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OVERVIEW ON PHYTOPLANKTON OF ALBANIAN LAGOONS

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ABSTRACT

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Data on the phytoplankton of the most important lagoons of Albanian coast: Butrinti (Ionian coast), Narta, Karavasta and Patoku (Adriatic coast) have been reported here. Monthly data in Butrinti shows that diatoms and dinoflagellates were the most abundant. The phytoplankton had a seasonal pattern with an evident peak in autumn and a smaller one in winter (January 06). The diatoms were the most abundant, represented mainly by *Cyclotella choctawhatcheeana* and *Pseudo-nitzschia seriata,* the last one known as toxic. The phytoplankton growth was relatively low in Patoku and Karavasta, lower than all the studied lagoons. Intense growth was observed in Narta, with blooming state in April. *Bacillariophyceae*, *Dinophyceae* and *Cryptophyceae* represented the most abundant part of the phytoplankton in all Adriatic lagoons; in Butrinti phytoplankton was represented mainly by *Bacillariophyceae* and *Dinophyceae*. Filamentous *Cyanopyceae* were present only occasionally, especially in Narta. *Pseudo-nitzschia seriata* (diatom) and *Prorocentrum minimum* (dinoflagellates) were the most abundant toxic species in the phytoplankton. The data on phytoplankton would inform better about the productivity, the stress conditions and the risk from the potentially toxic algae, as well. A permanent and reliable monitoring system, including phytoplankton, would be helpful to Albanian government and other interested institutions to understand the health of lagoon ecosystem for better integrated management, fulfilling also the required standards in the international scale.

Keywords: Albanian coastal lagoons, phytoplankton, toxic algae

Introduction

Important lagoons and wetlands, with a total surface of 150 km^2, extend along the Albanian coast (NEA/AKM, 1999). Starting from the northern part, Viluni, Merxhani, Ceka, Patoku, Karavasta, Narta and Orikumi are situated along Adriatic coast, respectively under the activity of rivers Buna, Drini, Mati, Erzeni, Shkumbini, Semani and Vjosa. Only Butrinti lagoon is situated in the Southern part, in Ionian Sea (Fig. 1). The main hydrological characteristics of Albanian territory including the coastal wetlands and lagoons, is given by Kabo (1990–91).

Albanian lagoons, wetlands and dunes are distinguished about the richness of breeding and refuge habitats for flora and fauna, especially for fishes and wintering of migratory of globally threatened birds. After World Database on Protected Areas (http://sea.unep-wcmc.org/wdpa/index.htm), along the Albanian cost there are extended three Wetlands of International Importance (Ramsar): Butrinti (13500), Karavasta Lagoon (20000) and Lake Shkodra and River Buna (49562); there are also 7 sites of Managed Nature Reserve (ca. 30000 ha) (Karaburuni/Vlora, Kulari, Kune-Vaina, Patoku-Fushe-Kuqe, Pishe Poro/Fieri, Pishe-Poro/Vlora, Rrushkulli, Velipoja). The ancient town in Butrinti belongs to World Heritage Convention, and two sites, Divjaka and Kune belong to Barcelona Convention. Beside the biodiversity and tourist values, the wetlands and lagoons are important habitats for fishing and aquaculture. After FAO, Yearbooks of Fishery Statistics (ftp://ftp.fao.org/FI/STAT/summary/default.htm), in yr. 2005 fisheries production, increased to 5275 t (primarily sea fish), 3802 t from capture and 1473 t from aquaculture.

The coastal zone and especially wetlands are under the continuous pressure of urbanization and tourism, aquaculture and fishing; the coast, mainly the Adriatic one, is affected by the intense activities of agriculture and industry, urban pollution, sand extraction from the river beds, etc. (Çullaj *et al*., 2005). Therefore, the knowledge of the food webs, of primary production of the lagoons would be always of interest to evidence better their potential values in fishing and aquaculture, as well as the quality of waters. In the present paper, recent data on the phytoplankton of the most representative lagoons of Albanian coast (Butrinti, Narta, Karavasta and Patoku) is reported, aiming to increase the interest of relevant institutions about their values and continues efforts to protect them.

Material and methods

The study of phytoplankton of three coastal Adriatic lagoons: Narta, Karavasta and Patoku, was carried on during yrs. 2004-07, with a sampling frequency two times per year (April and November), by the Faculty of Natural Sciences, University of Tirana. Four stations were selected in Narta, two in Karavasta, and two in Patoku. Four series of about 500 ml of surface water were sampled in each station. Net samples (mesh size of 25 µm) were taken to evidence the floristic composition, as well. Moreover, the study of phytoplankton was carried on in Butrinti lagoon during January 2006-April 2007, by the Institute of Veterinary Food Security; sampling was done in surface waters in three stations with a frequency one or two times per month.

Samples were stored in plastic bottles in formaldehyde up to 4% or Lugol solution. Counting was done as soon as possible, after Utermoehl method (1958), following also the EU Standard prEN 15204

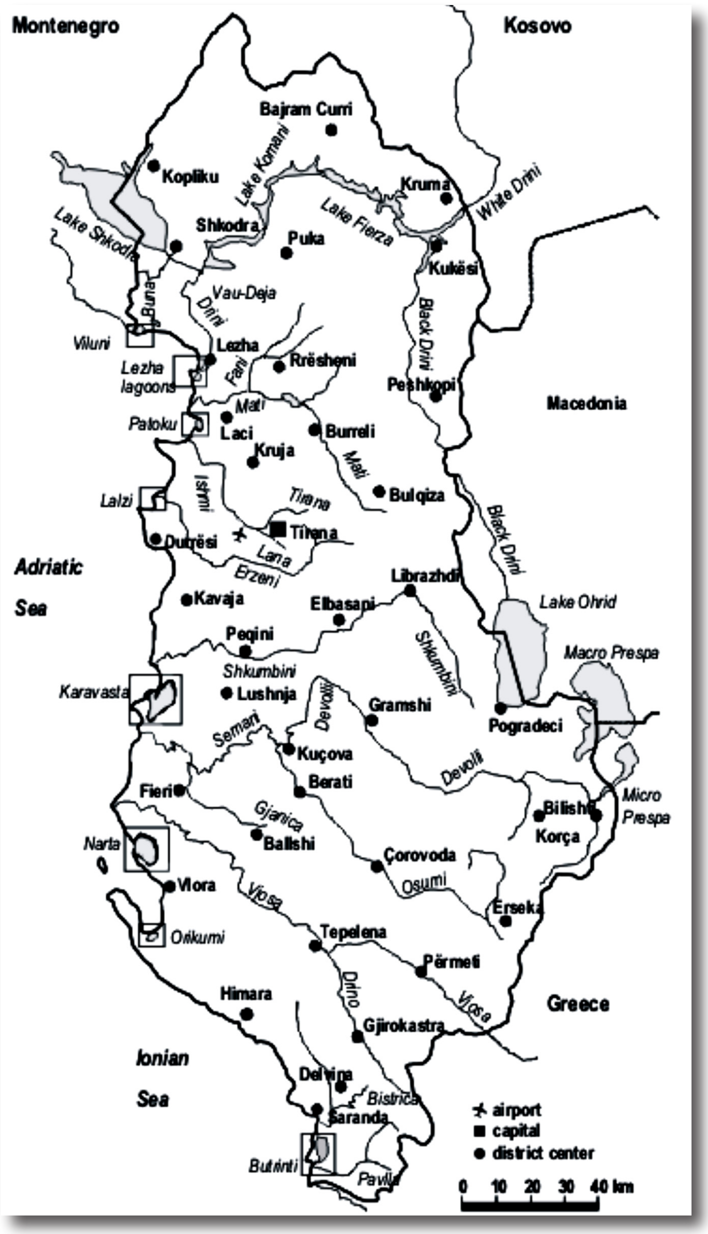

Fig. 1. Hydrological map of Albania, where the coastal lagoons are shown with squares

(2005). The sedimentation chambers of 25 ml (or 10 and 50 ml), using the inverted microscope XDS-1R, objective 40x and ocular 10x, or the microscope Zeiss, Axiovert 25 (ob. 40x & oc. 10x). Qualitative examinations and photographs were taken using an optical microscope Zeiss, Axiovert 40CFL (ob. 50x & oc. 10x), equipped with a digital camera. Cleaning of diatom frustules was performed using the acid method, as described by Krammer & Lange-Bertalot (1991). Additional observations were done with a normal optical microscope Leica, objective 100x and ocular 10x.

Results and discussion

The study of phytoplankton in Albanian lagoons started in Butrinti lagoon during yrs. 1987-91, by Miho (1994). Sporadic assessment of phytoplankton in the three Lezha lagoons (Ceka, Merxhani, Kenalla) was done in July 1996 by Miho & Mitrushi (1999). Occasional surveys were also carried on in other Albanian wetlands, i.e., Saranda, Karavasta, Narta, Patoku, Viluni and Durresi (Lalzi) (Dedej, 2005). Miho & Witkowski (2005) make a review of diatoms of Albanian coastal wetlands, focused in the taxonomy and ecology; a checklist of about 430 taxa was reported belonging to different coastal habitats (Butrinti, Karavasta, Lezha, etc.).

Preliminary data on phytoplankton of Narta, Karavasta and Patoku were reported previously by Xhulaj & Miho (2007); Xhulaj (2006; 2007) reported taxonomic data on plankton diatoms of Narta (ca. 90 species) and Patoku (up to 100 species), respectively. An overview of the whole study is presented here. The average values of the composition of phytoplankton groups (cells/ml) are given in Table 1. As shown in Figure 2, relatively, low values of phytoplankton were observed mainly in Patoku and Karavasta, the lowest of the studied lagoons. It was observed only slight difference between these two lagoons, but in Karavasta it was less abundant. Narta lagoon was the most productive of the studied lagoons with high or very high values, especially in spring period; the phytoplankton in Narta stations reached up to 3674 cells/ml (April 2005) and 4761 cells/ml (April 2006). *Bacillariophyceae*, *Dinophyceae* and *Cryptophyceae* represented the most abundant part. Filamentous *Cyanopyceae* (*Anabaena* sp., *Oscillatoria* sp. or *Spirulina* sp.) were present only occasionally, especially in Narta (up to 966 cells/ml in April 06).

The values of phytoplankton were higher in April than in November, as it can be foreseen from the other lagoons (i.e. Butrinti; Miho, 1994). It is

Tab. 1. Seasonal composition of the phytoplankton groups (average values cells/ml) in three Adriatic lagoons (Narta, Karavasta and Patoku) during years 2004-07

Groups	Autumn 2004			Spring 2005			Autumn 2005		
	Patoku	Karavasta	Narta	Patoku	Karavasta	Narta	Patoku	Karavasta	Narta
Diatoms-Centricae	3	23	33	6	10	760	14	72	30
Diatoms-Pennatae	108	81	391	244	73	204	251	171	143
Dinophyceae	1	123	280	26	39	305	21	116	148
Cryptophyceae	54	62	185	323	260	1516	135	95	218
Phytoflagellatae	25	16	35	19	49	30	0	0	0
Chrysophyceae	0	0	0	0	0	0	0	0	0
Haptophyceae	0	1	0	0	0	4	0	0	1
Cyanophyceae	0	0	6	0	0	13	35	0	2
Euglenophyceae	0	0	0	0	0	0	0	0	1
Prasinophyceae	0	0	1	13	0	2	0	0	0
Other Algae	0	0	12	0	0	100	27	0	15
Total (cells/ml):	**190**	**306**	**941**	**632**	**430**	**2934**	**484**	**454**	**557**
Groups	**Spring 2006**			**Autumn 2006**			**Spring 2007**		
	Patoku	**Karavasta**	**Narta**	**Patoku**	**Karavasta**	**Narta**	**Patoku**	**Karavasta**	**Narta**
Diatoms-Centricae	234	165	1042	80	66	127	175	64	214
Diatoms-Pennatae	263	225	770	179	147	226	434	410	828
Dinophyceae	121	145	734	295	113	263	105	228	425
Cryptophyceae	97	112	182	29	90	90	176	261	172
Phytoflagellatae	0	0	0	0	0	0	35	159	28
Chrysophyceae	0	0	0	0	0	0	0	0	0
Haptophyceae	0	0	5	0	0	0	0	0	0
Cyanophyceae	0	0	403	0	0	38	0	0	38
Euglenophyceae	0	0	0	0	0	0	0	0	0
Prasinophyceae	5	0	7	3	0	1	0	0	0
Other Algae	13	6	7	3	0	2	0	0	1
Total (cells/ml):	**733**	**652**	**3151**	**587**	**416**	**747**	**924**	**1122**	**1706**

worth to mention the presence in high quantity of species from genus *Prorocentrum* (*Dinophyceae*) in Narta, especially *P. micans* and *P. minimum* (up to 407 cells/ml). The scarce communication with the sea and the eventual high content of nutrients from the surrounding villages and cultivated fields were probably the consequence of the high presence of cyanobacteria in Narta, and the presence of dinoflagellates even in the other lagoons.

Phytoplankton of Butrinti was dominated mainly by species of microplankton, such as diatoms and dinoflagellates (Tab. 2). As it is shown in (Fig. 4), the phytoplankton shows a seasonal pattern with an evident peak in autumn and a smaller one in winter (January); there was also observed a small peak in summer, considered abnormal for the Mediterranean lagoons. The diatoms were the most abundant, mainly by *Cyclotella choctawhatcheeana* and *Pseudonitzschia seriata*. The relative increase of dinoflagellates was observed only during the summer and autumn, where the most abundant were *Heterocapsa* spp., *Prorocentrum micans*, *Scrippsiella* spp., etc.

Miho (1994) confirmed that the primary production in Butrinti was intense only in the upper layers (5–7 m depth), while the lagoon shows permanently stratified waters with anoxic bottom. The surface layers represent favorable habitat for shellfish reproduction; until yr. 1991, the harvesting of mussels (*Mytilus galloprovincialis*) in Butrinti reached up to 4500 t per year (Peja *et al*., 1996). Nevertheless, the phytoplankton values in Butrinti (Fig. 4) were much lower if compared with the data recorded by Miho (1994). After Miho (1994) the phyto-

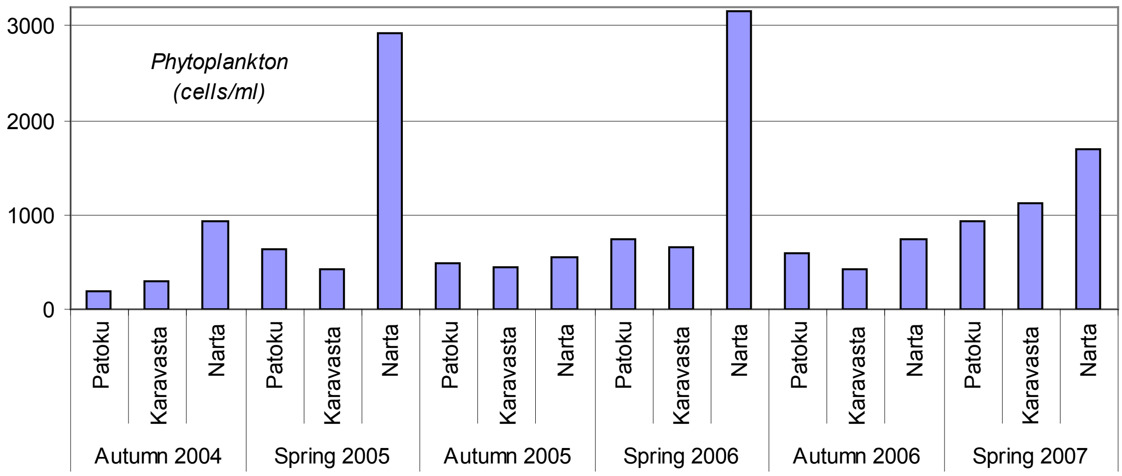

Fig. 2. Seasonal average values of phytoplankton (cells/ml) in Patoku, Karavasta and Narta lagoons during years 2004-07

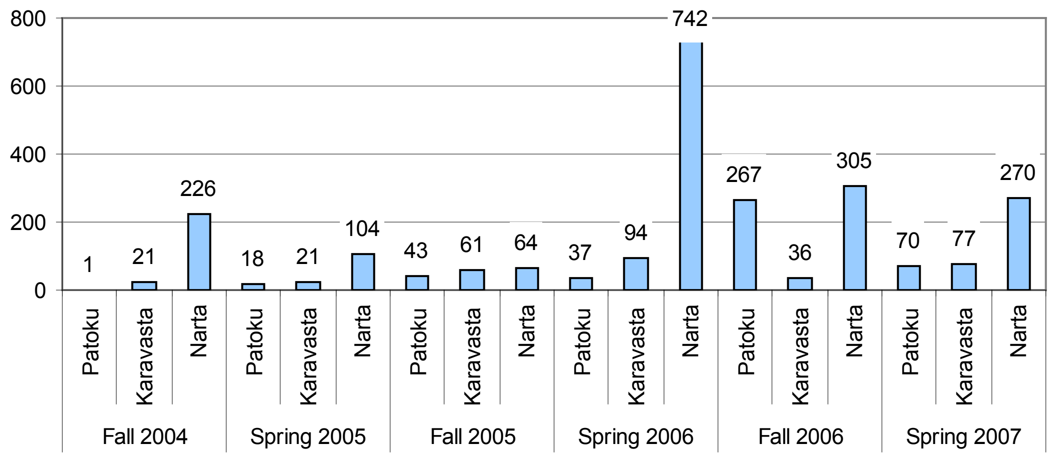

Fig. 3. Seasonal average values of toxic or eventually toxic algae in the phytoplankton (cells/ml) in Patoku, Karavasta and Narta lagoons during years 2004-07

plankton was dominated mainly by centric diatoms (*Chaetoceros* spp. and *Cyclotella choctawhatcheeana*, often more than 90% of the total phytoplankton), with a seasonal pattern involved a very pronounced peak in spring (up to 44000 cells/ml in March 1991) and a smaller one in the autumn. In the present assessment the spring peak was not observed, or mainly anticipated in January. Even the high amount of the centric diatoms *Chaetoceros* sp. diverse was quite scarce in spring period (March), contrary to what was observed by Miho in the year 1991 (1994). Is this a consequence of mild climatic condition during 2009-07, or some ecological changes have been happened in the system? It is difficult to say without further studies. Nevertheless, the phytoplankton growth in Butrinti seems relatively higher than the Adriatic lagoons Karavasta and Patoku, but not higher than in Narta lagoon (compare the Fig. 2 and 4).

In the Table 3 there are given the average values (cells/ml) of toxic algae present in the phytoplankton during the whole study, including also filamentous cyanobacteria; here are included even the species not exactly determined but suspected to be toxic referred to the list given by Moestrup (2004). Some of the most abundant and also potentially toxic microscopic algae are reported in Plate I. Generally, the growth of toxic species in lagoons was relatively low. The most common species were *Pseudo-nitzschia seriata* and *P. delicatissima*, and dinoflagellates of *Heterocapsa* spp. (only in Butrinti; Fig. 5) and Prorocentrum minimum (almost in all lagoons) and *P. lima* (in Adriatic lagoons). As it is shown in Fig. 3, *P. seriata* was abundant during all the year, in Butrinti. In January 2006, it reached a blooming state (up to 2050 cells/ml or ca. 70% of the total phytoplankton). It was also present in Adriatic lagoons (Tab. 3). After Moestrup (2004), *P. seriata* is a cold-water species known only from the Northern Hemisphere, in the Atlantic. The southernmost finds are from Germany (the Baltic Coast) and Scotland. From our finding it grows up in coastal lagoons of Albanian lagoons (Plate I-2). It is known to produce the domoic acid, the amino acid respon-

Tab. 2. Monthly mean values of phytoplankton in Butrinti lagoon during years 2006-07 (April 06: not carried on)

Period	2006												20	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II
B. - Centricae	218	418	219		507	495	509	538	119	902	327	200	130	378
B. - Pennatae	2601	1354	649		139	41	170	216	162	860	679	273	202	161
Dinophyceae	22	14	82		88	62	167	66	95	135	110	91	50	26
Chlorophyceae	0	0	0		0	0	0	0	0	0	0	0	0	0
Chlorophyceae	42	19	30		11	2	0	0	0	0	5	0	0	0
Euglenophyceae	14	2	1		2	0	0	0	0	0	69	0	9	1
Cyanophyceae	0	0	0		0	0	1	0	0	0	0	0	0	1
Not determined	0	0	0		0	0	0	0	1	15	0	0	0	0
TOTAL, cells/ml:	**2897**	**1808**	**980**		**747**	**600**	**846**	**819**	**377**	**1911**	**1191**	**565**	**390**	**567**

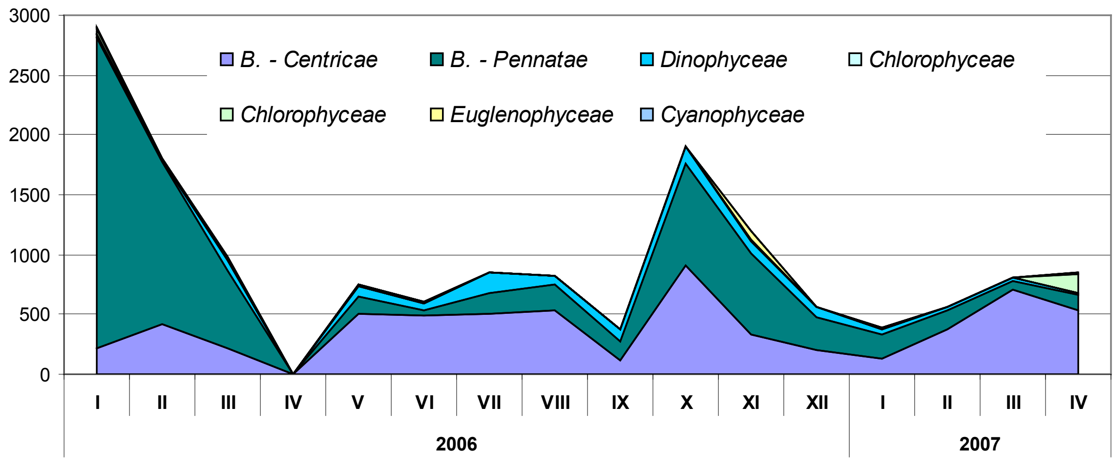

Fig. 4. Monthly average values of phytoplankton (cells/ml) in Butrinti lagoon during year 2006-07

sible for amnesic shellfish poisoning. In year 1987, *P. seriata* was found by Miho (1994) in a blooming state during late spring, together with *Prorocentrum micans* and *P. minimum. P. minimum* and *P. lima* are the other most abundant the toxic dinoflagellates in the phytoplankton of the lagoons. Extracts from *P. minimum* can be toxic to mice or the ingested cells can cause detrimental effects in mollusks. *P. lima* has been found to produce the Diarrhetic Shellfish Poisoning (DSP) toxins: okadaic acid (Moestrup, 2004).

Buric *et al*. (2007) show the presence of *Cyclotella choctawhatcheeana* for the first time in Eastern Adriatic (in the estuary of river Zrmanja, Croatia). We may confirm the *C. choctawhatcheeana* was also present in Albanian lagoons (Plate I-1),

Tab. 3. Mean values (cell/ml) of known toxic or potentially toxic algal species found in all lagoons during the period of study

Toxic or potentially toxic algal species	Butrinti	Patoku	Karavasta	Narta
Amphora cf. *coffeaeformis* (C.A. Agardh) Kützing	0.4	4.4	2.3	9.5
Pseudo-nitzschia seriata (P.T. Cleve) H. Peragallo	338.0	1.8	1.7	2.5
Pseudo-nitzschia delicatissima (P.T. Cleve) Heiden	72.0	0.0	0.0	0.0
Pseudonitzschia sp.	0.0	1.1	0.0	0.0
Alexandrium spp.	0.5	0.0	1.0	1.7
Amphidinium spp.	0.9	1.3	2.2	5.0
Dinophysis caudata Saville-Kent	0.0	0.0	7.0	0.6
Dinophysis fortii Pavillard	0.9	0.0	2.2	0.0
Dinophysis rotundata Claparède et Lachmann	0.0	0.0	0.9	3.0
Dinophysis sacculus Stein	0.2	0.0	6.6	0.0
Dinophysis sp.	0.0	0.0	7.2	0.0
Karenia spp.	3.7	0.0	0.0	0.0
Gymnodinium spp.	3.0	1.5	4.5	28.3
Gyrodinium sp.	0.0	0.3	0.4	0.6
Heterocapsa spp.	22.8	0.0	0.0	0.0
Prorocentrum lima (Ehrenberg) Stein	0.0	37.3	9.3	3.3
P. minimum (Pavillard) Schiller	2.0	18.9	2.8	145.9
Prorocentrum sp.	0.0	0.0	0.1	0.3
Protoperidinium sp.	0.0	0.2	3.7	1.3
Chrysocromulina sp.	0.0	0.0	0.1	0.0
Cyanophyceae	0.1	5.9	0.0	83.3
Total average values, cells/ml:	**445**	**73**	**52**	**285**

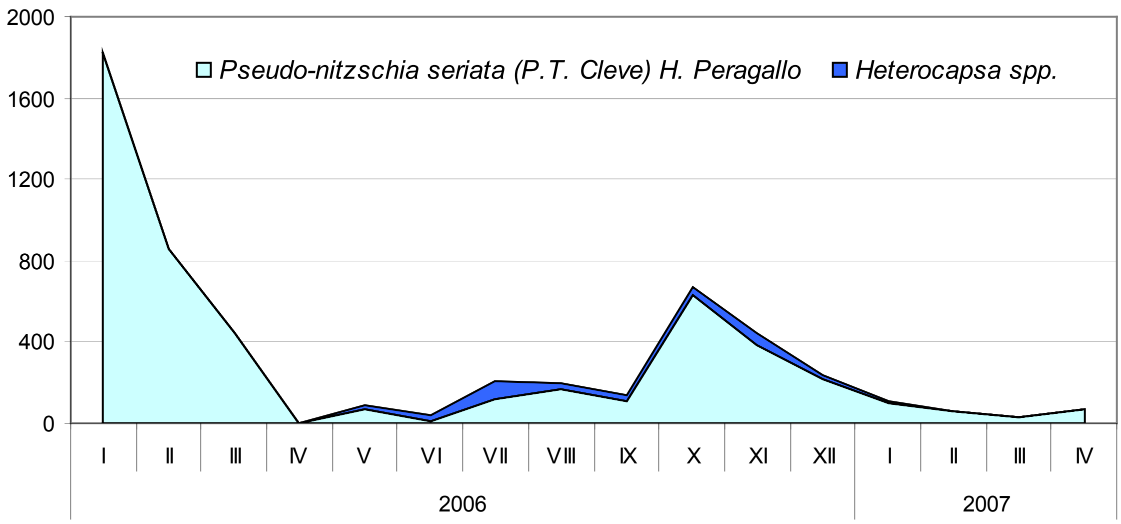

Fig. 5. Monthly average values of potentially toxic species of phytoplankton (cells/ml) in Butrinti lagoon during years 2006-07

dominant in the phytoplankton of Butrinti, confirmed also by Miho (1994). It reached a maximum of 1243 cell/ml in October 2006. Some taxonomic problems related to this species were discussed by Miho & Witkowski (2005).

Guelorget & Perthuisot (1984) summarize the biological indicators in paralic ecosystems, such us the coastal lagoons. After them, the high content of phytoplankton in all stations, indicate that the most part of Narta waters belong mainly to zone V, which are suitable to an extensive fishing (i.e. mullets) or shrimps (*Peneidae*). Karavasta and Patoku waters may belong mainly to the zones IV and V. It is also confirmed by Guelorget & Lefebre (1993) in the assessment made during their campaign in April 1993 in the lagoons of Butrinti, Karavasta and Patoku. According to Dutrieux and Guelorget (1988) the zones IV and V in Karawasta, Narta and Patoku are also

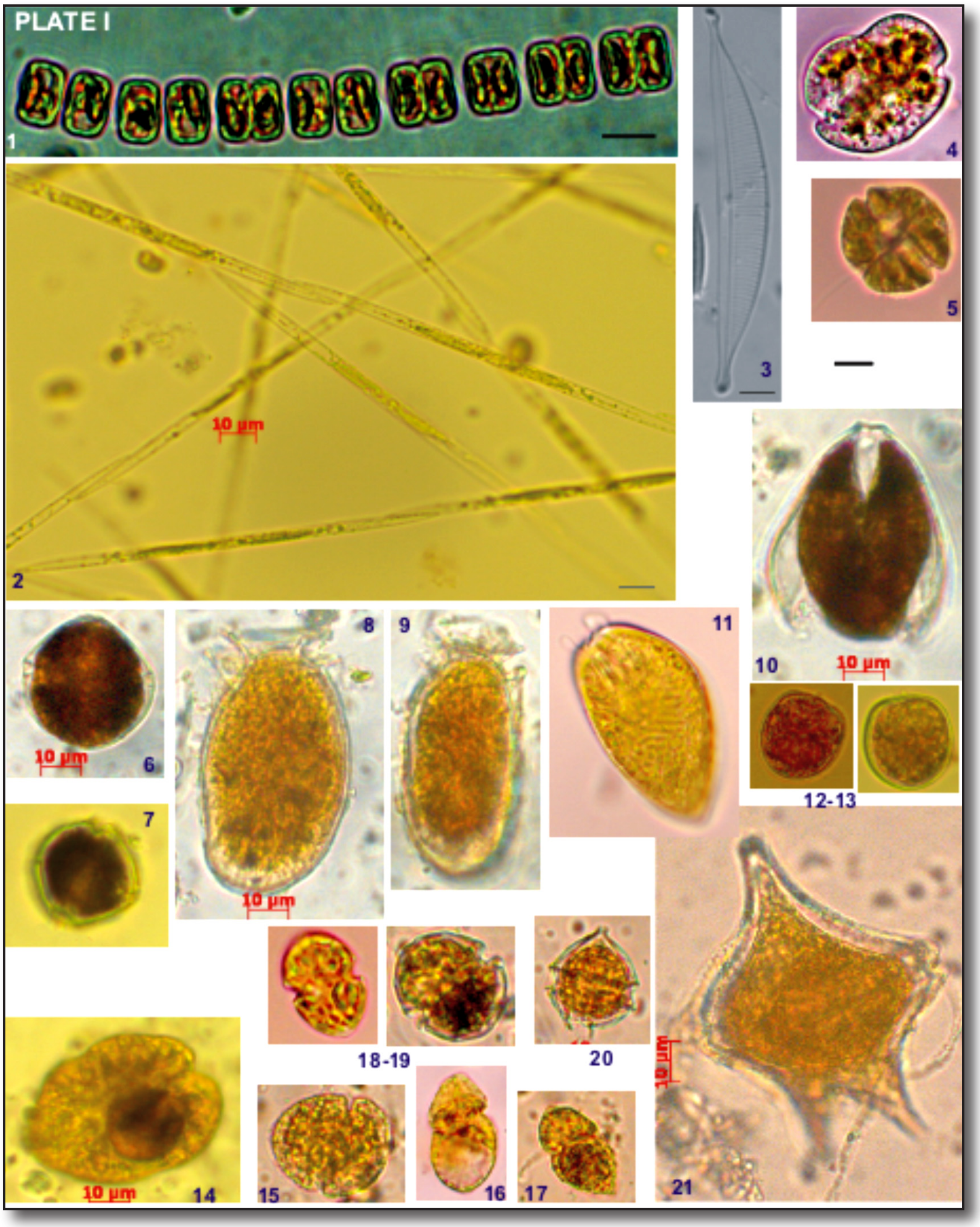

PLATE I. Microscopic algae present in Albanian lagoons (most abundant and/or potentially toxic species): 1. *Cyclotella choctawhatcheeana* Prasad; 2. *Pseudo-nitzschia seriata* (Cleve) Peragallo; 3. *Amphora coffeaeformis* (C.A. Agardh) Kützing; 4-5. *Heterocapsa* sp.; 6-7. *Alexandrium* sp.; 8. *Dinophysis sacculus* Stein; 9. *Dinophysis* sp.; 10. *Ostreopsis* sp.; 11. *Prorocentrium micans* Ehrenberg; 12-13. *P. minimum* Ehrenberg; 14-15. *Gymnodinium* sp.; 16-17. *Gyrodinium* sp.; 18-19. *Karenia* sp.; 20. *Protoperidinium* sp.1.; 21. *Protoperidinium* sp.2 (all bars = 10 μm) characterized by relatively scarce exchange/renewal of the waters, due to scarce communication with the sea. Unlike the other lagoons, intensive growth of phytoplankton in Butrinti, mainly the neritic forms of centric diatoms, shows that the upper layers of Butrinti belong to zone III. It represents a habitat favorable for shellfish reproduction, as evidenced by profusion of *Mytilus galloprovincialis* everywhere in Butrinti. However, this lagoon possesses a potential risk to aquaculture due to the permanently stratified and anoxic waters (hypolimnion).

Albanian coastal wetlands are very sensitive ecosystems that were under strong impact in the past due to the extensive agricultural reclamation and unsustainable industry (Cullaj *et al*., 2005; Miho *et al.*, 2005; UNEP, 2000). At present, they support the impact from the densely populated industrial centers, intensive agriculture and tourism along the whole coastal zone (INSTAT, 2004). The studied lagoons are under the direct influence of the rivers: Ishmi, Tirana, Lana, Gjanica, etc., heavily loaded with urban and industrial sewage waters. Moreover, high levels of heavy metals have been found in Vlora and Durresi bays, Mati delta, etc. Petroleum industry in Fieri and Vlora also result in an adverse ecological impact on the Semani and Vjosa deltas and their related lagoons. Coastal dune forests are under pressure of tourist development (urbanization), too. Also, the high rate of erosion caused by excessive woodcutting, overgrazing or firing in relative shallow water basins, further increases the amount of suspended matter transported to the sea by the rivers. As already mentioned here, most of the lagoons continues suffering from the obstruction of the channels that link with the sea, causing scarce exchange/renewal of the waters, as well.

Coastal lagoons possess important natural and economic values for Albania and the whole Mediterranean region. The data on of phytoplankton would inform better about their productivity and stress conditions. Continuous information in the potentially toxic algae would prevent the risks in aquatic livings and humans. A permanent and reliable monitoring system, including phytoplankton, would be helpful to Albanian government and other interested institutions to understand the health of lagoon ecosystem for better integrated management, fulfilling also the required standards in the international scale.

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