

Marine Environment of Cyprus and the Ecological Status of Limassol Bay

by

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Content

→ Information on the Marine and Coastal Environment

- The State of the Marine Environment
- Habitats and species of interest
- Protected areas and species in Cyprus

→ Main factors affecting marine/coastal environment

- Pollution with nutrients

→ Activities / research projects undertaken in relation to the quality of coastal waters for the assessment of the status of the marine environment

- MED POL /UNEP
- Water Framework Directive

The marine and coastal environment

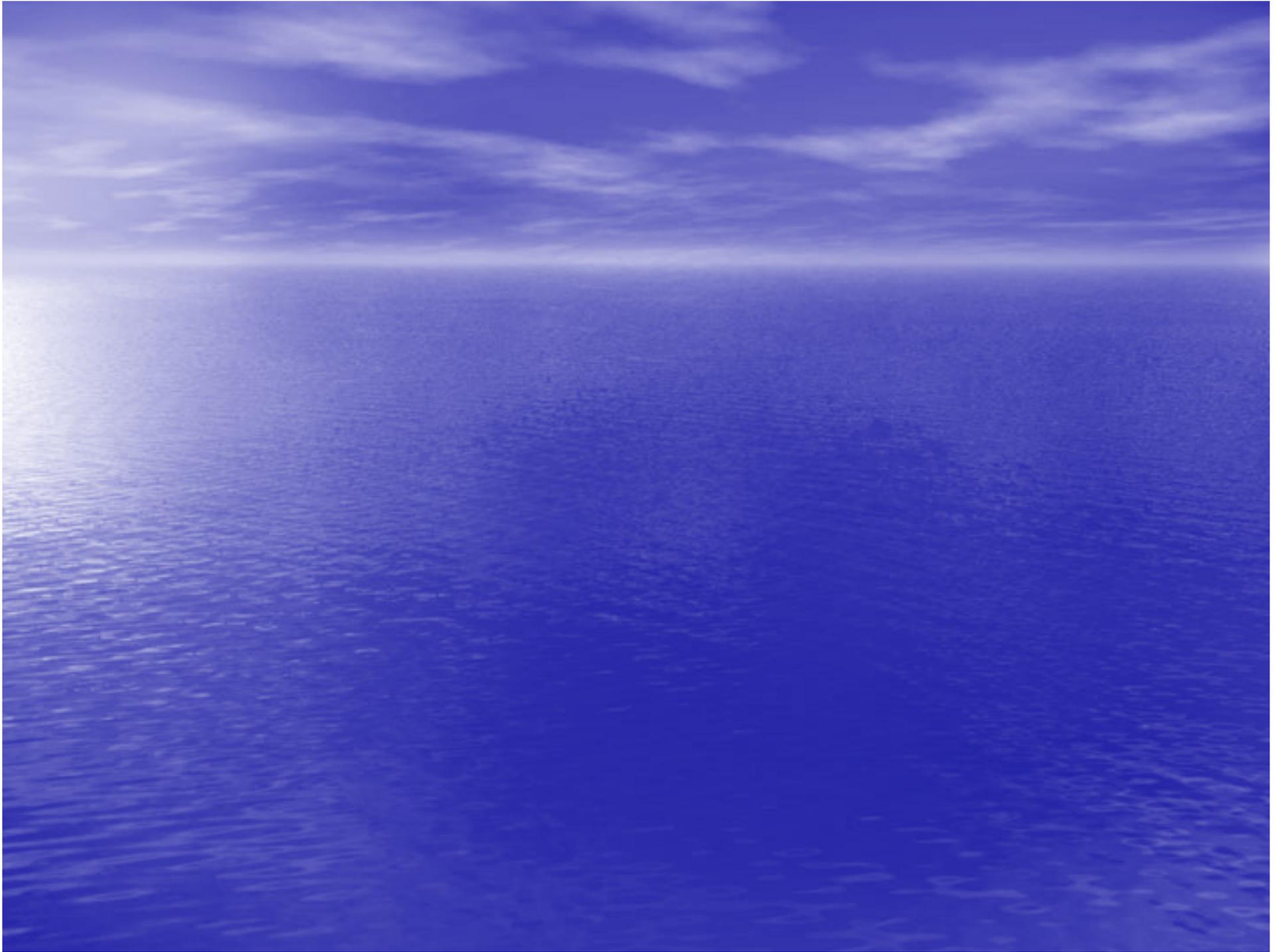
The Sea Around Cyprus

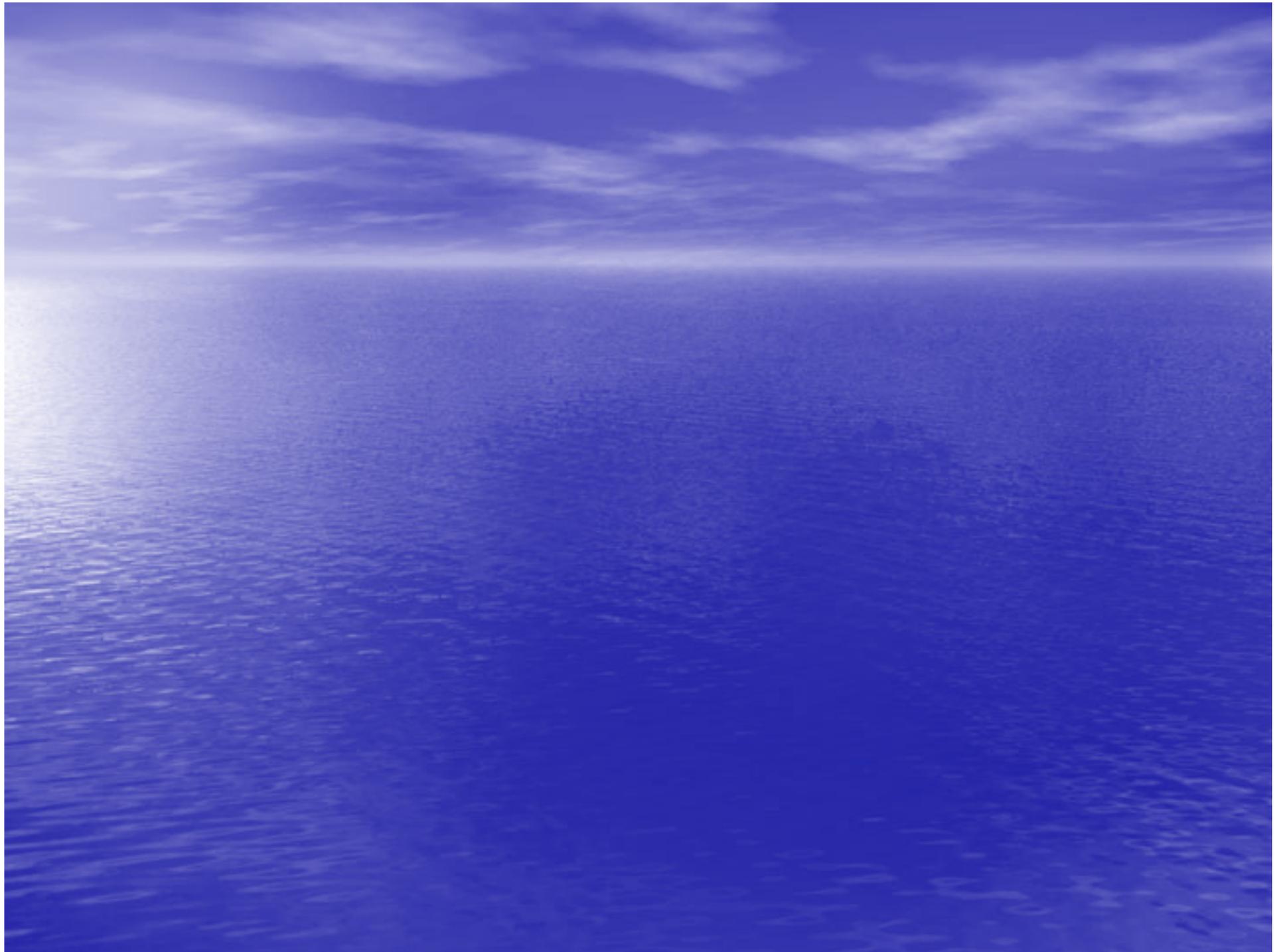
- The Levantine Basin, because of its relative isolation, has a high degree of endemism.
- Salinity and temperature in surface waters, is higher than the rest of the Mediterranean,
- It is characterized as ultra-oligotrophic, i.e. low concentration of nutrients
- It has low productivity due to its highly oligotrophic environment but,
- It has a relatively high biodiversity and very low biomass.

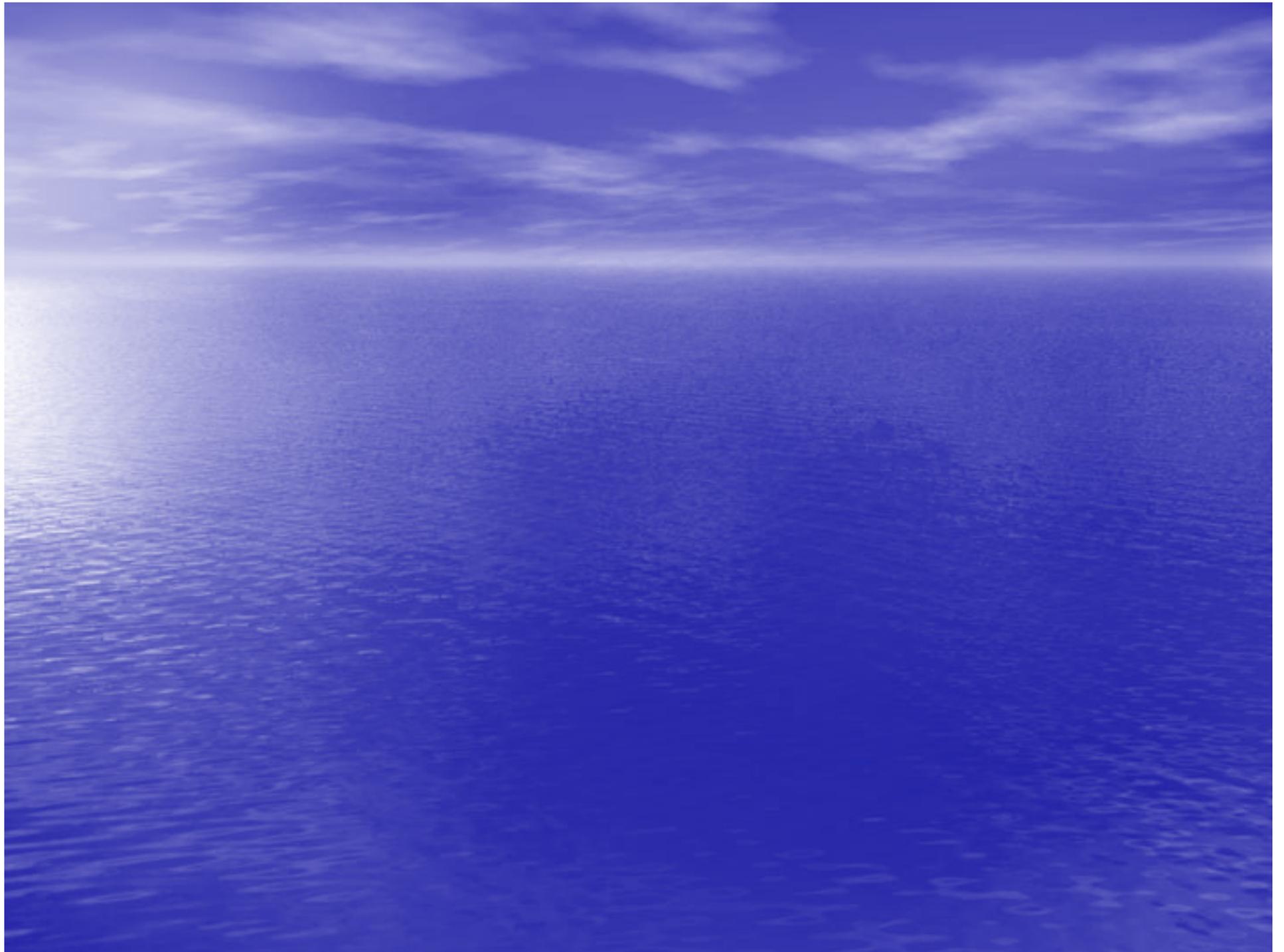
Soft Substrate

Characteristic zonation

- Sandy from shallow ~ 20 meters; gradually becomes muddy
- *Cymodocea nodosa* predominates in shallower waters - between 3- 10 metres, on soft substrates,
- *Posidonia oceanica* thrives in extensive meadows at depths of about 5 - 42 metres.
- *Caulerpa prolifera* and *Halophila stipulacea* are found in deeper waters. *Pinna nobilis* thrives here.





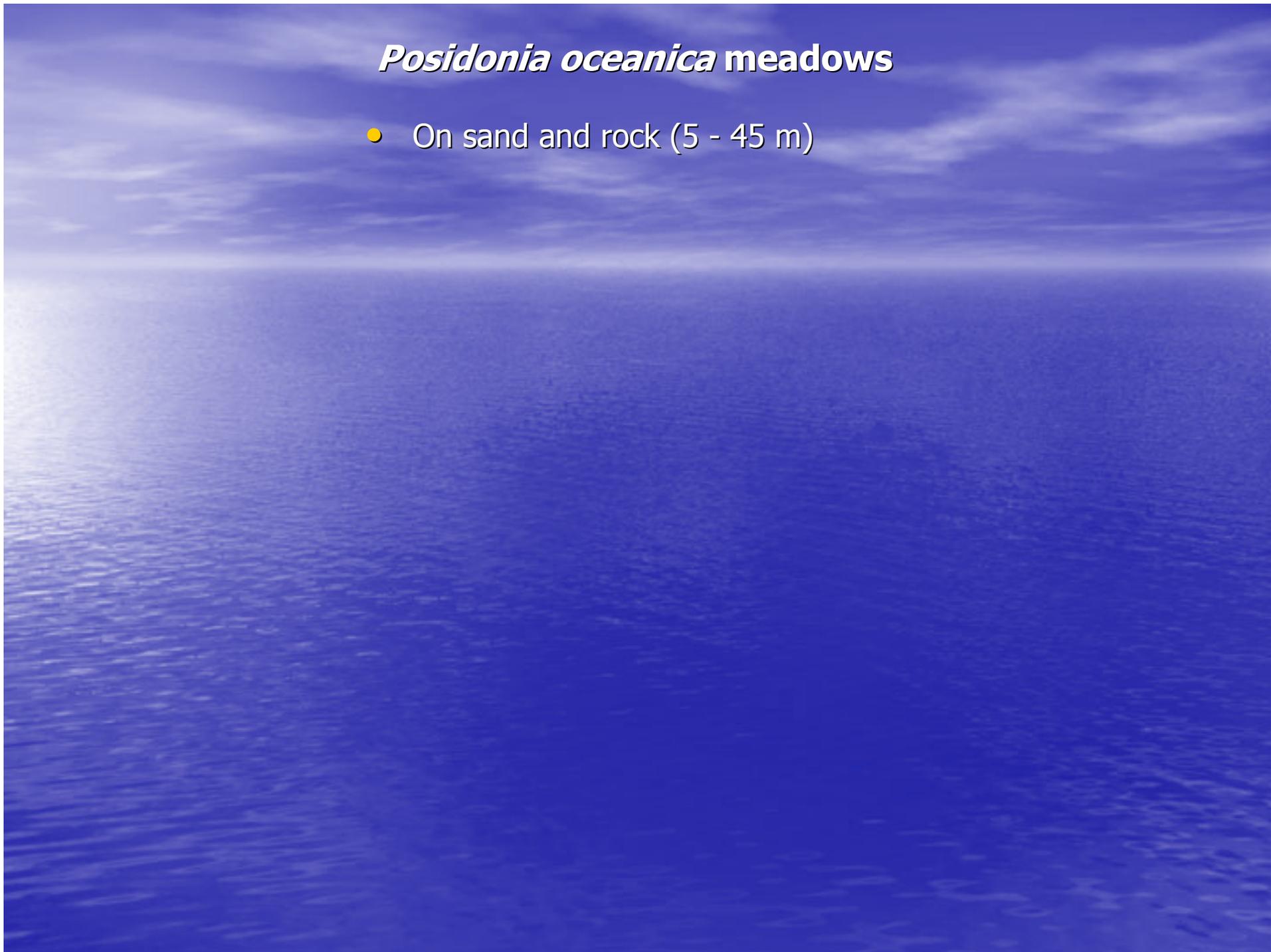


A wide-angle photograph of a vast, deep blue ocean under a blue sky with wispy clouds. The horizon is visible in the distance, and the water's surface shows gentle ripples. The overall color palette is dominated by various shades of blue.

Cymodocea nodosa

Posidonia oceanica meadows

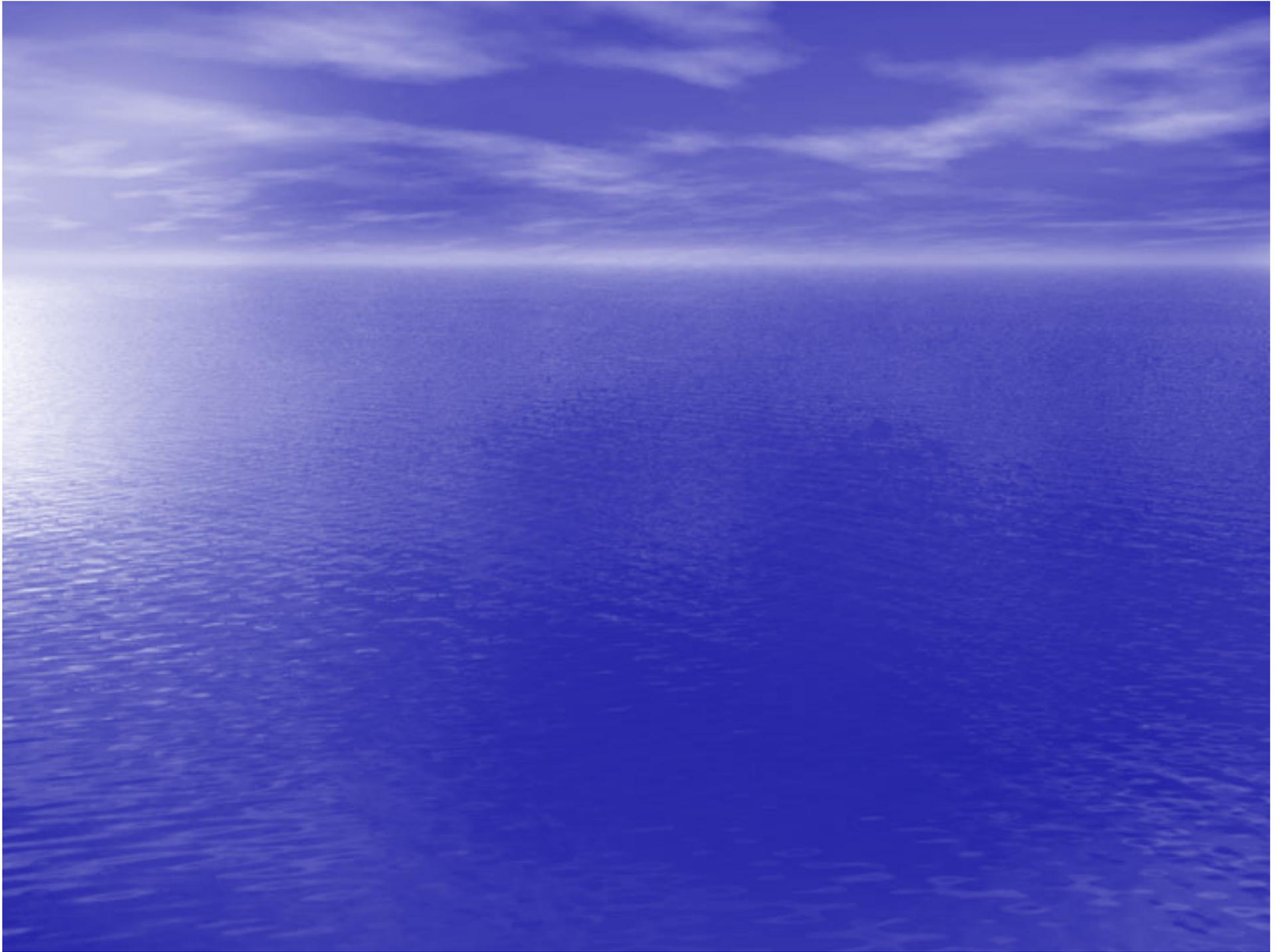
- On sand and rock (5 - 45 m)



Importance of *Posidonia oceanica* meadows

- *Posidonia* is an endemic species in the Mediterranean and is a priority species under the EU Habitat Directive (92/43/EEC).
- They are protected.
- They support high biodiversity.
- They provide one of the most reproductive habitat and refuge for many different species.
- They enrich seawater with oxygen.
- They stabilize the sea bottom.
- They are pollution - sensitive .

Posidonia oceanica



A wide-angle photograph of a vast, deep blue ocean under a blue sky with wispy clouds. The horizon is visible in the distance. The water has a slight ripple, and the sky is filled with soft, white clouds.

Halophila stipulacea & Caulerpa prolifera

A wide-angle photograph of a vast, deep blue ocean under a blue sky with wispy clouds. The horizon is visible in the distance. The water has a slight ripple, and the sky is filled with soft, white clouds.

Pinna nobilis in *Caulerpa prolifera* bed

Rocky substrate

Littoral habitats (zone lies between tide and is thus immersed at high tides and exposed at low tides; no tides, less than 0,5 meters)

- ***Rocky shores*** in Cyprus are of many different kinds. The most notable and ecologically interesting are the hard limestone shores, which predominate.
- The south-eastern part of the island, all the way from Cape Pyla to Paralimni, is of such rock (with several pocket beaches) - as is part of Akamas
- ***Vermetus reefs*** or shelf can be found in some areas. The shelf can be narrow 1 metre or so or it may be several metres wide, in exposed coasts.

Sublittoral habitats

- ***Rocky habitats*** – mainly from Cape Pyla to Paralimni and parts of Akamas
- ***Underwater Caves***

Rocky substrates habitats

Littoral Habitats (0-1m):

Vermetus shelf: *Dendropoma petraeum*
formations

Lithophyllum trocanter formations

Cystoseira amentacea forests (exposed rock)

Habitats of interest

Shallow *Cystoseira* spp. forests (*C. cf. humilis*, *C. spinosa* v. *tenuior*, *C. foeniculacea*) (0-37m)

Coralligenous community

- Encrusting calcareous algae, sponges, ascidia and filter-feeding animals (45-57m)

Submarine caves



Species of interest: Echinodermata

- diadema sea-urchin (*Centrostephanus longispinus*),
purple sea star (*Ophidiaster ophidianus*)

Species of interest: Ichthyofauna

- Sea groupers (*Epinephelus aeneus*, *E. costae*, *E. marginatus*, *Mycteroperca rubra*), black corb (*Sciaena umbra*)

Species of interest: Porifera

- *Axinella* spp. (*A. polypoides*, *A. cannabina*, *A. verrucosa*)
- Spongidae (*Spongia officinalis*, *Hippospongia communis*)

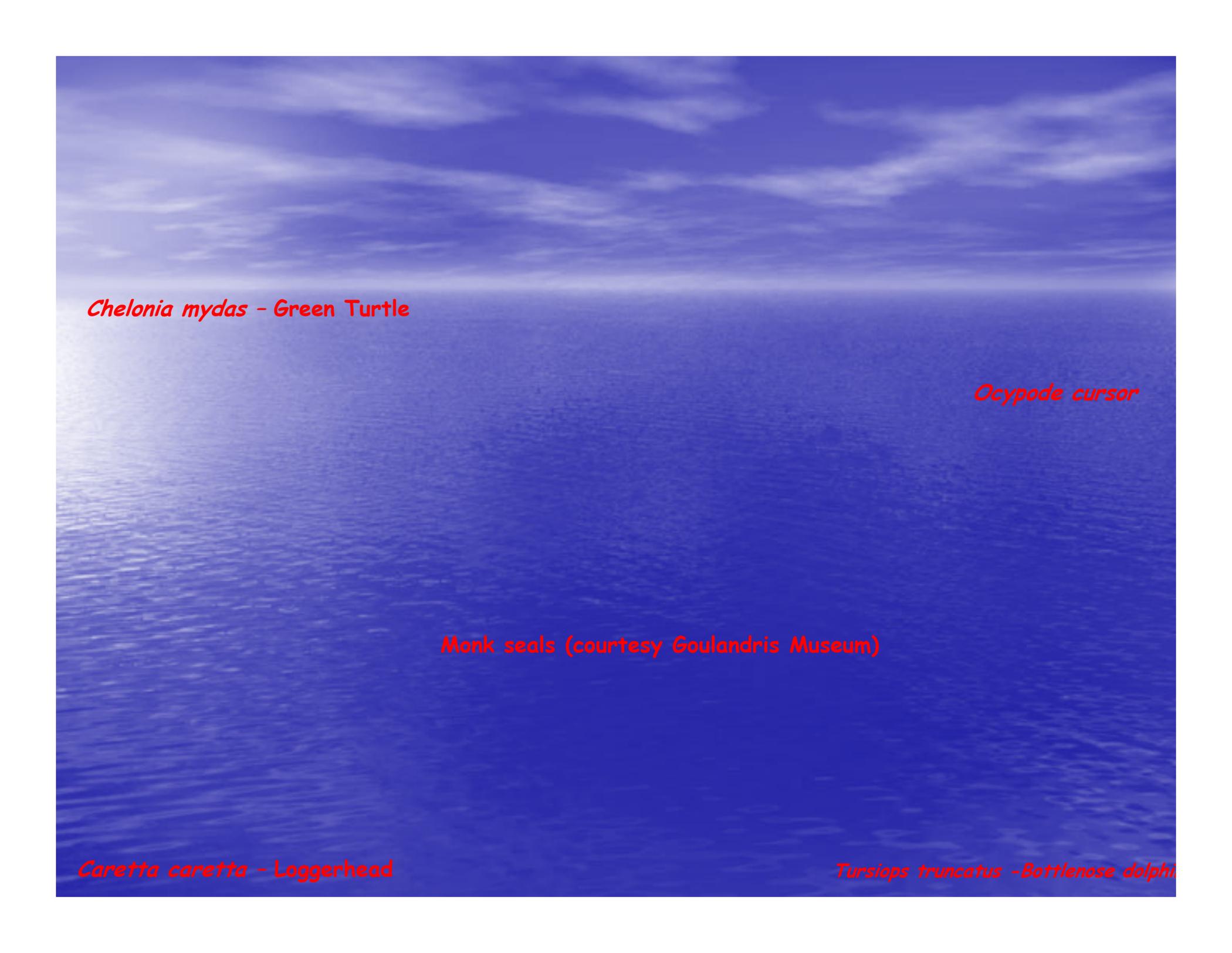
Species of interest: Mollusca Gastropoda

- Cypraeidae (*Erosaria spurca*, *Luria lurida*), *Tonna galea*, *Charonia tritonis variegata*

Protected Species

The following aquatic species are specifically protected by the Fisheries legislation from 1971:

- - All species of marine turtles
- - All dolphin species
- - The Mediterranean Monk seal
- - The crab *Ocypode cursor*
- - The terrapin *Mauremys caspica*
- - All fauna species of inland waters



Chelonia mydas - Green Turtle

Ocyrops cursor

Monk seals (courtesy Goulandris Museum)

Caretta caretta - Loggerhead

Tursiops truncatus - Bottlenose dolphin

Marine Protected Areas (MPAs)

One of the most important tools for preserving marine biodiversity and ensuring sustainable development of marine resources is the creation of **MPAs**

- They protect vulnerable ecosystems, threatened species and overall biodiversity;
- They are essential elements for the sound fisheries management;
- They act as reservoir for commercial and non-commercial species, refuge for different life stages;
- They increase breeding stock and subsequently enhance fish stocks in the neighbouring grounds;
- They conserve genetic diversity

Marine Protected Areas

Coastal/Marine Protected Areas

Lara/Toxeftra Turtle Reserve

- The Lara/Toxeftra, has been protected, since 1989, under the Fisheries Legislation as a coastal/marine reserve for turtle conservation.
- Both Green and Loggerhead turtles nest there.
- The management regulations for this area are spelled out in the Fisheries Regulations (273/90). It includes the foreshore (95m) and the adjacent sea area to the 20m isobath.
- The regulations prohibit boats and fishing in the area, the presence of the public on the beaches at night, driving on the beaches and umbrellas and sunbeds on the beaches. The Foreshore Protection Law was also amended at the same time (1989) incorporating into it the notion of Ecologically Important areas.

ΠΡΟΣΤΑΤΕΥΟΜΕΝΗ ΠΕΡΙΟΧΗ ΛΑΡΑΣ LARA RESERVE

ΠΡΟΣΤΑΤΕΥΟΜΕΝΗ ΠΕΡΙΟΧΗ ΧΕΛΩΝΩΝ TURTLE PROTECTED AREA

-  Παραλιακή Περιοχή : 90 μέτρα από τη θάλασσα.
Coastal Area : 90 metres from the sea.
-  Θαλάσσια Περιοχή : Μέχρι βάθους 20 μέτρων.
Sea Area : To 20 metres depth.

Ο ΠΕΡΙ ΑΛΙΕΙΑΣ ΝΟΜΟΣ, ΚΕΦ. 135
Κανονισμοί 1989

ΑΠΑΓΟΡΕΥΕΤΑΙ ΕΝΤΟΣ ΤΗΣ ΠΕΡΙΟΧΗΣ ΑΥΤΗΣ:

- Η τοποθέτηση ομπρελών, κρεββατιών, αντισκίμων, τροχοσπίτων κ.λ.π.
- Η παραμονή πάνω στην παραλιακή περιοχή κατά τη νύκτα, αρχίζοντας μία ώρα πριν τη δύση του ηλίου.
- Το ψάρεμα, εκτός το καλάμι.
- Η χρήση ή σγκυροβόληση σκάφους χωρίς άδεια.
- Η οδήγηση οποιουδήποτε οχήματος πάνω στις παραλίες.

FISHERIES LAW, CAP. 135
Regulations, 1989

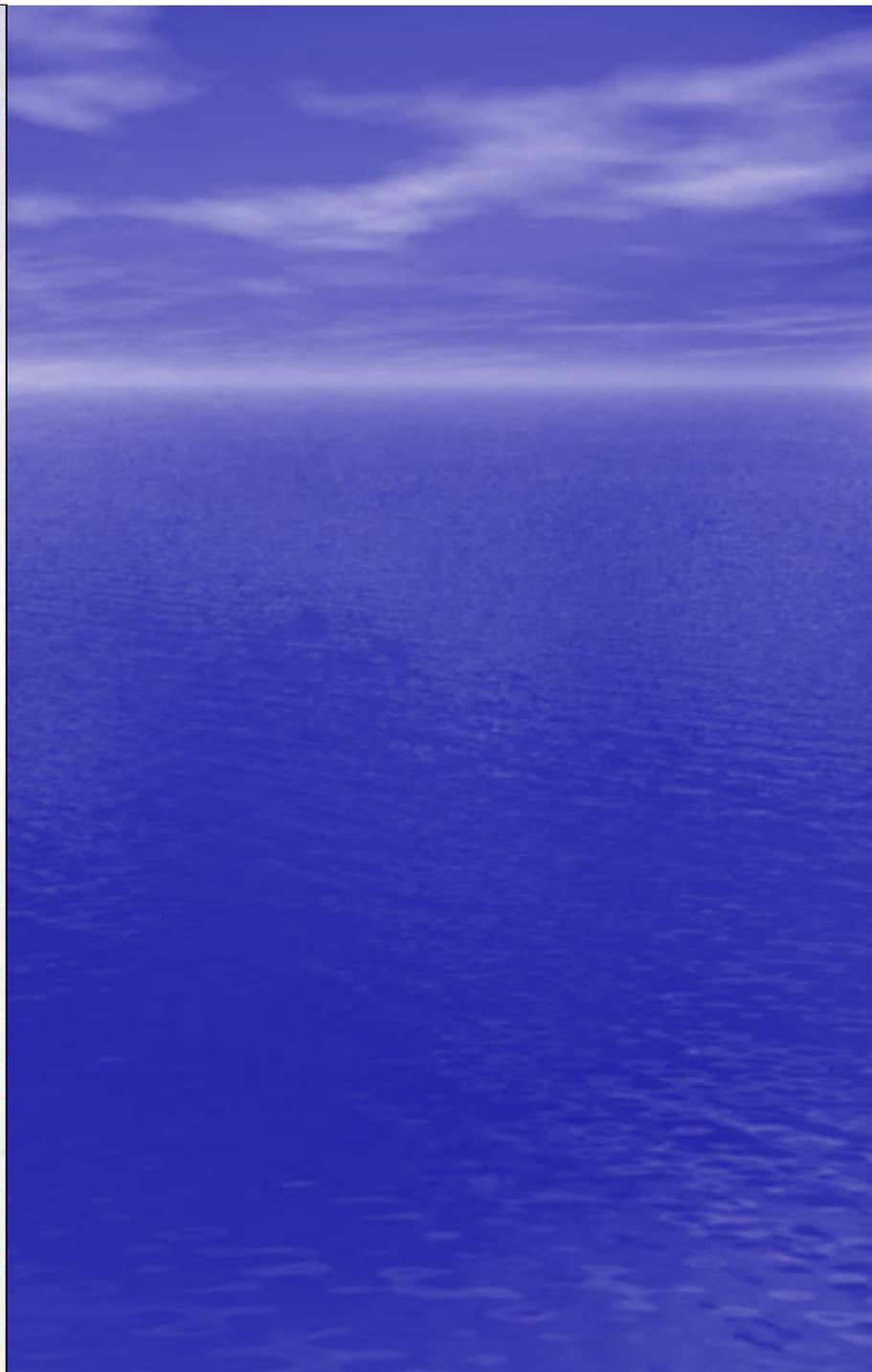
IN THIS AREA IT IS FORBIDDEN TO:

- Place any sunbed, umbrella, caravan, tent, etc.
- Stay on the beaches or the coastal area at night, starting one hour before sunset.
- Fish, except with a rod and line.
- Use or anchor a boat without a permit.
- Drive any vehicle on the beaches.

1 Km

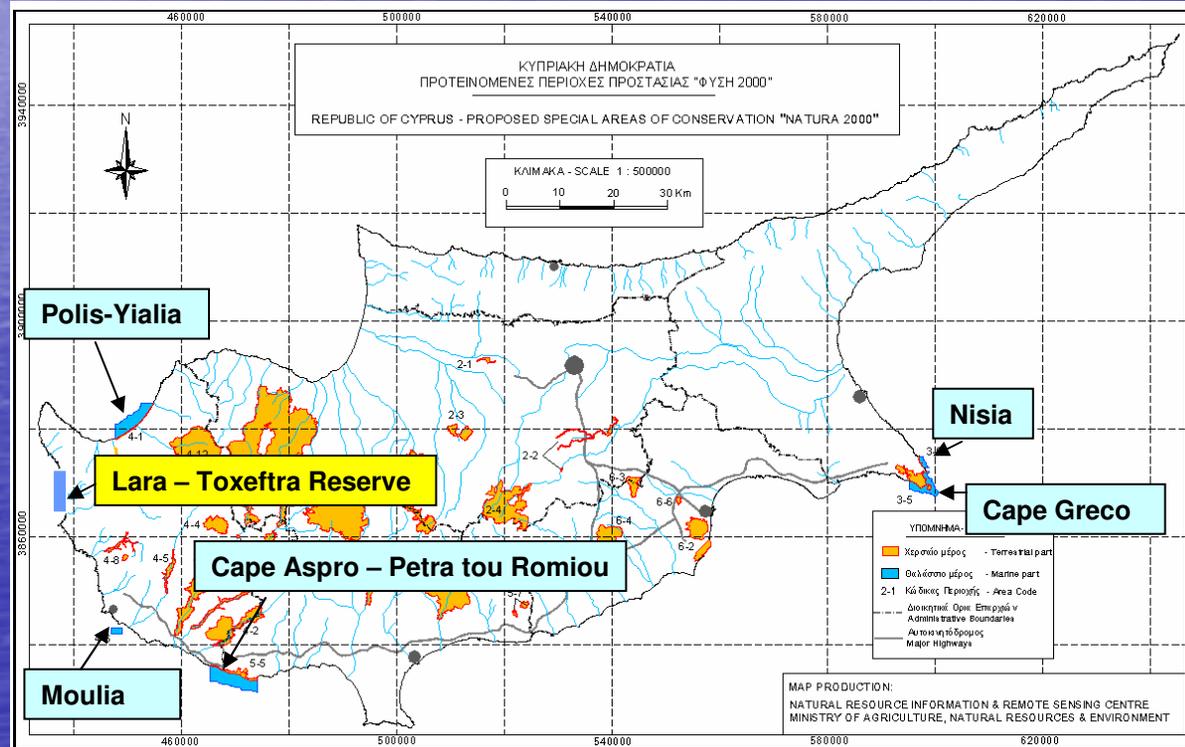
ΤΜΗΜΑ ΑΛΙΕΙΑΣ
FISHERIES DEPT.

Επισημάνσεις - Τυπικό Τυπογραφικό Εργαστήριο
Prepared by the Geological Survey Dept.



Proposed MPAs

Within the framework of the "Natura 2000" network, 5 marine areas, which include important habitat types and fauna and flora species that meet the criteria of the Habitats Directive, 92/43/EEC, are proposed to be protected.



Marine Reserve established in 1989

Proposed Natura sites

Factors affecting marine and coastal environment

- **Tourism and urban development** of the coastal zone impacts habitats and species dependent on this zone (turtles, monk seals, ghost crabs etc)
- **Fishing and overfishing** in particular with trawlers, fishing on non target-species & smaller size organisms.
- **Invasive species.** Mainly the Lessepsian immigration through the Suez canal.
- **Pollution** - especially nutrients
 - ❖ **Main sources of nutrients in Cyprus coastal /marine environment**
 - Agriculture (groundwater seepage, runoff)
 - Aquaculture
 - Urban treated effluents

Pollution from nutrients

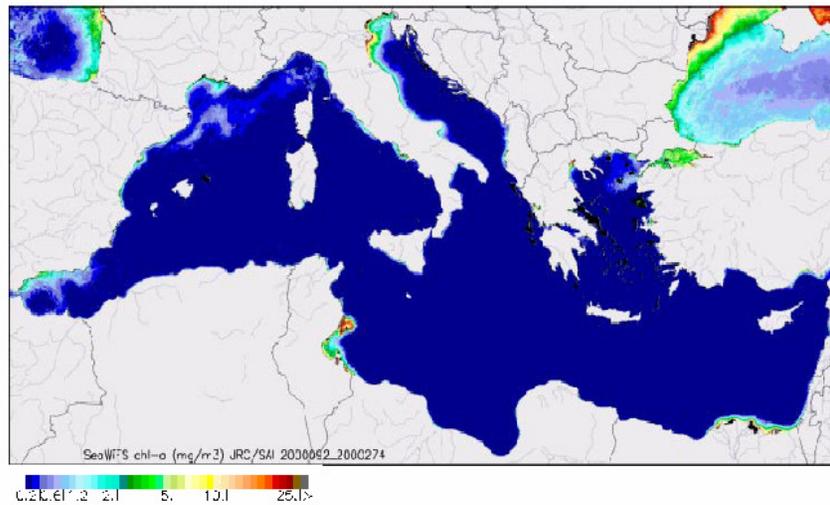
- Nutrient enrichment of marine ecosystems leads to **eutrophication** events, the extent of which depends largely on the functionality of the marine ecosystem.
- **Eutrophication**, in general, is an excessive increase in primary production caused by the load of excess nutrients (i.e. nitrogen, phosphorus) from human activities.
- Eutrophication in the **Mediterranean** basin, at the moment, appears to be limited mainly to specific coastal and adjacent offshore areas. Several and sometimes severe cases of eutrophication are evident, especially in sensitive areas, as enclosed coastal bays, which receive elevated nutrient loads from rivers, together with direct discharges of domestic and industrial waste (EEA/UNEP 1999)

Pollution from nutrients

- Coastal waters of Cyprus are classified among the poorest in nutrients (ultra-oligotrophic) of the world's ocean, since the background values of these are very low.
- Loading of nutrients exceeding some threshold values in this sensitive marine environment has an impact that is comparatively more significant than in other, richer areas, like the West Mediterranean.
- A certain quantity of nutrients, with no doubt, could be beneficial for the ecosystem, since it effectively assimilated by the ecosystem and contributes positively to the productivity of the area in terms of biomass, but the form this will take effect in, is difficult to predict.
- Exceeding the threshold values, the over-enrichment with nutrients causes negative impact to the ecosystem, which leads to eutrophication.
- In the last 16 years, episodic eutrophication events with the ephemeral filamentous macroalga *Cladophora spp.* were observed in summers of 1990-91, 1998, 2004 & 2005 in some of the coastal areas (Liopetri/ Aya Napa, Limassol) of Cyprus causing nuisance problems on the shore.
- The special nature of the seas of Cyprus has, therefore, to be taken into consideration, as the effects of pollution with nutrients on its ecological balance will not be the same as those in other marine areas (i.e. western Mediterranean).

Mean spring-summer (April-September) concentrations of chlorophyll-a in 2000 in the Mediterranean Sea

Figure 31c. Mean spring-summer (April-September) concentrations of chlorophyll-like pigments in 2000 in the Mediterranean Sea as determined from SeaWiFS satellite observations



Note: The concentration scale (µg/l) is valid

Source: Eut
European E

- Integrated or surficial water samples are collected on seasonal basis and chlorophyll-a is determined fluorometrically.
- Range of chl-a is in general less than 0,1 µg/l (20 - 90 ng/l)
- No correlation exists between chl-a and nutrients
- No changes of chl-a observed in relation to nutrient inputs and there are no significant changes between sites.

Chlorophyll-a concentrations measured in 2005 along the coastal waters of Cyprus

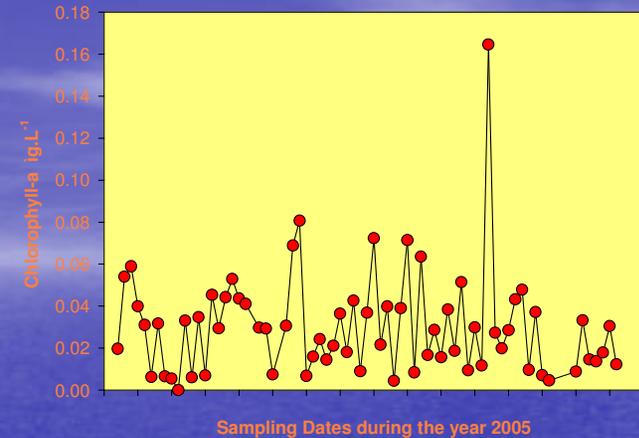
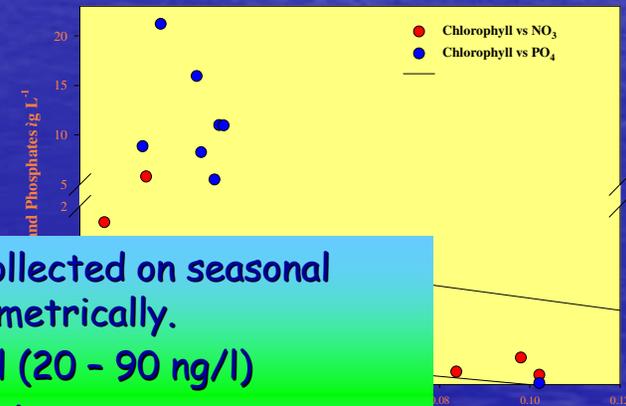
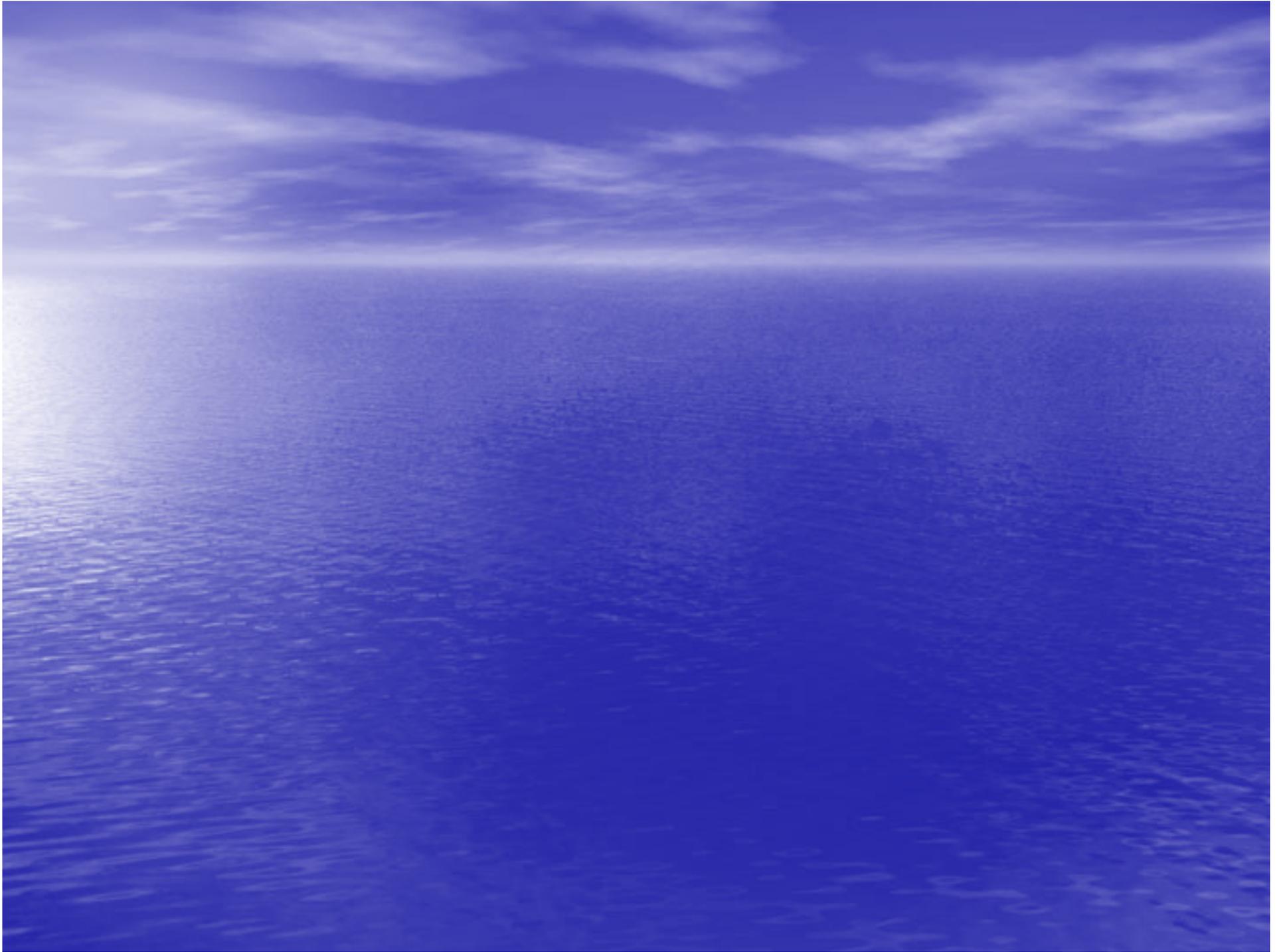


Fig. 1. Variation of chlorophyll-a concentrations along the coastal waters of Cyprus for the year 2005



chl-a with nitrates

Source: Argyrou, M. 2006. National Monitoring report for the year 2005, MED POL



Pollution with nutrients

- The episodic eutrophication with *Cladophora* was associated with excess nutrients derived from several sources, such as agriculture (groundwater seepage, runoff), aquaculture and urban wastes, combined with complex interactions of other synergistic factors, such as abrupt increases of water temperature, appropriate substrate, weather conditions etc.

Activities/Projects for the monitoring and assessment of the quality of the marine environment

UNEP

MED POL. Monitoring and research program for the assessment of the quality of marine waters.

EU

Water Frame Directive. DFMR is responsible for the implementation of the Directive's requirements for the coastal waters. It participates in the Intercalibration (IC) process through the working group MED-GIG. The overall aim of the IC process is to achieve a common evaluation of the ecological status using existing data on biological quality elements (BQE) required for the classification of coastal waters. Through this process two classification systems, AMBI (Borja *et al.* 2000) and BENTIX (Simboura & Zenetos, 2002), were tested for benthic macrofauna from Limassol Bay.

Monitoring of Coastal Waters within MED POL / UNEP

Monitoring of the coastal waters of Cyprus is being undertaken, since the beginning of MAP, within the framework of MEDPOL. Following the various phases of MEDPOL, monitoring of coastal waters has been updated aiming at acquiring information on:

- the **assessment of the quality of coastal waters**, through the **state and trend monitoring**,
 - ❖ Monitoring of effluents in hot spot areas and loads to the coastal waters from Land Based Sources
 - ❖ Assessment of the state and temporal changes in contaminants inputs and levels in the coastal waters
 - ❖ Trend monitoring using biota in coastal areas
 - ❖ Assessment of the quality status of coastal waters through eutrophication monitoring
- the **degree of compliance** with the national, regional and EU Regulations
 - ❖ Compliance monitoring for bathing waters, to verify the degree of compliance to the UNEP/MAP common criteria and the EU Bathing Directive (76/160/EEC)
 - ❖ Compliance monitoring for industrial discharges to the sea to determine whether the quality characteristics of the effluents comply with the National Legislation

Compliance Monitoring

● Monitoring of Industrial Effluents

The industrial point sources of pollution related to the coastal waters of Cyprus are limited to a small number of industries. Although these industries have a minor impact on the marine environment, they are considered as "hot spots" in Cyprus, since their effluents end up to the marine environment.

- The most significant are the 4 wineries and a brewery, which are located in Limassol Bay.

In 2004 they were all connected to the sewage for discharging their domestic effluents, while the liquid waste from distillation is been dumped in a pre-defined site. No effluents are discharged to the sea except their cooling water, which is enriched in nutrients and has high BOD. This is due to the fact that the origin of the cooling water is from the adjacent boreholes.

Monitored Parameters
BOD, COD, NUTS

Compliance Monitoring

● Monitoring of Industrial Effluents

Other Industrial sources:

- Oil Refinery

The refinery terminated its operations in 2004. Currently, it operates as a fuel terminal Station, and thus, its effluents have been reduced.

Monitored Parameters

TSS, TM (Pb, Fe, Cu, Cr, Zn)

- 2 Desalination plants

Monitored Parameters

Salinity, Conductivity
TM (Pb, Fe, Cu, Cr, Zn)

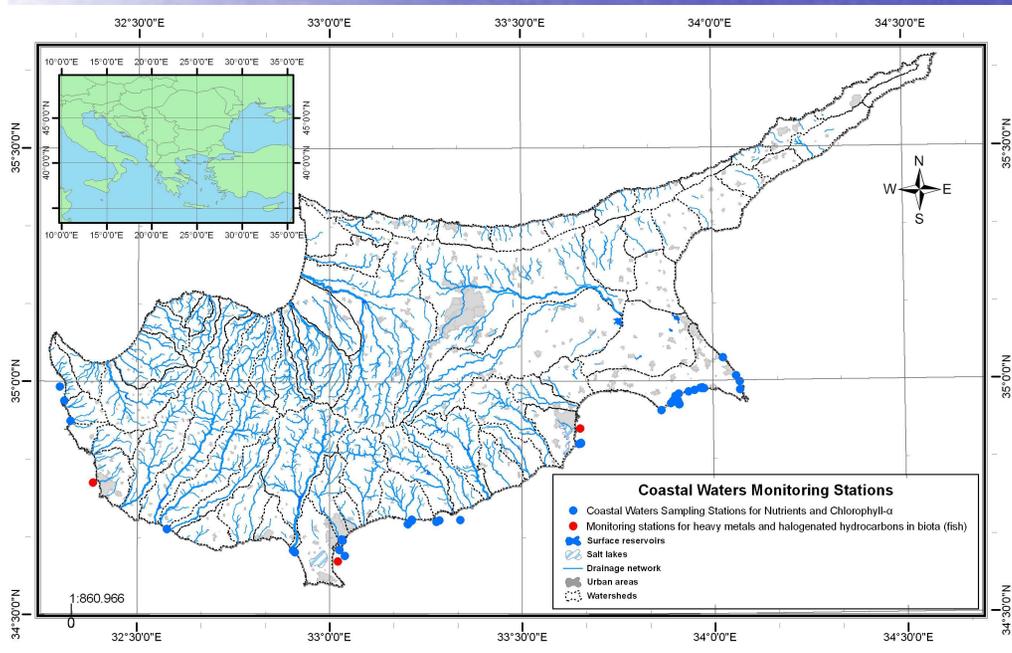
- 3 Aquaculture hatcheries and a shrimp farm

Monitored Parameters

DO, NUTS

State and Trend Monitoring

Trend Monitoring of trace metals and halogenated hydrocarbons in biota (fish: *Mullus barbatus*)

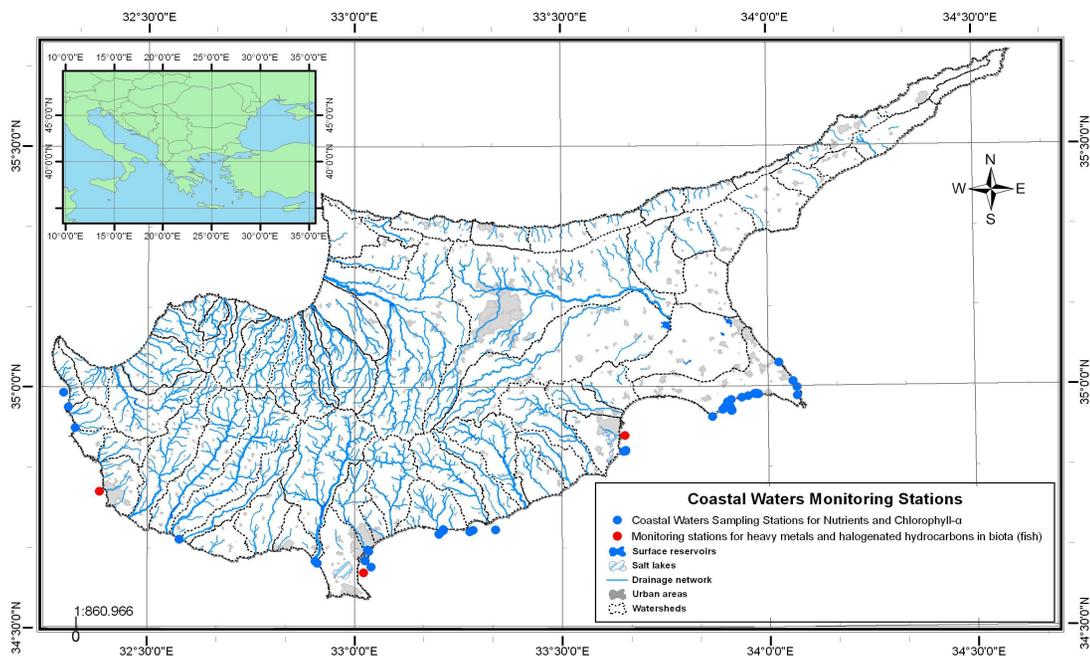


- 3 stations are monitored in the coastal area of Larnaca, Limassol and Paphos.
- **Trace metals:** Hg, Cd, Pb, Zn, Cu, Fe, Cr.
- **Halogenated hydrocarbons:** HCB, Lindane, Aldrin, Dieldrin, Heptachlor, Heptachlor epoxide, pp-DDT, pp-DDD, pp-DDE, op-DDT, op-DDD.

State and Trend Monitoring

Eutrophication monitoring in coastal waters. Assessment of coastal waters quality status.

- The nutrients and chlorophyll-a are monitored to have an assessment of their dynamics along the coastal waters of Cyprus.
- At 40 stations located along the coastline, integrated water samples are collected 3-4 times per year for determination of nuts and chl-a.
- The sampling sites included in the monitoring network comprises:



- Monitoring of offshore Aquaculture units, which are practiced using the open sea cages technology. Monitored stations are located at the cages area and at 50 m distance from the cages following the direction of the prevailed currents;
- Coastal areas, in which industrial effluents, such as effluents from the wineries and hatcheries, brine from desalination etc., are discharged;
- Reference areas

Water Framework Directive (2000/60/EC)

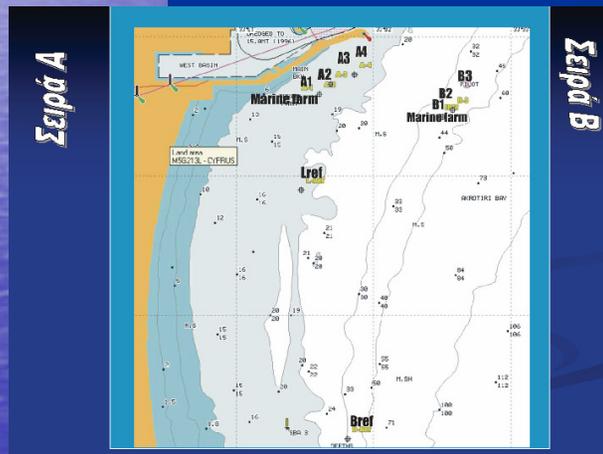
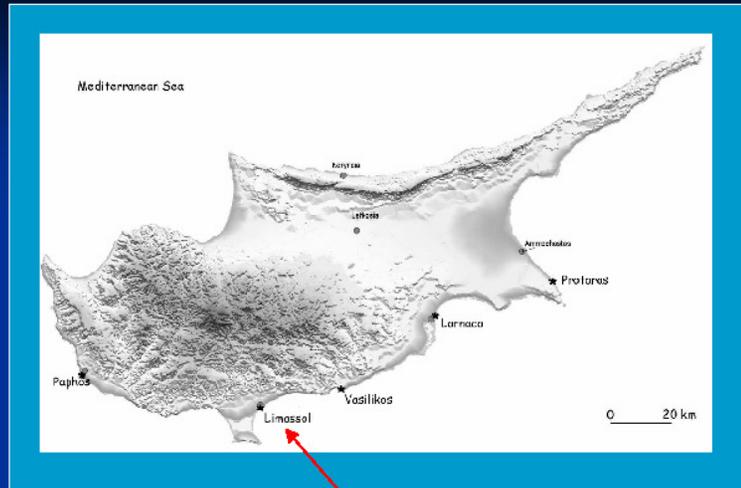
- The Water Framework Directive, WFD, (2000/60/EC) is a legislative framework to protect and improve the quality of all water resources such as rivers, lakes, groundwater, transitional and coastal water.
- The Directive aims at achieving "good status" for all European waters by 2015.
- The WFD requires member states to assess the ecological quality status (EcoQ) of the water bodies. The EcoQ will be based upon the status of the biological, hydromorphological and physico-chemical quality elements, with particular emphasis on the Biological Quality Elements (BQEs).
- The BQEs for the coastal waters are:
Phytoplankton, Macroalgae, Angiosperma, Benthic macroinvertebrates.

ΒΙΟΛΟΓΙΚΑ ΣΤΟΙΧΕΙΑ	ΥΨΗΛΗ	ΚΑΛΗ	ΜΕΤΡΙΑ
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EC, 2003

Application of Water Frame Directive in Cyprus: application of the biotic index Bentix in the Limassol Bay (N. Simboura & M. Argyrou, 2006)

The biotic index Bentix was applied in sea farm areas of Limassol Bay (Cyprus). A gradient of the values of the index along the axis of increasing distance from fish cages was observed. The ecological status ranged from "moderate" close to the cages improving with increasing distance to "good" while in reference areas it reached the high class. Also the presence of *Posidonia oceanica* beds was proved to be a significant factor in shaping the ecological status of an area.



$$\text{Bentix} = \frac{\{ 6 \times \% \text{GI} \} + 2 \times (\% \text{GII} + \% \text{GIII})}{100}$$

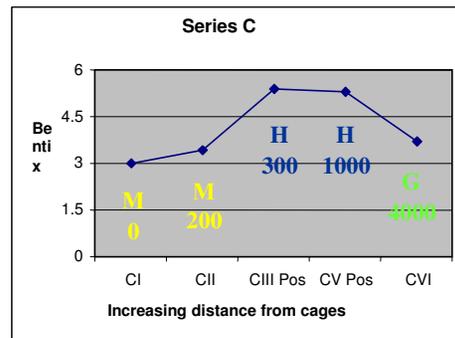
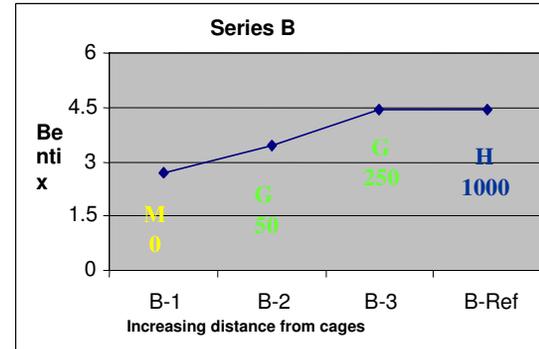
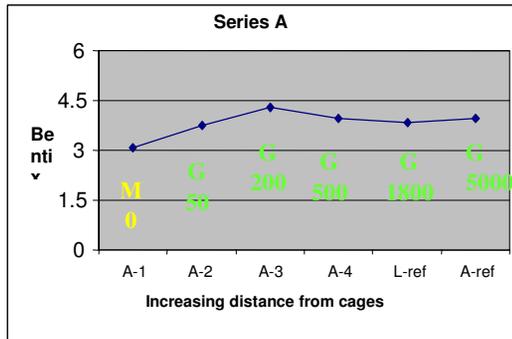
$$\frac{(6 \times \% \text{GS} + 2 \times \% \text{GT})}{100}$$

GS	GI: ευαίσθητα, αδιάφορα	1
GT	GII: ανθεκτικά, ευκαιριακά β' τάξης	3
	GIII: ευκαιριακά α' τάξης	

Ecological Status	Bentix	EQR (value/6)
Υψηλή	6	1
Καλή	4.5	0.75
Μέτρια	3.5	0.58
Ελλειπής	2.5	0.42
Κακή	0	0

Simboura & Zenetos, 2002.

Ecological status based on Bentix and trends

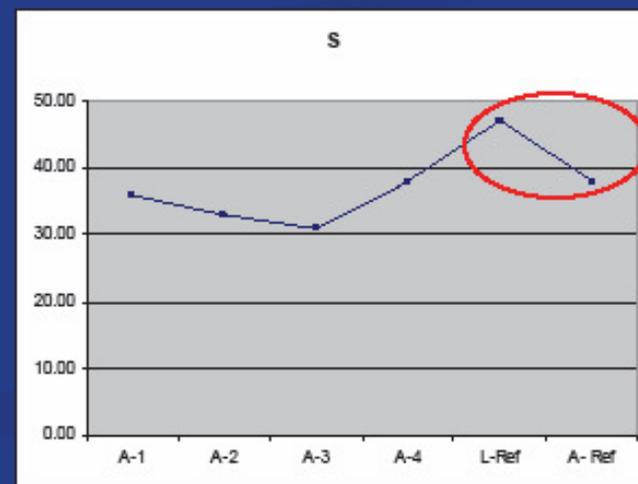
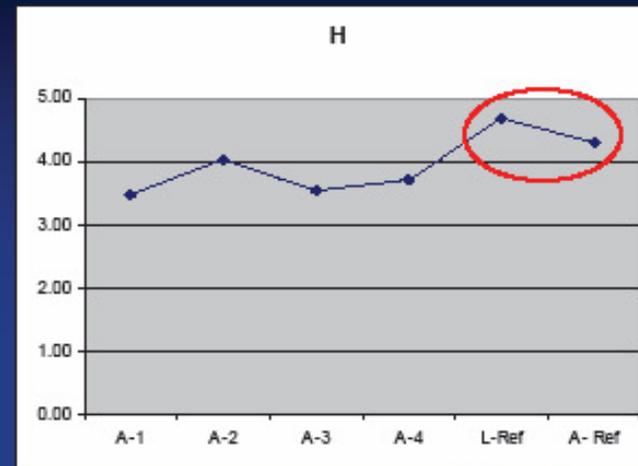
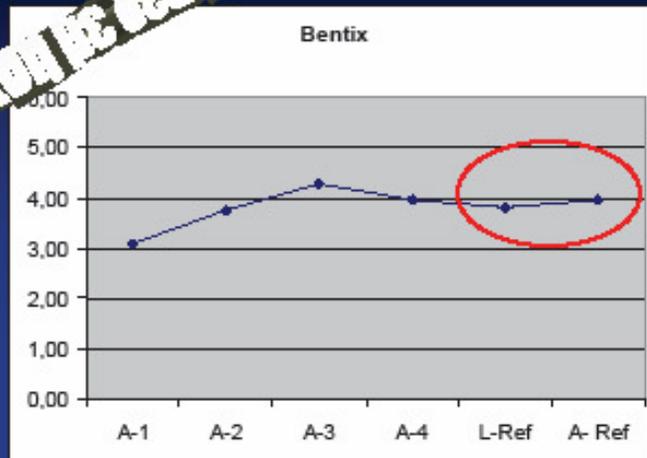


Simboura, N. & Argyrou, M. 2006

Variation of the Bentix index and resulted EQS along a gradient of increasing distance from fish farm cages in Cyprus (distances in meters are marked below the EQS).

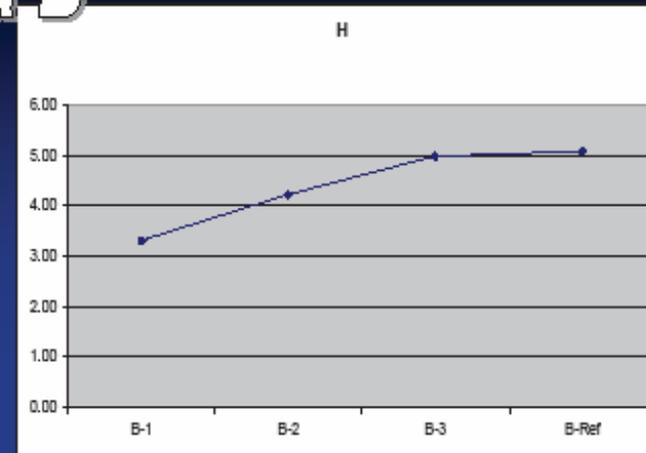
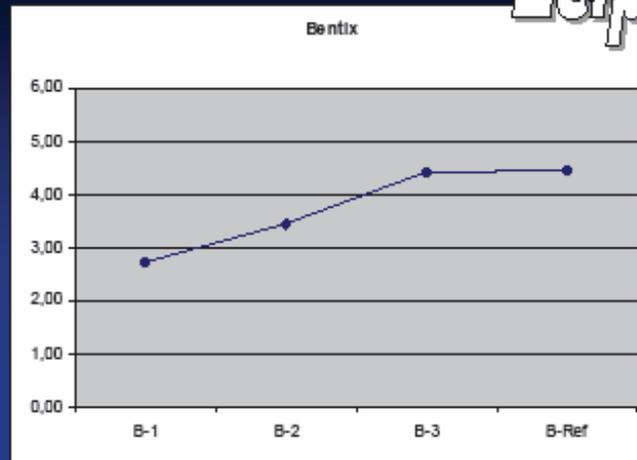
ΚΑΛΩΣΤΕ ΤΕΣ ΔΕΙΚΤΕΣ ΠΡΟΚΑΛΩΣΤΕ

Σειρά Α

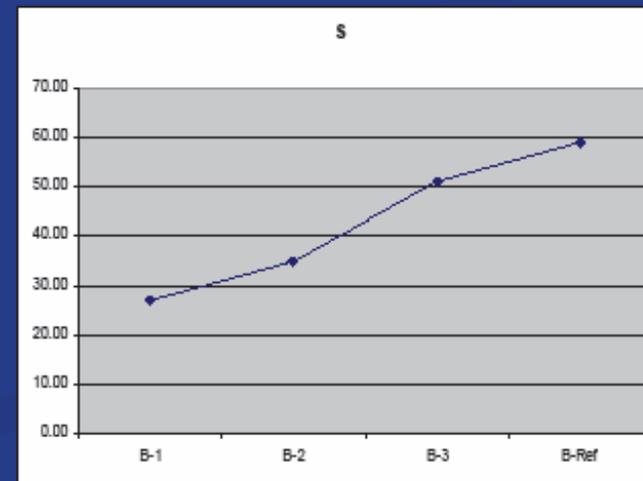


- Καλή συμμεταβλητότητα με τους άλλους δείκτες.
- Στους σταθμούς αναφοράς η κατάσταση αξιολογείται ως απλώς καλή ενώ οι άλλοι δείκτες εμφανίζουν μέγιστες τιμές.
- Η ασυμβατότητα αυτή αποδίδεται στην συνύπαρξη στους σταθμούς αυτούς ειδών ευαίσθητων και ειδών ευκαιριακών σε μεγάλες σχετικά πυκνότητες (*N. unicornis* 13%, *Melinna palmata* 15%)
- Οι σταθμοί «αναφοράς» έχουν χαρακτηριστικά μεταβατικών ζωνών διατάραξης.

Σειρά Β

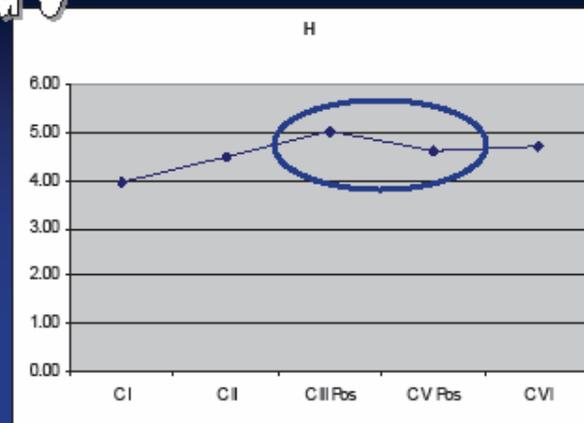
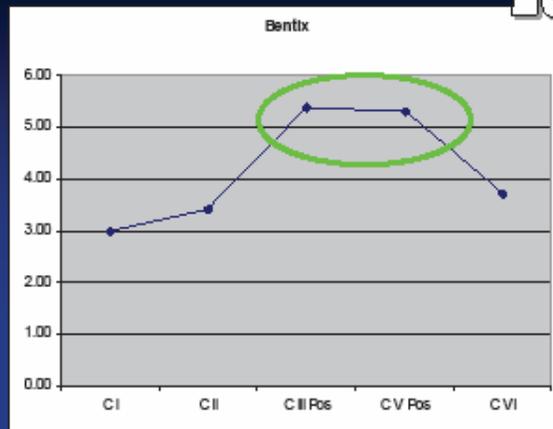


- Πολύ καλή συσχέτιση με τους άλλους δείκτες
- Γραμμική σχέση αύξησης του Bentix με την απόσταση ($R^2=0.9$)



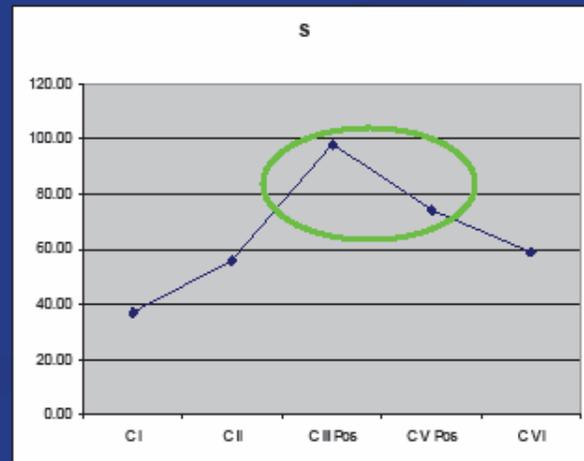
Simboura, N. & Argyrou, M. 2006

Σειρά C



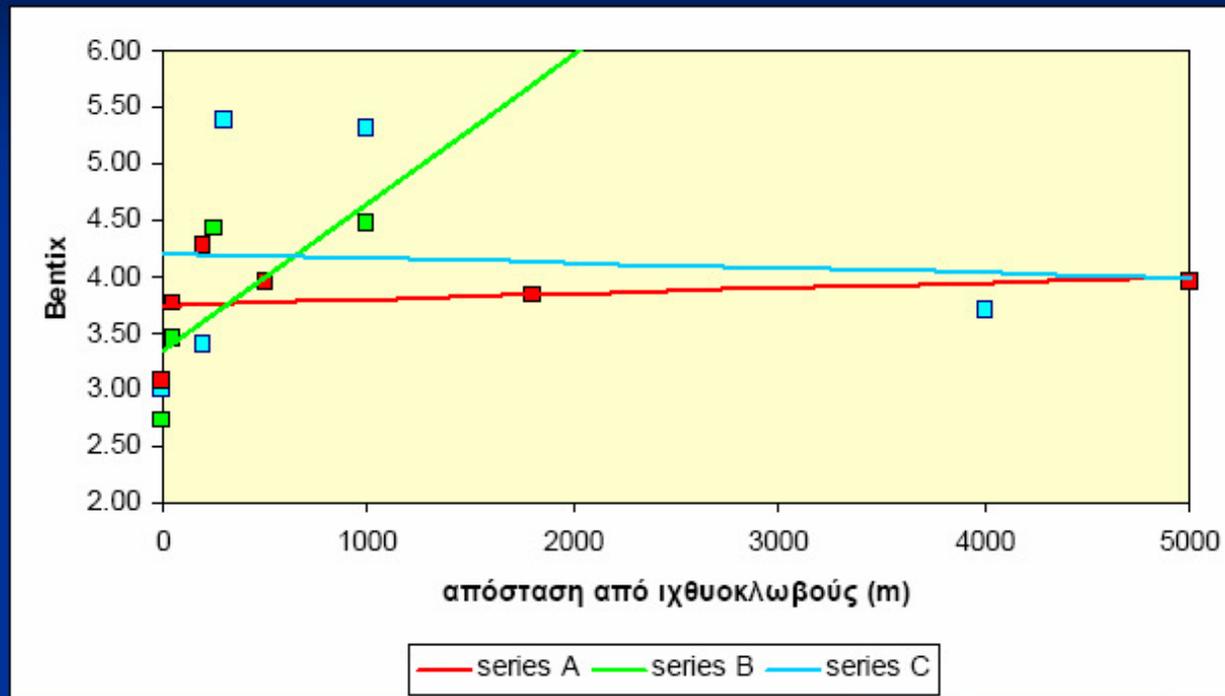
• Ο δείκτης Bentix διακρίνει την ποιότητα του περιβάλλοντος στους σταθμούς με *Posidonia* αναδεικνύοντας το υψηλό ποσοστό τους σε ευαίσθητα είδη.

• Η οικολογική ποιότητα στους σταθμούς με *Posidonia* δεν επηρεάζεται από την σχετική γειτνίαση από τις καλλιέργειες (300 και 1000μ)



Simboura, N. & Argyrou, M. 2006

Συσχέτιση των τάσεων αύξησης του Bentix με την απόσταση από τους ιχθυοκλωβούς στις τρεις σειρές.



• Η σειρά Β δείχνει την υψηλότερη κλίση στην τάση αύξησης-διαβάθμισης του δείκτη με την απόσταση.

Simboura, N. & Argyrou, M. 2006

✓ Τα αποτελέσματα του δείκτη Bentix όσο αφορά την διακύμανση της οικολογικής κατάστασης κατά μήκος του άξονα απομάκρυνσης από τους κλωβούς αξιολογούνται με βάση :

- Τον βαθμό και την ακτίνα επίδρασης της διατάραξης των βιοκοινωνιών στο σημείο των κλωβών.

- Την κατάσταση στους σταθμούς “αναφοράς”

- Την ιδιαιτερότητα των οικοτόπων στα σημεία ελέγχου (πχ. Λειβάδια με *Posidonia*)

✓ Τα αποτελέσματα της κατάταξης είναι συμβατά με τα βιονομικά δεδομένα και τις τάσεις των άλλων δεικτών

Simboura, N. & Argyrou, M. 2006

Other Activities/Projects for the monitoring and assessment of the quality of the marine environment

National

Marine Ecology. Research on marine biodiversity and on the ecological relationships among marine macrobenthic assemblages and the ambient environment. This also includes research studies on the effects of environmental disturbances caused by human activities, i.e. aquaculture, desalination etc. on marine ecosystem.

Eutrophication monitoring. Monitoring for observation of eutrophication with macroalgae, i.e. *Cladophora spp.*, *Enteromorpha spp.* .

Conservation. Implementation of protection and conservation programs for the marine turtles etc.

EU

MedVeg. Effects of nutrient release from Mediterranean fish farms on benthic vegetation in coastal ecosystems.

MedMPA. Regional Project for the development of marine protected areas in the Mediterranean region.

- Overall, the marine environment of Cyprus is in quite **good state**, with minor environmental impacts.
- The implementation of the requirements of the Water Frame Directive through the monitoring of BQEs will substantially contribute to the enhancement of scientific knowledge of the ecological evaluation of the coastal waters and will provide the link between ecosystems functioning and surrounding pressures. Acquired data would be essential for the sustainable management of coastal ecosystems and human activities in order to retain or achieve the good ecological status.

Thank you for your attention