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ECOLOGICAL STRESSES ON A DELTA AREA IN WESTERN GREECE

A. DIAPOULIS, TH. KOUSSOURIS and I. BERTAHAS

National Centre for Marine Research, 16604 Hellenikon, Athens, Greece

G. PHOTIS

University of Thessaloniki, Veterinary School, Ichthyology Department, 54006 Thessaloniki, Greece

The studied area from ecological point of view can be divided into: the coastal lagoons, the marsh regions with salt plains and the mouths of the rivers (Louros and Arachthos). Most of the lagoons being located at the delta area and their boundaries fluctuate depending on climate and hydrological conditions. Their functions are like a natural fishery and can be classified from a nutrition point of view as oligomesotrophic. Their fauna and flora typical for brackish water. This lagoon system is one of the largest in the Mediterranean region.

INTRODUCTION

The delta area under investigation is located at the Amvrakikos Gulf (20° 44–21° 07 E and 38° 59–39° 11 B). This Gulf represents the major Gulf along the West Greek coast (Figure 1). The Amvrakikos Gulf is an almost enclosed embayment with a surface of 385 Km² and a maximum depth of 60 m. The whole delta coastal region covers an area of about 450 Km². The delta forming rivers of Louros and Arachthos differ with respect to their hydrology and kind of drifts.

The well-known economic prosperity in the non-agricultural part of the studied region was mainly depended on fishing within the Gulf (shrimp, sole, bream) and fish-farming (mullet, bass, eel) in the lagoon system.

Recent references for that area limited to information pertinent to hydrobiological state^{6,7,10} and its ecological assessment for environmental management of the whole area.¹²

MATERIAL AND METHODS

Samples of marine phytobenthos were collected at six stations at depths ranging from the coast line to 1 meter on hard substrate with a sampling area of 400 cm² (20 × 20 cm). Samples of brackish to freshwater aquatic flora and fauna were also collected from the two rivers, salt plains, mudflats and the marsh regions. The

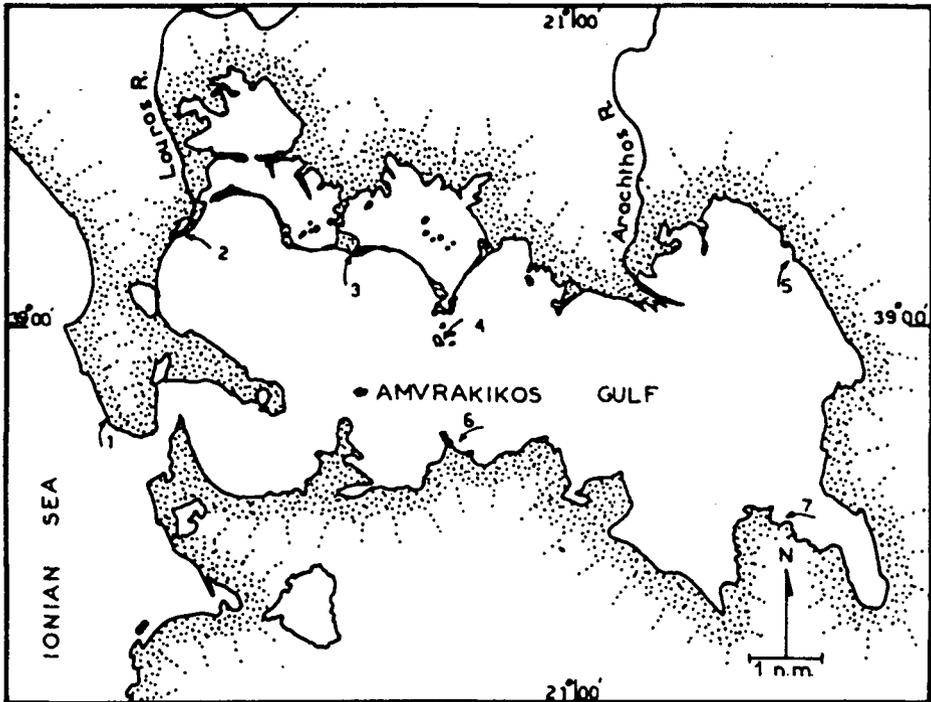


Figure 1 Amvrakikos Gulf with the sampling stations.

samples were preserved in 4% formaldehyde solution and 70% alcohol solution respectively for flora and fauna components.^{1,2,9}

RESULTS AND DISCUSSION

According to recent information dealing with the studied area Louros and Arachthos rivers are the main contributors from a great run-off basin of 4.400 Km². The delta area which is bounded by the two rivers, the extended wetlands between them, as well as the lagoon system with their coastal ridges, cover an area of 450 Km². The climatic conditions of the area (Figure 2) are characterized by an uneven distribution of rainfall and alternating prolonged dry and wet periods.

Most of the lagoons are located at the delta area and their boundaries fluctuate depending mainly on climatic and hydrological conditions. The total surface area and mean depth of all lagoons is about 64 Km² and 1 meter respectively. The bottom of the lagoons is composed of decomposing mud where anaerobic processes occur, typical of natural conditions. The main aquatic vegetation, which covers part of the bottom, consists with *Zostera noltii* Horneman and *Ruppia maritima* Linne. Salinity fluctuates from mesohaline to polyhaline level and is weak alkaline (pH=8.8). Their typical functions are like a natural fishing grocer and

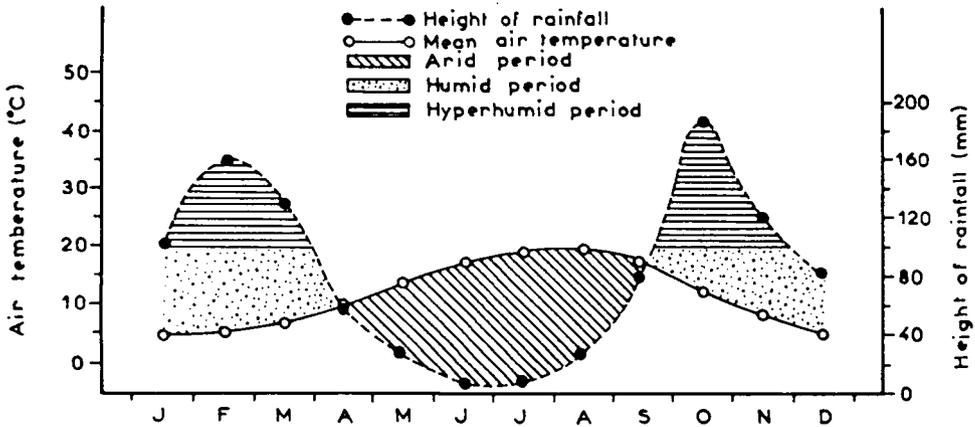


Figure 2 Mean climatic data for the studied area.

with respect to water quality, from a nutrition point of view, can be classified as mesotrophic.

The coastal lagoon systems are protected from the sea by coastal bar ridges that consist mostly of coastal sands (shells, detritus, sludge and other organic materials). In the early summertime some areas dry out and are covered with the green algae *Valonia utricularis* (Roth) Agardh, forming balls. Late in summer *Salicornia europea* Linne and other halophytes colonize the area.

Along the littoral zone of the sea coast, sea grass meadows cover the area in patches. Here predominate *Cymodocea nodosa* (Ucria) Aschers and *Zostera noltii*. Most of them are degraded by the grazing activities of sea urchins, mainly *Paracentrotus lividus* Lam and *Psamechinus* sp. The abundance of these species are rather high in most areas (except in areas close to the proximity of the river estuaries), as high as 20 individuals per square meter. It has been estimated⁸ that the feeding rate (in situ experiments), of *Paracentrotus lividus* on *Posidonia* meadows and its epiphytic flora, exceeds the 0.51 gr of dry weight per day. The mean consumption per sea urchin, per day, is about 1/10 of the primary production of the seagrasses bed.

Moreover it must be taken into account the monnegligible quantity of leaf parts which are severed by *P. lividus*, drift away and are lost to that bed.

According to our results with regard to the marine algae of the studied area, the number of species and the values of coverage are very low (Tables 1 and 2) as compared to those of other Greek areas.²⁻⁵ In more detail it can be observed that at station 2 the high proportion (Tables 1 and 2) of Chlorophyceae is due to the euryaline species of *Ulva rigida* Thuret, *Enteromorpha* spp and *Cladophora* spp. High values were also recorded at station 2 due to the exclusive existence of *Ulva rigida* and the absence of Phaeophyceae. Stations 5, 6 and 7 which are not influenced by river waters, and the salinity fluctuates from 28‰ to 32‰, Rhodophyceae dominate (Tables 1 and 2).

Marsh regions have an extensive reed belt with an area of 31 Km² and with a rich diversified fauna (fish, insects, birds). The major reed belt area on the Louros

Table 1 Number of species (*Q*) and qualitative dominance (*DQ*) of the phytobenthos in the sampling stations

Stations		1	2	3	4	5	6	7
Chlorophyceae	Q	9	4	7	2	3	2	5
	DQ%	24.3	50	41.2	50	13.6	13.3	27.8
Phaeophyceae		5	—	—	1	1	—	3
		13.5	—	—	25	4.5	—	16.7
Rhodophyceae		23	4	10	1	18	13	10
		62.2	50	58.8	25	81.8	86.7	55.5
	ΣQ	37	8	17	4	22	15	18
	ΣDQ%	100	100	100	100	100	100	100

Table 2 Quantitative dominance (*DRi*) and Salinity in the sampling stations

Stations		1	2	3	4	5	6	7
Chlorophyceae	DRi	7.9	100	68.6	9.4	7.4	15.2	7.4
Phaeophyceae		49.7	—	—	12.5	28.3	—	37.5
Rhodophyceae		42.4	—	31.4	78.1	64.3	84.8	55.1
ΣDRi		100	100	100	100	100	100	100
Salinity ‰		33.5	18	32.2	32.5	32.5	32.5	27.5

can be characterized as one of the large coherent *Phragmites australis* (Cav.) Trin. belt in Greece. Numerous small marshes, possibly the remnants of formerly very extensive marshes, are located in the eastern sector, which tend to follow the irrigation and draining channels and various small water courses. The extended zone of *Phragmites australis* is bordered in consisted locations of the Louros and the lagoons, with stands mainly of *Schoenoplectus tabernaemontani* Palla, while in locations with strong wave activity *Typha angustifolia* Ch. and B., *Bolboschoenus maritimus* Palla and *Iris pseudacorus* Linne, occur. In slow flowing areas with waters rich in nutrients stands are consisted mainly of *Botomus umbellatus* Linne, *Alisma plantago-aquatica* Line, *Sparganium erectum* Linne, *Sagittaria sagitifolia* Linne, predominate. Among them have been found species of *Eleocharis*, *Sium*, *Nasturtium*, *Rumex*, *Rorippa* and the *Ranunculus aquatilis* Linne. The associations of floating plant are consisted of *Potamogeton natans* Linne, *Nymphaea alba* Linne, *Lemna minor* Linne, *Spirodela polyrhiza* [L.]Schleid. and the water fern *Salvinia natans* All. In the channel systems the following species thrive: *Potamogeton crispus* Linne, *Potamogeton natans*, *Lemna minor* and *Spirodela polyrhiza* as well as *Ceratophyllum demersum* Linne and other aquatic plants.¹¹

The salt plains are usually covered by halophilous vegetation. Recently, they are threatened by agricultural activities (pasture land, crops etc.). The undisturbed halophytic biotopes are covered with *Salicornia europea*. The zone of *Arthrocnemum* and *Halocnemum* species extends further inland. Beyond the salt tolerant *Juncus maritimus* Lam. and *Juncus acutus* are found.

The existing mudflats areas in the coastal areas between the two rivers are succeeded by perennial glasswort species that, in turn, are succeeded by *Juncus* meadows which are adjoined to the cultivated land. The mudflats are endangered mainly by grazing, burning and drainage activities.

The two rivers discharging to the delta area differ both in morphology flora and fauna. This is primarily due to their different water hydrographic characteristics the slower continuously flowing Louros river, with an average annual flow rate of 19.4 m³/sec, spillover bank fine sediments have led to highly oxygenized and nutritive riverside soils. Vegetation communities predominantly reed belts (*Phragmites australis*, *Iris pseudacorus* etc.) have developed in clearly zoned regions of great extension and the aquatic fauna characterized by a high diversity. Green algae (*Cladophora* spp and *Enteromorpha* spp) and the red algae *Thorea ramosissima* Bory are encountered in the area of river mouths. The water moss *Salvinia natans* is found in the higher region of the river. The benthic or epiphytic fauna of the Louros river composed of gastropods (*Theodoxus fluviatilis* Linne, *Hydrobia ulvae* Pennant, *Potamopyrgus jenkinsi* Smith, *Planorbis carinatus* Muller, *Valvata* spp and *Lymnaea* spp), crustacea (*Asellus* sp, *Melita* sp, *Carinogammarus* sp) and larval stages of odonata (*Ischnura* sp, *Aeshna imperator* Leach and *Ajuncae* Linne), diptera (*Atherix ibis* F., Chironomidae) and trichoptera (*Hydropsyche* spp).

Arachthos river has a peculiar hydrological regime. It depends on the water that the dam of Public Power Corporation releases, thus regulating the flow of the river. Due to the short distance to its mouth, the coarse components of drifts cannot be eroded down to sand size fraction. Hence, the formerly finger shaped delta of Arachthos river, with the new hydrological regime,¹² according to the functional activities of the hydroelectric station have been disrupted.

Due to the new hydrological situations the transported materials of the river consists mainly of heavy and coarse materials which are instantly deposited on the bottom and cannot be carried out to its mouth. The detrimental effects of Arachthos waters that greatly influence the ecosystem of the Amvrakikos Gulf are mainly due to:

- Its cold waters that are unevenly liberated from the hydroelectric dam
- Its torrent like high velocity flow in time and season and the increased load of eroded agricultural soils originated from its banks.

The diversity of the flora and fauna is very low. Around the mouth area the sea grass *Cymodocea nodosa*, the red algae *Lemanea* sp and blue green algae (*Phormidium* sp, etc.) are found. Along its banks in rare stands the *Phragmites australis* grows up, while in salt plains stands of *Juncus* spp are found.

Further upstream odonata *Ischnura elegans* Vanderl., hemiptera (*Corixa* sp) and the gastropoda *Theodoxus fluviatilis*, *Valvata piscinalis* Muller, *Limnaea peregra* Muller, etc. dominate.

The slower moving river waters (Louros) seem to possess in effective self cleaning mechanism is broken down by its uneven hydrological regime.

Finally the potential resources of the delta areas are severely altered by various anthropogenic and or natural disturbances.

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