

Water mass characteristics and degree of eutrophication
in a shallow water embayment of the Ionian Sea :
Amvrakikos Gulf

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Amvrakikos Gulf is a shallow water (max. depth 60m.) semi-enclosed embayment, in the Ionian Sea. It is connected with the Ionian Sea through a narrow channel. The bulk of the run-off is supplied by the Rivers Arachthos and Louros (Fig. 1), both draining agricultural areas. The annual mean flow rates of the Arachthos and Louros Rivers are about 70 m³/s and 19 m³/s, respectively.

Seasonal temperature and salinity data from selected depths, were obtained in 1987, from a total of 46 stations, using conventional instrumentation. In addition, measurements of inorganic nutrients were made. The methods adopted have been described by Friligos (1).

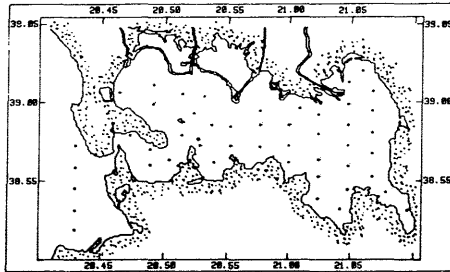


Fig. 1. The study area, showing the location of the oceanographic sampling stations.

Water property distributions suggest, that surface salinity remains very low throughout the year (22.4-32.4‰ in winter, 16.8-26.8‰ in spring, 26.4-28.8‰ in summer and 26.6-34.8‰ in autumn), resulting in strong stratification, in the upper layers. Density gradients are particularly stronger in spring (due to increased flow of the rivers) and in summer (due to high surface temperatures; 28.8-29.9 °C). Horizontal and vertical variations of the water property in the Bay are great, throughout the year, suggesting that the various sea areas are influenced to a varying degree from the freshwater discharge of the rivers. The northeastern part of the study area is subjected to the greatest influence (owing to the freshwater discharge of the River Arachthos), whilst the least freshwater influence is seen in the southeastern section of the Bay.

To estimate the extent of eutrophication in Amvrakikos Gulf a comparison is made with previous data collected in different polluted coastal waters of the Aegean Sea. The same background values were used in various regions of the Aegean waters. The relative factors of increase from background following the same methodology are summarized in Table I.

TABLE I. RATIO OF TOTAL NUTRIENT PER STUDIED AREA TO BACKGROUND NUTRIENTS

Area	PO ₄ -P	SiO ₂ -Si	NH ₄ -N	NO ₂ -N	NO ₃ -N	IN	Reference
Elefsis Bay	5.11	4.15	15.80	3.05	7.00	0.87	(1)
West Saronikos Gulf	2.25	2.85	2.50	1.11	6.38	4.00	(2)
Inner Saronikos Gulf	2.50	1.39	4.10	1.55	2.80	3.97	(3)
North Euboikos Gulf	2.87	13.20	1.95	0.49	10.20	5.27	(4)
Evain Gulf	1.80	1.49	1.00	0.51	1.41	1.10	(5)
Alexandroupolis Gulf	1.32	3.28	1.00	0.65	6.21	3.27	(5)
South Euboikos Gulf	1.46	1.41	0.85	0.48	1.17	0.86	(4)
Pagassitikos Gulf	1.02	2.80	2.80	1.25	2.38	2.28	(8)
Thessaloniki Bay	5.33	3.35	4.50	3.63	3.88	4.14	(7)
N. Thermaikos Gulf	2.08	3.81	2.91	2.40	3.80	3.22	(7)
S. Thermaikos Gulf	1.18	2.21	1.87	1.53	2.20	2.00	(7)
Amvrakikos Gulf	3.87	12.90	1.13	0.80	3.90	2.28	

Elefsis Bay, the most industrialized area in Greece, showed a tendency to concentrate all nutrients, but especially ammonium (up to 16 times background). Elefsis Bay, Amvrakikos Gulf and Thessaloniki Bay showed the highest values of phosphate. The northwestern part of Thermaikos Gulf, Thessaloniki Bay and Alexandroupolis Gulf contained three times as much silicate as background, owing to the contribution of rivers. Eastern Thermaikos Gulf, Pagassitikos Gulf and South Euboikos Gulf presented only slightly greater concentrations of nutrients than those of the Aegean Sea. North Euboikos Gulf displayed a marked accumulation of nitrate and silicate, due mostly to the great depths and underwater springs, whilst Amvrakikos Gulf presented the same accumulation of silicate due to the contribution of the rivers and the morphology of the area. All nutrients were present in all areas at levels well above background. The quality of the receiving waters, with respect to nutrients, depended on the different sources of nutrients, the morphology of the area and the water circulation.

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Rapp. Comm. int. Mer Médit., 31, 2 (1988).

Endemism of *Limonium* (Statice)
in Yugoslav halophytic vegetation

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RÉSUMÉ : Endémicité du *Limonium* (Statice) dans la végétation halophile de Yougoslavie. *Limonium* (Plumbaginaceae) est un genre très remarquable des marais salés et flots qui est en Yougoslavie le plus riche en espèces halophiles y inclus 7 endémiques adriatiques. Il y est présenté par *L. serotinum*, *L. oleifolium*, *L. bellidifolium*, *L. ferulaceum*, *L. cancellatum*, *L. anfractum*, *L. vestitum* et plus récemment on y a enregistré aussi *L. hungaricum*, *L. hirsuticalyx*, *L. asterotrichum*, *L. dubium*, *L. tommasinii*, *L. diomedium*, *L. visianii* et *L. dictyophorum* dont la synécologie est étudiée.

INTRODUCTION. The *Limonium* (Statice pro parte, fam. Plumbaginaceae) is a very remarkable genus of the European salt marshes and skerry seashores, and among the halophytic genera in the Mediterranean coasts and islands it is justly the most diversified one, including the numerous coastal species and local endemics. Despite its considerable biogeographical and phytoecological importance, along the East Adriatic it was quite scarcely known, and this is the first special paper devoted to the *Limonium* of Yugoslavia. Thus in the classical floras covering E Adriatic prior to 1980ies, the presence of its 7 species only has been registered: *L. serotinum*, *L. oleifolium*, *L. bellidifolium*, *L. ferulaceum*, *L. anfractum*, *L. cancellatum* and *L. vestitum*. The recent detailed prospectations in the field added 8 other taxa of E Adriatic whose vouchers are in Herbarium ADZ: *L. hungaricum*, *L. dubium*, *L. hirsuticalyx*, *L. asterotrichum*, *L. tommasinii*, *L. diomedium*, *L. visianii*, and *L. dictyophorum*. Thus Yugoslavia includes at least 15 different *Limonium* species, that is rather comparable with other Mediterranean countries.

Among the 7 Adriatic endemics, *L. visianii* and *L. dictyophorum* may be the primitive prototypes of a considerable evolutionary interest, for being the distinctive halophytic shrubs with the candelabriform woody branches, and with terminal rosette leaves. Its other Adriatic endemics are *L. cancellatum* s.s., *L. vestitum*, *L. diomedium*, *L. anfractum*, and *L. tommasinii*.

RESULTS. The related saltmarsh species growing chiefly in the alluvial lagoonal shores (*Salicornietea* s.lat.), in Yugoslavia are presented by 5 *Limonium* taxa:

- L. serotinum* (Rchb.) Pign. (*Statice limonium* auct. adr.) is widespread in E Adriatic salt marshes of *Limonietalia* Br.-Bl.
 - L. oleifolium* Mill. (*St. virgata* Willd.) is frequent in E Adriatic salt marshes within the hypersaline *Limonio-Artemisietum caeruleoventris* Hic.
 - L. bellidifolium* (Gou.) Dum. (*St. caspia* Willd.) is also frequent in the Adriatic salt marshes, especially within the *Arthrocnemum fruticosum* Br.-Bl.
 - L. tommasinii* Pign. (*St. confusa* auct. adr.) is endemic to NW Adriatic salt marshes, from the Venice lagoons to the Punat lagoon in Krk island, growing mostly within the *Salicornietum venetae* Pign.
 - L. hungaricum* Klok. (*St. gmelinii* auct. pannon.) is endemic to the inland salt marshes and salt springs of Yugoslavia and Hungary, growing there chiefly within the *Limonio-Artemisietum monogynae* Soo.
- The beach species of the backshore nitro-halophytic vegetation (*Cakiletales* Tx.) are presented by the next 3 taxa of *Limonium*:
- L. hirsuticalyx* Pign. (*St. gmelinii* auct. adr.) is an East Mediterranean halophyte, with its westernmost locality in the beaches (*Euphorbia peplis* Tx.) of Dugi island in Northern Dalmatia.
 - L. asterotrichum* (Salm.) Salm. (*St. latifolia* hort. non Sm.) is native to West Black Sea, but it is cultivated in some Adriatic gardens and also sporadically naturalized in NE Adriatic beaches within the nitro-halophytic vegetation of *Cakiletales*.
 - L. dubium* (Guss.) Lov. (*St. smithii* Ten.) is a Central Mediterranean taxon of the Italian coasts, presented also in NE Adriatic islands Cres, Krk, Pag, and in the Ravni Kotari peninsula, in the beaches within *Limonio-Goniolimonetum dalmatici* Hic.
- The skerry coast species of subhorizontal stony shores (*Cirithio-Limonietalia* Mol.) include only two taxa of East Adriatic:

- L. ferulaceum* (L.) Ktze. (*Myriolepis ferulacea* M.G.) is a South-Mediterranean halophyte with its northernmost sites in SE Adriatic especially in the isles Korčula, Elafiti, and in Pelješac peninsula, within the alliance *Microrrhinion litoralis* (Hic.) Lov.
 - L. cancellatum* (Bernh.) Ktze. s.str., is the subendemic Circum-Adriatic halophyte, and the very most frequent *Limonium* across the Yugoslav coast and islands. Its typical form grows within the *Plantagin-Limonietum cancellati* Hic. in semiexposed skerry shores.
- The seaciff species of the stormy aerosaline escarpments (*Euphorbiales dendroides* Zoh.) are the most interesting group of 5 suffrutescent or shrubby endemics, that previously have been generally confused within the pseudonym "Statice cancellata" auct. s.lat.:
- L. anfractum* (Salm.) Salm. is endemic in the stormy seaciffs of the Aurinio-Capparian Lov. along Eastern Adriatic, from the northernmost Kvarner islands along the Dalmatian mainlands to Albania. It is a suffrutescent taxon to 40 cm tall.
 - L. vestitum* (Salm.) Salm. is a stenoendemic undershrub restricted to the remote Mid-Adriatic islets Jabuka, Kamik and Brusnik, within the stormy aerosaline cliffs of *Puccinellio-Centaureetum crithmifoliae* (Lov.) Lov.
 - L. diomedium* Brullo is also stenoendemic to the Mid-Adriatic islets of Tremiti (loc. class.), with the new sites in islets Palagruža and Sušac within the stormy aerosaline cliffs of *Aurinio-Brassicetum frutescentis* Lov.

4. *L. visianii* (M.G.) Lov. (*L. adriaticum* Lov.) is also a Mid-Dalmatian endemic of the islands Vis, Hvar, Lastovo and of the adjacent minor islets, growing in the stormy seaciffs of alliance *Aurinio-Capparian*. It is the distinct shrub to 50 cm with a trunk to 2 cm Ø thick, with the candelabriform woody branches, grey-pubescent evergreen leaves in terminal rosettes, and with the suberect inflorescences.

5. *L. dictyophorum* (Tsch.) Deg. s.str. non al. (*L. croaticum* Lov.) is stenoendemic to NE Adriatic and restricted to the excessively stormy isles Prvic, Grgur, Goli, Baska, and to NW Velebit coast of mainland, within the aerosaline seaciffs of *Aurinio-Astragaletum dalmatici* Lov., overexposed to the strongest Bora winds. It is a shrub to 60 cm, trunk to 3 cm Ø with woody candelabriform branches, big evergreen glabrous leaves to 5 cm in terminal rosettes, and the inflorescences intricately angulate-reticulate.

Rapp. Comm. int. Mer Médit., 31, 2 (1988).