Production Assessment of Eelgrass, *Zostera marina* Using the Plastochrone Method Compared with the Conventional Leaf Marking Technique

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Since seagrasses are highly productive and provide a source of organic carbon for a wide variety of marine organisms in coastal and estuarine ecosystem, accurate assessment of seagrass production is critical to understand the functions and values of seagrasses in these ecosystems. Zieman's leaf marking technique has been mostly used to estimate seagrass leaf production rates. However, inherent problems on the traditional leaf marking technique have been discussed by the several researchers, and these problems can cause underestimation of seagrass production. To develop an accurate and reliable assessing method for seagrass production, production rates of eelgrass, *Zostera marina* in three bay systems on the south coast of the Korean peninsula were estimated using the conventional leaf marking technique and the plastochrone method. The plastochrone method has been recently suggested as an effective method for reliable assessments of seagrass production. In the present study, leaf production rates estimated by the plastochrone method were significantly higher than the rates derived from the traditional leaf marking technique. Annual eelgrass leaf production assessed using the leaf marking technique was about 65 to 89% of the estimated production using the plastochrone method. The differences in annual productions between assessment techniques imply that the conventional leaf marking technique significantly underestimated eelgrass leaf production. Total eelgrass productions estimated using the plastochrone method in the present study sites were about 600 to 806 g DW m^{-2} y^{-1}, and below-ground production accounted for about 20 to 23% of the total production. The plastochrone method was suggested to be an effective and accurate assessing method for eelgrass production.

Key words: Eelgrass, *Zostera marina*, Seagrass, Production, Plastochrone Method, Leaf Marking Technique

INTRODUCTION

Seagrasses are an important component of estuarine and coastal ecosystems, and are among the most productive of plant communities (McRoy and McMillan 1977), providing habitat and food for a wide variety of flora and fauna (Heck and Westone 1977; Orth et al. 1984; Summerson and Peterson 1984; Huh and Kitting 1985). Although few herbivores consume seagrass directly (Ogden 1980; Mann 1988), a substantial fraction of seagrass carbon enters coastal and estuarine food webs through microbial transformation of litter and particulate detritus (Kenworthy and Thayer 1984; Mann 1988; Chin-Leo and Benner 1991; Koepfler et al. 1993; Peduzzi and Herndl 1991; Opsahl and Benner 1993). Seagrasses also influence the immediate abiotic environment by enhancing sedimentation

and sediment binding, reducing current and wave velocities and acting as a nutrient filter (Ward et al. 1984; Fonseca 1989). Thus, seagrasses are a cornerstone to the health and productivity of coastal and estuarine ecosystems.

Since organic carbon produced by seagrasses is significantly important for coastal and estuarine food webs, accurate measurement of seagrass primary production is critical to understand energy flow in coastal and estuarine ecosystems. Above-ground production of seagrasses having strap-like leaves can be easily estimated using the leaf marking technique, which was developed to account for the underestimation of growth when using oxygen metabolism measurements (Hartman and Brown 1967; Zieman 1974; Vermaat et al. 1987; Lee and Dunton 1996). Zieman (1974) developed the leaf marking technique to measure leaf growth in *Thalassia testudinum*. Leaf blade above sheath was marked with a small staple at the height of a frame placed above the sed-

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iments. Seagrass leaf productivity was determined by dividing the dry weight of new leaf tissues produced after marking by the number of days since marking. Zieman's leaf marking technique has been modified and applied to other seagrass species. However, seagrass leaf growth within the sheath cannot be measured using the leaf marking technique (Sand-Jensen 1975; Brouns 1985a; Ibarra-Obando and Boudouresque 1994; Gaeckle and Short 2002). Additionally, the maturing process of seagrass leaves, which involves cell expansion and an increase in leaf mass, cannot be measured by the conventional leaf marking technique (Gaeckle and Short 2002). Thus, leaf elongation and weight gain that are part of total leaf production have been considered to reduce the possibility of underestimating leaf production by weighing immature leaf sections from newly grown leaf tissues (Jacobs 1979; Short 1987; Gaeckle and Short 2002).

In contrast to above-ground production, accurate assessment of total seagrass production is remarkably difficult since a substantial fraction of plant biomass is below-ground (Kaldy and Dunton 2000). Rhizome tagging has been used to estimate below-ground productivity in *Zostera marina* (Dennison 1990), but tagging in rhizomes is extremely difficult in field conditions. The plastochrone interval is defined as the period between successive initiation of two leaves or pairs of leaves (Schmidt 1924; Jacobs 1979; Fahn 1990; Kaldy *et al.* 1999). The plastochrone method has been developed for measuring above- and below-ground production

in many seagrass species based on the time interval between the production of new plant parts and the size of a mature leaf (Jacobs 1979; Short and Duarte 2001; Gaeckle and Short 2002). In the present study, above-ground (leaf+sheath), below-ground (rhizome +root), and total production of eelgrass, *Zostera marina* in the bay systems on the south coast of the Korean peninsula were estimated using the leaf marking technique and the plastochrone method. Assessments of above-ground productivities using the conventional leaf marking technique and the plastochrone method were compared at eelgrass meadows in three bay systems.

MATERIALS AND METHODS

Study sites

The study sites were located in Koje Bay, Kosung Bay, and Jindong Bay on the south coast of the Korean peninsula (Fig. 1). The present study was conducted on the monotypic meadows of eelgrass, *Zostera marina* with average water depths of about 2–3 m. The Koje Bay site has sandy sediments, while the Kosung Bay and Jindong Bay sites was characterized by high silt and clay content in sediments. Eelgrass productivities were estimated using the conventional leaf marking technique and the plastochrone method in Koje Bay and Kosung Bay from June 2001 to May 2003, and in Jindong Bay from March 2002 to December 2003.
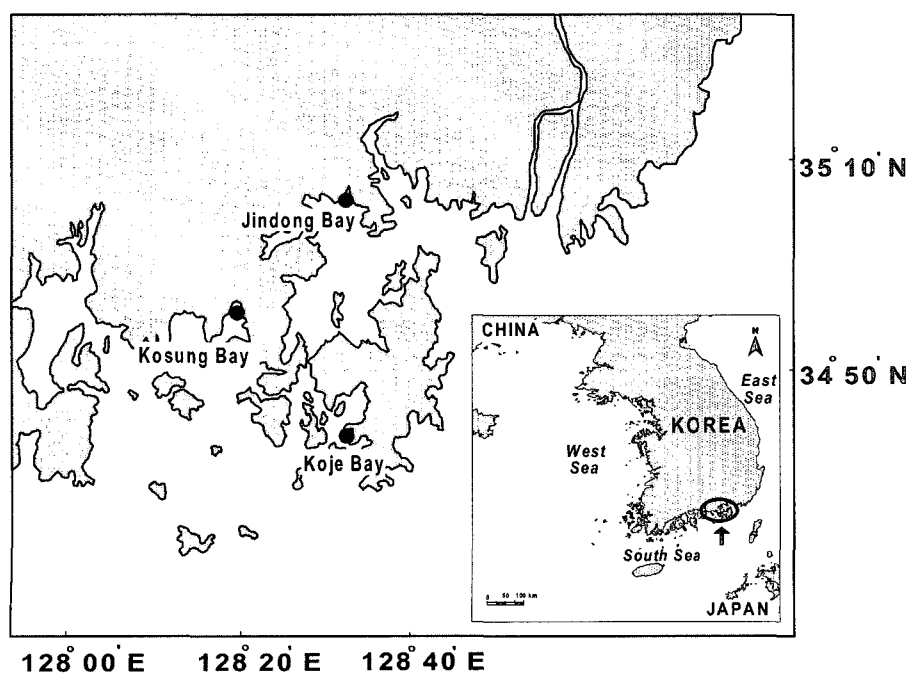

Fig. 1. Site sites in Koje Bay, Kosung Bay, and Jindong Bay on the south coast of the Korean peninsula.

Eelgrass productivity measurements

Eelgrass productivity was estimated using both the conventional leaf marking technique and the plastochrone method to compare methods of measuring eelgrass production. For the conventional leaf marking technique, ten to fifteen randomly chosen eelgrass shoots were punched the bundle sheath with a hypodermic needle, causing permanent scarring of the tissues. After an elapsed time of 2 to 5 weeks the marked shoots were harvested. Separated leaf materials into leaf tissues produced before and after punching were measured lengths and widths and then were dried at 60°C to a constant weight (Zieman 1974; Kentula and McIntire 1986). Leaf production rate per shoot (g DW shoot^{-1} d^{-1}) was determined by dividing the dry weight of new leaf tissue produced by the number of days since marking. Areal productions (g DW m^{-2} y^{-1}) were obtained by multiplying shoot production rates by the average shoot density. Plastochrone intervals were calculated by dividing the marking period (days) by the number of new leaves produced after marking.

For the plastochrone method, ten to fifteen mature terminal eelgrass shoots were collected individually at the sampling sites. Eelgrass plants were rinsed in fresh water, and the dry weights of the third leaf and rhizomes from the first to sixth youngest nodes were measured every sampling time. The third leaf is usually longest mature leaf in Zostera marina (Jacobs 1979; Gaeckle and Short 2002). Since each eelgrass leaf corresponds to one rhizome node, rhizome segments form at the same rate of leaves. Above-ground and below-ground productivities of each shoot were calculated as:

Above-ground productivity (mg DW shoot^{-1} d^{-1})= dry weight of the third leaf (mg DW shoot^{-1})/plastochrone interval (d)

Below-ground productivity (mg DW shoot^{-1} d^{-1})= dry weight of a segment of rhizome and root (mg DW shoot^{-1})/plastochrone interval (d)

Leaf productivities result from the leaf marking technique and the plastochrone method were compared for statistically significant differences.

Statistics

All values were reported as means ±1 standard error. Statistical analyses were performed using a general linear model procedure (SAS). Data were tested for normality and homogeneity of variance to meet the assumptions of parametric statistics prior to analysis. Significant differences in eelgrass productivity, plastochrone intervals, dry weights of the third leaf and a segment of rhizome and root among sampling times were tested using a one-way ANOVA. A two-way ANOVA with time as a block was used to test significant differences in above-ground productivity between productivity measuring methods and among sampling times. When a significant difference among variables was observed, the means were analyzed by a Tukey multiple comparison test to determine where the significant differences occurred among treatments.

RESULTS

Eelgrass leaf productivity estimated by the leaf marking technique

Eelgrass leaf production rates per shoot (mg DW shoot^{-1} d^{-1}) measured using the conventional leaf marking technique were exhibited distinct seasonal variations at all study sites (Fig. 2). Leaf production rates at the Koje Bay site were highest during summer periods, while the rates were highest during spring months at the Kosung Bay and Jindong Bay sites. Leaf production rates in Koje Bay ranged from 8.33 mg DW shoot^{-1} d^{-1} in November 2001 to 30.81 mg DW shoot^{-1} d^{-1} in July 2002 (Fig. 2A). In Kosung Bay the rate ranged from 4.31 mg DW shoot^{-1} d^{-1} in January 2003 to 32.57 mg DW shoot^{-1} d^{-1} in late March 2002, while leaf production rates in Jindong Bay ranged from 3.18 mg DW shoot^{-1} d^{-1} in November 2002 to 29.96 mg DW shoot^{-1} d^{-1} in May 2001 (Fig. 2B, C).

Plastochrone intervals and dry weights of leaf and rhizome units

Plastochrone intervals also varied significantly (P< 0.001) with sampling time, but did not showed clear seasonal trends at the present study sites (Fig. 3). Average plastochrone intervals in Koje Bay and Kosung Bay were 14.35 and 14.55 days, respectively. Average plastochrone intervals in Jindong Bay (17.29 days) were significantly (P<0.001) longer than those in Koje Bay and Kosung Bay.

Dry weights of third leaf in eelgrass shoots exhibited clear seasonal variations, increasing during spring and summer and decreasing during fall and
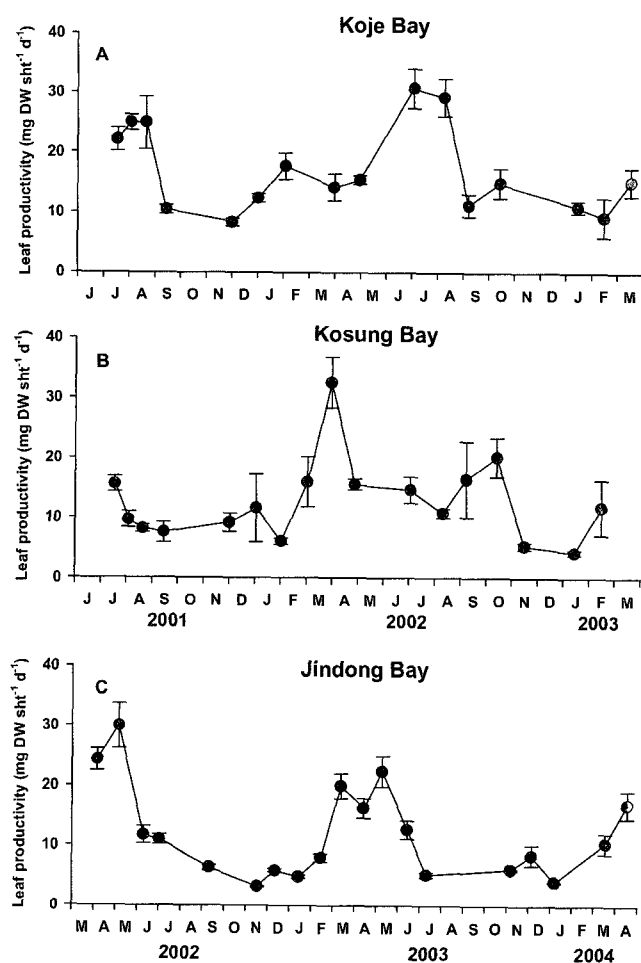
Fig. 2. Eelgrass leaf production rates estimated using the leaf marking technique from Koje Bay (A), Kosung Bay (B), and Jindong Bay (C) on the south coast of the Korean peninsula. Values are mean±1SE (n=10 to 15).
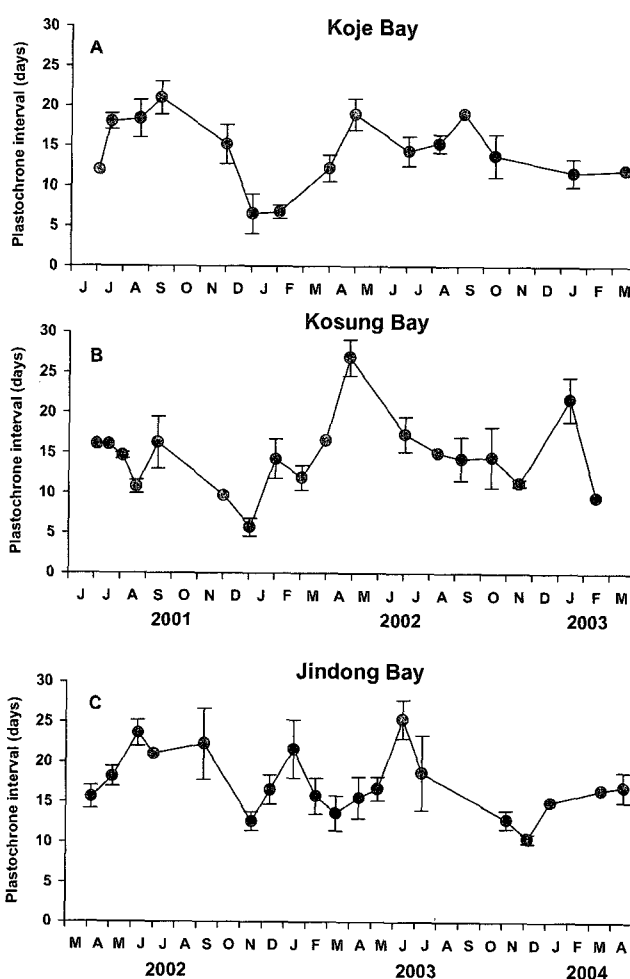

Fig. 3. Seasonal changes in plastochrone intervals of eelgrass, *Zostera marina* from Koje Bay (A), Kosung Bay (B), and Jindong Bay (C) on the south coast of the Korean peninsula. Values are mean±1SE (n=10 to 15).

winter (Fig. 4). Dry weight of third leaf was highest in July 2001 (696.9 mg DW shoot^{-1}) and lowest in February 2002 (121.7 mg DW shoot^{-1}) in Koje Bay (Fig. 4A). In Kosung Bay, the weight ranged from 143.8 mg DW shoot^{-1} in December 2001 to 675.7 mg DW shoot^{-1} in June 2002, while the weight in Jindong Bay ranged from 105.9 mg DW shoot^{-1} in December 2002 to 765.5 mg DW shoot^{-1} in early July 2003 (Fig. 4B, C). Dry weight of a segment of rhizome and root was significantly (P<0.001) changed with sampling time, but did not exhibit a distinct seasonal trend in the present study sites (Fig. 5). Weights of a below-ground segment in Koje Bay (mean=81.6 mg DW shoot^{-1}) were relatively constant with seasons compared to the Kosung Bay and the Jindong Bay sites. Dry weight of a below-ground segment in Kosung Bay ranged from 30.6 mg DW shoot^{-1} in September 2001 to 139.1 mg DW shoot^{-1} in April 2002, while the weight in Jindong Bay ranged from 22.7 mg DW shoot^{-1}

in September 2002 to 179.8 mg DW shoot^{-1} in May 2002 (Fig. 5B, C).

Eelgrass production rates estimated using the plastochrone method

Estimated leaf production rates using the plastochrone method exhibited seasonal variations at the present study sites (Fig. 6). Leaf production rates measured using the plastochrone method were highest during summer months and lowest during winter in Koje Bay and Kosung Bay, but the rates were highest during spring and lowest during winter in Jindong Bay. Leaf production rates in Koje Bay ranged from 6.03 mg DW shoot^{-1} d^{-1} in February 2003 to 34.83 mg DW shoot^{-1} d^{-1} in July 2001. In Kosung Bay, the rates ranged from 6.76 mg DW shoot^{-1} d^{-1} in January 2003 to 39.08 mg DW shoot^{-1} d^{-1} in July 2002, while
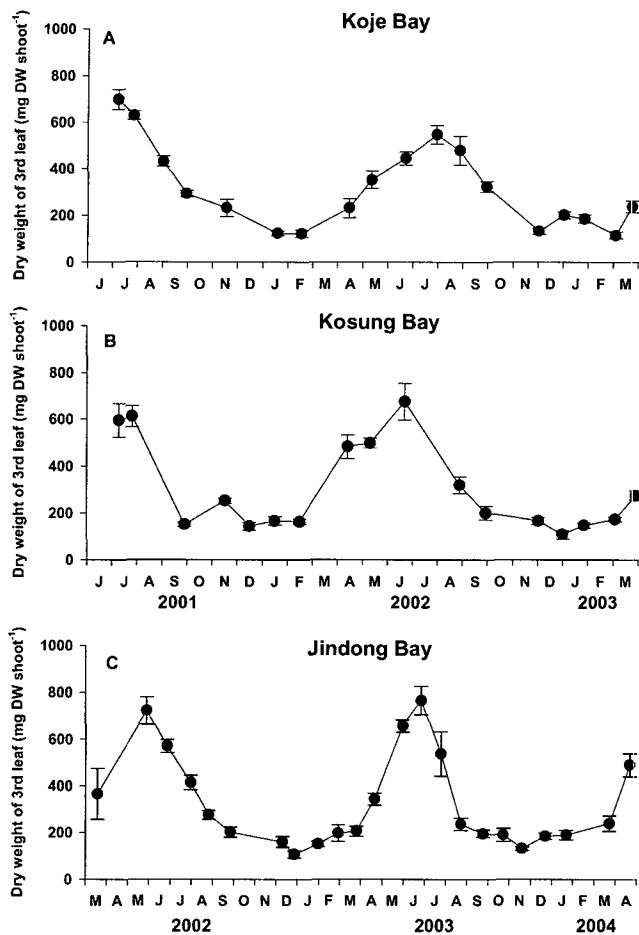
Fig. 4. Dry weight of 3rd leaf of eelgrass, *Zostera marina* from Koje Bay (A), Kosung Bay (B), and Jindong Bay (C) on the south coast of the Korean peninsula. Values are mean ±1SE (n=10 to 15).
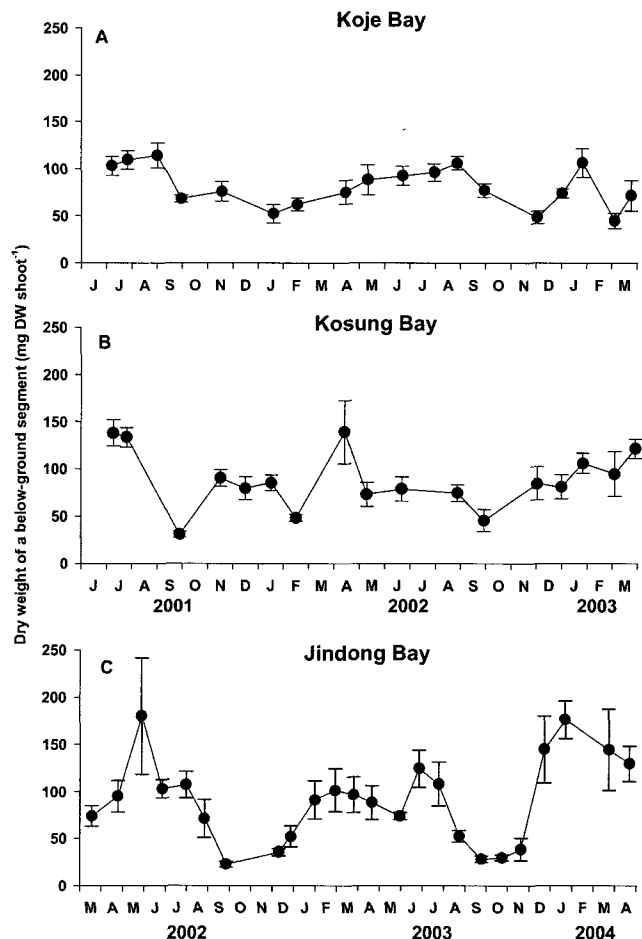

Fig. 5. Dry weight of a below-ground segment of eelgrass, *Zostera marina* from Koje Bay (A), Kosung Bay (B), and Jindong Bay (C) on the south coast of the Korean peninsula. Values are mean±1SE (n=10 to 15).

the rates in Jindong Bay ranged from 6.41 mg DW shoot^{-1} d^{-1} in December 2002 to 39.34 mg DW shoot^{-1} d^{-1} in May 2003 (Fig. 6B, C).

Below-ground production rates estimated using the plastochrone method also changed significantly (P<0.001) with sampling time, but did not show clear seasonal trend (Fig. 7). Average below-ground production rates in Koje Bay, Kosung Bay, and Jindong Bay were 5.93, 5.41, and 5.77 mg DW shoot^{-1} d^{-1}, respectively. Seasonal changes in total production rates of eelgrass, *Zostera marina* were closely correlated with variations in leaf production rates, since leaf production rates were much higher than below-ground production rates (Fig. 8). Total production rates in Koje Bay ranged from 8.38 mg DW shoot^{-1} d^{-1} in February 2003 to 42.26 mg DW shoot^{-1} d^{-1} in July 2002 (Fig. 8A). In Kosung Bay, total production rates were highest during July 2001 (46.57 mg DW shoot^{-1} d^{-1}), and lowest during September 2001 (11.16 mg DW shoot^{-1}

d^{-1}), while the rates in Jindong Bay were highest during May 2003 (43.77 mg DW shoot^{-1} d^{-1}), and lowest during December 2002 (9.57 mg DW shoot^{-1} d^{-1}; Fig. 8B, C).

Annual eelgrass productions estimated using the plastochrone method were 757, 586, and 806 g DW m^{-2} y^{-1} in Koje Bay, Kosung Bay, and Jindong Bay, respectively (Table 1). On an annual basis, above-ground production of eelgrass, *Zostera marina* accounted for about 77 to 80% of total eelgrass production, while below-ground production accounted for about 20 to 23% of total production at the present study sites (Table 1).

Comparison of the leaf marking technique with the plastochrone method

Eelgrass leaf production rates derived from the plastochrone method were significantly (P<0.01) higher than
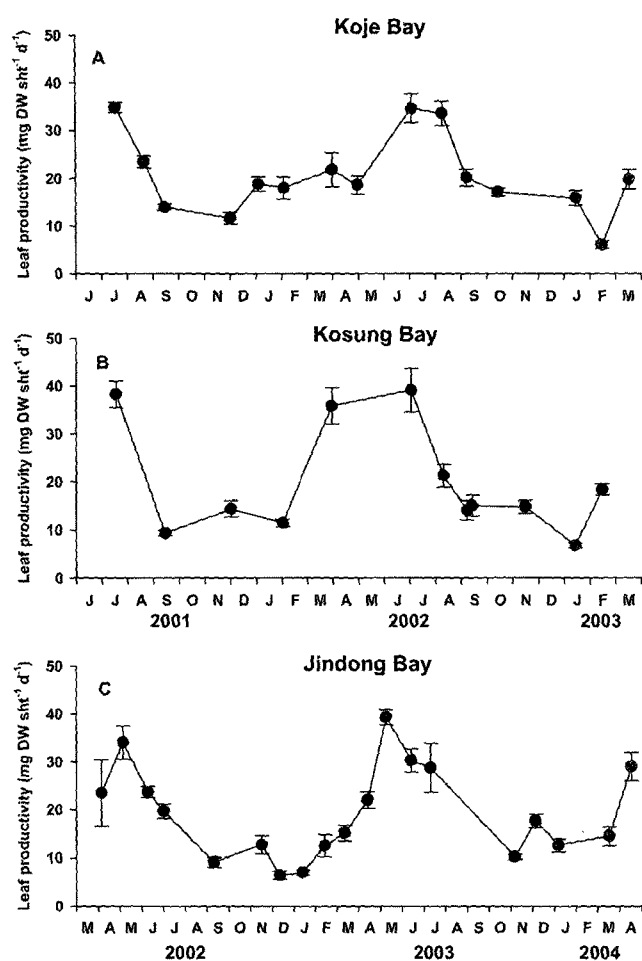
Fig. 6. Seasonal changes in eelgrass leaf production rates estimated using the plastochrone method from Koje Bay (A), Kosung Bay (B), and Jindong Bay (C) on the south coast of the Korean peninsula. Values are mean±1SE (n=10 to 15).
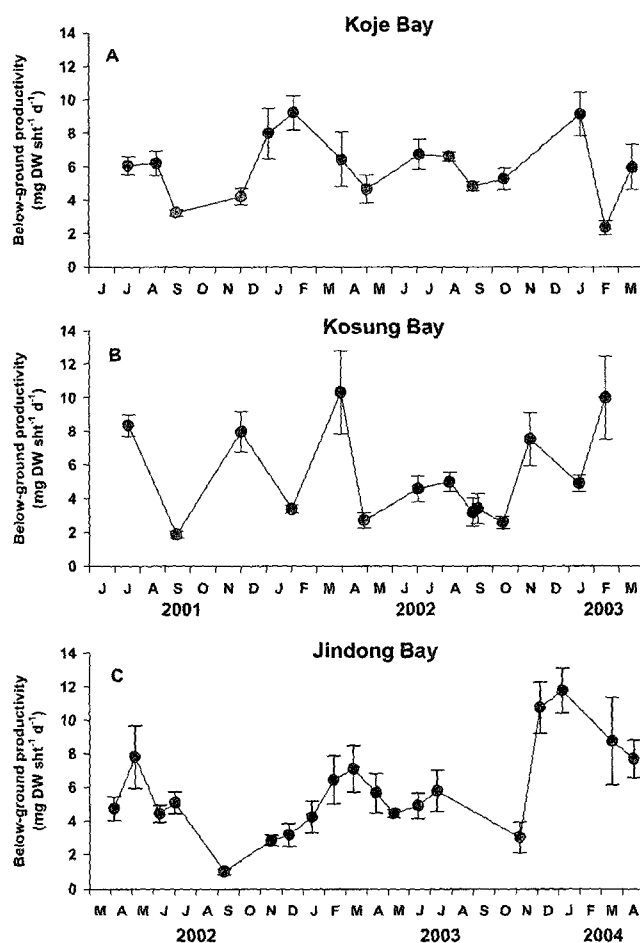

Fig. 7. Seasonal changes in eelgrass below-ground production rates estimated using the plastochrone method from Koje Bay (A), Kosung Bay (B), and Jindong Bay (C) on the south coast of the Korean peninsula. Values are mean±1SE (n=10 to 15).

those estimated using the conventional leaf marking technique at all the study sites (Fig. 9). Estimated leaf production rates using both the leaf marking technique and the plastochrone method exhibited similar seasonal trends at the present study sites. In Koje Bay site, leaf production the rates derived from the conventional leaf marking technique were about 89% of the rates obtained with the plastochrone method (Table 2). In Kosung Bay and Jindong Bay, the rates from the leaf marking technique were about 72 and 65% of the rates from the plastochrone method, respectively (Table 2).

DISCUSSION

Since primary production of seagrasses is significantly important for trophic dynamics in coastal and estuarine ecosystems, accurate assessment of seagrass

production is critical to understand functions and values of seagrass habitats in these ecosystems. Zieman's leaf marking technique has been used to assess leaf productivity of seagrasses (Zieman 1974; Zieman and Wetzel 1980), and the technique has been modified with regard to both the marking device and reference level (Sand-Jensen 1975; Jacobs 1979; Kentula and McIntire 1986; Roman and Able 1988; Ibarra-Obando and Boudouresque 1994). However, some technical problems of the leaf marking method have been discussed by the several researchers (Sand-Jensen 1975; Brouns 1985a; Short 1987; Ibarra-Obando and Boudouresque 1994; Gaeckle and Short 2002). There is a possibility to lose the older marker leaves, thereby losing the initial reference mark, if leaf blades above the sheath were marked. Additionally, leaf growth occurred below the mark and growths caused by the maturation of tissues as it ages will be ignored, when
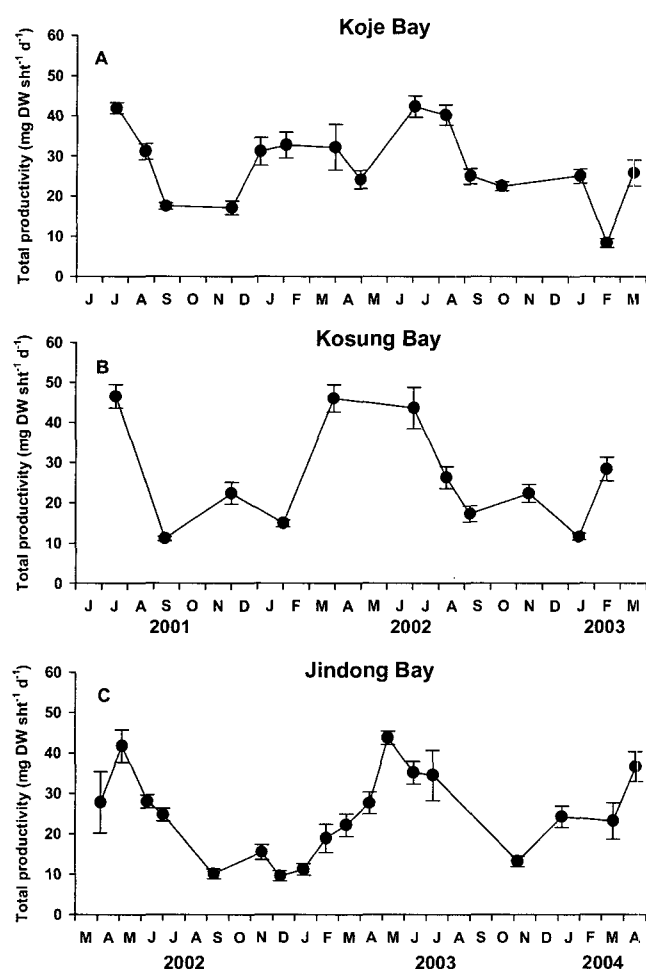
Fig. 8. Seasonal changes in total eelgrass production rates estimated using the plastochrone method from Koje Bay (A), Kosung Bay (B), and Jindong Bay (C) on the south coast of the Korean peninsula. Values are mean±1SE (n=10 to 15).

Fig. 9. Comparisons of eelgrass leaf production rates estimated using the conventional leaf marking technique and the plastochrone method from Koje Bay (A), Kosung Bay (B), and Jindong Bay (C) on the south coast of the Korean peninsula. Values are mean±1SE (n=10 to 15).

seagrass leaf production is assessed using the leaf marking technique. These problems of the leaf marking technique can cause underestimation of the seagrass leaf production.

The plastochrone method, which bases on the time interval between the production of new plant parts and the size of a mature leaf, has been developed for more efficient and accurate measurements of eelgrass growths (Jacobs 1979; Short and Duarte 2001;
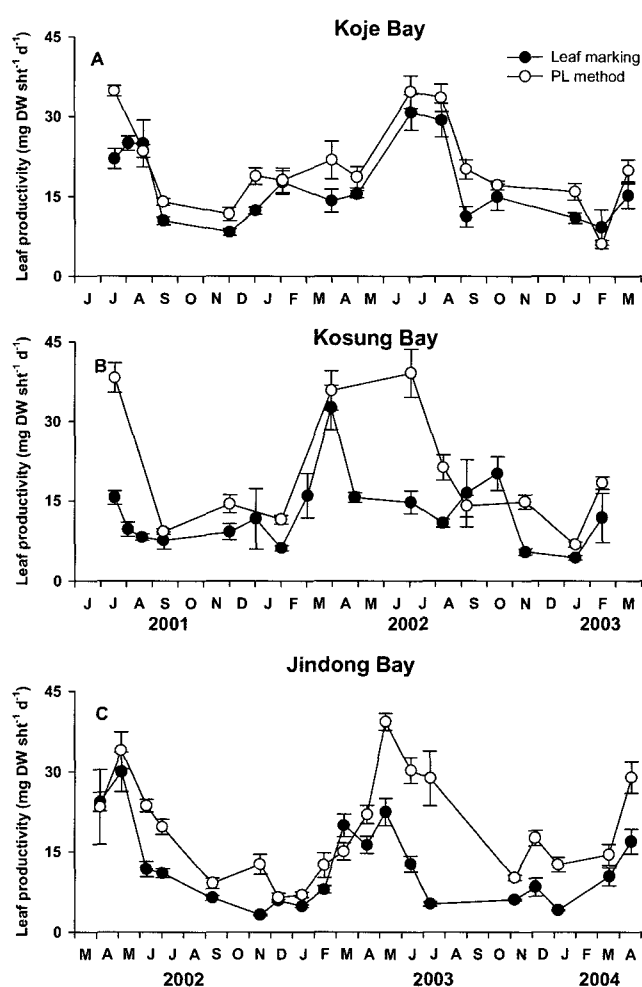
Gaeckle and Short 2002). In the present study, annual eelgrass leaf productions estimated by the leaf marking technique were about 65% to 89% of the leaf productions obtained with the plastochrone method. This result implies that the traditional leaf marking technique underestimate eelgrass leaf production by about 10 to 30% of the production. Most previous leaf production measurements of eelgrass and some

Table 1. Annual above-ground, below-ground, and total productions of eelgrass, *Zostera marina* estimated using the plastochrone method from Koje Bay, Kosung Bay, and Jindong Bay on the south coast of the Korean peninsula

	Annual eelgrass production (g DW m^{-2} y^{-1}) (% of total production)		
	Above-ground	Below-ground	Total production
Koje Bay	582 (76.9)	175 (23.1)	757 (100.0)
Kosung Bay	472 (79.2)	124 (20.8)	596 (100.0)
Jindong Bay	642 (79.7)	164 (20.3)	806 (100.0)

Table 2. Comparisons of annual eelgrass leaf productions estimated using the leaf marking technique and the plastochrone method form Koje Bay, Kosung Bay, and Jindong Bay on the south coast of the Korean peninsula

	Annual eelgrass leaf production (g DW m^{-2} y^{-1}) (% of production estimated by the plastochrone method)	
	Leaf marking technique	Plastochrone method
Koje Bay	520 (89.3)	582 (100.0)
Kosung Bay	338 (71.6)	472 (100.0)
Jindong Bay	418 (65.1)	642 (100.0)

other seagrass species have been conducted using the leaf marking technique (Table 3). Thus, many reported seagrass productions are probably underestimated due to inherent problems of the leaf marking technique.

More accurate growth measuring techniques are required to adequately estimate annual seagrass productions, and the plastochrone method is probably an effective and reliable method for accurate assessments of seagrass production.

Accurate assessment of total seagrass production is difficult since a substantial fraction of seagrass tissues is located in below-ground (Lee and Dunton 1996; Kaldy and Dunton 2000). Production dynamics of above-ground tissues of seagrasses are generally well documented, but those of below-ground tissues in whole plant production dynamics are less well known. Below-ground tissues of seagrasses comprise between 50 to 80% of total biomass (Powell et al. 1989; Fourqurean and Zieman 1991; Lee and Dunton 1996), and serve as carbon storage tissues, in the

Table 3. Density, biomass, and leaf production rates of eelgrass, Zostera marina from various geographical locations

Area	Density (sht m^{-2})	Biomass (g DW m^{-2})	Leaf production		Method	Time	Source
			(mg DW sht$^-$ d^{-1})	(g DW m^{-2} d^{-1})			
Odawa Bay, Japan	59-501	4-192		1-6	Leaf marking	Seasonal	Aioi (1980); Mukai et al. (1979)
San Quintin Bay, Mexico		60-420	2.6-9.9	1.8-13	Leaf marking	Jun. Dec.	Ibarra-Obando and Huerta-Tamayo (1987)
The Nauset Marsh system, U.S.A.		30-340		0.06-10.8	Leaf marking	Seasonal	Roman and Able (1988)
Padila Bay, U.S.A.	20-820	10-280		0-8.2	Leaf marking	Apr. Aug.	Thom (1990)
Waquoit Bay, U.S.A.	57±5-2662±28	9±1-80±19(L)	1.89±0.08-3.51±0.22	0.13-0.93	Leaf marking	Annual mean	Hauxwell et al. (2003)
Limfjorden, Denmark	596-1054	94-144		1.8-2.7	Biomass change	Seasonal	Olesen (1999)
Åland, Finland	70-400	4-33		0.06-0.6	Leaf marking	May-Oct.	Boström et al (2004)
North Carolina, U.S.A.	105	36-122		2-4	^{14}C method	March	Penhale (1977)
Isefjord, Denmark	1055-1810	58-226		2.3-7.9	Leaf marking	Apr.Oct.	Sand-Jensen (1975)
Øresund, Denmark	550-3500	12-280		0.1-11.8	Leaf marking		Wium-Andersen and Borum (1984)
Brittany, France	500-800	80-400		1.5-3.1	Leaf marking	Sesaonal	Jacobs (1979)
Oregon, U.S.A.	500-3850	0-326		1-13.6	Leaf marking	Seasonal	Kentula and McIntire (1986)
Nova Scotia, Canada	470-763	15-200		0.2-4.0	Leaf marking		Robertson and Mann (1984)
Koje Bay, Korea			8.3-30.8	0.2-3.7	Leaf marking	Seasonal	Present study
			3.6-34.8	0.2-5.7	PL method*		
Kosung Bay, Korea			4.3-32.6	0.04-2.8	Leaf marking	Seasonal	
			6.8-39.1	0.1-3.3	PL method*		
Jindong Bay, Korea			3.2-30.0	0.1-3.7	Leaf marking	Seasonal	
			7.0-34	0.2-4.2	PL method*		

form of non-structural carbohydrates, that support growth and maintenance of other plant parts during periods of low photosynthetic production (Dawes and Lawrence 1979, 1980; Durako and Moffler 1985; Pirc 1985; Dawes and Guiry 1992). Although below-ground biomass usually accounts for over 50% of total sea-grass biomass, the production of above-ground tissues is absolutely dominating owing to the turnover rate of leaves being about 2.5 times as great as that of below-ground tissues (Sand-Jensen 1975). Below-ground production of seagrasses is typically esti-mated to account for about 10 to 30% of total pro-duction (Patriquin 1973; Gallegos et al. 1993; Kaldy and Dunton 2000), but these estimates are based on limited empirical data.

Rhizome tagging has been used to estimate pro-duction of below-ground tissues in eelgrass, Zostera marina (Dennison 1990b). However, as a result of the inherent difficulties in measuring below-ground production, few measurements of below-ground pro-duction have been completed. In the present study, below-ground productions of eelgrass were easily estimated using the plastochrone method. Annual below-ground productions of eelgrass in the present study sites were 124 to 175 g DW m^{-2} y^{-1}, and accounted for about 20 to 23% of total eelgrass pro-duction. Rhizome production of Thalassia testudinum in Texas coast accounted for 25 to 35% of total pro-duction (Kaldy and Dunton 2000). Based on rhizome tagging, Erftemeijer et al. (1993) reported that below-ground production of Thalassia hemprichii accounted for 5 to 15% of total production. The advantage of the plastochrone method for measuring below-ground production and/or total seagrass production is the sim-plicity of its measurement and calculations (Gaeckle and Short 2002).

Leaf production rates of eelgrass, Zostera marina estimated using the leaf marking technique and the plastochrone method ranged from 0.04 to 5.7 g DW m^{-2} d^{-1} in the present study sites, and these estimated rates are similar to the previously reported production rates (Table 3). Eelgrass leaf production rates in Japan estimated by the leaf marking technique ranged from 1 to 6 g DW m^{-2} d^{-1} (Mukai et al. 1979; Aioi 1980), while the rates reported from eelgrass beds in North America ranged 0 to 13.6 g DW m^{-2} d^{-1} (Pen-hale 1977; Jacobs 1979; Robertson and Mann 1984; Kentula and McIntire 1986; Ibarra-Obando and Huerta-Tamayo 1987; Roman and Able 1988; Thom 1990; Hauxwell et al. 2003). In conclusion, total annual eel-grass productions estimated using plastochrone method

were about 760 to 806 g DW m^{-2} y^{-1} in eelgrass beds on the south coast of the Korean peninsula. The conventional leaf marking technique underestimated about 10 to 35% of eelgrass leaf production. Below-ground production assessed by the plastochrone method accounted for about 20 to 23% of total eel-grass production. The plastochrone method was sug-gested to be a more effective and reliable assessing method than the traditional leaf marking technique for eelgrass production.

ACKNOWLEDGEMENTS

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