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# Species Composition and Distributional Patterns of Marine Benthic Algae at Intertidal Zone in Masan Bay

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# 마산만 조간대에 서식하는 해조류 군집의 종조성 및 분포 패턴

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**Abstract** : *The species composition and distributional patterns in marine benthic algae at intertidal zone in Masan Bay were investigated seasonally throughout 2007. A total of 42 species, 5 Chlorophyta 8 Phaeophyta and 29 Rhodophyta were recorded, and dominant species were Enteromorpha linza, Ulva pertusa, Sargassum thunbergii, Gelidium amansii, G. divaricatum, Corallina pilulifera, Gracilaria textorii, and Polysiphonia morrowii during study periods. Especially the vertical distribution of dominant algal species was remarkable : U. pertusa and G. divaricatum were dominated in the upper part, E. intestinalis, E. linza, S. thunbergii and G. divaricatum were in the middle part, and U. pertusa, Undaria pinnatifida, S. thunbergii, G. amansii, G. divaricatum and C. pilulifera mainly occurred in the low part of tidal zone. The numbers of species were different with seasons and stations; Higher number of species was 38 species in winter, whereas 28 species were the lowest in fall. The number of species was higher at stations 4 and 6 while the lower value was at stations 1 and 2 than other stations. The spatial distributional patterns of marine benthic algal composition at each station in dendrogram and MDS ordination were due to the differences of local topography and physical characteristics such as currents and water movements.*

**Key words** : *Marine benthic algae, Intertidal zone, Masan Bay, Vertical distribution, Ulva pertusa, Sargassum thunbergii, Gelidium divaricatum, Gracilaria textorii, Polysiphonia morrowii*

**요 약** : 마산만 조간대에서 서식하는 해조류 군집의 종조성 및 분포패턴을 2007년도에 계절별로 조사하였다. 조사기간 동안 총 42종의 해조류가 서식하였으며, 이 중 녹조류 5종, 갈조류 8종, 그리고 홍조류가 29종으로 나타났다. 우점종은 *Enteromorpha linza, Ulva pertusa, Sargassum thunbergii, Gelidium amansii, G. divaricatum, Corallina pilulifera, Gracilaria textorii,* 그리고 *Polysiphonia morrowii* 으로 나타났다. 특히 우점종들은 수직분포가 뚜렷하였는데, 조간대 상부에는 *U. pertusa, G. divaricatum*가, 중부에는 *E. intestinalis, E. linza, S. thunbergii, G. divaricatum*이 우점하였다. 한편 하부에는 *U. pertusa, Undaria pinnatifida, S. thunbergii, G. amansii, G. divaricatum, C. pilulifera*이 주로 출현하였다. 조사기간 동안 출현한 출현종수는 계절 및 정점에 따라 변하였다. 겨울에 가장 많은 38종이 출현하였으며, 가을에는 28종으로 가장 적었다. 정점별로는 정점 4, 6에서 가장 많았으며, 정점 1, 2에서 가장 낮게 나타났다. 해조류 군집의 공간적 분포를 파악하기 위한 군집분석을 이용한 수지도 및 MDS 분석 결과에서는 해조류의 종조성 및 현존량이 각 정점의 지형적인 차이 및 조류, 해수의 움직임과 같은 물리해양학적인 특징에 의한 것으로 나타났다.

**핵심용어** : 해조류 군집, 조간대, 마산만, 수직분포, *Ulva pertusa, Sargassum thunbergii, Gelidium divaricatum, Gracilaria textorii, Polysiphonia morrowii*

## 1. Introduction

The ecological importance of marine benthic algae as high production, food source, and nursery habitats in estuaries and coastal areas have been well established worldwide(Terawaki et al., 2001; Zhuang and Zhang, 2001; Wells et al., 2007). Intertidal marine benthic algal community were mainly influenced by physical factors such as temperature, salinity, light intensity, and water movement, and then temporal and spatial variations of marine benthic algae were remarkable occurred(Duxburg and Duxburg, 1991).

Masan Bay have been known one of heavily polluted area in the southern part of Korea. Environmental

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disturbances such as red tide and pollutant load have occurred every year due to industrial complex around coastal areas since 1980's, however, improving of water quality with construction of sewage treatment plant were in Masan Bay nowadays(Kim, 2003; Oh et al., 2005). To date the study in Masan Bay has been confined to sustainable management for target water quality(Ju et al., 2000; Lee and Park, 2003; Oh et al., 2005), and far less is known about the studies on marine benthic algal community compared with other regions of Korea. On the other hand, several studies of marine benthic algal community were described in the southern area, Korea. For example, floristic composition and seasonal variation of marine benthic algae in Odongdo, Dolsando, Kwangyang Bay, and Jinhae Bay(Song, 1986; Choi, 1992; Kim et al., 1996; Choi and Huh, 2008; Kwak, 2009). The pollution and disturbance of macroalgal habitats by human impacts reduce species diversity and simplify its community structure(Diez et al., 1999). Thus benthic macroalgal flora and community structures are good indicators for evaluating environmental conditions and monitoring coastal marine ecosystems(Vadas and Steneck, 1988; Wells et al., 2007).

The aims of present study was to examine the species composition and distributional patterns in marine benthic algae at intertidal zone in Masan Bay and to compare results between this study and other areas in the southern sea, Korea.

## 2. Materials and methods

The sampling sites was exposed to open sea with a little steep slope in upper part but gentle in mid to lower part at intertidal zone in Masan Bay(Fig. 1). Water temperature was from 7.6℃ in February to 27.1℃ in August 2007, whereas mean salinity was 34.3 psu throughout 2007. The difference of mean sea level between ebb and flow tides was 0.1 m to 0.6 m.

The marine benthic algae was investigated seasonally throughout 2007 with a quadrat method along a vertical transect line set across the intertidal zone perpendicularly to the coastal line. Additional collections for flora were carried out on each sampling occasions. The specimens collected except for crustose coralline algae were fixed in 5~10% formaline-seawater solution and carried to the laboratory. These samples were cleaned and then were identified according to Lee and Kang(1986, 2001).

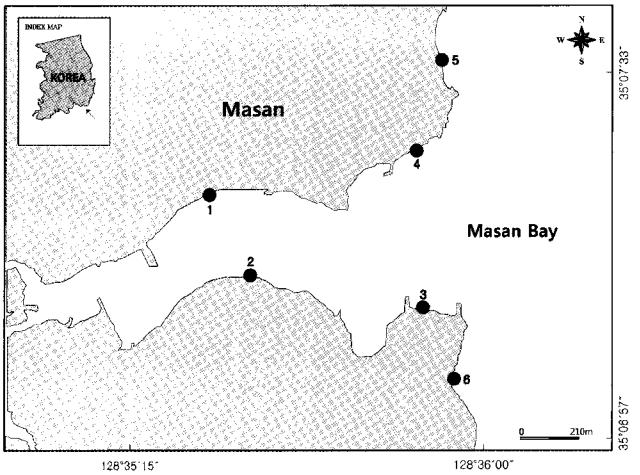


Fig. 1. Map showing the sampling sites.

The marine benthic algae data was analysed to obtain the following community variables for local characteristics of algal community; R/P(Feldmann, 1937), C/P(Segawa, 1956), (R+C)/P(Cheney, 1977). The association of marine benthic algae species at each station was demonstrated with dendrogram of average linkage cluster analysis, and non-metric multi-dimensional scaling ordination(MDS) plotted each sample as a point on an ordination plot. The extent to which the composition of the different stations were either similar or different was examined visually. This was applied by PRIMER computer package.

## 3. Results and discussions

A total of 42 species, 5 Chlorophyta, 8 Phaeophyta, and 29 Rhodophyta, were recorded at intertidal zone in Masan Bay(Table 1). These marine benthic algae occurred 38 species in winter, 33 spring, 36 summer, and 28 fall, respectively(Fig. 2). Especially number of species was higher in winter with 5 Chlorophyta, 7 Phaeophyta, and 26 Rhodophyta. Higher percentage of Chlorophyta was in summer, whereas Phaeophyta and Rhodophyta were higher in winter. Round(1981) demonstrated that number of algal species were higher in winter and spring in temperate areas worldwide. The number of algal species were also differed with stations(Fig. 3). Overall higher number of species were at station 3,4 while the lower was at station 1, 2 than other stations. The total number of species was the lower in the study area than those of in other areas. For example, 93 and 78 species at intertidal zone, 171 species at subtidal zone in Gwangyang Bay, 45 species in Jinhae Bay(Lee and Kim, 1977; Song, 1986; Choi and Huh, 2008; Kwak, 2009). These results might it be explained to

different topography of intertidal zone, physical factors, and human impacts. Choi and Huh(2008) have demonstrated that the lower of number of algal species was due to change environmental characteristics with increasing industrial complex around Gwangyang Bay.

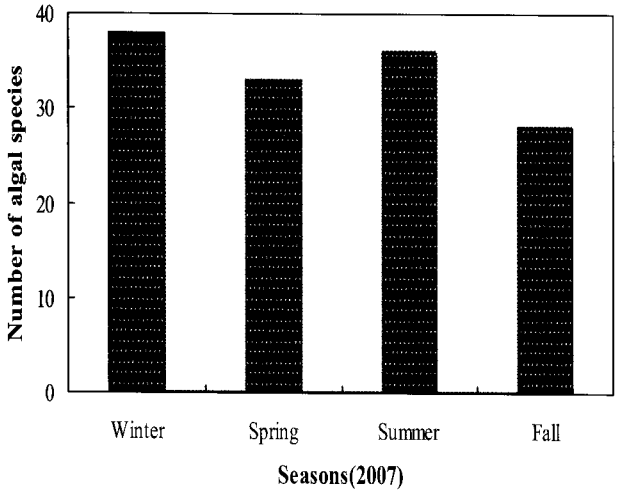


Fig. 2. Seasonal variation in number of algal species at intertidal zone in Masan Bay.

The dominant algal species were *Enteromorpha linza, Ulva pertusa, Sargassum thunbergii, Gelidium amansii, G. divaricatum, Corallina pilulifera, Gracilaria textorii,* and *Polysiphonia morrowii* during study periods. These species were occurred at intertidal zone in Masan Bay regardless of seasons. Broad-scale surveys of marine benthic algal communities from other regions in southern area, Korea suggest a similar community structure. *U. pertusa, S. horneri, G. divaricatum, G. textorii,* and *P. morrowii* dominated the algal community in Gwangyang Bay(Kim et al., 1996; Choi and Huh, 2008), genus *Sargassum, Gracilaria, Gelidium* and *Polysiphonia* at Myodo in Gwangyang Bay and west-southern coast, Korea(Lee et al., 1975; Choi, 1992), and *U. pertusa, U. conglobata, S.horneri, G. divaricatum, G. textorii,* and *P. morrowii* were also dominant species in Jinhae Bay close to our study sites(Kwak, 2009).

The vertical distribution of algal species appear to be considerable for marine benthic algal community utilizing intertidal zone in Masan Bay(Table 2). *U. pertusa* in Chlorophyta, and *G. divaricatum* in Rhodophyta occurred in the upper part, and *E. intestinalis, E. linza* in Chlorophyta, *S. thunbergii* in Phaeophyta, *G. divaricatum, Chondria crassicaulis* in Rhodophyta were in the middle part of tidal zone. On the other hand, *Ulva pertusa* in Chlorophyta,

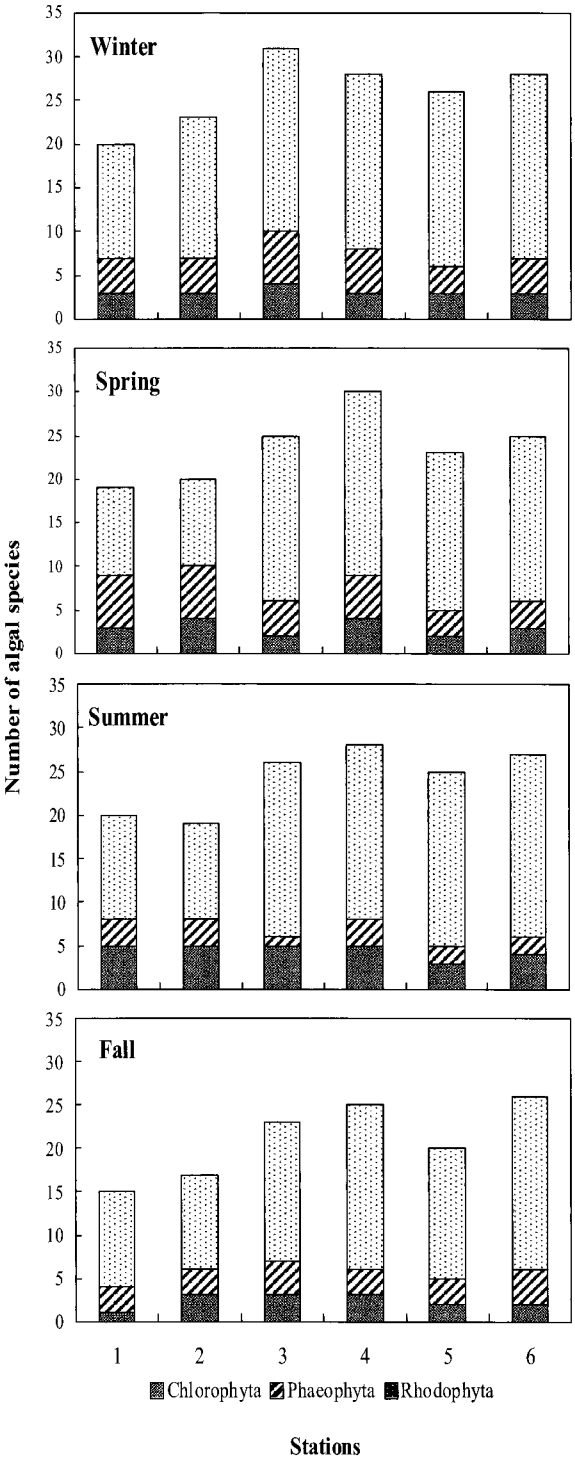


Fig. 3. Seasonal variation in number of algal species and floristic composition at intertidal zone in Masan Bay.

Table 1. Total list of benthic marine algal species observed at intertidal zone in Masan Bay throughout 2007

| Species | Winter | Spring | Summer | Fall |
|---|---|---|---|---|
| Chlorophyta | | | | |
| *Enteromorpha intestinalis* | + | + | + | |
| *E. linza* | + | + | + | + |
| *Ulva conglobata* | + | | + | |
| *U. pertusa* | + | + | + | + |
| *Codium fragile* | + | + | + | + |
| Phaeophyta | | | | |
| *Ishige okamurae* | + | + | | + |
| *Colpomenia sinuosa* | + | + | + | |
| *Undaria pinnatifida* | + | + | + | |
| *Dilophus okamurae* | + | | + | |
| *Sargassum horneri* | + | + | + | + |
| *S. miyabei* | + | | | |
| *S. thunbergii* | + | + | + | + |
| *S. nigrifolium* | | + | + | + |
| Rhodophyta | | | | |
| *Gelidium amansii* | + | + | + | + |
| *G. divaricatum* | + | + | + | + |
| *Dumontia simplex* | + | | | |
| *Amphiroa beauvoisii* | + | | + | |
| *Corallina pilulifera* | + | + | + | + |
| *Carpopeltis affinis* | + | + | + | + |
| *C. prolifera* | + | + | + | + |
| *C. cornea* | + | + | + | + |
| *Grateloupia divaricata* | + | + | + | + |
| *G. filicina* | + | + | + | + |
| *G. okamurae* | | + | + | |
| *G. sparsa* | + | + | + | |
| *G. turuturu* | + | + | + | + |
| *Gracilaria textorii* | + | + | + | + |
| *G. verrucosa* | + | + | + | + |
| *Gymnogongrus flabelliformis* | + | + | + | + |
| *Chondrus ocellatus* | + | + | + | |
| *C. pinnulatus* | | + | + | |
| *Gigartina tenerra* | + | | | + |
| *G. intermedia* | + | + | + | + |
| *G. tenella* | + | + | + | + |
| *Lomentaria hakodatensis* | + | | + | + |
| *L. lubrica* | + | | | + |
| *Champia parvula* | | | + | |
| *Ceramium japonica* | + | + | | |
| *Acrosorium polyneurum* | + | + | + | + |
| *Chondria crassicaulis* | + | + | + | + |
| *Laurencia undulata* | + | + | + | + |
| *Polysiphonia morrowii* | + | + | + | + |

+ : Occurrence of marine benthic algal species in 0.5m x0.5m quadrat

Table 2. The vertical distribution of marine benthic algal species observed at intertidal zone in Masan Bay throughout 2007

| Intertidal zone | Marine benthic algal species |
|---|---|
| Upper | *Ulva pertusa, Gelidium divaricatum,* |
| Middle | *Enteromorpha intestinalis, E. linza, Sargassum thunbergii, Gelidium divaricatum Chondria crassicaulis* |
| Low | *Ulva pertusa, Undaria pinnatifida, Sargassum thunbergii, Gelidium amansii, G. divaricatum Corallina pilulifera, Chondria crassicaulis* |

Table 3. The comparisons between R/P, C/P, (R+C)/P value in this study and those of other studies in southern sea, Korea

| Study area | R/P | C/P | (R+C)/P | Remark |
|---|---|---|---|---|
| Masan Bay | 3.63 | 0.63 | 4.25 | This study |
| Jinhae Bay | 2.90 | 0.60 | 3.50 | Kwak (2009) |
| Gwangyang Bay | 3.48 | 0.77 | 4.26 | Song (1986) |
| West-southern coast | 4.10 | 0.90 | 5.00 | Choi (1992) |
| Daedo in Gwangyang Bay | 2.68 | 0.53 | 3.21 | Kim et al. (1996) |
| Gwangyang Bay | 2.82 | 0.76 | 3.59 | Choi and Huh (2008) |

*Undaria pinnatifida, S. thunbergii* in Phaeophyta, *G. amansii, G. divaricatum, Corallina pilulifera, C. crassicaulis* in Rhodophyta occurred in the low part of tidal zone. Compared with other areas, *U. pertusa, G. divaricatum* also occurred in the upper part, *E. linza, S. thunbergii, G. divaricatum, C. crassicaulis* in Rhodophyta were in the middle part, and *U. pertusa, U. pinnatifida, S. thunbergii, G. amansii, G. divaricatum, C. pilulifera* occurred in the low part of tidal zone in Gwangyang Bay(Song, 1986; Kim et al., 1996; Choi and Huh, 2008). These results were due to water movements such as current, wave, and tide and air-water interactions(Dring, 1982; Choi, 1992; Choi and huh, 2008). The vertical distribution of marine benthic algae was thus similar patterns regardless of locations. Choi (1992) have studied that *U. pertusa* and *G. divaricatum* were also dominated in the upper part, but *Sargassum* sp., *Gelidium* sp., and *Chondria* sp. were in the lower part of tidal zone in west-southern area, Korea.

The R/P and C/P value was 3.63, 0.63, and (R+C)/P was 4.25 in the study area, and then this value indicated typical temperate marine benthic algal composition(Table 3). Especially these index were used to determine between algal community and temperature. Several studies have described that the variation of R/P value was correlated with water temperature(Choi, 1992; Choi and Huh, 2008). For example, higher R/P value was especially influenced by higher water temperature in the southern sea, however, the R/P ranged from 0.5 to 2.0 always occurred in the eastern sea, Korea.

Most of benthic algal species occurred a patch distribution in the intertidal zone of Masan Bay. Species composition have been showed a diverse array at each station, and seasonal periodicity was also varied with temperature in the study area. Seasonal variation of species composition were not significant differed in the intertidal zone of Masan Bay despite of higher *E. linza, U. pertusa* in Chlorophyta at summer. The dendrogram has shown two clusters which identify the floristic composition at each station(Fig. 4). The first group was composed of station 3, 4 and station 5, 6 were another group as group 2. However, station 1, 2 were independently occurred. The difference between the species composition of each station was also enhanced by the spatial MDS ordination(Fig. 4). The six stations appear separated from each other. The distance among stations reflect the extent of differences in marine benthic algal composition; two groups and station 1, 2 occurred regardless of seasons. Group 1 was consisted of station 3 and 4 where were at intertidal zone in coastal waters, whereas group 2 was composed of station 5 and 6 where were in the open sea with strong current. In the case of algal composition, *Ulva* in Chlorophyta, and *Gracilaria, Polysiphonia* in Rhodophyta mainly occurred at station 5 and 6, while *Sargassum, Undaria* in Phaeophyta at station 3 and 4. Such conclusion was in agreements with other studies(Shepherd and Womersley, 1981; Choi and Huh, 2008; Kwak, 2009). Hence the patterns of species composition in marine benthic algal community were due to local topography and physical characteristics such as tidal current and water movements.

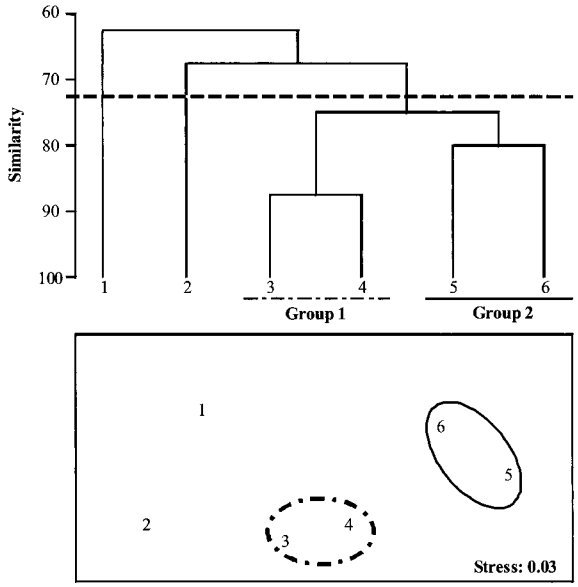


Fig. 4. The dendrogram and spatial MDS ordination in composition and occurrence of marine benthic algae between stations at intertidal zone in Masan Bay.

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