

## Studies on the Algal Productivity in South Aegean Region of Turkey

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**Özet:** *Türkiye'nin Güney Ege Bölgesinde Alg Verimliliği Çalışmaları.* Bu çalışmada Güney Ege Denizi'ndeki 11 farklı bölgeden periyodik toplanılan *Ulva lactuca* Linnaeus, *Cystoseira compressa* (Esper) Gerloff *et* Nizamuddin, *C. crinita* Duby, *C. elegans* Sauvageau, *C. schiffneri* G.Hamel, *Hypnea musciformis* (Wulfen) J.V.Lamaouroux, *Laurencia papillosa* (C.Agardh) Greville and *Halopithys incurva* (Hudson) Batters türlerinin kuru ağırlıkları karşılaştırılmıştır. Ayrıca, ekonomik olan bu türlerin uygun toplanma zamanları önerilmiştir.

**Anahtar Kelimeler:** Alg, ekonomik, produktivite, Ege Denizi, Türkiye.

**Abstract:** In this study, *Ulva lactuca* Linnaeus, *Cystoseira compressa* (Esper) Gerloff *et* Nizamuddin, *C. crinita* Duby, *C. elegans* Sauvageau, *C. schiffneri* G.Hamel, *Hypnea musciformis* (Wulfen) J.V.Lamaouroux, *Laurencia papillosa* (C.Agardh) Greville and *Halopithys incurva* (Hudson) Batters were collected from 11 stations of South Aegean Sea. The dry and fresh weights of these algae were compared. In addition, collection periods of these commercial species were suggested.

**Key Words:** Algae, commercial, productivity, Aegean Sea, Turkey.

### Introduction

Algal industry is growing tremendously in Far East, Europe and America where marine ranches are being created at a large scale just like the ones on the terrestrial parts of our earth. This naturally has increased the importance of studies on the systematics and ecology of the algal taxa too. In Turkey not much has been done in this connection in spite of the fact that it is surrounded on three sides by seas. Fritsch made the first studies on the systematics of marine algae of Turkey in 1899 and those of Öztürk (1957, 1959, 1961, 1962) and Karamanoğlu (1964) and Güven and Öztürk (1971) followed these. A real impetus to this field was given by Zeybek (1966, 1969, 1976), Zeybek and Güner (1973), who was followed in our study area by Güner (1968, 1970, 1973),

Güner and Aysel (1977, 1987, 1996), Güner *et al.* (1984,1985), Aysel (1977, 1981, 1987, 1992, 1997a, 1997b), Aysel *et al.* (1978, 1984, 1986, 1987, 1993), Aysel and Güner (1977, 1978), Aysel and Gezerler-Şipal (1996), Çirik (1978), Çirik *et al.* (2000), Öztürk (1980, 1984), Sukatar (1981), Sukatar *et al.* (1986) and Dural (1986, 1990), Dural *et al.* (1997) and Everest *et al.* (1998). Similar studies are still going on. In addition to these floral aspects, Güner (1975, 1978, 1979), Güner and Aysel (1978, 1979, 1984), Aysel and Güner (1979, 1980, 1982) Sukatar (1994) and Sukatar *et al.* (1992, 1993) have carried out phytogeographic studies. In this paper, coastal algal populations existing in the southern part of the Aegean Region have been studied in relation to their ecology, productivity and reproductive capacities.

## Material and Methods

Area between Çeşme and Marmaris was surveyed during 1990-1991. Mainly commercial important algal species were selected. For productivity studies, methods outlined by Braun-Blanquet and Pavillard (1928) and Boudouresque (1971) were used. Multiple 25 x 25 cm<sup>2</sup> iron squares with plankton net open on one side were laid for minimum area studies. This gave us good results on the basis of 25 x 25 x 25 cm<sup>3</sup> area. These were laid randomly and specimens thus collected were scratched and separated with a spatula, cleaned and placed on filter paper for a time, finally weighted to get their fresh weights. Samples were placed for 10-15 days on drying papers in the laboratory, left for 6 hours at 80°C in an incubator and then their dry weights recorded. The measurements were followed in all four seasons and the productivity, is calculated as kg/m<sup>2</sup>. Temperatures and pH were measured with a thermometer and indicator paper, respectively.

## Study Area

Study area covers the stations extending from Altinkum coast, southern most point of Çeşme; up to Datça (Figure 1). Stations were selected on the basis of algal density and these are listed below:

1. Backside of Datça Bay
2. Bodrum Akyarlar
3. Bodrum Güvercinlik
4. Güllük Bay and its environs
5. Kuşadası Kadınlar Sea
6. Kuşadası frontside of Tusan Motel
7. Ahmetbeyli
8. Seferihisar Sığacık
9. Urla Demircili Village
10. Çeşme Alaçatı
11. Çeşme Altinkum

## Results

Table 1 shows the pH values and temperatures of seawater of our study sites. In general, pH varies between 7.5-8.5 and temperatures between 21-27°C in summer (June-August), 24-27°C in early autumn (September), 18-19° in late autumn (November), 15-19.5°C in winter (December-January), 19-20.5°C in spring (April-May). Previous studies undertaken by Zeybek (1966), Güner (1975, 1978, 1979), Güner and Aysel (1978, 1979, 1984), Aysel and Güner (1979, 1980, 1982), Cirik (1978) and Öztürk (1980, 1984) presented some data concerning the algae with commercial value from south Aegean coast. These studies and our observations revealed the following species of commercial value from this area.

We tried to find out which species from this list are abundant, which ones could be evaluated by collecting from their natural habitats, in which season or month do the reproductive organs develop, best time for collection without destroying their natural sites, seasonal growth of these algae and their morphological changes.

All eight algae were seen to grow well in the form of populations. These are *Ulva lactuca* Linnaeus (Chlorophyta), *Cystoseira compressa* (Esper) Gerloff et Nizamuddin, *C. crinita* Duby, *C. elegans* Sauvageau, *C. schiffneri* G.Hamel (Phaeophyta), *Hypnea musciformis* (Wulfen) J.V.Lamouroux, *Laurencia papillosa* (C.Agardh) Greville and *Halopithys incurva* (Hudson) Batters (Rhodophyta).

### 1. *Ulva lactuca* Linnaeus populations

It generally occurs in areas polluted by domestic effluents, densely growing in Sığacık Seferihisar, being 15-30 cm in wavy seas but is 1.5 -2 m long in our

station, which generally is calm. Results maximum in August and minimum in obtained for its productivity studies December, whereas values in spring and (Table 2) show that production is autumn are close to each other.

**Table 1.** Water temperatures and pH values from the chosen stations in Southern Aegean Sea.

Stations	Date	Hour	Temperature (°C)	pH
1. Backside of Datça Bay	26.06.1990	10.15	22.0	7.5
	10.09.1990	18.20	24.5	7.5
	05.12.1990	12.10	18.0	7.5
	30.04.1991	11.00	19.0	8.0
2. Bodrum Akyarlar	27.06.1990	17.30	23.0	8.0
	11.09.1990	17.50	25.5	8.0
	06.12.1990	09.10	19.0	7.5
3. Bodrum Güvercinlik	01.05.1991	17.30	19.0	8.0
	27.06.1990	09.50	23.0	7.5
	11.09.1990	15.10	26.5	8.0
	06.12.1990	15.30	19.5	8.0
4. Güllük Bay and its environment	01.05.1991	14.10	19.5	8.0
	28.06.1990	13.30	25.0	7.5
	11.09.1990	12.00	27.0	7.5
	06.12.1990	14.30	19.0	7.5
5. Kuşadası Kadınlar Sea	01.05.1991	12.10	19.5	8.0
	28.06.1990	18.30	25.0	8.0
	12.09.1990	12.30	25.0	8.0
	07.12.1990	10.10	18.0	8.0
6. Kuşadası Frontside of Tusan Motel	02.05.1991	11.20	19.5	7.5
	29.06.1990	09.00	22.0	7.5
	12.09.1990	15.20	25.0	8.0
	07.12.1990	11.30	18.0	8.0
7. Ahmetbeyli	02.05.1991	13.05	20.5	8.0
	29.06.1990	14.30	21.0	7.5
	23.08.1990	10.35	27.0	7.5
	07.12.1990	12.50	17.5	7.5
8. Seferihisar Sığacık	02.05.1991	15.10	19.0	8.0
	23.08.1990	16.30	26.0	7.5
	13.09.1990	15.20	24.0	7.5
	07.12.1990	14.30	17.5	7.5
9. Urla Demircili Village	02.05.1991	18.15	19.5	8.5
	27.08.1990	13.10	27.0	8.0
	08.11.1990	16.30	19.0	7.5
	15.01.1990	16.20	16.5	7.5
10. Çeşme Alaçatı	07.05.1991	17.15	19.0	8.5
	27.08.1990	16.05	27.0	7.5
	08.11.1990	14.20	18.0	7.5
	15.01.1990	14.30	16.5	7.5
11. Çeşme Altınkum	07.05.1991	13.30	19.5	8.0
	27.08.1990	09.35	27.0	8.0
	08.11.1990	11.10	18.0	7.5
	15.01.1990	12.15	15.0	7.5
	07.05.1991	12.10	19.0	8.0

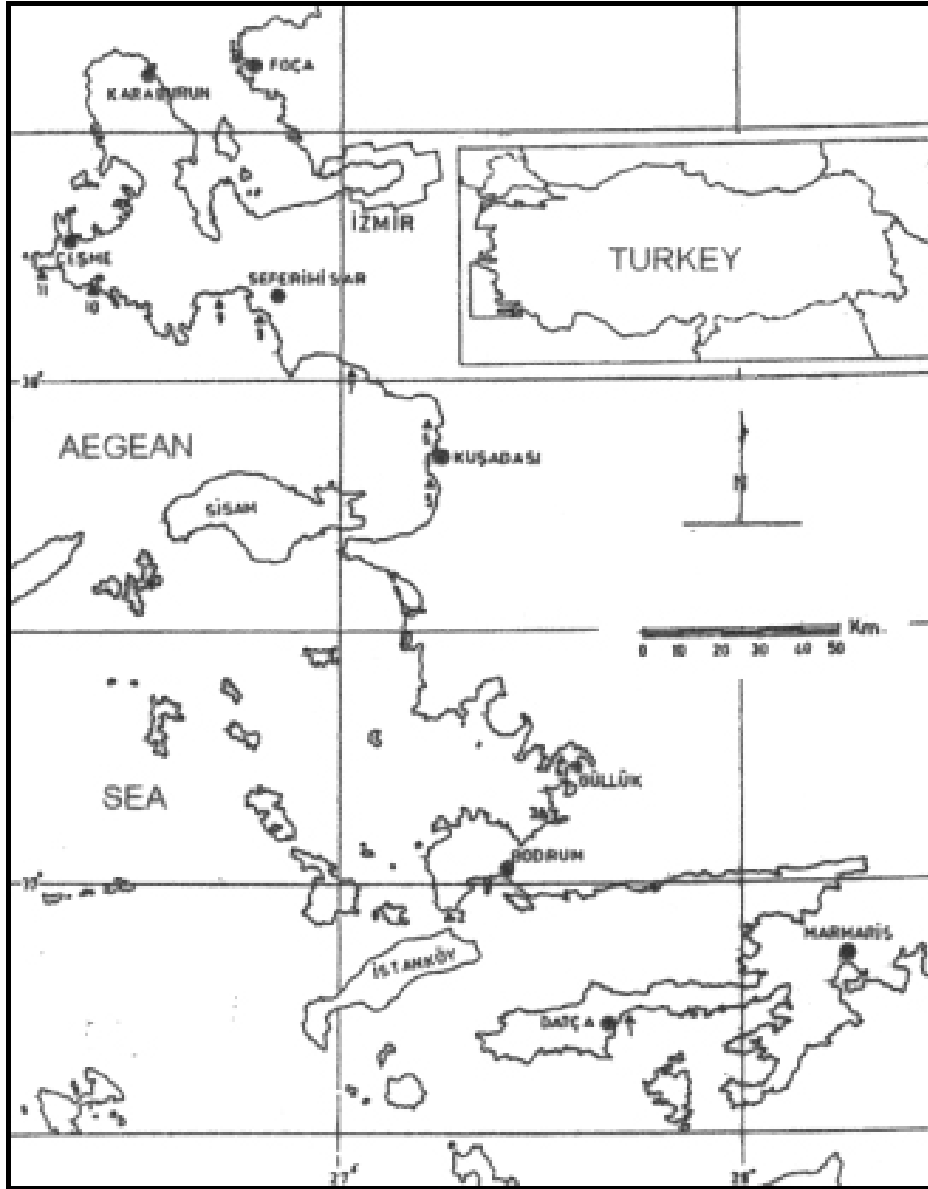


Figure 1. Study area

## 2. *Cystoseira* C.Agardh sp.

*Cystoseira* C.Agardh species show distribution in Atlantic, Mediterranean,

Aegean and Black Sea and detailed work on their distribution have been given by Delepine *et al.* (1987). 11 species of *Cystoseira* show distribution in Turkish

seas. Of this genus four form dense populations in our study area.

**2a. *Cystoseira compressa* (Esper) Gerloff et Nizamuddin population**

*C. compressa* (Esper) Gerloff et Nizamuddin shows good growth in June around infralittoral zones of backside of Datça Bay and in Kuşadası in frontside of Tusan Motel area and can be easily distinguished from other *Cystoseira* species by the presence of a compressed basal part in thallus. In other seasons it occurs in small patches (Table 3).

**Table 2.** Fresh and dry weights of *Ulva lactuca* Linnaeus on seasonal basis.

Station	Date	Weight (kg/m <sup>2</sup> )	
		Fresh	Dry
Seferihisar	23.08.1990	12.800	3.067
Sığacık			
Seferihisar	13.09.1990	9.760	2.147
Sığacık			
Seferihisar	07.12.1990	2.400	0.579
Sığacık			
Seferihisar	02.05.1991	9.120	1.765
Sığacık			
Annual average		8.520	1.890

**2b. *Cystoseira crinita* Duby population**

Generally this alga was found in the upper infralittoral zones of clean and partly wavy waters. It shows good branching at the base of thallus and possesses air sacs, which differentiate this species from the others. Length in rough waters 15-20 cm, but 40-50 cm in calm seas. Many epiphytic algae grow on the naked basal parts of the branches of this alga. Reproductive organs occur in all seasons except autumn. Much work has been done on this species (Güner 1975, 1978, 1979, Kocataş 1978, Huve 1972, Boudouresque 1973, Amico et al. 1985). It forms dense

populations in some stations of our study area (Table 4). Highest annual fresh weight productivity is seen around Güllük Bay being 8.68 kg/m<sup>2</sup> and lowest 4.94 kg/m<sup>2</sup> around backside of Datça Bay. On annual dry weight basis, best growth is seen at Demircili Village-Urla (2.187 kg/m<sup>2</sup>) and poor at backside of Datça Bay (1.437 kg/m<sup>2</sup>).

**2c. *Cystoseira elegans* Sauvageau population**

It occurs in the upper infralittoral zones of the Mediterranean, Adriatic and the Aegean seas between 50-100 cm depths. Disc shaped holdfast allows it to remain attached to hard substrates together with its tofuls covered by thick and spiny projections. It shows iridescency and serves as a habitat for many epiphytic algae and animals. Side branches of toful are good looking and elastic. Reproductive organs develop in winter on the lower parts of side branchlets of tofuls. It is found only in Çeşme Alaçatı at a depth of 50-100 cm and has been investigated for the first time by me on population basis. Maximum productivity is seen in spring and minimum in autumn (Table 5).

**Table 3.** Fresh and dry weights of *Cystoseria compressa* (Esper) Gerloff et Nizamuddin on seasonal basis.

Station	Date	Weight (kg/m <sup>2</sup> )	
		Fresh	Dry
Backside of	27.06.1990	7.520	1.582
Datça Bay			
Kuşadası	29.06.1990	7.200	1.529
Frontside of			
Tusan Motel			

**Table 4.** Fresh and dry weights of *Cystoseira crinita* Duby on seasonal base.

Station	Date	Weight (kg/m <sup>2</sup> )			
		Fresh	Dry	Annual Average	
				Fresh	Dry
Backside of Datça Bay	26.06.1990	4.640	1.206		
	10.09.1990	5.600	1.832		
	05.12.1990	5.120	1.392		
	30.04.1991	4.400	1.320	4.940	1.437
Bodrum Akyarlar	27.06.1990	6.080	1.570		
	11.09.1990	9.040	2.297		
	06.12.1990	4.200	1.233		
Bodrum Güvercinlik	01.05.1991	8.960	1.837	7.080	1.734
	28.06.1990	7.040	1.542		
	11.09.1990	5.600	1.818		
	06.12.1990	4.000	1.182		
Güllük Bay	01.05.1991	7.360	1.831	6.000	1.593
	28.06.1990	12.160	2.912		
	11.09.1990	5.040	1.586		
Kuşadası Frontside of Tusan Motel *	06.12.1990	7.680	1.814		
	01.05.1991	9.840	2.369	8.680	2.170
	12.09.1990	3.600	1.086		
	07.12.1990	8.800	2.333		
Urla Demircili Village	02.05.1991	5.440	1.207	5.946	1.542
	28.08.1990	6.160	1.830		
	08.11.1990	10.720	2.706		
Çeşme Altınkum	15.01.1991	8.800	2.171		
	07.05.1991	7.840	2.042	8.380	2.187
	27.08.1990	4.320	1.553		
	08.11.1990	8.640	2.956		
	15.01.1991	7.680	2.457		
	07.05.1991	5.280	1.731	6.480	2.174

\* In July no population was found

**Table 5.** Fresh and dry weights of *Cystoseira elegans* Sauvageau on seasonal basis.

Station	Date	Weight (kg/m <sup>2</sup> )	
		Fresh	Dry
Çeşme Alaçatı	27.08.1990	9.440	2.558
Çeşme Alaçatı	08.11.1990	8.640	2.408
Çeşme Alaçatı	15.01.1990	10.720	3.136
Çeşme Alaçatı	07.05.1991	15.840	4.969
Annual average		11.160	3.267

**2d. *Cystoseira schiffneri* G.Hamel population**

It is distributed in the Mediterranean,

Aegean and the Atlantic seas between 50-100 cm and 6-7 m depths. Yellowish brown thallus is 60-70 cm long without toful. Disc shaped holdfasts fix it to the substratum. It has a small stalk, which possesses lateral branchlets covered with leaflets and needle like projections. Leaflets have a mid vein and margins are thickly dentate. It forms a good population around Tusan Motel-Kuşadası in winter. In summer only basal parts of the thallus are visible. Reproductive organs are seen in spring. Length is 15-20 cm in autumn but 35-40 cm in winter. Air sacs also develop during winter (Table 6).

**Table 6.** Fresh and dry weights of *Cystoseira schiffneri* G.Hamel on seasonal basis.

Station	Date	Weight (kg/m <sup>2</sup> )	
		Fresh	Dry
Kuşadası Frontsite of Tusan Motel	12.09.1990	6.720	1.730
Kuşadası Frontsite of Tusan Motel	07.12.1990	7.320	1.918
Kuşadası Frontsite of Tusan Motel	02.05.1991	4.000	1.348
Annual average		6.346	1.665

**Table 7.** Fresh and dry weights of *Hypnea musciformis* (Wulfen) J.V.Lamouroux on seasonal basis.

Station	Date	Weight (kg/m <sup>2</sup> )	
		Fresh	Dry
Ahmetbeyli	29.06.1990	2.640	0.467
Seferihisar Sığacık	23.08.1990	2.560	0.487

### 3. *Hypnea musciformis* (Wulfen) J.V.Lamouroux population

It is commercially important because 30-40% dry weight of this alga contains phycocolloids. It is distributed all over the world and has been investigated ecologically, biochemically and from the culture aspect too. This alga is cultivated too. The genus consists of eight species out of which two are found in Turkey. Growth is observed between infralittoral and mediolittoral zones as an epiphyte on other macroscopic algae like *Laurencia papillosa* (C.Agardh) Greville, *Corallina elongata* J.Ellis et Solander and *Cystoseira* C.Agardh species. Length in many open seas is 3-5 cm but 10-15 cm or even 20 cm in calm and slightly shady areas. Thallus is full of spiny projections with hooks at the apex. It is found in all seasons but forms good populations around Ahmetbeyli and Seferihisar Sığacık in summer. Reproductive organs

too develop in all seasons. Productivity was studied only during summer, which is the peak period in our study area (Table 7)

### 4. *Laurencia papillosa* (C.Agardh) Greville population

This alga was 5-15 cm long, with different colours like olive green, honey yellow or light red, with a cartilaginous thallus, which branches on all sides. Branches are short, covered with rounded blunt papillae densely. Grows on stones and rocks between 0-50 cm in mediolittoral and infralittoral zones, attached to the substratum by a holdfast. Perennial thallus starts growth in April and dies in September except for a few pieces of thalli which produce new thalli in the following year. It grows in all temperate seas of the world (Delepine *et al.* 1987). It forms dense colonies around Kuşadası Kadınlar Sea station and produces reproductive organs in June and September. Fresh weight is highest in autumn and lowest in winter (Table 8).

**Table 8.** Fresh and dry weights of *Laurencia papillosa* (C.Agardh) Greville on seasonal basis.

Station	Date	Weight (kg/m <sup>2</sup> )	
		Fresh	Dry
Kuşadası Kadınlar Sea	28.06.1990	4.400	0.826
Kuşadası Kadınlar Sea	12.09.1990	3.840	0.918
Kuşadası Kadınlar Sea	07.12.1990	0.800	0.308
Kuşadası Kadınlar Sea	02.05.1991	3.040	0.788
Annual average		3.022	0.710

### 5. *Halopithys incurva* (Hudson) Batters population

This dark red coloured alga with cross striations on cylindrical main thallus as

well as lateral branches. Thallus hook shaped, 15-20 cm long branch apices too curved. It grows on hard substrata in infralittoral zone between 50-100 cm depths. Güner (1978) has done some population studies of this alga around Urla, Çeşme, Çanakkale and Erdek coasts (North Aegean and Marmara seas) We found large populations around Bodrum Akyarlar. It has attracted much attention lately from medicinal as well as agricultural points of view (Delepine *et al.*, 1987). Fresh and dry weights in our studies were found to be highest in May and lowest in September (Table 9)

**Table 9.** Fresh and dry weights of *Halopithys incurva* (Hudson) Batters on seasonal base

Station	Date	Weight (kg/m <sup>2</sup> )	
		Fresh	Dry
Bodrum Akyarlar	27.06.1990	9.440	3.184
Bodrum Akyarlar	11.09.1990	3.360	1.202
Bodrum Akyarlar	06.12.1990	5.600	1.753
Bodrum Akyarlar	01.05.1991	9.760	3.417
Annual average		7.040	2.389

### Discussion

According to Güner and Aysel (1978), dry and fresh weights of *Ulva lactuca* Linnaeus vary between 2.700-15.800kg/m<sup>2</sup> and 0.580-3.600kg/m<sup>2</sup> respectively. Our values were a little bit lower. After these data, it is reasonable to collect this algae in the summer because of the maximal values were reached in the beginning of summer. Güner (1975) found that the dry and fresh weights of *Cystoseria compressa* (Esper) Gerloff *et* Nizamuddin vary between 3.175-4.005kg m<sup>2</sup> and 0.245-0.385kg/ m<sup>2</sup>, respectively. In the stations in Datça and Kuşadası where the environmental conditions so good that the dry and fresh weights were

up to 127% and 524% more respectively. This alga reached the highest values in the end of spring, it is ingenious to collect in the summer. After Güner (1979), dry and fresh weights of *C. crinita* Duby vary between 9.200-13.240kg/m<sup>2</sup> and 2.378-3.120kg/m<sup>2</sup>, respectively. Our values ranged between 3.600-12.160kg/m<sup>2</sup> and 1.086-2.956kg/m<sup>2</sup>, respectively, which show that the collected areas of Güner has better environmental conditions for this alga especially in out of view of fresh weights. According to this data, this alga should be collected in autumn. *C. elegans* Sauvageau was never been studied before in view of productivity capacities, therefore it was not possible to compare our data. This species should be collected in spring.

The study of Güner (1975) shows that dry and fresh weights of *C. schiffneri* G. Hamel vary between 4.460-5.440kg/m<sup>2</sup> and 0.788-1.048kg/m<sup>2</sup>, respectively. Due to different environmental conditions, our results were up to %53 and %73 higher as dry and fresh weights compared with Güner's results, respectively.

The dry and fresh weights of *Hypnea musciformis* (Wulfen) J.V. Lamouroux that we found varies between 2.560- 2.640kg/m<sup>2</sup> and 0.467-0.487kg/m<sup>2</sup>, respectively, while this weights were reported by Güner (1978) and Güner and Aysel (1984) higher (Dry: 2.120-7.450 kg/m<sup>2</sup>, fresh: 0.520-2.050 kg/m<sup>2</sup>). This alga should be collected for commercial use in summer and in early autumn. Like *Cystoseria elegans* Duby, *Laurencia papillosa* (C.Agardh) Greville was also never been studied before in view of productivity. Our observation shows that this alga should be collected for commercial use in early September, because into this month, this alga disappears.

According to Güner (1978), *Halopithys incurva* (Hudson) Batters weighted as dry 7.850 kg/m<sup>2</sup> at highest,



which is harmonious with our values. The collection time for this alga for commercial use lies in end of May, before this alga disappears.

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