Sargassum horneri, Gelidium amansii, Lithophyllum okamurae, Amphiroa dilatata, Corallina pilulifera, Grateloupia elliptica, G. turuturu, Prionitis cornea, Plocamium telfairiae, Chondracanthus intermedia, Lomentaria catenata, Acrosorium polyneurum*, and Melobesioidean algae.

Fig. 2 illustrates the value of mean biomass (g dry weight) during the survey periods. Mean biomass of marine algal species showed highest during the spring season. The dominant species for biomass at St. 1 was *Sargassum horneri*, while at St. 5 and St. 6 were *Undaria pinnatifida*. The value of mean biomass at all study sites were 39.8 to 287.5 g/m^2, respectively. The highest value of biomass at St. 5 was obtained during the spring season. The biomass differed according to the seasons at all sites and the increased gradually during the autumn and winter seasons, then decreased abruptly in summer season.

The numerically abundant species are referred to as dominants and used to characterize a community (Nybakken, 1988). The importance value of marine algal species estimated by a mean of relative coverage, frequency and organic matter is investigated seasonally (Table 3 and Fig. 3). The algal community of this area

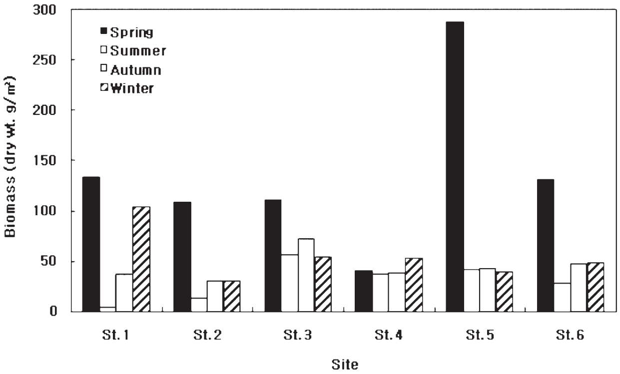

Fig. 2. Seasonal mean biomass (dry weight g/m^2) of algal species from each quadrat at Jisepo in Geoje.

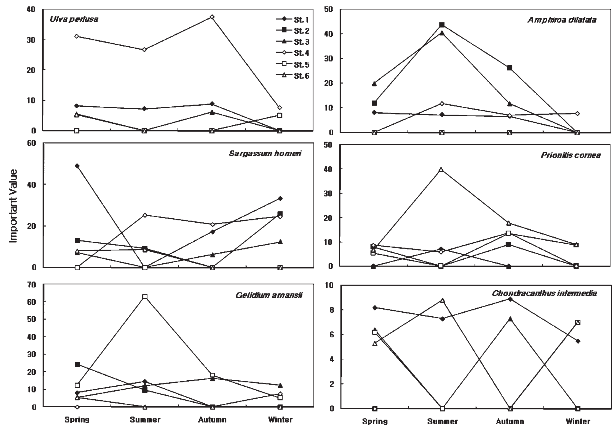

Fig. 3. Seasonal variation of importance value (IV) for major algal species at Jisepo in Geoje.

Table 2. Marine algal and floristic composition at Jisepo in Geoje

Season	Division	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6
Spring	Chlorophyta	2	2	1	3	2	1
	Phaeophyta	2	3	4	2	6	4
	Rhodophyta	4	7	14	9	11	9
	Total	8	12	19	14	19	14
Summer	Chlorophyta	2	1	2	2	2	2
	Phaeophyta	1	3	2	3	0	5
	Rhodophyta	10	10	12	15	9	9
	Total	13	14	16	20	11	16
Autumn	Chlorophyta	4	0	2	2	2	1
	Phaeophyta	6	6	5	2	4	4
	Rhodophyta	15	13	14	4	16	14
	Total	25	19	21	8	22	19
Winter	Chlorophyta	2	2	1	1	2	1
	Phaeophyta	3	5	5	4	4	7
	Rhodophyta	11	6	9	10	16	14
	Total	16	13	15	15	22	22

Table 3. Importance value (Ⅳ*) estimated from the relative frequency (RF) and relative coverage (RC) in the algal community at Jisepo in Geoje. * indicates Ⅳ > 5.0

Season	Species	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6
Spring	*Ulva pertusa*	8.2		5.6	31.1		5.3
	Codium adhaerens		15.1				
	Codium fragile	10.1			5.5		
	Colpomenia sinuosa				17.3		
	Undaria pinnatifida					18.5	30.6
	Dictyopteris latiuscula	8.2	8.0				8.2
	Dictyota dichotoma			12.0		9.3	8.2
	Dilophus okamurae					5.8	
	Sargassum horneri	49.1	13.1	7.2			8.2
	Gelidium amansii	8.2	24.3	5.6		12.3	5.3
	Amphiroa dilatata	8.2	12.0	19.9			
	Prionitis cornea		8.0		8.8	5.4	6.7
	Grateloupia turuturu						5.3
	Hypnea saidana				5.5		
	Chondracanthus intermedia	8.2		6.4		6.2	5.3
	Rhodymenia intricata			6.4		6.2	5.3
	Lomentaria catenata			8.8		6.2	6.7
	Acrosorium polyneurum					5.4	5.3
	Laurencia okamurae				5.5		
Summer	*Ulva pertusa*	7.3			26.7		
	Codium adhaerens			8.3			
	Codium fragile				7.3		
	Dictyopteris prolifera	13.6					11.3
	Dictyota dichotoma				5.9		8.8
	Sargassum horneri		9.4		25.3		8.8
	Gelidium amansii	14.6	9.4	12.3		63.0	
	Pterocladia capillacea	7.3	9.4				
	Lithophyllum okamurae		9.4	8.3		14.5	
	Amphiroa dilatata	7.3	43.8	40.5	11.8		
	Corallina pilulifera			8.3			8.8
	Carpopeltis affinis	20.9	9.4		11.3		
	Prionitis cornea	7.3			5.9		40.0
	Gracilaria textorii		9.4	22.5		22.5	
	Chondrus ocellatus	7.3					
	Chondracanthus intermedia	7.3					8.8
	Chondracanthus tenellus	7.3					
	Acrosorium polyneurum						8.8
	Laurencia okamurae				5.9		
Autumn	*Ulva pertusa*	8.9			37.5		
	Colpomenia sinuosa	8.0			20.8		
	Undaria pinnatifida	5.2				7.8	7.3
	Dictyopteris prolifera		10.7				6.2
	Dilophus okamurae			7.3			8.9
	Sargassum horneri	17.3		6.2	20.8		
	Gelidium amansii			16.4		18.0	
	Amphiroa dilatata	6.6	26.3	11.8	7.0		
	Corallina pilulifera						12.2

Table 3. (Continued)

Season	Species	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6
Autumn	*Prionitis cornea*		9.0		13.9	13.5	17.8
	Grateloupia prolongata					6.7	
	Grateloupia turuturu			6.2			
	Chondracanthus intermedia	8.9		7.3			
	Lomentaria catenata					5.6	16.7
	Acrosorium polyneurum			6.2			
Winter	*Ulva pertusa*				7.6	5.1	
	Codium adhaerens	7.6	6.2				
	Undaria pinnatifida					9.8	
	Dictyopteris latiuscula			8.0		6.1	
	Dictyota dichotoma		9.3				7.0
	Dilophus okamurae		6.2			9.8	
	Sargassum horneri	33.4	26.0	12.4	24.6		
	Gelidium amansii			12.4	7.6	5.1	
	Pterocladia capillaceae					5.1	
	Amphiroa beauvoisii		9.3	7.0	17.6		
	Amphiroa dilatata				7.8		
	Corallina pilulifera	6.3					6.1
	Carpopeltis affinis	5.5					
	Prionitis cornea					8.8	9.0
	Hypnea saidana			5.7			
	Gracilaria textorii			12.4			
	Chondracanthus intermedia	5.5				7.0	7.0
	Rhodymenia intricata		12.3	11.3		7.0	6.1
	Lomentaria catenata						8.8
	Champia parvula	7.1					
	Platythamnion yezoense						5.1
	Acrosorium polyneurum		12.3	9.1		7.0	5.1
	Polysiphonia morrowii					5.1	6.1
	Symphyocladia latiuscula						5.1

* indicates Ⅳ > 5.0

was dominated by *Ulva pertusa, Undaria pinnatifida, Sargassum horneri, Gelidium amansii*, and *Amphiroa dilatata* throughout the year, and subdominated by *Colpomenia sinuosa* and *Prionitis cornea* in spring and autumn, *Carpopeltis affinis* in summer, and *Gracilaria textorii* in winter. *Codium adhaerens*, *Colpomenia sinuosa*, and *Prionitis cornea* were a persistent subdominant species throughout the year.

The dendrograms by clustering seasonally flora on the basis of the similarities of the species composition are shown in Fig. 4. In describing this dendrogram, levels of similarity are subjectively chosen to delineate the obvious clusters. Two clusters emerge at the 50 level of threshold. The first group represents the characteristics of spring and summer flora. The representative species are *Sargassum horneri, Gelidum amansii* and *Amphiroa dilatata*. The second group represents the characteristics of autumn and winter flora. The representative species are *Undaria pinnatifida, Prionitis cornea* and *Lomentaria catenata*. Based on these comparisons, St. 3 in the spring and summer season were most similar. St. 1 and St. 2 were also similar in the spring

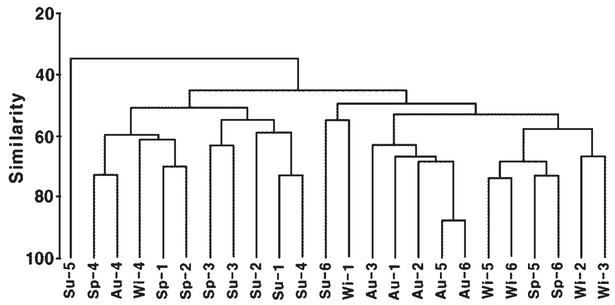

Fig. 4. A dendrogram produced by clustering location flora using average linkage at 6 sampling sites at Jisepo in Geoje (Sp: Spring, Su: Summer, Au: Autumn, Wi: Winter).

and summer season.

The comparison of value of R/P, C/P, and (R+C)/P ratio at study sites was given in Table 4. A total of 59 taxa are recorded in seasonally survey, as listed in Table 1. The numbers of brown algae are the low about 18.6% than other results (Boo and Lee, 1986; Sohn *et al.*, 2007). Thus, the R/P, C/P, and (R+C)/P value were 3.63, 0.73, and 4.36 in this survey, respectively.

DISCUSSION

Discontinuities in seaweed distribution have long been intrigued phycologists, although continental drift, climatic change and dispersal/transport systems have all been suggested as mechanisms which could create discontinuities (van den Hoek, 1975; Druehl, 1981; Boo and Lee, 1986). However, Michanek (1979), discussing seaweed distribution of the world based on the surface seawater temperature, suggested that Korean flora belonged to the Cold Temperate Region, while Jeju Island belonged to the Warm Temperate Region.

This study area is belonged to the South Coast Section by Kang (1966). Taniguti (1981) suggests that it belongs to the boundary between the temperate and subarctic zones and the vegetation may be poor.

In the previous results on south coast (Kang *et al.*, 1993), it was suggested that a floristic composition would be strong similarities with other reported on the south coast of Korea (Lee *et al.*, 1975; Sohn *et al.*, 1983; Koh, 1990; Kim, 1991; Lee *et al.*, 1991; Kim *et al.*, 1996) as follows; 10–15% green, 20–30% brown, and 50–70% red algae. It is interesting to note that the present results showed a relatively similar floristic percentage composition (Table 1).

The floristic investigations of the subtidal macroalgae in south coasts (Sohn *et al.*, 1983; Kim, 1991) reported that the subtidal vegetation is dominated by *Ulva pertusa, Codium fragile, Colpemenia sinuosa, Undaria pinnatifida, Sargassum horneri, S. miyabei, S. macrocarpum, Myagropsis myagroides, Chondracanthus intermedia* and *Gracilaria textorii*. Even though the difference site compared with previous studies (Sohn *et al.*, 1983; Koh, 1990; Kim, 1991, Choi, 2008; Choi and Huh, 2008) and this survey results probably related to the random clumped distribution found typically in benthic marine algal vegetation of subtidal zones in the south coast of Korea. Due to the plenty of information and results on the other subtidal studies in south coasts of Korea, it was easy to determine whether communities described here are typical of this region.

Lee *et al.* (1975) suggested the biomass proportion of marine algae in Kwang Yang Bay were greater during spring season than during the summer period. These results indicates that the biomass proportion similar compare with this survey results. It is clear from several previous studies (Nam, 1986; Koh, 1990; Nam and Kim, 1999) and the present results that the seasonally fluctuation of biomass is likely to exert a large influence on the biomass proportion change of subtidal marine algae. The present work confirms that fluctuation of biomass affected to the brown algae such as *Sargassum* spp., *Undaria pinnafitida* and coralline red algae like *Corallina* spp. and *Amphiroa dilatata*.

Some investigators reported on the importance value of subtidal macroalgae in south coasts of Korea (Kang *et al.*, 1993; Kang and Kim, 2004). They observed the importance value dominated by *Chondracanthus tenellus, Sargassum sagamianum, Pterocladia capillacea, Corallina pilulifera, Grateloupia lanceolata, Amphiroa dilatata* and *Dictyopteris prolifera* in Yorkjido, Bijindo and Geumodo the vicinity of this study region. This importance value pattern was similar to those reported from locations on the south coast of Korea, although the characteristic species and the assemblages of the species were different. In the present observations, 6 species (*Ulva pertusa, Sargassum horneri, Gelidium amansii, Amphiroa dilatata, Prionitis cornea* and *Chondracanthus intermedia*) are representative of importance value (Ⅳ), although they do not form distinct communities regularly (Fig. 3).

Kristiansen (1972) reported the marine algal vegetation in Tuborg, Denmark into three algal seasons; spring (February–March to June), summer (June to September) and autumn–winter (October to February). On the basis of vegetative phenology, Hooper *et al.* (1980) reported that the phytobenthos of Newfoundland Island was divided into two seasonal groups, a summer–autumn flora and a winter–spring flora.

The result of cluster analysis on species composition data exhibits discontinuities in seasonal periodicity of algal distribution in Geoje subtidal zone. It is evident from Fig. 4 that through the year there are two major floral groups at position, which can be estimated as 50 of threshold value.

The temperature of seawater has been regarded as one of the physical factors determining seaweed distribution (Druehl, 1981; Boo and Lee, 1986). In order to characterize the flora of this area, R/P, C/P, and (R+C)/P ratios were applied (Cheney, 1977). Among these three ratios, (R+C)/P value calculated to be 4.36 is comparatively higher than 2.33 to 3.21 of the other region (Kim, 1991; Kang *et al.*, 1993; Kim *et al.*, 1996). The benthic algal flora of the south coast of Korea therefore can be included safely to temperate and mixed ones. Also, we evaluate the study sites flora through the Rhodophyta/Phaeophyta index, a criterion introduced by Feldmann (1937) and widely adopted to study the comparative floristics by phycologists (Druehl, 1981; Sohn *et al.*, 2007; Choi, 2008). This survey, the R/P value used as a function

Table4. The comparison of value of R/P, C/P, (R+C)/P ratio at Jisepo in Geoje

Value	Kim (1991)	Kang *et al.* (1993)	Kim *et al.* (1996)	This study
R/P	2.11	2.59	2.68	3.63
C/P	0.22	0.18	0.53	0.73
(R+C)/P	2.33	2.77	3.21	4.36

for change of flora coincides with temperature. The R/P value of flora during this survey period is above 3 (Table 4). It means that the flora during this period is characteristic of the Warm Temperate Region (Feldmann, 1937). As a result, the algal flora of Geoje is suspected to be a type with warm temperate region. Thus, the R/P value can be a reasonable index for comparative floristics in a local area (Boo and Lee, 1986).

ACKNOWLEDGEMENTS

This work was supported by Korea Research Foundation Grant (KRF–2004–075–C00015).

REFERENCES

Boo, S. M. and I. K. Lee 1986 Studies on benthic algal community in the East coast of Korea. 1. Floristic composition and periodicity of a Sokcho rocky shore. *Korean J. Phycol.*, **1**: 107–116

Cheney, D. P. 1977 R & C/P – A new and improved ratio for comparing seaweed floras. *Suppl. J. Phycol.*, **13**: 129

Choi, C. G. 2008 Algal flora in Hallyeo–haesang national park, Southern coast of Korea. *J. Kor. Fish. Soc.*, **41**: 371–380

Choi, C. G. and S. H. Huh 2008 Composition of marine algal community at the intertidal zone in Gwangyang Bay, South sea, Korea. *J. Kor. Fish. Soc.*, **41**: 201–207

Choi, C. G., J. H. Kim and I. K. Chung 2008a Temporal variation of seaweed biomass in Korean coasts: Yokjido, Gyeongnam Province. *Algae*, **23**: 311–316

Choi. H. G., K. H. Lee, X. Q. Wan, H. I. Yoo, H. H. Park, J. H. Kim and I. K. Chung 2008b Temporal variation in seaweed biomass in Korean coasts: Woejodo and Jusamdo, Jeonbuk. *Algae*, **23**: 335–342

Clarke, K. R. and R. N. Gorley 2006 *PRIMER V6*: User Manual/Tutorial. PRIMER–E Ltd, Plymouth, pp. 190

Druehl, L. P. 1981 Geographic distribution. *In* "The Biology of Seaweeds" (eds,) Lobban, C. R. and M. J. Wynne. Blackwell Sci. Publ. Boston, pp. 306–325

Feldmann, J. 1937 Recherches sur la vegetation marine de la Miditerranee. La cote des Alberes. *Rev. Algol.*, **10**: 1–339

van den Hoek, C. 1975 Phytogeographic regions in the northern Atlantic Ocean. *Phycologia*, **14**: 317–330

Hooper, R. G., G. R. South and A. Whittick 1980 Ecological and phonological aspects of the marine phytobenthos of the Island of Newfoundland. *In* "The Shore Environment" (eds,) Price, J. H., D. E. G. Irvine and W. F. Farnham. Academic Press, London, pp. 395–423

Kang, J. W. 1966 On the geographical distribution of marine algae in Korea. *Bull. Pusan Fish. Coll.*, **7**: 1–125

Kang, J. W. 1968 Illustrated encyclopedia of fauna and flora of Korea. Vol. 8. *Marine algae.* Ministry of Education, Seoul, pp. 465

Kang, R. S. and J. M. Kim 2004 Seaweed community of the subtidal rocky habitats along the coast of Geumo Archipelago in the central south sea of Korea. *Algae*, **19**: 339–347

Kang, R. S., J. G. Je and C. H. Sohn 1993 Summer algal communities in the rocky shore of south sea of Korea. Ⅱ. Subtidal communities. *Bull. Korean Fish. Soc.*, **26**: 182–197

Kim, K. Y. and I. K. Lee 1995 Community structure of subtidal macroalgae around Neobdo Island on the West–southern coast of Korea. *J. Plant Biol.*, **38**: 153–158

Kim, K. Y., S. H. Hur and G. H. Kim 1996 Diversity and abundance of sublittoral macroalgae around Daedo island, the south coast of Korea. *Algae*, **11**: 171–177

Kim, N. G. 1991 Benthic marine algal flora of Chungmu area in the southern coast of Korea. *Bull. Tong–yeong Fish. Tech. Coll.*, **27**: 118–126

Kim, Y. H., H. J. Yoon and J. S. Yoo 1995 Species composition and biomass of marine algal community on the mid–western coast of Korea. *J. Plant Biol.*, **38**: 389–398

Ko, Y. W., G. H. Sung, C. H. Yi, H. H. Kim, D. M. Choi, Y. D. Ko, W. J. Lee, H. B. Koh, J. H. Oak, I. K. Chung and J. H. Kim 2008 Temporal variation of seaweed biomass in Korea coasts: Munseom, Jeju Island. *Algae*, **23**: 295–300

Koh, N. P. 1990 An ecological study on resources of marine plants in Geomundo islands. *Korean J. Phycol.*, **5**: 1–37

Kristiansen, A. 1972 A seasonal study of the marine algal vegetation in Tuborg Harbour, the Sound, Denmark. *Bot. Tidsskr.*, **67**: 201–244

Lawson, G. W. 1978 The distribution of seaweed in the tropical and subtropical Atlantic Ocean: a quantitative approach. *Bot. J. Linn. Soc.*, **76**: 177–193

Lee, I. K. and J. W. Kang 1986 A check list of marine algae in Korea. *Korean J. Phycol.*, **1**: 311–325

Lee, I. K., D. S. Choi, Y. S. Oh, G. H. Kim, J. W. Lee, K. Y. Kim and J. S. Yoo 1991 Marine algal flora and community structure of Chongsando Island on the south sea of Korea. *Korean J. Phycol.*, **6**: 131–143

Lee, I. K., Y. H. Kim, J. H. Lee and S. W. Hong 1975 A study on the marine algae in the Kwang Yand Bay. 1. The seasonal variation of algal community. *Korean J. Botany*, **18**: 109–121

Lee, Y. P. and S. Y. Kang 2001 *A catalogue of the seaweeds in Korea.* Cheju National University Press, Cheju, pp. 662

Michanek, G. 1979 Phytogeographic provinces and seaweed distribution. *Bot. Mar.*, **22**: 375–391

Nam, K. W. 1986 On the marine benthic algal community of Chuckdo in eastern coast of Korea. *Korean J. Phycol.*, **1**: 185–202

Nam, K. W. and Y. S. Kim 1999 Benthic marine algal flora and community structure of Yongho–dong area in Pusan, Korea. *J. Korean Fish. Soc.*, **32**: 374–384

Neto, A. I. 2001 Macroalgal species diversity and biomass of subtidal communities of Sao Miguel (Azores). *Helgol. Mar. Res.*, **55**: 101–111

Nybakken, J. W. 1988 *Marine biology, an ecological approach.* Harper Collins Publishers, pp. 514

Segawa, S. 1956 *Coloured illustrations of the seaweeds of Japan.* Hoikusha Publ. Co. Osaka

Sohn, C. H., C. G. Choi and H. G. Kim 2007 Algal communities and useful seaweed distribution at Gangnung and it's vicinity in East coast of Korea. *Algae*, **22**: 45–52

Sohn, C. H., I. K. Lee and J. W. Kang 1983 Benthic marine algae of Dolsan Island in the southern coast of Korea. 1. Structure of algal communities of subtidal zone. *Bull. Korean Fish. Soc.*, **16**: 379–388

Taniguti, M. 1981 Distribution theory of marine algal vegetation in the Far East. *Mar. Alg. Res.*, **22**: 1–19