Marine Algal Flora on Goheung Coast, Korea

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Abstract − To understand the marine algal flora on Goheung coast, Korea, marine algae at 8 points were collected from November 2008 to February 2009 and from April to June 2009. Thirty-seven species (2 species of angiosperms, 5 chlorophytes, 12 phaeophytes, and 18 rhodophytes) occurred from fall to winter and 52 species (2 species of angiosperms, 9 chlorophytes, 18 phaeophytes, and 23 rhodophytes) occurred from spring to summer. Commonly occurring species were *Ulva pertusa, Sargassum thunbergii, Hizikia fuziformis*, and *Gelidium amansii*, and dominant species at most points were *Ulva pertusa, Sargassum thunbergii*, and *Gelidium amansii*. The average of the ratio of total rhodophytes and chlorophytes to phaeophytes ((R+C)/P) was 1.61 in fall to winter and 1.69 in spring to summer, and the average Laminariales/Fucales/Dictyotales (LFD) ratio was 1.14 in fall to winter and 1.18 in spring to summer. These results show that the marine algal flora of Goheung could be considered as temperate. The LFD ratio was fit for showing a feature of algal flora of Goheung. Species diversity index was high at Points 4～6 while low at Points 1 and 8. Detrended correspondence analysis (DCA) showed that the similarity of occurring species at Points 3 and 4 was higher than the other points from fall to winter, whereas the occurred species at Points 1～4 were similar from spring to summer. The average values of ecological evaluation index (EEI) of the investigation points were 6.8 from fall to winter and 6.3 from spring to summer, which means that the ecological environment of the investigation points were middle class and the EEI values of outer sea points were higher than the inner bay points.

Key words : marine algal flora, intertidal zone, subtidal zone, seasonal changes

INTRODUCTION

Marine algae inhabit about 2% of the seafloor. The presence of benthic seaweeds defines the inner continental shelf, where the marine community largely depends on the food and protection that seaweeds provide (Karleskint *et al*. 2006).

Marine macroalgae have also been studied to monitor and detect water pollution (Jayasekera and Rossbach 1996; Orfanidis *et al*. 2001; Ballesteros *et al*. 2007), and they have been studied as a possible way to resolve the greenhouse gas problem.

Many scientists and policymakers have called for adopting an entirely new approach to managing and sustaining marine biodiversity as well as the important ecological and economic services provided by the seas. The primary objective of this ecosystem-based approach is to protect and sustain whole marine ecosystems for current and future generations instead of focusing primarily on protecting individual species (Miller and Spoolman 2009).

Yack Jun Chyung (Chyung 1991) was the first to initiate natural historical studies of the Southwest coast of Korea in 1814. He reported 38 algal species of Heuksan island of Wando. Kang (1966) studied the geographical distribution

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of algae in Korea. The algae and especially the *Porphyra* cultivation industries of Goheung are very developed, but the algal flora of this location have not been well studied.

MATERIALS AND METHODS

In order to study the resources and ecological characteristics of marine algae in Goheung, marine algae were collected from fall to winter (November 2008 to February 2009) and from spring to summer (April to June 2009) at 8 points on the Goheung coast (Fig. 1). The investigations of algal flora were carried out at the intertidal zone as well as the high and low parts of the subtidal zone by SCUBA diving, and a 50×50 cm quadrat was used to collect the marine algae samples (Saito and Atobe 1970; Saito *et al*. 1971). After the samples were transported to the lab and washed thoroughly, parts of the samples were made into dry specimens and their photos taken. The species were identified based on the information in published papers (Kang 1968; Okamura 1974; Tseng 1983; Chihara 2004; Tanaka and Nakamura 2004; Ohba and Miyata 2007; Lee 2008). The biomass was calculated based on the wet weight (g wet weight) of the samples per unit area (m^2).

1. Relative coverage (RC), relative frequency (RF) and seasonal important value (IV)

The IV was calculated based on the RC and RF to identify the dominant species, and the formulas followed Muller-Dombios (1974) and Yoo (1980).

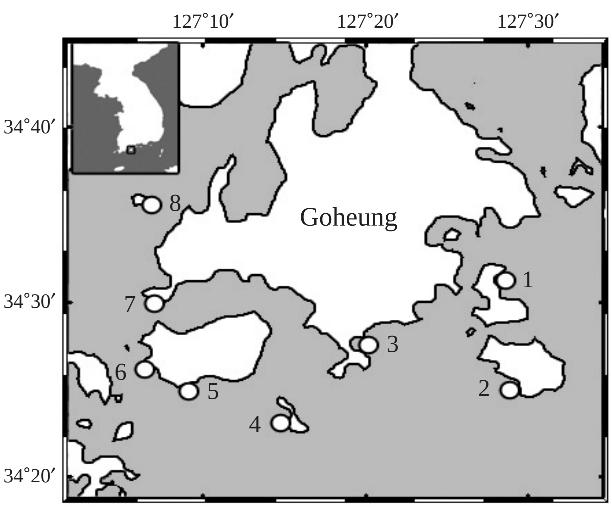

Fig. 1. Locations of investigation points.

Coverage (C)=[area of the species (i)/area of the quadrat] ×100

Frequency (F)=[the little quadrat numbers which taken by species (i)/the total subdivision of the quadrat]×100

RC=(total C of species i/total C of all species)×100

RF=(total F of species i/total F of all species)×100

IV=(RC+RF)/2

2. R/P, C/P, (R+C)/P, L/F, LFD

The ratio of rhodophytes to phaeophytes (R/P), the ratio of chlorophytes to phaeophytes (C/P), and the ratio of total rhodophytes and chlorophytes to phaeophytes [(R+C)/P] were calculated to determine the characteristics of the algal flora (Feldmann 1938; Cheney 1977). If the value of (R+C)/P is less than 3, the algal flora should be a warm or cold water type, if the value is 6 or higher, the algal flora should be a hot water type, and if the value is between 3 and 6, the algal flora should be a mixed type.

The ratio of the number of species of Laminariales to the number of species of Fucales was also calculated (Arasaki 1976). When the L/F ratio falls in the range of 0 and 0.1, the algal flora is a hot water type; when in the range of 0.2 and 0.7, the algal flora should be a warm water type; and when the ratio was higher than 0.7, the algal flora should be a cold water type. The formula of L/F was showed as follows:

L/F=species of Laminariales numbers/species of Fucales numbers

Members of Laminariales, Fucales, and Dictyotales of brown algae can be separated into two or three groups based on their distributions. In Laminariales (L), cold and warm species groups are separated at the rank of family or genus, in Fucales (F), cold, warm, and hot water species groups at the rank of genus or subgenus, and in Dictyotales (D), warm and hot water species groups at the rank of genus (Tanaka 1997). Based on the number of species belonging to these groups, LFD was calculated for the investigation points. The LFD index ranged between 0 and 2, since LFD was positively correlated with the water temperature; as the value of LFD approached 2, the algal flora more closely resembled a hot water algal flora. The formula of LFD was as follows:

$$LFD=(C\times 0+W\times 1+H\times 2)/(C+W+H)$$

where C is the number of cold water species; W is the number of warm water species; H is the number of hot water species.

3. Species diversity index (H′ index)

The H′ index was calculated using the Shannon-Wiener index,

$$H' = \sum P_i \ln(P_i)$$

where P_i is the probability of macroalgae species '*i*' occurring in the assemblage.

For this study, P_i was equal to RB_i, which is the relative biomass of species *i* (Wilhm 1968; Masson and Greig 1988; Zhuang *et al*. 2004).

Table 1. Marine algae occurring from fall to winter (2008～2009)

Category	Species	1	2	3	4	5	6	7	8
Angiospermae	*Halophila nipponica*							+	
	Phyllospadix japonicus				+		+		
	Total 2	0	0	0	1	0	1	1	0
Chlorophyta	*Caulerpa okamurae*							+	
	Cladophora sakaii							+	
	Codium contractum	+		+	+				
	Codium fragile		+			+			
	Ulva pertusa			+	+		+	+	+
	Total 5	1	1	2	2	1	1	3	1
Phaeophyta	*Dictyta divaricata*				+				
	Ecklonia cava					+	+		
	Hizikia fusiformis	+	+	+	+	+	+	+	
	Ishige okamurae			+	+		+	+	
	Ishige foliacea	+	+						
	Myagropsis myagroides					+	+	+	
	Sargassum coreanum					+			
	Sargassum horneri		+	+	+		+	+	+
	Sargassum macrocarpum					+	+		
	Sargassum pallidum			+			+		
	Sargassum thunbergii	+		+	+			+	+
	Sargassum yendoi	+	+	+	+				
	Total 12	4	4	6	6	5	7	5	2
Rhodophyta	*Acrosorium polyneurum*						+		
	Amphiroa anceps				+	+	+		
	Amphiroa beauvoisii	+	+	+	+			+	
	Bangia atropurpurea							+	
	Carpopeltis affinis					+	+		
	Chondracanthus tenellus	+	+	+			+		
	Chondria crassicaulis						+		
	Chondrus ocellatus					+	+	+	
	Chondrus pinnulatus	+	+	+					
	Corallina officinalis		+		+	+	+		
	Gelidium amansii	+	+	+	+	+	+	+	+
	Gelidium pacificum					+		+	
	Grateloupia turuturu					+	+	+	
	Peyssonnelia caulifera				+	+			
	Phacelocarpus japonicus					+	+	+	
	Plocamium telfairiae		+		+			+	
	Prionitis cornea		+						
	Rhodymenia intricata								+
	Total 18	4	7	4	6	9	10	8	2

Table 2. Marine algae occurring from spring to summer (2009)

Category	Species	1	2	3	4	5	6	7	8
Angiospermae	*Halophila nipponica*							+	
	Phyllospadix japonicus				+		+		
	Total 2	0	0	0	1	0	1	1	0
Chlorophyta	*Caulerpa okamurae*							+	
	Cladophora japonica			+					
	Cladophora sacaii							+	
	Cladophora wrightiana	+							
	Codium contractum	+		+	+				
	Codium fragile		+			+			
	Collinsiella japonica			+					+
	Microdictyon nigresceus								+
	Ulva pertusa			+	+		+	+	+
	Total 9	2	1	4	2	1	1	3	3
Phaeophyta	*Dictyopteris prolifera*	+							
	Dictyta divaricata				+				
	Ecklonia cava					+	+		
	Ectocarpus siliculosus			+					+
	Hizikia fusiformis	+	+	+	+	+	+	+	
	Ishige okamurae			+	+		+	+	
	Ishige foliacea	+	+						
	Leathesia difformis				+	+	+		
	Myagropsis myagroides					+	+	+	
	Padina arborescens					+			
	Padina crassa						+		
	Sargassum coreanum					+			
	Sargassum horneri		+	+	+		+	+	+
	Sargassum macrocarpum					+	+		
	Sargassum pallidum			+			+		
	Sargassum thunbergii	+		+	+			+	+
	Sargassum yendoi	+	+	+	+				
	Sphacelaria califoraica							+	
	Total 18	5	4	7	7	7	9	6	3
Rhodophyta	*Acanthopeltis* sp.		+					+	
	Acrosorium polyneurum						+		
	Amphiroa anceps				+	+	+		
	Amphiroa beauvoisii	+	+	+	+			+	
	Bangia atropurpurea							+	
	Carpopeltis affinis					+	+		
	Chondracanthus tenellus		+	+			+		
	Chondria crassicaulis		+				+	+	
	Chondrus ocellatus					+	+	+	
	Chondrus pinnulatus		+	+					
	Corallina officinalis	+	+		+	+	+		
	Gelidium amansii	+	+	+	+	+	+	+	+
	Gelidium pacificum					+		+	
	Grateloupia chiangii		+						
	Grateloupia turuturu					+	+	+	
	Heterosiphonia japonica				+				
	Lithophyllum okamurae		+				+		
	Peyssonnelia caulifera				+	+			
	Phacelocarpus japonicus					+	+	+	
	Plocamium telfairiae		+		+			+	
	Polysiphonia morrowii				+	+			
	Prionitis cornea	+	+						
	Rhodymenia intricata								+
	Total 23	4	11	4	8	10	11	10	2

4. Detrended correspondence analysis (DCA)

The program CANOCO was used to ordinate the studied points (Lepš and Šmilauer 2003). DCA was carried out as an indirect ordination method (Hill 1973; Hill and Gauch 1980; Ter Braak 1986, 1987; Palmer 1993; Bolton *et al*. 2004).

5. Ecological evaluation index (EEI)

The EEI was designed to estimate the ecological status of transitional and coastal waters. Marine benthic macrophytes (marine algae, seagrasses) were used as bioindicators of ecosystem shifts due to anthropogenic stress, from the pristine state with late-successional species [high ecological status class (ESC)] to the degraded state with opportunistic species (bad ESC). Shifts in marine ecosystem structure and function were evaluated by classifying marine benthic macrophytes into two ecological state groups (ESG I, II) (Orfanidis *et al*. 2001). The absolute abundance (%) of each ESG was estimated by coverage (%) in each sample. To evaluate the ecological status of the samples, the mean absolute abundance (%) of ESGs I and II was non-linearly corresponded to five different ESCs (≤ 2, Bad; $2<$ to ≥ 4, Low; ≤ 6 to >4, Moderate; ≤ 8 to >6, Good; ≤ 10 to >8, High) (Orfanidis *et al*. 2001, 2003).

RESULTS

1. Communities of marine algae

Thirty-seven species (2 species of angiosperms, 5 chlorophytes, 12 phaeophytes, and 18 rhodophytes) occurred from fall to winter, and 52 species (2 species of angiosperms, 9 chlorophytes, 18 phaeophytes, and 23 rhodophytes) occurred from spring to summer (Tables 1 and 2).

From fall to winter, the occurred species were plentiful at Point 6 (19 species) and Point 7 (17 species). The biomasses of the investigation points were 1324.8 to 6929.6 gWWt · m^{-2} at 8 investigation points, and the high-biomass species were phaeophytes such as *Sargassum thunbergii* and *Hizikia fusiformis* (Table 3).

From spring to summer, the points with more occurred species, which were Point 6 (22 species) and Point 7 (20 species), were the same from fall to winter. Biomasses were 1592.3 to 7922.8 gWWt · m^{-2}, and the high-biomass species were as same from fall to winter (Table 4).

Table 3. Number of species and wet weight of marine algae from fall to winter (2008～2009)

Point	Chlorophyta		Phaeophyta		Rhodophyta		Angiospermae		Total	
	Number of species	Wet weight (gWWt · m^{-2})	Number of species	Wet weight (gWWt · m^{-2})	Number of species	Wet weight (gWWt · m^{-2})	Number of species	Wet weight (gWWt · m^{-2})	Number of species	Wet weight (gWWt · m^{-2})
1	1	50.4	4	1256.0	4	708.4	–	–	9	2014.8
2	1	1033.6	4	1262.8	7	799.6	–	–	12	3096.0
3	2	1037.2	6	2969.2	4	414.4	–	–	12	4420.8
4	2	201.6	6	1501.2	6	925.6	1	444.4	15	3072.8
5	1	4.8	5	1843.6	9	3815.9	–	–	15	5664.3
6	1	325.6	7	2051.2	10	4148.8	1	404.0	19	6929.6
7	3	492.8	5	1997.2	8	1583.2	1	20.0	17	4093.2
8	1	174.0	2	1009.2	2	141.6	–	–	5	1324.8

Table 4. Number of species and wet weight of marine algae from spring to summer (2009)

Point	Chlorophyta		Phaeophyta		Rhodophyta		Angiospermae		Total	
	Number of species	Wet weight (gWWt · m^{-2})	Number of species	Wet weight (gWWt · m^{-2})	Number of species	Wet weight (gWWt · m^{-2})	Number of species	Wet weight (gWWt · m^{-2})	Number of species	Wet weight (gWWt · m^{-2})
1	2	147.6	5	1551.2	4	829.4	–	–	11	2528.2
2	1	1188.6	4	1452.2	11	1194.6	–	–	16	3835.4
3	4	1304.8	7	3473.4	4	620.1	–	–	15	5398.3
4	2	231.8	7	1775.2	8	1154.5	1	511.1	18	3672.6
5	1	5.5	7	2148.1	10	4412.9	–	–	18	6566.5
6	1	374.4	9	2389.1	11	4694.7	1	464.6	22	7922.8
7	3	566.7	6	2315.9	10	1695.2	1	23.0	20	4600.8
8	3	233.3	3	1196.2	2	162.8	–	–	8	1592.3

Table 5. Coverage (C), frequency (F), relative coverage (RC), relative frequency (RF), and important value (IV) of marine algae from fall to winter (2008～2009)

Point	Location	Species	C	F	RC	RF	IV
1	Intertidal	*Hizikia fusiformis*	14.0	100.0	25.0	26.0	25.5
		Sargassum thunbergii	26.0	100.0	46.4	26.0	36.2
		Sargassum yendoi	5.0	64.0	8.9	16.7	12.8
		Corallina officinalis	9.0	88.0	16.1	22.9	19.5
		Prionitis cornea	2.0	32.0	3.6	8.3	6.0
	High subtidal	*Codiumcontractum*	4.0	36.0	12.1	12.7	12.4
		Ishige foliacea	3.0	12.0	9.1	4.2	6.7
		Sargassum yendoi	5.0	40.0	15.2	14.1	14.6
		Corallina officinalis	11.0	88.0	33.3	31.0	32.2
		Gelidium amansii	6.0	80.0	18.2	28.2	23.2
		Prionitis cornea	4.0	28.0	12.1	9.9	11.0
	Low subtidal	*Amphiroa beauvoisii*	3.0	64.0	21.4	32.7	27.0
		Gelidium amansii	7.0	92.0	50.0	46.9	48.5
		Prionitis cornea	4.0	40.0	28.6	20.4	24.5
2	Intertidal	*Codium fragile*	9.0	44.0	21.4	16.7	19.0
		Hizikia fusiformis	20.0	100.0	47.6	37.9	42.7
		Ishige foliacea	8.0	60.0	19.0	22.7	20.9
		Chondracanthus tenellus	5.0	60.0	11.9	22.7	17.3
	High subtidal	*Codium fragile*	6.0	64.0	28.6	21.6	25.1
		Sargassum horneri	4.0	60.0	19.0	20.3	19.7
		Chondrus pinnulatus	3.0	44.0	14.3	14.9	14.6
		Chondracanthus tenellus	4.0	36.0	19.0	12.2	15.6
		Plocamium telfairiae	2.0	52.0	9.5	17.6	13.5
		Prionitis cornea	2.0	40.0	9.5	13.5	11.5
	Low subtidal	*Sargassum yendoi*	3.0	68.0	12.0	16.2	14.1
		Amphiroa beauvoisii	4.0	100.0	16.0	23.8	19.9
		Corallina officinalis	8.0	100.0	32.0	23.8	27.9
		Gelidium amansii	6.0	92.0	24.0	21.9	23.0
		Plocamium telfairiae	4.0	60.0	16.0	14.3	15.1
3	Intertidal	*Codium contractum*	10.0	88.0	16.9	15.8	16.4
		Ulva pertusa	4.0	44.0	6.8	7.9	7.3
		Hizikia fusiformis	10.0	96.0	16.9	17.3	17.1
		Ishige okamurae	9.0	100.0	15.3	18.0	16.6
		Sargassum thunbergii	16.0	100.0	27.1	18.0	22.6
		Amphiroa beauvoisii	6.0	88.0	10.2	15.8	13.0
		Gelidium amansii	4.0	40.0	6.8	7.2	7.0
	High subtidal	*Ulva pertusa*	6.0	68.0	18.8	18.5	18.6
		Hizikia fusiformis	7.0	56.0	21.9	15.2	18.5
		Sargassum pallidum	7.0	64.0	21.9	17.4	19.6
		Sargassum yendoi	4.0	60.0	12.5	16.3	14.4
		Chondracanthus tenellus	2.0	60.0	6.3	16.3	11.3
		Chondrus pinnulatus	1.0	8.0	3.1	2.2	2.6
		Gelidium amansii	5.0	52.0	15.6	14.1	14.9
	Low subtidal	*Sargassum horneri*	2.0	40.0	12.5	24.4	18.4
		Sargassum pallidum	5.0	40.0	31.3	24.4	27.8
		Chondracanthus tenellus	3.0	36.0	18.8	22.0	20.4
		Gelidium amansii	6.0	48.0	37.5	29.3	33.4
4	Intertidal	*Phyllospadix japonicus*	14.0	64.0	18.9	20.3	19.6
		Ulva pertusa	4.0	12.0	5.4	3.8	4.6
		Hizikia fusiformis	19.0	60.0	25.7	19.0	22.3
		Ishige okamurae	12.0	80.0	16.2	25.3	20.8
		Sargassum thunbergii	25.0	100.0	33.8	31.6	32.7
	High subtidal	*Hizikia fusiformis*	10.0	56.0	13.7	13.5	13.6
		Sargassum horneri	3.0	40.0	4.1	9.6	6.9
		Sargassum yendoi	6.0	40.0	8.2	9.6	8.9
		Amphiroa anceps	15.0	92.0	20.5	22.1	21.3
		Amphiroa beauvoisii	31.0	100.0	42.5	24.0	33.3
		Gelidium amansii	8.0	88.0	11.0	21.2	16.1

Table 5. Continued

Point	Location	Species	C	F	RC	RF	IV
4	Low subtidal	*Codiumcontractum*	8.0	40.0	9.1	8.4	8.7
		Ulva pertusa	17.0	88.0	19.3	18.5	18.9
		Dictyta divaricata	4.0	44.0	4.5	9.2	6.9
		Sargassum yendoi	5.0	68.0	5.7	14.3	10.0
		Corallina officinalis	40.0	100.0	45.5	21.0	33.2
		Gelidium amansii	6.0	76.0	6.8	16.0	11.4
		Peyssonnelia caulifera	3.0	12.0	3.4	2.5	3.0
		Plocamium telfairiae	5.0	48.0	5.7	10.1	7.9
5	Intertidal	*Codium fragile*	1.0	32.0	1.3	5.8	3.5
		Hizikia fusiformis	1.0	8.0	1.3	1.4	1.4
		Myagropsis myagroides	3.0	36.0	3.8	6.5	5.2
		Sargassum coreanum	1.0	32.0	1.3	5.8	3.5
		Sargassum macrocarpum	5.0	60.0	6.4	10.9	8.6
		Amphiroa anceps	37.0	100.0	47.4	18.1	32.8
		Chondrus ocellatus	8.0	60.0	10.3	10.9	10.6
		Corallina officinalis	9.0	92.0	11.5	16.7	14.1
		Gelidium amansii	8.0	68.0	10.3	12.3	11.3
		Peyssonnelia caulifera	5.0	64.0	6.4	11.6	9.0
	High subtidal	*Ecklonia cava*	10.0	40.0	16.4	6.4	11.4
		Myagropsis myagroides	5.0	44.0	8.2	7.0	7.6
		Phacelocarpus japonicus	3.0	48.0	4.9	7.6	6.3
		Sargassum macrocarpum	4.0	36.0	6.6	5.7	6.1
		Amphiroa anceps	13.0	92.0	21.3	14.6	18.0
		Carpopeltis affinis	6.0	88.0	9.8	14.0	11.9
		Chondrus ocellatus	2.0	48.0	3.3	7.6	5.5
		Gelidium amansii	5.0	80.0	8.2	12.7	10.5
		Gelidium pacificum	7.0	92.0	11.5	14.6	13.1
		Grateloupia turuturu	6.0	60.0	9.8	9.6	9.7
	Low subtidal	*Amphiroa anceps*	46.0	100.0	90.2	69.4	79.8
		Gelidium amansii	5.0	44.0	9.8	30.6	20.2
6	Intertidal	*Ulva pertusa*	33.0	96.0	47.8	18.6	33.2
		Ecklonia cava	5.0	20.0	7.2	3.9	5.6
		Hizikia fusiformis	10.0	60.0	14.5	11.6	13.1
		Ishige okamurae	4.0	64.0	5.8	12.4	9.1
		Chondria crassicaulis	3.0	40.0	4.3	7.8	6.0
		Chondrus ocellatus	6.0	68.0	8.7	13.2	10.9
		Gelidium amansii	3.0	92.0	4.3	17.8	11.1
		Grateloupia turuturu	5.0	76.0	7.2	14.7	11.0
	High subtidal	*Ulva pertusa*	15.0	84.0	21.1	12.4	16.8
		Myagropsis myagroides	6.0	96.0	8.5	14.2	11.3
		Phacelocarpus japonicus	4.0	56.0	5.6	8.3	7.0
		Acrosorium polyneurum	2.0	64.0	2.8	9.5	6.1
		Carpopeltis affinis	4.0	60.0	5.6	8.9	7.3
		Chondracanthus tenellus	3.0	56.0	4.2	8.3	6.3
		Chondria crassicaulis	3.0	76.0	4.2	11.2	7.7
		Chondrus ocellatus	4.0	52.0	5.6	7.7	6.7
		Corallina officinalis	25.0	88.0	35.2	13.0	24.1
		Gelidium amansii	5.0	44.0	7.0	6.5	6.8
	Low subtidal	*Phyllospadix japonicus*	10.0	60.0	10.6	7.9	9.3
		Ulva pertusa	21.0	100.0	22.3	13.2	17.7
		Ecklonia cava	10.0	28.0	10.6	3.7	7.2
		Hizikia fusiformis	3.0	44.0	3.2	5.8	4.5
		Myagropsis myagroides	2.0	68.0	2.1	8.9	5.5
		Phacelocarpus japonicus	6.0	52.0	6.4	6.8	6.6
		Sargassum horneri	2.0	36.0	2.1	4.7	3.4
		Sargassum macrocarpum	3.0	32.0	3.2	4.2	3.7
		Sargassum pallidum	3.0	28.0	3.2	3.7	3.4
		Amphiroa anceps	10.0	72.0	10.6	9.5	10.1
		Carpopeltis affinis	9.0	68.0	9.6	8.9	9.3
		Gelidium amansii	7.0	76.0	7.4	10.0	8.7
		Grateloupia turuturu	8.0	96.0	8.5	12.6	10.6

Table 5. Continued

Point	Location	Species	C	F	RC	RF	IV
7	Intertidal	*Cladophora sacaii*	4.0	40.0	10.0	9.4	9.7
		Ulva pertusa	12.0	44.0	30.0	10.4	20.2
		Myagropsis myagroides	3.0	52.0	7.5	12.3	9.9
		Sargassum horneri	1.0	36.0	2.5	8.5	5.5
		Amphiroa beauvoisii	10.0	88.0	25.0	20.8	22.9
		Bangia atropurpurea	2.0	32.0	5.0	7.5	6.3
		Gelidium amansii	3.0	48.0	7.5	11.3	9.4
		Gelidium pacificum	2.0	32.0	5.0	7.5	6.3
		Plocamium telfairiae	3.0	52.0	7.5	12.3	9.9
	High subtidal	*Ulva pertusa*	13.0	100.0	14.1	18.4	16.3
		Hizikia fusiformis	21.0	100.0	22.8	18.4	20.6
		Ishige okamurae	9.0	96.0	9.8	17.6	13.7
		Sargassum thunbergii	40.0	100.0	43.5	18.4	30.9
		Chondrus ocellatus	6.0	72.0	6.5	13.2	9.9
		Gelidium amansii	3.0	76.0	3.3	14.0	8.6
	Low subtidal	*Halophila nipponica*	4.0	20.0	4.4	3.6	4.0
		Caulerpa okamurae	10.0	88.0	11.0	15.8	13.4
		Ulva pertusa	10.0	40.0	11.0	7.2	9.1
		Myagropsis myagroides	11.0	68.0	12.1	12.2	12.2
		Phacelocarpus japonicus	3.0	56.0	3.3	10.1	6.7
		Sargassum horneri	2.0	28.0	2.2	5.0	3.6
		Amphiroa beauvoisii	30.0	96.0	33.0	17.3	25.1
		Gelidium amansii	10.0	88.0	11.0	15.8	13.4
		Grateloupia turuturu	11.0	72.0	12.1	12.9	12.5
8	Intertidal	*Ulva pertusa*	8.0	56.0	16.0	24.1	20.1
		Sargassum thunbergii	37.0	96.0	74.0	41.4	57.7
		Gelidium amansii	2.0	44.0	4.0	19.0	11.5
		Rhodymenia intricata	3.0	36.0	6.0	15.5	10.8
	High subtidal	*Sargassum horneri*	6.0	28.0	50.0	36.8	43.4
		Sargassum thunbergii	5.0	44.0	41.7	57.9	49.8
		Rhodymenia intricata	1.0	4.0	8.3	5.3	6.8
	Low subtidal	*Ulva pertusa*	33.0	100.0	47.1	31.3	39.2
		Sargassum horneri	4.0	36.0	5.7	11.3	8.5
		Sargassum thunbergii	26.0	100.0	37.1	31.3	34.2
		Gelidium amansii	4.0	40.0	5.7	12.5	9.1
		Rhodymenia intricata	3.0	44.0	4.3	13.8	9.0

2. Relative coverage (RC), relative frequency (RF) and seasonal important value (IV)

The coverage (C), frequency (F), RC, RF, and IV of the investigated marine algae are shown in Tables 5 and 6.

From fall to winter, *Codium fragile* (Point 2, IV: 25.1) and *Ulva pertusa* (Point 6, IV: 33.2) of Chlorophyta, *Corallina officinalis* (Point 1, IV: 32.2), *Gelidium amansii* (Point 1, IV: 48.5), and *Amphiroa beauvoisii* (Point 4, IV: 33.3) of Rhodophyta, and *Hizikia fusiformis* (Point 2, IV: 42.7), *Ishige okamurae* (Point 4, IV: 20.8), and *Sargassum thunbergii* (Point 8, IV: 57.7) of Phaeophyta had high IV.

From spring to summer, *Ulva pertusa* (Point 8, IV: 33.5) of Chlorophyta, *Gelidium amansii* (Point 1, IV: 28.1), *Dictyopteris prolifera* (Point 1, IV: 40.4), and *Amphiroa beauvoisii* (Point 2, IV: 20.9) of Rhodophyta, and *Hizikia fusiformis* (Point 2, IV: 49.9), *Sargassum pallidum* (Point 3, IV: 25.2), *Ishige okamurae* (Point 4, IV: 22.5), *Sargassum horneri* (Point 8, IV: 20.9), and *Sargassum thunbergii* (Point 8, IV: 38.6) of Phaeophyta had high IV.

The results show that from fall to winter, at most points, the dominant chlorophytes were *Ulva pertusa*, dominant phaeophytes were *Hizikia fusiformis*, *Sargassum thunbergii*, and *Sargassum horneri*, and dominant rhodophytes were *Amphiroa epherdraea* and *Gelidium amansii*. The dominant species from spring to summer were almost the same as from fall to winter, and the dominant species were species with isomorphic and no alternation of generations.

3. R/P, C/P, (R+C)/P, I/H, L/F and LFD

The number of species of Laminariales and Fucaceae, and

Table 6. Coverage (C), frequency (F), relative coverage (RC), relative frequency (RF) and important value (IV) of marine algae from spring to summer (2009)

Point	Location	Species	C	F	RC	RF	IV
1	Intertidal	*Hizikia fusiformis*	35.0	100.0	35.4	23.1	29.3
		Sargassum thunbergii	40.0	100.0	40.4	23.1	31.8
		Sargassum yendoi	3.0	88.0	3.0	20.4	11.7
		Corallina officinalis	13.0	96.0	13.1	22.2	17.7
		Prionitis cornea	8.0	48.0	8.1	11.1	9.6
	High subtidal	*Codiumcontractum*	8.0	64.0	12.5	14.5	13.5
		Ishige foliacea	4.0	32.0	6.3	7.3	6.8
		Sargassum yendoi	10.0	48.0	15.6	10.9	13.3
		Corallina officinalis	15.0	96.0	23.4	21.8	22.6
		Gelidium amansii	11.0	96.0	17.2	21.8	19.5
		Prionitis cornea	10.0	48.0	15.6	10.9	13.3
		Cladophora wrightiana	6.0	56.0	9.4	12.7	11.1
	Low subtidal	*Amphiroa beauvoisii*	5.0	44.0	8.8	19.3	14.0
		Gelidium amansii	12.0	80.0	21.1	35.1	28.1
		Prionitis cornea	10.0	40.0	17.5	17.5	17.5
		Dictyopteris prolifera	30.0	64.0	52.6	28.1	40.4
2	Intertidal	*Codium fragile*	9.0	68.0	12.5	21.5	17.0
		Hizikia fusiformis	50.0	96.0	69.4	30.4	49.9
		Ishige foliacea	8.0	80.0	11.1	25.3	18.2
		Chondracanthus tenellus	5.0	72.0	6.9	22.8	14.9
	High subtidal	*Codium fragile*	8.0	84.0	11.8	20.2	16.0
		Sargassum horneri	6.0	48.0	8.8	11.5	10.2
		Chondrus pinnulatus	9.0	60.0	13.2	14.4	13.8
		Chondracanthus tenellus	10.0	36.0	14.7	8.7	11.7
		Plocamium telfairiae	6.0	40.0	8.8	9.6	9.2
		Prionitis cornea	5.0	44.0	7.4	10.6	9.0
		Acanthopeltis sp.	13.0	56.0	19.1	13.5	16.3
		Chondria crassicaulis	11.0	48.0	16.2	11.5	13.9
	Low subtidal	*Sargassum yendoi*	4.0	72.0	6.7	12.6	9.6
		Amphiroa beauvoisii	15.0	96.0	25.0	16.8	20.9
		Corallina officinalis	10.0	100.0	16.7	17.5	17.1
		Gelidium amansii	9.0	96.0	15.0	16.8	15.9
		Plocamium telfairiae	4.0	72.0	6.7	12.6	9.6
		Grateloupia chiangii	10.0	64.0	16.7	11.2	13.9
		Lithophyllum okamurae	8.0	72.0	13.3	12.6	13.0
3	Intertidal	*Codium contractum*	12.0	96.0	14.0	16.3	15.1
		Ulva pertusa	8.0	36.0	9.3	6.1	7.7
		Hizikia fusiformis	16.0	96.0	18.6	16.3	17.5
		Ishige okamurae	8.0	100.0	9.3	17.0	13.2
		Sargassum thunbergii	20.0	100.0	23.3	17.0	20.1
		Amphiroa beauvoisii	16.0	88.0	18.6	15.0	16.8
		Gelidium amansii	6.0	72.0	7.0	12.2	9.6
	High subtidal	*Ulva pertusa*	16.0	76.0	21.1	10.1	15.6
		Hizikia fusiformis	8.0	64.0	10.5	8.5	9.5
		Sargassum pallidum	9.0	100.0	11.8	13.3	12.6
		Sargassum yendoi	6.0	88.0	7.9	11.7	9.8
		Chondracanthus tenellus	6.0	92.0	7.9	12.2	10.1
		Chondrus pinnulatus	3.0	36.0	3.9	4.8	4.4
		Gelidium amansii	10.0	72.0	13.2	9.6	11.4
		Cladophora japonica	7.0	88.0	9.2	11.7	10.5
		Collinsiella japonica	5.0	72.0	6.6	9.6	8.1
		Ectocarpus siliculosus	6.0	64.0	7.9	8.5	8.2
	Low subtidal	*Sargassum horneri*	3.0	64.0	12.0	23.5	17.8
		Sargassum pallidum	6.0	72.0	24.0	26.5	25.2
		Chondracanthus tenellus	3.0	36.0	12.0	13.2	12.6
		Gelidium amansii	7.0	60.0	28.0	22.1	25.0
		Collinsiella japonica	2.0	12.0	8.0	4.4	6.2
		Ectocarpus siliculosus	4.0	28.0	16.0	10.3	13.1

Table 6. Continued

Point	Location	Species	C	F	RC	RF	IV
4	Intertidal	*Phyllospadix japonicus*	11.0	96.0	13.9	23.8	18.8
		Ulva pertusa	4.0	16.0	5.1	4.0	4.5
		Hizikia fusiformis	17.0	92.0	21.5	22.8	22.1
		Ishige okamurae	16.0	100.0	20.3	24.8	22.5
		Sargassum thunbergii	31.0	100.0	39.2	24.8	32.0
	High subtidal	*Hizikia fusiformis*	15.0	64.0	17.0	10.1	13.6
		Sargassum horneri	9.0	60.0	10.2	9.5	9.9
		Sargassum yendoi	8.0	72.0	9.1	11.4	10.2
		Amphiroa anceps	15.0	96.0	17.0	15.2	16.1
		Amphiroa beauvoisii	20.0	100.0	22.7	15.8	19.3
		Gelidium amansii	7.0	100.0	8.0	15.8	11.9
		Leathesia difformis	4.0	28.0	4.5	4.4	4.5
		Heterosiphonia japonica	5.0	48.0	5.7	7.6	6.6
		Polysiphonia morrowii	5.0	64.0	5.7	10.1	7.9
	Low subtidal	*Codiumcontractum*	10.0	60.0	12.2	9.4	10.8
		Ulva pertusa	24.0	88.0	29.3	13.8	21.5
		Dictyta divaricata	6.0	80.0	7.3	12.5	9.9
		Sargassum yendoi	4.0	72.0	4.9	11.3	8.1
		Corallina officinalis	16.0	100.0	19.5	15.6	17.6
		Gelidium amansii	9.0	96.0	11.0	15.0	13.0
		Peyssonnelia caulifera	7.0	48.0	8.5	7.5	8.0
		Plocamium telfairiae	4.0	60.0	4.9	9.4	7.1
		Leathesia difformis	2.0	36.0	2.4	5.6	4.0
5	Intertidal	*Codium fragile*	2.0	48.0	2.9	7.3	5.1
		Hizikia fusiformis	4.0	24.0	5.9	3.7	4.8
		Myagropsis myagroides	3.0	64.0	4.4	9.8	7.1
		Sargassum coreanum	5.0	28.0	7.4	4.3	5.8
		Sargassum macrocarpum	6.0	80.0	8.8	12.2	10.5
		Amphiroa anceps	17.0	100.0	25.0	15.2	20.1
		Chondrus ocellatus	8.0	88.0	11.8	13.4	12.6
		Corallina officinalis	10.0	92.0	14.7	14.0	14.4
		Gelidium amansii	8.0	68.0	11.8	10.4	11.1
		Peyssonnelia caulifera	5.0	64.0	7.4	9.8	8.6
	High subtidal	*Ecklonia cava*	4.0	48.0	4.4	5.4	4.9
		Myagropsis myagroides	6.0	72.0	6.6	8.1	7.4
		Phacelocarpus japonicus	5.0	44.0	5.5	5.0	5.2
		Sargassum macrocarpum	7.0	48.0	7.7	5.4	6.6
		Amphiroa anceps	13.0	100.0	14.3	11.3	12.8
		Carpopeltis affinis	8.0	96.0	8.8	10.9	9.8
		Chondrus ocellatus	12.0	52.0	13.2	5.9	9.5
		Gelidium amansii	8.0	100.0	8.8	11.3	10.1
		Gelidium pacificum	6.0	100.0	6.6	11.3	9.0
		Grateloupia turuturu	11.0	96.0	12.1	10.9	11.5
		Leathesia difformis	4.0	36.0	4.4	4.1	4.2
		Padina arborescens	4.0	44.0	4.4	5.0	4.7
		Polysiphonia morrowii	3.0	48.0	3.3	5.4	4.4
	Low subtidal	*Amphiroa anceps*	46.0	100.0	83.6	47.2	65.4
		Gelidium amansii	6.0	60.0	10.9	28.3	19.6
		Polysiphonia morrowii	3.0	52.0	5.5	24.5	15.0
6	Intertidal	*Ulva pertusa*	39.0	100.0	41.5	18.4	29.9
		Ecklonia cava	6.0	36.0	6.4	6.6	6.5
		Hizikia fusiformis	20.0	88.0	21.3	16.2	18.7
		Ishige okamurae	3.0	36.0	3.2	6.6	4.9
		Chondria crassicaulis	4.0	44.0	4.3	8.1	6.2
		Chondrus ocellatus	9.0	72.0	9.6	13.2	11.4
		Gelidium amansii	3.0	92.0	3.2	16.9	10.1
		Grateloupia turuturu	10.0	76.0	10.6	14.0	12.3

Table 6. Continued

Point	Location	Species	C	F	RC	RF	IV
6	High subtidal	*Ulva pertusa*	20.0	78.0	22.2	9.6	15.9
		Myagropsis myagroides	8.0	96.0	8.9	11.8	10.3
		Phacelocarpus japonicus	6.0	64.0	6.7	7.9	7.3
		Acrosorium polyneurum	4.0	64.0	4.4	7.9	6.2
		Carpopeltis affinis	4.0	68.0	4.4	8.4	6.4
		Chondracanthus tenellus	6.0	72.0	6.7	8.8	7.8
		Chondria crassicaulis	4.0	60.0	4.4	7.4	5.9
		Chondrus ocellatus	6.0	64.0	6.7	7.9	7.3
		Corallina officinalis	15.0	100.0	16.7	12.3	14.5
		Gelidium amansii	7.0	52.0	7.8	6.4	7.1
		Leathesia difformis	4.0	32.0	4.4	3.9	4.2
		Padina crassa	3.0	28.0	3.3	3.4	3.4
		Lithophyllum okamurae	3.0	36.0	3.3	4.4	3.9
	Low subtidal	*Phyllospadix japonicus*	8.0	88.0	8.4	9.5	9.0
		Ulva pertusa	23.0	100.0	24.2	10.8	17.5
		Ecklonia cava	12.0	64.0	12.6	6.9	9.8
		Hizikia fusiformis	4.0	36.0	4.2	3.9	4.0
		Myagropsis myagroides	3.0	72.0	3.2	7.8	5.5
		Phacelocarpus japonicus	8.0	76.0	8.4	8.2	8.3
		Sargassum horneri	3.0	40.0	3.2	4.3	3.7
		Sargassum macrocarpum	2.0	48.0	2.1	5.2	3.6
		Sargassum pallidum	1.0	32.0	1.1	3.4	2.3
		Amphiroa anceps	12.0	92.0	12.6	9.9	11.3
		Carpopeltis affinis	6.0	88.0	6.3	9.5	7.9
		Gelidium amansii	5.0	92.0	5.3	9.9	7.6
		Grateloupia turuturu	8.0	100.0	8.4	10.8	9.6
7	Intertidal	*Cladophora sacaii*	9.0	44.0	11.5	7.3	9.4
		Ulva pertusa	18.0	48.0	23.1	7.9	15.5
		Myagropsis myagroides	3.0	52.0	3.8	8.6	6.2
		Sargassum horneri	6.0	16.0	7.7	2.6	5.2
		Amphiroa beauvoisii	12.0	100.0	15.4	16.6	16.0
		Bangia atropurpurea	5.0	56.0	6.4	9.3	7.8
		Gelidium amansii	3.0	72.0	3.8	11.9	7.9
		Gelidium pacificum	6.0	48.0	7.7	7.9	7.8
		Plocamium telfairiae	5.0	64.0	6.4	10.6	8.5
		Sphacelaria califoraica	6.0	56.0	7.7	9.3	8.5
		Acanthopeltis sp.	5.0	48.0	6.4	7.9	7.2
	High subtidal	*Ulva pertusa*	20.0	92.0	22.7	16.4	19.6
		Hizikia fusiformis	21.0	100.0	23.9	17.9	20.9
		Ishige okamurae	8.0	96.0	9.1	17.1	13.1
		Sargassum thunbergii	25.0	100.0	28.4	17.9	23.1
		Chondrus ocellatus	9.0	72.0	10.2	12.9	11.5
		Gelidium amansii	3.0	64.0	3.4	11.4	7.4
		Chondria crassicaulis	2.0	36.0	2.3	6.4	4.4
	Low subtidal	*Halophila nipponica*	3.0	48.0	4.1	7.8	6.0
		Caulerpa okamurae	7.0	72.0	9.6	11.7	10.6
		Ulva pertusa	9.0	44.0	12.3	7.1	9.7
		Myagropsis myagroides	7.0	76.0	9.6	12.3	11.0
		Phacelocarpus japonicus	3.0	64.0	4.1	10.4	7.2
		Sargassum horneri	6.0	48.0	8.2	7.8	8.0
		Amphiroa beauvoisii	19.0	100.0	26.0	16.2	21.1
		Gelidium amansii	9.0	100.0	12.3	16.2	14.3
		Grateloupia turuturu	10.0	64.0	13.7	10.4	12.0
8	Intertidal	*Ulva pertusa*	20.0	48.0	30.8	15.0	22.9
		Sargassum thunbergii	33.0	100.0	50.8	31.3	41.0
		Gelidium amansii	2.0	52.0	3.1	16.3	9.7
		Rhodymenia intricata	4.0	44.0	6.2	13.8	10.0
		Collinsiella japonica	3.0	40.0	4.6	12.5	8.6
		Microdictyon nigresceus	3.0	36.0	4.6	11.3	7.9

Table 6. Continued

Point	Location	Species	C	F	RC	RF	IV
8	High subtidal	*Sargassum horneri*	4.0	36.0	16.0	25.7	20.9
		Sargassum thunbergii	10.0	52.0	40.0	37.1	38.6
		Rhodymenia intricata	1.0	12.0	4.0	8.6	6.3
		Microdictyon nigresceus	4.0	16.0	16.0	11.4	13.7
		Ectocarpus siliculosus	6.0	24.0	24.0	17.1	20.6
	Low subtidal	*Ulva pertusa*	39.0	100.0	43.3	23.6	33.5
		Sargassum horneri	5.0	64.0	5.6	15.1	10.3
		Sargassum thunbergii	36.0	100.0	40.0	23.6	31.8
		Gelidium amansii	5.0	64.0	5.6	15.1	10.3
		Rhodymenia intricata	3.0	52.0	3.3	12.3	7.8
		Ectocarpus siliculosus	2.0	44.0	2.2	10.4	6.3

Table 7. Number of species of Laminariales and Fucaceae, and species of cold, warm, and hot water type from fall to winter (2008～2009)

Item	Point							
	1	2	3	4	5	6	7	8
Laminariales	0	0	0	0	1	1	0	0
Fucaceae	3	3	5	4	4	5	4	2
C*	0	0	0	0	0	0	0	
W*	2	2	4	3	5	6	4	2
H*	1	1	1	1	0	0	0	0

*C is species of cold water, W is species of warm water, H is species of hot water.

Table 8. Number of species of Laminariales and Fucaceae, and species of cold, warm, and tropical water type from spring to summer (2009)

Item	Point							
	1	2	3	4	5	6	7	8
Laminariales	0	0	0	0	1	1	0	0
Fucaceae	3	3	5	4	4	5	4	2
C*	0	0	0	0	0	0	0	0
W*	3	2	4	3	5	6	4	2
H*	1	1	1	2	1	1	0	0

*C is species of cold water, W is species of warm water, H is species of hot water.

the number of species of cold, warm, and hot water type are shown in Tables 7 and 8. The number of chlorophytes, rhodophytes, and phaeophytes are shown in Tables 3 and 4. The results of R/P, C/P, (R+C)/P, L/H, L/F, and LFD are shown in Tables 9 and 10.

The values of (R+C)/P ratio were in the range from 1 to 2 in fall to winter and from 1.14 to 3 in spring to summer; the algal flora of Goheung should be warm or cold water algal flora.

The L/F ratio was in the range from 0 to 0.25 during both fall to winter and spring to summer. The L/F ratios of 6 points were 0, as there were no Laminariales species.

Table 9. R/P, C/P, (R+C)/P, L/H, L/F, and LFD of studied points from fall to winter (2008～2009)

Item	Point							
	1	2	3	4	5	6	7	8
C/P	0.25	0.25	0.33	0.33	0.20	0.14	0.60	0.50
R/P	1.00	1.75	0.67	1.00	1.80	1.43	1.60	1.00
(R+C)/P	1.25	2.00	1.00	1.33	2.00	1.57	2.20	1.50
L/F	0.00	0.00	0.00	0.00	0.25	0.20	0.00	0.00
LFD	1.33	1.33	1.20	1.25	1.00	1.00	1.00	1.00

Table 10. R/P, C/P, (R+C)/P, L/H, L/F, and LFD of studied points from spring to summer (2009)

Item	Point							
	1	2	3	4	5	6	7	8
C/P	0.40	0.25	0.57	0.29	0.14	0.11	0.50	1.00
R/P	0.80	2.75	0.57	1.14	1.43	1.22	1.67	0.67
(R+C)/P	1.20	3.00	1.14	1.43	1.57	1.33	2.17	1.67
L/F	0.00	0.00	0.00	0.00	0.25	0.20	0.00	0.00
LFD	1.25	1.33	1.20	1.40	1.17	1.14	1.00	1.00

The ratio of LFD fell in the range from 1.00 to 1.33 in fall to winter and from 1.00 to 1.40 in spring to summer, which shows that the marine algal flora of Goheung was temperate water algal flora.

4. H′ index

The H′ indexes of Points 4 to 6 were higher than those of the other points, and Point 8 had the lowest value (Fig. 2).

5. DCA

DCA was based on the occurred species. The distance between the symbols in the diagram approximates the similarity of distribution of relative abundance of those species across the points. The DCA result of the investigation points

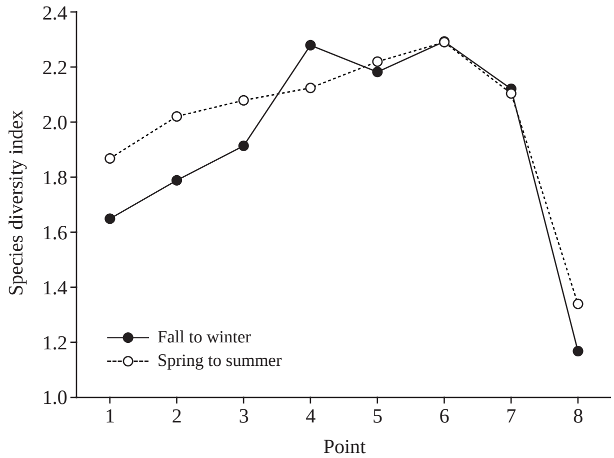

Fig. 2. The species diversity index of the investigation points (2008 ～2009).

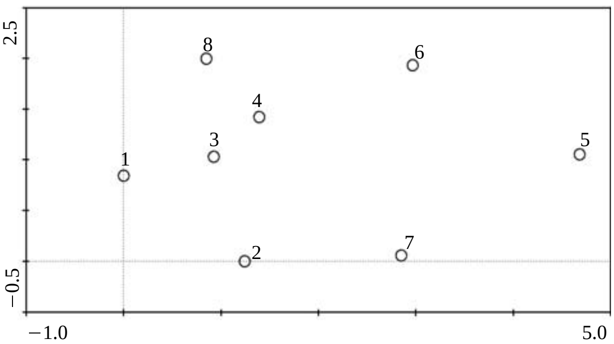

Fig. 3. Detrended correspondence analysis (DCA) of investigation points from fall to winter (2008～2009).

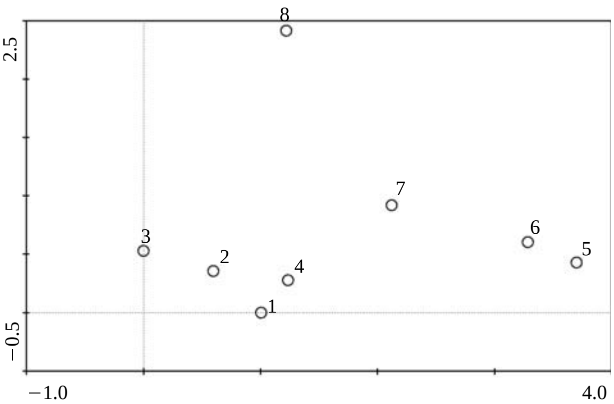

Fig. 4. Detrended correspondence analysis (DCA) of investigation points from spring to summer (2009).

from fall to winter (Fig. 3) showed that the similarity of occurred species at Points 3 and 4 was higher than those of the other points, whereas, from spring to summer, the similarities at Points 1 to 4 was high, and that at Points 5 and 6 was high (Fig. 4).

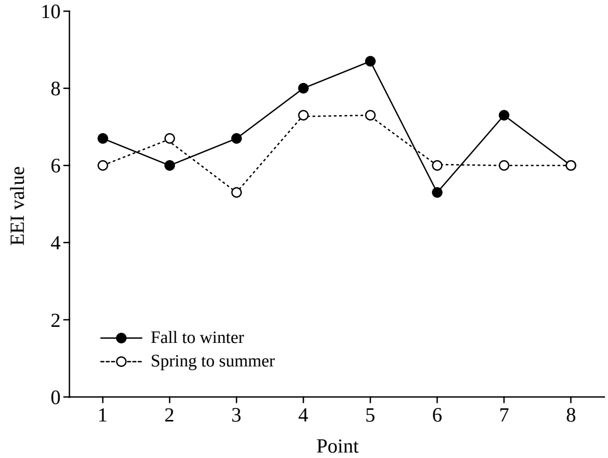

Fig. 5. The ecological evaluation index (EEI) at 8 points (2008 ～2009).

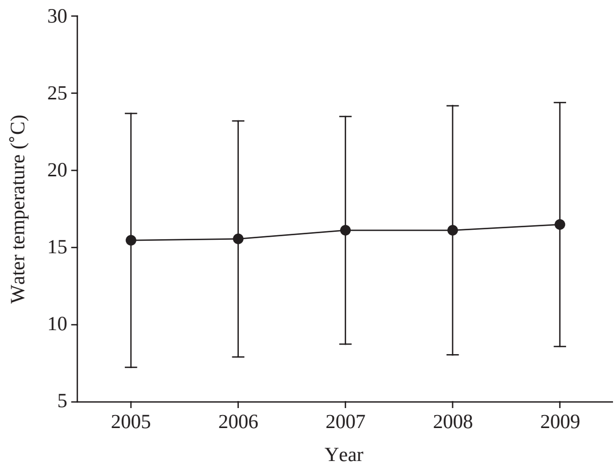

Fig. 6. Annual average seawater temperature of Goheung from 2005 to 2009 (From Korea Hydrographic and Oceanographic Administration, http://www.khoa.go.kr).

6. EEI

The EEI of the investigation points in fall to winter and spring to summer are shown in Fig. 5. The ecological environment of most points was above the moderate class, especially Point 5. The EEI value of Point 5 was in the good class. The results also show that EEI values of the outer sea points (Points 3-5) were higher than those of the inner bay points.

DISCUSSION

1. Composition of intertidal marine algae

In this study, there were 37 species (2 species of angiosperms, 5 cholophytes, 12 phaeophytes and 18 rhodophytes) that occurred from fall to winter, and 52 species (2 species of angiosperms, 9 cholophytes, 18 phaeophytes, and 23 rhodophytes) occurred from spring to summer. The dominant species were *Ulva pertusa*, *Hizikia fusiformis*, *Sargassum thunbergii*, *Sargassum horneri*, and *Amphiroa beauvoisii*. There were 56 species (7 species of chlorophytes, 13 phaeophytes, and 36 rhodophytes) in the report on marine algae flora on the Goheung coast (Marine and Fisheries Office of Goheung of Former Ministry of Maritime Affaris & Fisheries 2007), and the dominant species were *Ulva pertusa*, *Sargassum thunbergii*, *Gloiopeltis tenax*, *Gigartina tenella*, and *Chondrus ocellatus*. In a comparison of the results between the Marine and Fisheries Office of Goheung and this study, the dominant species were the same, but the number of occurred species in this study was lower, due to the number of rhodophytes.

2. C/P, R/P, (R+C)/P, L/F and LFD of marine algae

Experimentally determined lethal temperatures and growth- or reproduction-limiting temperatures could be used to infer possible phytogeographic boundaries in the studied sea areas (van den Hoek 1982a, b). As shown in Fig. 6, the annual average sea water temperatures from 2002 to 2009 were in the range from 15.5°C to 16.5°C. Therefore, the Goheung coast could be considered as the temperate area.

The (R+C)/P ratios were less than 3 (Tables 9 and 10); thus, the algal flora of Goheung should be warm or cold water type.

The L/F ratios at the 6 points were 0, whereas those of the other two points were 0.25 (Point 5) and 0.20 (Point 6), both from fall to winter and spring to summer. According to Arasaki (1976), the algal flora of Goheung should be hot water type. However, as shown in Tables 7 and 8, there were no Laminariales species at the 6 points with a L/F ratio of 0; therefore, the L/F method was not as applicable as the (R+C)/P value in this study.

The LFD index ranged from 0 and 2, since LFD was positively correlated with water temperature. As the value of LFD approached 2, the algal flora became hot water type (Tanaka 1997). The LFD ratios of the surveyed locations were in the range from 1.00 to 1.40. According to Tanaka (1997), the algal floras of Goheung should be warm water type.

Based on the water temperature data, and based on a comparison of the results of (R+C)/P, L/F, and LFD, the applicable methods for judging the characteristics of algal flora in this study were the LFD and (R+C)/P ratios. Therefore, algal flora of Goheung could be considered as warm water type.

3. H′ index of marine algae

Based on the biomasses of the investigation points, H′ index was estimated by Shannon-Wiener's index (Wilhm 1968; Masson and Greig 1988; Zhuang *et al*. 2004) (Fig. 2). The values at Points 4～6 were higher than those of the other points, and Point 8 had the lowest value. This means that the biomass of Point 8 was much lower compared to the other points. This might be the beginning of whitening progress.

4. DCA of marine algae

As shown in Figs. 3 and 4, the X axis of the graph means the species occurrence characteristic of the surveyed points, with high occurrence of hot water species points on the left and high occurrence of warm species points on the right. The Y axis of the graph means the number of occurred species and biomasses of the species. The species occurrence similarities are also shown in the DCA graphs. The results show that the similarities of species composition at Points 3 and 4 were higher than those of the other points from fall to winter, whereas that at Points 1～4 was high, and those at Points 5 and 6 was high in spring to summer.

5. EEI of marine algae

In order to describe the degree of human impact on the biological communities living in a body of water, the term "classes of ecological status" is used in the text of the EU frame Directive for Water Policy (WFD, 2000/60/EC) [European Economic Community (EEC) 2000]. Five classes of quality (high, good, moderate, low, and bad) are foreseen. For the management of ecosystems, it is critical to identify the key biological signals (impacts) that indicate the intensity of anthropogenic stress or ecological status. Marine benthic marcophytes (phytobenthos) were mentioned in the European Water Framework Directive (WFD) as a “quality element” for the classification of marine coastal areas. They include two fundamentally different groups of plants: marine macroscopic algae and seagrasses (vascular plants). The three major taxonomic groups of marine algae, Chlorophyceae, Phaeophyceae, and Rodophyceae, although representing distinct evolutionary lines, show similar ranges of morphologies. Since marine benthic macrophytes are mainly sessile organisms, they respond directly to the abiotic and biotic aquatic environment and thus represent sensitive indicators of environmental changes (Orfanidis *et al*. 2001).

The EEI of the investigation points from fall to winter and spring to summer are shown in Fig. 5. The ecological environment of most points were better than moderate class, and the EEI values of the outer sea points were higher than those of the inner bay points, which means that the ecological environments of the outer sea points was batter than that of the inner bay points.

In conclusion, by studying marine algal communities, characteristics of algal flora, species diversity index, and ecological evaluation index, the environment of Goheung coast was understood. As the climate changes, continual investigation of the marine environment, control pollution resources, and setting of artificial reefs must be carried out in order to protect or rebuild the environments of Goheung coast.

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