BIODIVERSITY IN THE KOUTAVOS LAGOON OF KEFALONIA

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Abstract
Biodiversity represents the variety of species and genes in an ecosystem. The richness of biodiversity in an aquatic ecosystem is a quality that indicates whether the ecosystem is healthy or deserves protection and intervention measures. Recently, water quality in the Koutavos Lagoon of Kefalonia has improved, due to a decrease in human activity along the coastline. As a result, recent studies evince an increase in biodiversity. In this work, we report the following taxa, with percent contribution in parenthesis: Eight phytoplankton genera or species (8%), four phytobenthic genera or species (4%), 16 main zooplankton groups (15%), 56 zoobenthic genera or species (54%), 19 fish species (18%) and the loggerhead turtle *Caretta caretta* (1%).
Keywords: *Biodiversity, Argostoli Gulf, coastal ecosystems.*
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1. Introduction

Lagoon ecosystems sustain important ecological functions such as export of nutritive organic matter, creation of habitats for rare species and shelter for the juvenile stages of open water species. The Koutavos Lagoon has been characterised as eutrophic (Conides et al. 2006). Mean salinity is highest in the western part due to sea water influx, whereas mean temperature is highest in the southern part due to fresh water influx and shallower depth (Spinos et al. 2007 & 2012). Phytobenthos and zoobenthos play perhaps the most important role in the food web of a lagoon ecosystem. Benthos is a food source for a multitude of animal organisms, therefore impacting directly or indirectly human nutrition. Benthic micro- and macroflora are sources of decomposing organic matter and dissolved oxygen. Any disturbance in this ecosystem reflects on the composition and structure of benthos and may have deleterious results. As far as the phytobenthos, four species have been identified so far (Georga 2004). The major phytoplankton groups in the Koutavos Lagoon are diatoms and dinoflagellates. Phytoplankton are primary producers and as such are at the bottom of the food chain. The primary productivity of a lagoon indicates its trophic status. Earlier studies classified the Koutavos lagoon as mesotrophic, although during the summer months when temperature rises it becomes eutrophic (Spinos et al. 2007). Phytoplankton appear mostly in the region with sea-like characteristics, i.e., near the Drapano bridge where it is deepest and the ingress of sea water is more pronounced (Conides et al. 2006). Zooplankton are secondary producers, a food source for larger organisms, and feed on phytoplankton or smaller individuals of the same or other species. They are considered indicators of a healthy aquatic environment (Spinos et al. 2012).

The Koutavos Lagoon hosts a large number of mostly euryhaline fish, whereas stenohaline fish are limited to the bridge area where the ingress of sea water is strongest. Another notable organism inhabiting the Lagoon is the loggerhead turtle *Caretta caretta*, a species with cosmopolitan distribution; outside the Mediterranean it is found in the Atlantic, Pacific and Indian Oceans. In Greece, the main oviposition grounds are in the Bay of Laganas in Zakinthos and in the Bay of Kyparissia in Western Peloponnese. In Kefalonia, most oviposition grounds are along the south coast. The loggerhead turtle is omnivorous and feeds on invertebrates on the sea floor, jellyfish, and fish trapped in fishing implements. The loss of suitable oviposition grounds has impacted their population. The conservation status of the loggerhead turtle is vulnerable and is protected by national and international legislation.

2. Materials and Methods

The Koutavos Lagoon is in the island of Kefalonia, at the south end of the Bay of Argostoli, approximately 0.5 km SE of Argostoli (38° 10.267' N, 20° 30.167' E). It covers approximately 120 ha. Its shape is oblong with general direction NW to SE. The coastline is approximately 4 km long. The Lagoon is separated from the rest of the Bay via the Drapano bridge which is founded on stone pillars. The arches under the bridge allow for some circulation of sea water inside the Lagoon. The earthquakes

of 1953 caused the foundation of the bridge to subside, so that several of the 22 arches remain submerged (Spinos et al. 2007).

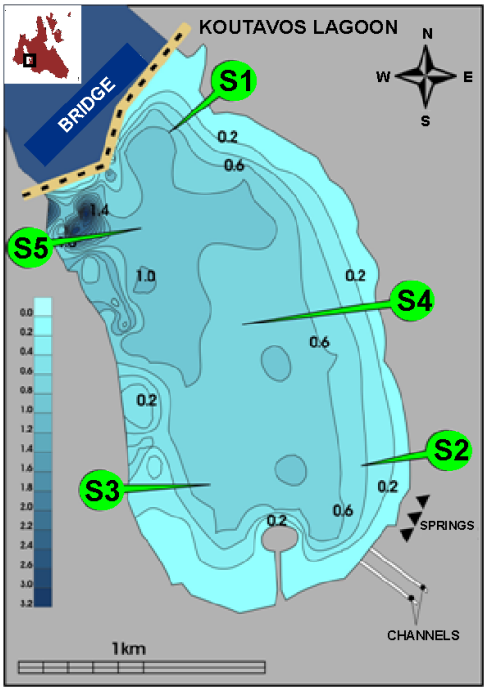

Figure 1. Bythometry of the Koutavos Lagoon (in metres).

Tectonic activity has so changed the bathymetry of the Lagoon that the northern side is notably shallow (Fig. 1). Moreover, sea water influx has been reduced, affecting hydrological and biological properties (Spinos et al. 2012). The data for this study were assembled from the literature of the last 14 yr and supplemented with field observations.

3. Results

Table 1 reports the taxa identified within the Koutavos Lagoon. Phytoplankton taxa include *Nitzschia closterium, N. longissima, N. seriata, Rhizosolenia alata, Thalassiothrix frauenfeldii, Ceratium furca, Peridinium* sp., and *Prorocentrum micans* (Conides et al. 2006). As far as the phytobenthos, the identified taxa include:

The green alga *Ulva rigida*, found in saline and brackish waters, such as estuaries and lagoons. It is coloured bright or dark green. *U. rigida* grows best in enclosed and protected areas, rich in minerals. Its presence may indicate fresh water influx or water pollution. Thus, extensive growth of these algae may indicate increased pollutant loading. Within lagoons, *U. rigida* grows mostly in the shallower parts, where water circulation is weaker and exchange with the open sea is limited. In the Koutavos Lagoon, *U. rigida* covers only a small area, a favourable indicator of ecosystem health. The genus *Gelidium* encompasses red algae distributed worldwide, except in the Arctic and the Antarctic. *Gelidium* species vary widely in size and structure. The colour varies among and within species, from red to purple to green-black. *Gelidium* species grow attached to hard rocky substrates, from the subtidal to the supratidal zone, and prefer exposure to intense wave action. In the Koutavos Lagoon, it was observed that *Gelidium* is more abundant than *Ulva rigida*. The genus *Laurencia* belongs to the red algae. It has an annual life cycle and grows in sheltered, shallow, euphotic biotopes, and is attached to hard substrates via a disk. Its colour varies from bright to dark red. The species reported from the Koutavos Lagoon is *L. obtusa*. The marine phanerogam *Cymodocea nodosa* is one of five species of angiosperms that is found in the Mediterranean Sea. These plants establish extensive seagrass beds of notable ecological importance, mostly because they generate large quantities of organic matter. Also, they serve as suitable substrate for epiphytic algae and zoobenthic species that attach to them or depend on them for their subsistence.

Through photosynthesis, they largely contribute to the diurnal and seasonal variation in O_2 and CO_2 (Georga 2004).

Zooplankton communities exhibit high diversity. Whichever group dominates depends on the stage of their life cycle. With respect to copepods, there appears to be a wide diversity, although in the summer the dominant species is *Oithona nana*. Salinity and temperature seem to affect the spatial distribution of various species. Thus, eurytherm and euryhaline species may occupy habitats with widely varying salinity and temperature. The main zooplankton groups found in the Koutavos Lagoon are reported in Table 1 (Spinos et al. 2012).

Table 1. Biodiversity in the Koutavos Lagoon, with percent contribution in parenthesis.

S/N	Phytoplankton (8%)	Phytobenthos (4%)	Zooplankton (15%)	Zoobenthos (54%)	Fish Fauna (18%)	Sea Turtles (1%)
1	*Nitzschia closterium*	*Ulva rigida*	Fish eggs	*Cerithium vulgatum*	*Liza ramada*	*Caretta caretta*
2	*Nitzschia longissima*	*Gelidium* sp.	Eucaridea	*Gibbula ardens*	*Solea vulgaris*	
3	*Nitzschia seriata*	*Laurencia* sp.	Isopods	*Gibbula adansonii*	*Hippocampus hippocampus*	
4	*Rhizosolenia alata*	*Cymodocea nodosa*	Cladocera	*Onoba gianninii*	*Mugil cephalus*	
5	*Thalassiothrix frauenfeldii*		Appendicularia	*Parvicardium exiguum*	*Gobius niger*	
6	*Ceratium furca*		Copepods	*Rissoa ventricosa*	*Mullus barbatus*	
7	*Peridinium* sp.		Cnidaria	*Tellina donacina*	*Dicentrarchus labrax*	
8	*Prorocentrum micans*		Ostracods	*Callinectes sapidus* (crustacean)	*Pagellus mormyrus*	
9			Polychaete larvae	*Eriphia verrucosa* (crustacean)	*Mullus surmuletus*	
10			Shrimp larvae	47 mollusk species	*Liza aurata*	
11			Gastropod		*Diplodus*	

	larvae	*puntazzo*
12	Bivalve larvae	*Syngnathus abaster*
13	Decapod larvae	*Blennius ocellaris*
14	Fish larvae	*Sarpa salpa*
15	Chaetognaths	*Diplodus vulgaris*
16	Mysids	*Diplodus sargus*
17		*Diplodus annularis*
18		*Sparus aurata*
19		*Anguilla anguilla*

Fifty-four species (54) of mollusks have been reported, of which 16 (30%) bivalves and 38 (70%) gastropods. The largest number of individuals (89%) belong to just seven species: *Cerithium vulgatum, Gibbula ardens, G. adansonii, Onoba gianninii, Parvicardium exiguum, Rissoa ventricosa*, and *Tellina donacina*. In the southern part of the Lagoon, the higher diversity of mollusks, as well as the larger populations of herbivorous gastropods may be due to the degree of isolation from the sea, higher primary productivity, and an abundance of micro-habitats created by ample macrophytic vegetation (Masouras et al. 2012). Two invasive species of crabs have been reported, *Callinectes sapidus* and *Eriphia verrucosa* (Spinos et al. 2016). Finally, holothurians, urchins, starfish, and crinoids have been observed; however, they have not been tallied, pending classification at the genus or species level.

The 19 species of fish that have been reported (Table 1 and Fig. 2) indicate the ecological significance of the Lagoon for the Bay of Argostoli to which it is connected. The diversity of fish as well as the presence of fish eggs counted among zooplankton suggest that the Lagoon functions as a natural fish hatchery that enriches itself with fish as well as the Bay of Argostoli at large. In conclusion, we reported the following taxa in the Koutavos Lagoon, with percent contribution in parenthesis: Eight phytoplankton genera or species (8%), four phytobenthic genera or species (4%), 16 zooplankton groups (15%), 56 zoobenthic genera or species (54%), 19 fish species (18%) and the loggerhead turtle *Caretta caretta* (1%).

The phytobenthos of the Lagoon stabilises and conserves the upper layer of sediment in the benthic zone. Moreover, phytobenthos along with phytoplankton foster a micro-environment with mild conditions during both winter and summer via temperature regulation, O_2 production and atmospheric CO_2 sequestration (Garrido et al. 2011). The Lagoon creates habitats for a wide variety of organisms, promoting biodiversity and thus increasing its ecological importance. During the warm months of the year, mostly in the summer, loggerhead turtles enter the Koutavos Lagoon to feed, and occasionally to mate. Any attempt to restore natural populations of loggerhead turtles requires international collaboration, since they wander across vast expanses of ocean, and oviposition grounds are dispersed in various countries.

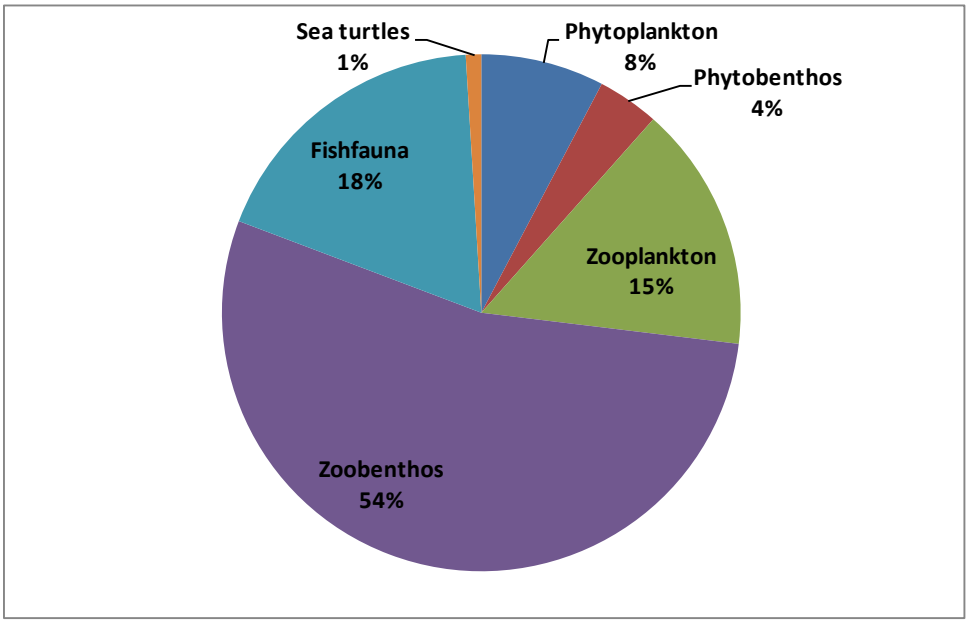

Figure 2. Graphical representation of biodiversity within the Koutavos Lagoon.

To this day, the Koutavos Lagoon has not been afforded institutional protection, except for a ban on fishing imposed by the Regulation of the Port of Argostoli. We strongly advocate that institutional protection must be granted to the Koutavos Lagoon in order to protect, conserve and promote its biodiversity.

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