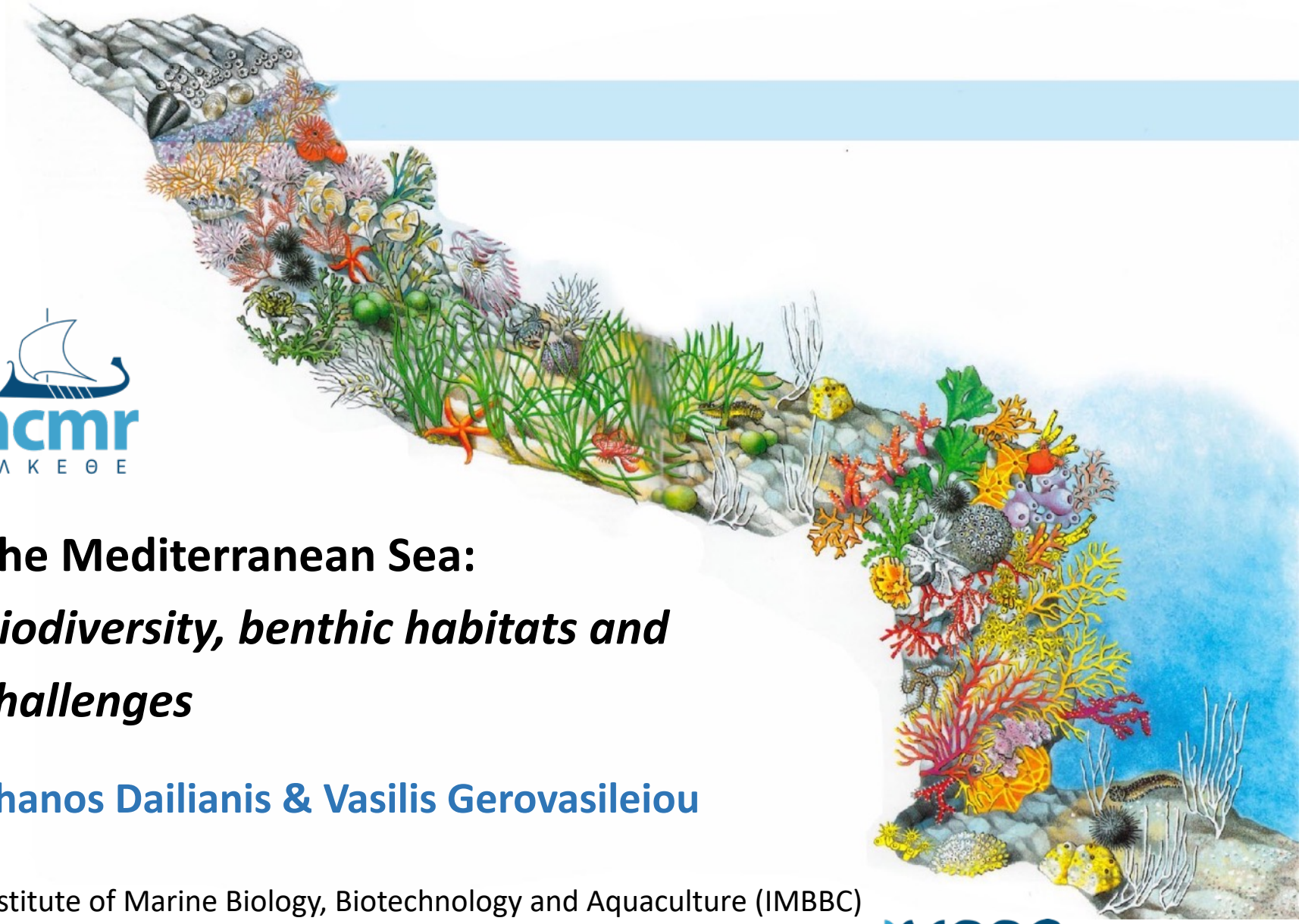


The Mediterranean Sea:

biodiversity, benthic habitats and challenges

Thanos Dailianis & Vasilis Gerovasileiou

Institute of Marine Biology, Biotechnology and Aquaculture (IMBBC)
Hellenic Centre for Marine Research (HCMR)
21 October 2021, Heraklion, Greece

1. Introduction to the Mediterranean ecosystem

2. Key benthic habitats and communities

3. Threats, challenges and conservation

4. Main research activities and interests of the IMBBC-HCMR biodiversity lab

1. Introduction to the Mediterranean ecosystem

Mediterranean Sea

Mare mediterraneum

“sea in the middle of the land”

(in Latin)

Μεσόγειος (*mesógeios*)

from μέσος (*mésos*, “in the middle”) and γήινος (*gḗinos*, “of the earth”), from γῆ (*gê*, “land, earth”)

“the sea in the middle of the earth”

(in Greek)

ΣΦΕΝΔΟΝΗ, hoc est, FVNDA POSIDONII

DELINEATA A P. BERTIO *Christianissimi Regis* LVDOVICI XIII. *Geographo & Professore.*

DIONYSIVS EN TH OIKOYMENHΣ ΠΕΡΙΗΓΗΣΕΙ

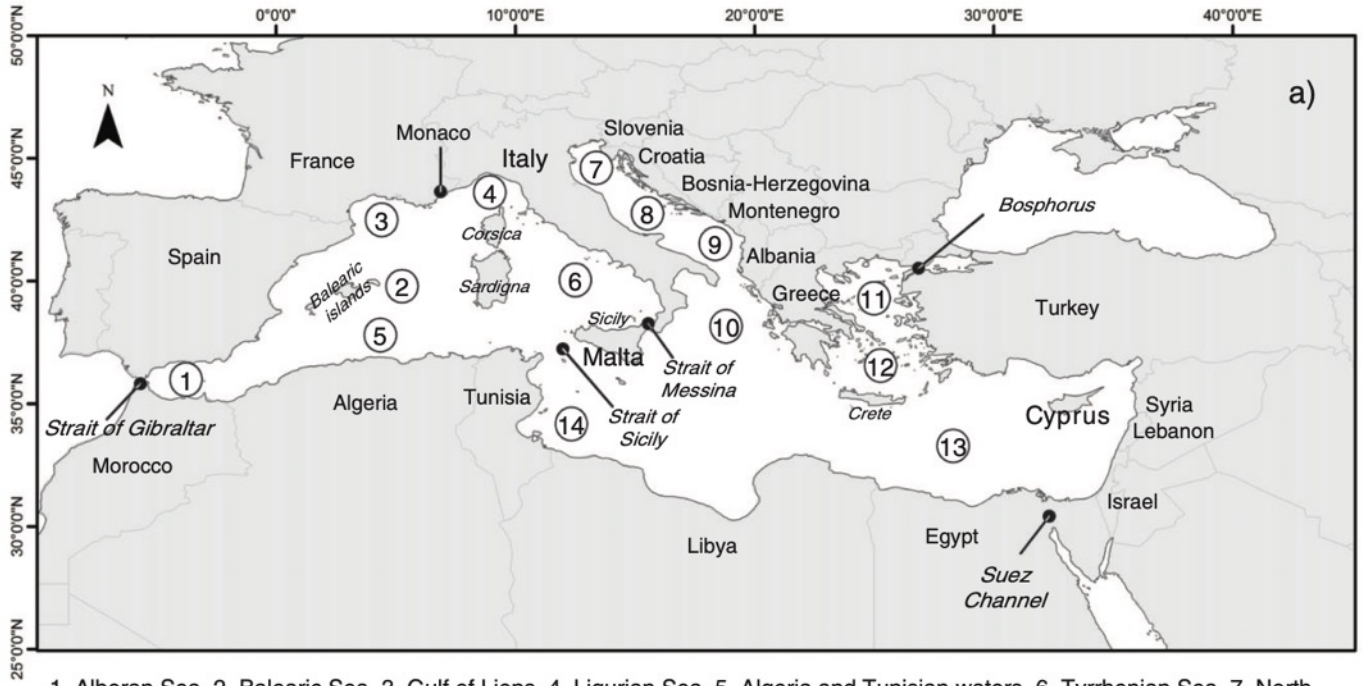
Πᾶ ϕα χθὼν, ἅτε νῆ ος ἀωσίριτος, ἐσεφάνω ται
Οὐ μιλῶ πᾶϕα διαπρὸ περίδρομος, ἀλλά διαμφὶς

Εὐρυτέρη βεβαυῖα πρὸς Ἠέλιοιο κελεύθους
ΣΦΕΝΔΟΝΗ εἰκυῖα

Cælauit
LVTETIAE PARISIOR.
MELCHIOR TAVERNIER
Anno ∞ IↃ CXXVIII

- Currently encompasses 21 modern states
- Important hub for international economy and trade
- Among the top tourist destinations in the world (200 million visitors per year)
- Complex geopolitical status, with implications for management & conservation

Biogeographic regions



1. Alboran Sea, 2. Balearic Sea, 3. Gulf of Lions, 4. Ligurian Sea, 5. Algeria and Tunisian waters, 6. Tyrrhenian Sea, 7. North Adriatic Sea, 8. Central Adriatic Sea, 9. South Adriatic Sea, 10. Ionian Sea, 11. North Aegean Sea, 12. South Aegean Sea, 13. Levant Sea, 14. Gulf of Gabés.

Bathymetry

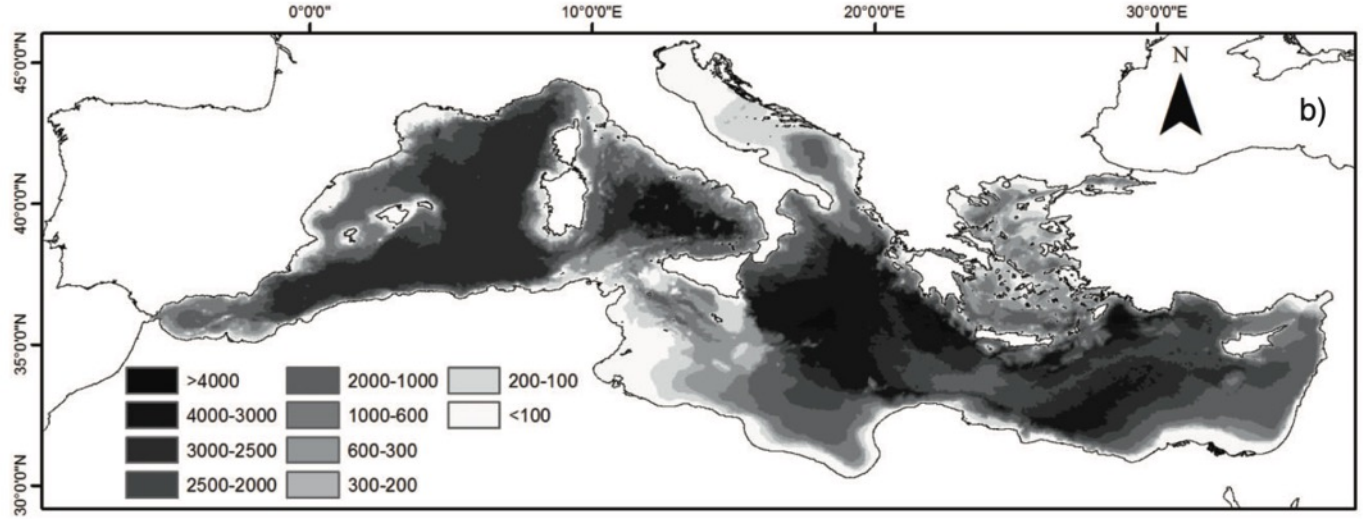
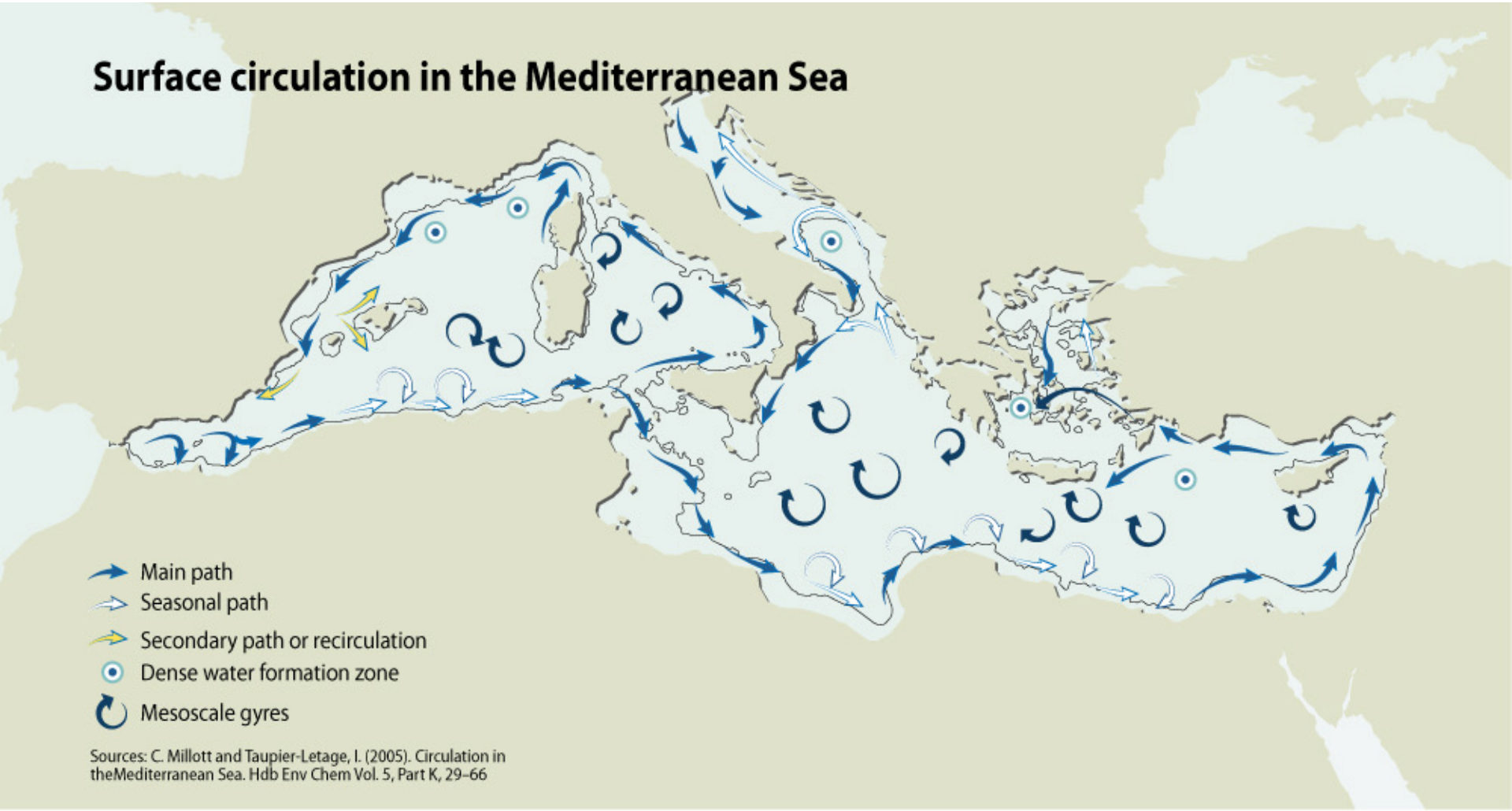


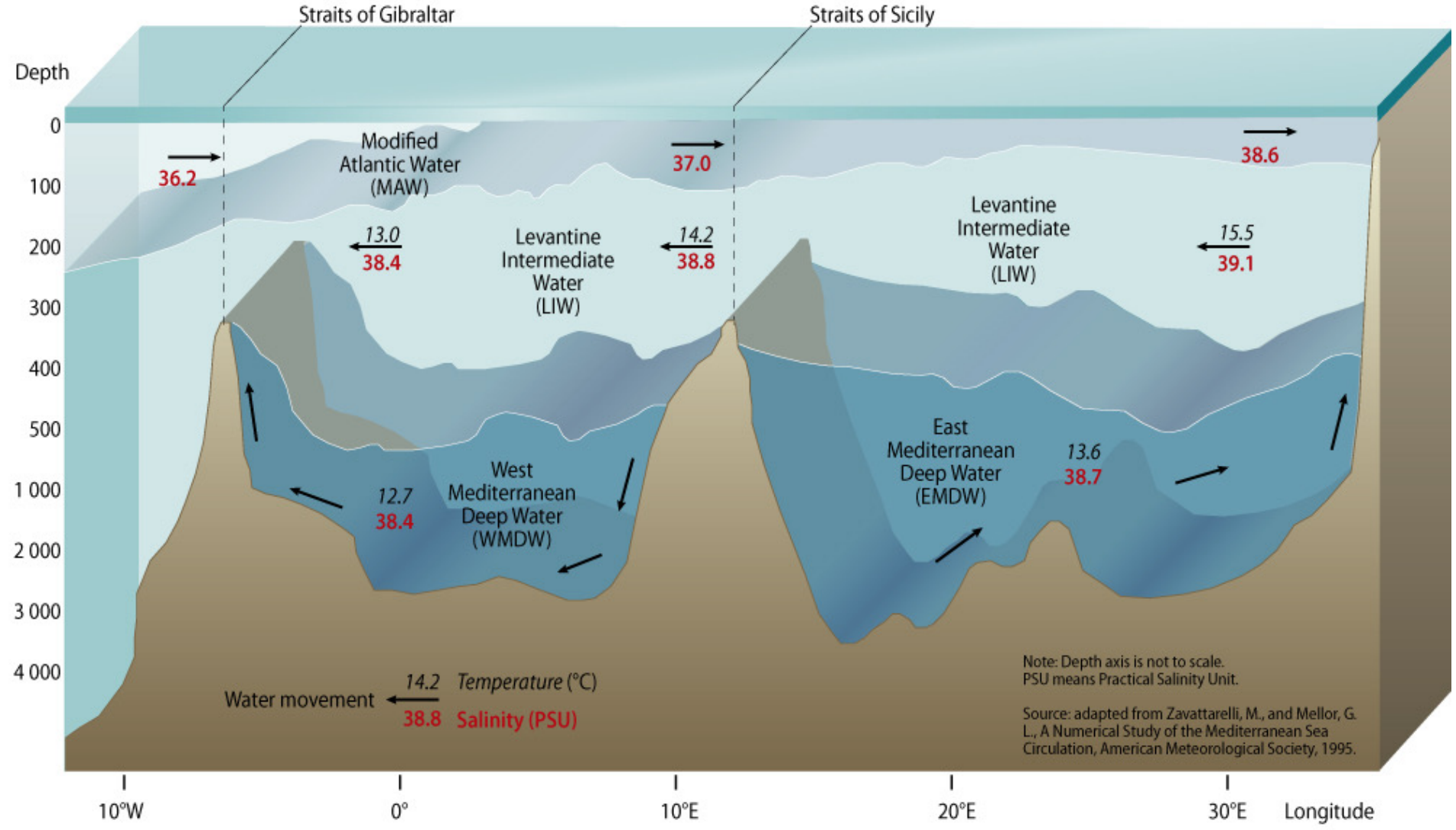
Figure 1 The Mediterranean Sea: (a) main biogeographic regions, basins and administrative divisions, and (b) maximum average depth (m).

Source: Coll et al. (2011) Global Ecology and Biogeography

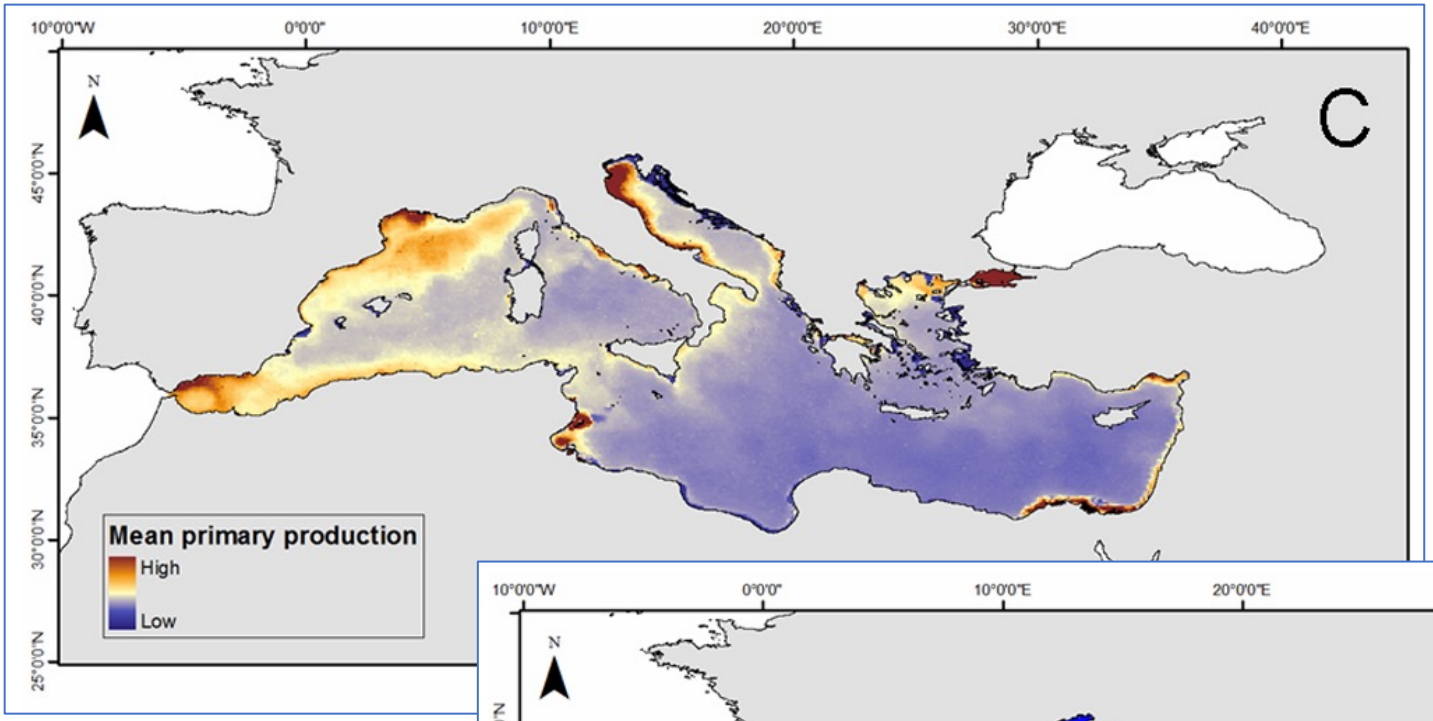


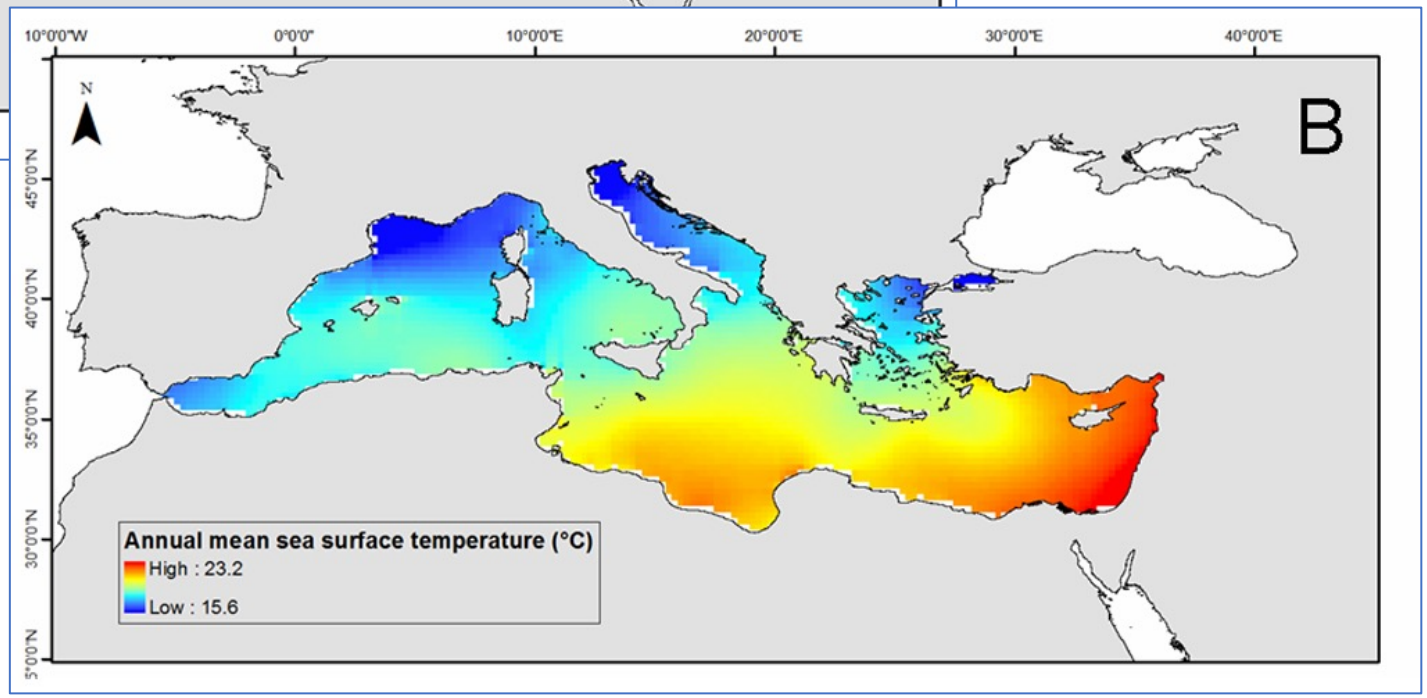
*It is a **concentration basin**: evaporation is higher in its eastern half, causing the water level to decrease and salinity to increase from west to east. The resulting pressure gradient pushes relatively cool, low-salinity water from the Atlantic across the Mediterranean basin. This water warms up to the east, where it becomes saltier and then sinks in the Levantine Sea before circulating west and exiting through the Strait of Gibraltar.*

Mediterranean Sea water masses: vertical distribution



Strong environmental gradients





West to East
&
North to South

Source: Coll et al. (2010) PLOS ONE

Biodiversity hotspot

Taxa	No. species this work	No. species worldwide*	%
Macrophytes			
Phaeophyta	277	1600	17.31
Chlorophyta	190	2500	7.60
Rhodophyta	657	6200	10.60
Magnoliophyta	7	60	11.67
Metazoans			
Porifera	681	5500	12.38
Cnidaria	757	9795	7.73
Platyhelminthes	1000	15000	6.67
Mollusca	2113	52525	4.02
Annelida	1172	12000	9.77
Crustacea	2239	44950	4.98
Bryozoa	388	5700	6.81
Echinodermata	154	7000	2.20
Ascidiacea	229	4900	4.67
Other invertebrates	2168	18565	11.68
Vertebrata (Pisces)	650	16475	3.95
Other Vertebrata	43	481	8.94
Total	**12725**	**203051**	**6.27**

*Based on Bouchet [82], Green and Short [26], and Groombridge and Jenkins [83].

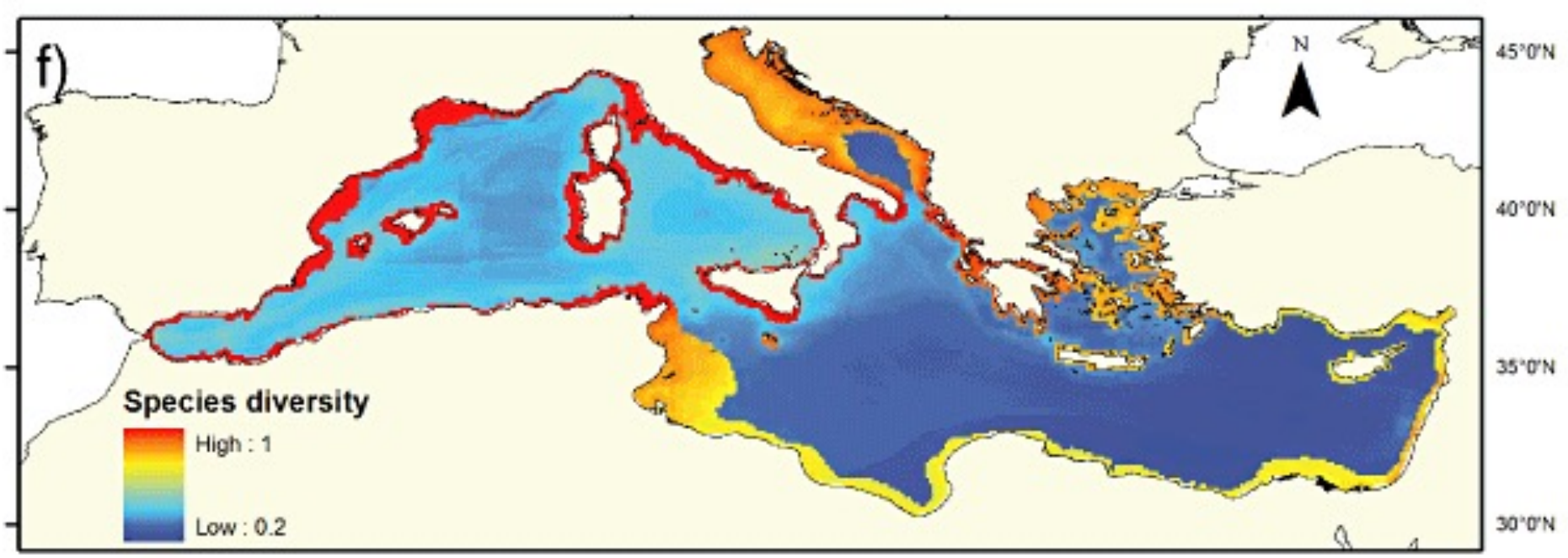
doi:10.1371/journal.pone.0011842.t004

Located between Africa, Europe and Asia, it is a **hotspot** of terrestrial and marine biodiversity.

17,000 described marine species and contributes an estimated **7%** to the world's marine biodiversity, including high percentages of endemic species.

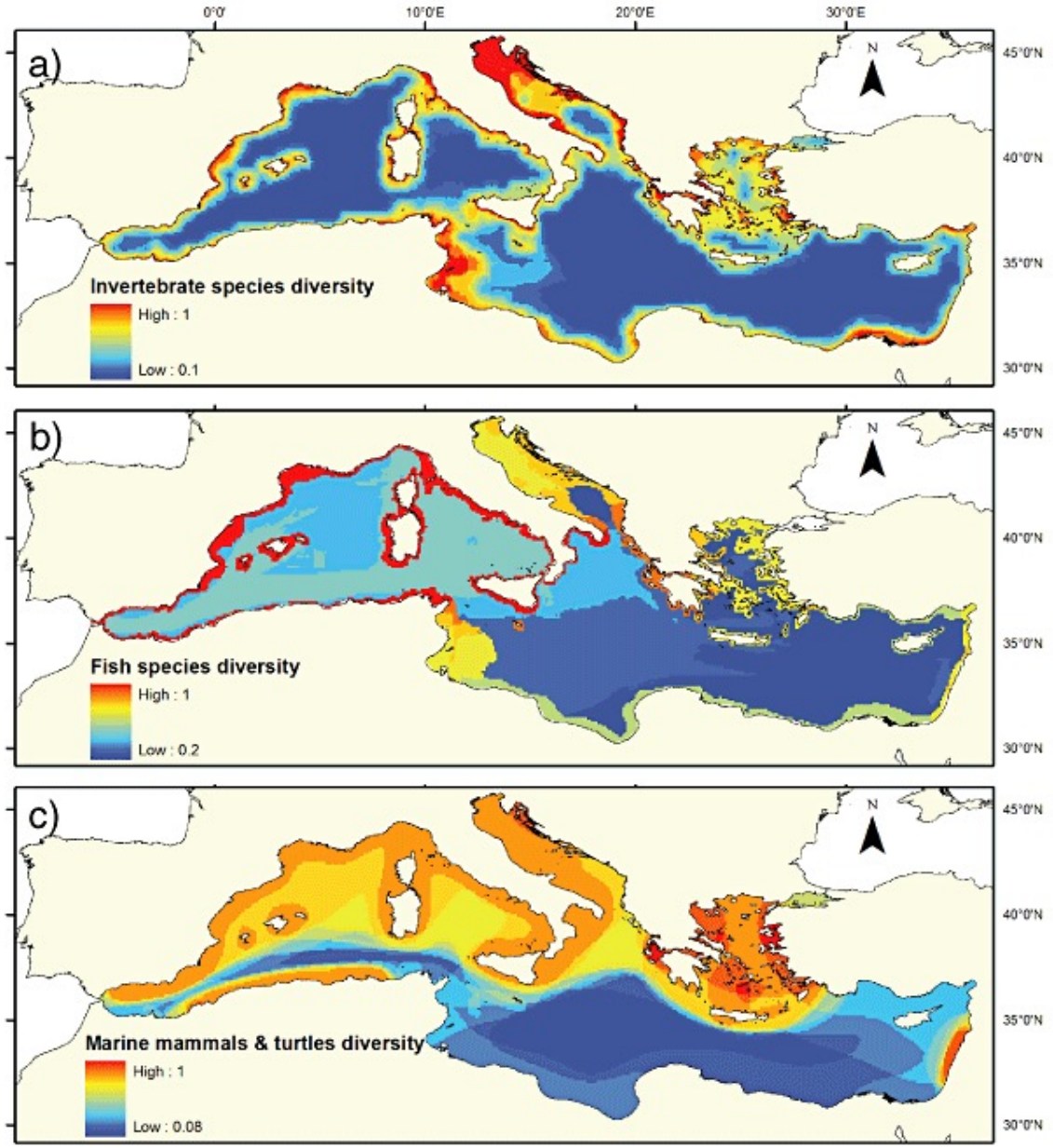
Source: Coll et al. (2010) PLOS ONE

Biodiversity gradients



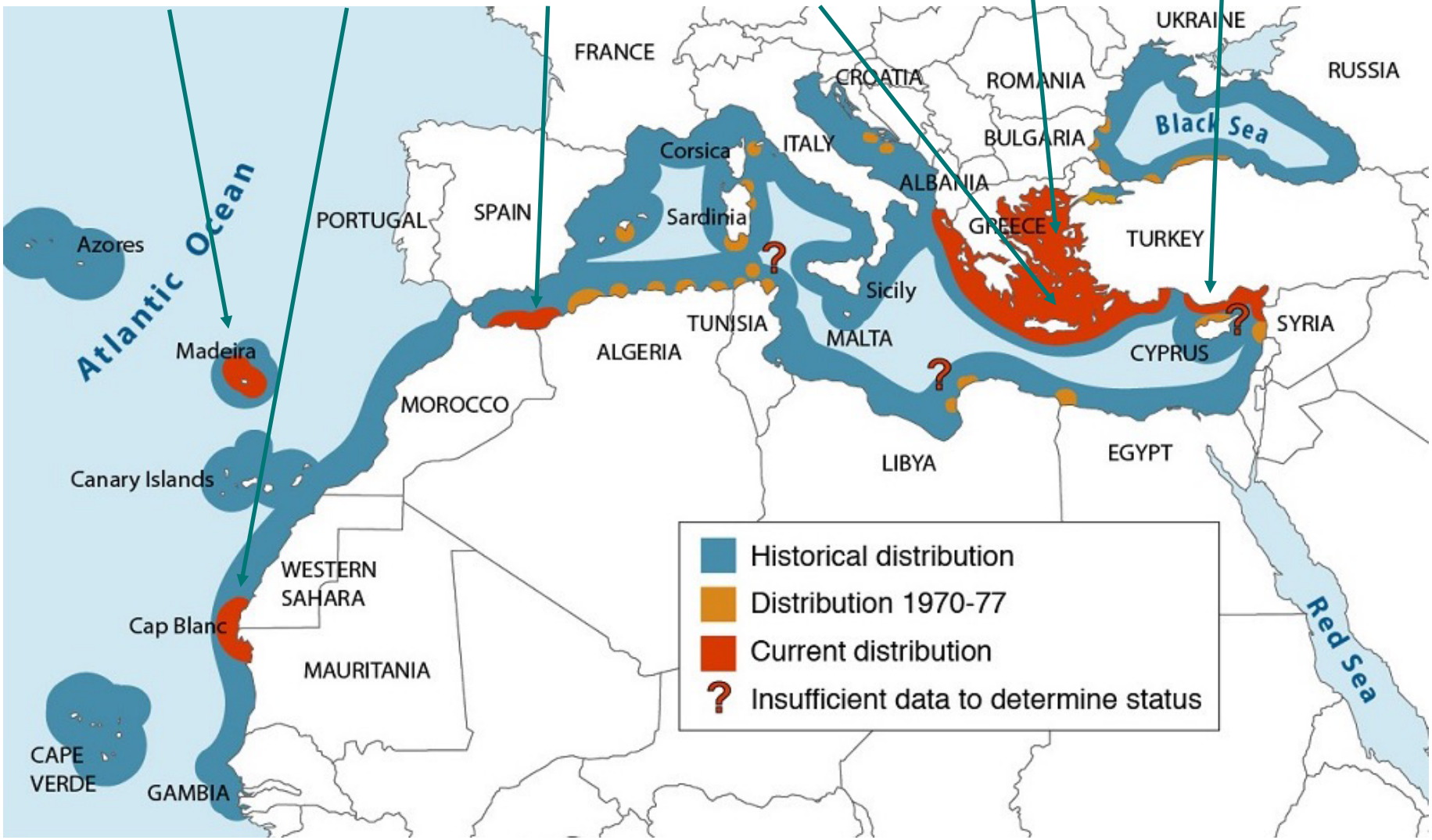
Source: Coll et al. (2011) Global Ecology and Biogeography

Biodiversity gradients



Source: Coll et al. (2011) Global Ecology and Biogeography

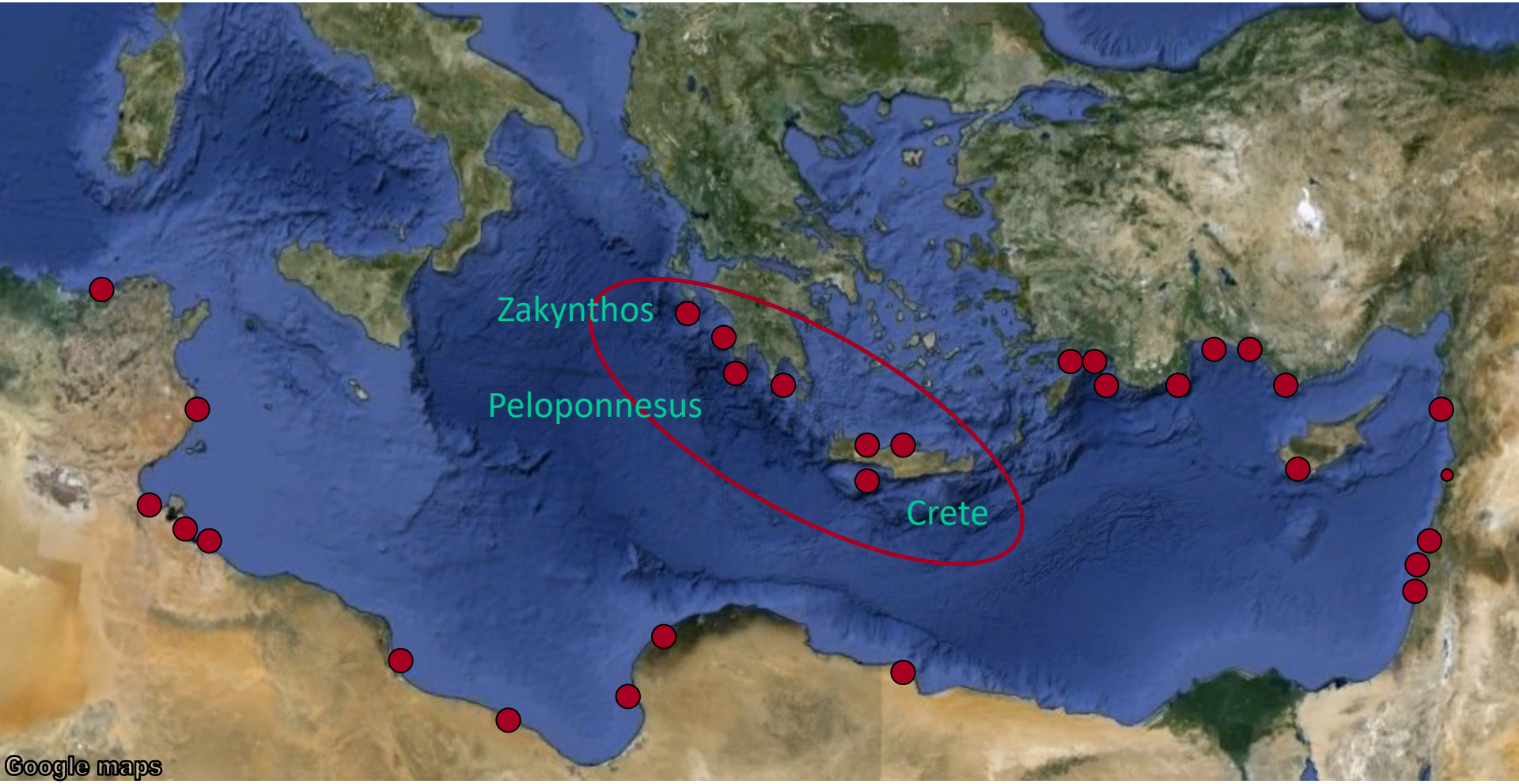
The monk seal *Monachus monachus*



The loggerhead turtle *Caretta caretta*

Greece: 60% of total nesting in the Mediterranean
Zakynthos Island: 26% of total nesting in the Mediterranean

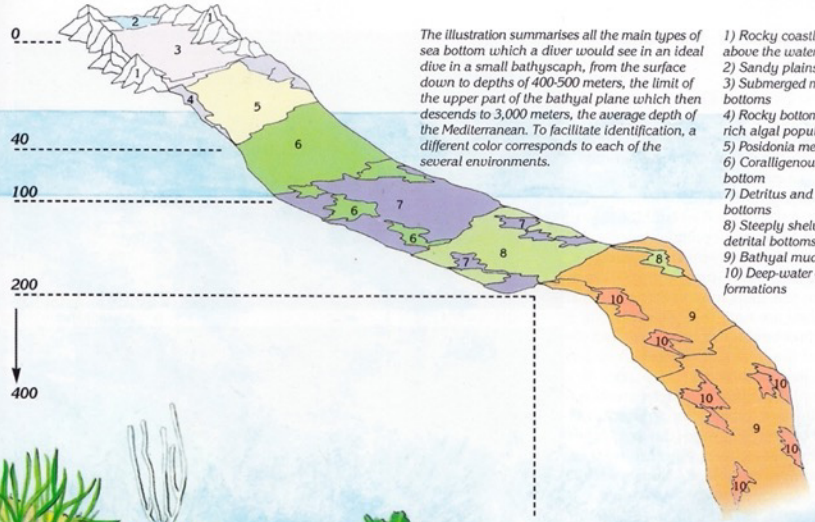
Nesting areas



2. Key benthic habitats and communities

MEDITERRANEAN ITINERARIES

Rocky bottoms are without doubt the most interesting and varied sea beds in the Mediterranean; they are home to a series of different kinds of organisms, animal and vegetable, invertebrates and vertebrates, which create highly diversified populations, each of which has adapted to the predominant environmental conditions. The increase in depth, the reduction of luminous radiations and the effect of the waves, has led scientists to divide the part of the Mediterranean closest to the surface (from 0 to around 80-100 meters) into four bands. These bands, beginning with the one closest to the surface, which is only bathed by the waves and splashes, are named the supralittoral, mesolittoral, infralittoral and circumlittoral respectively. Within these definitions, the mesolittoral comprises the area, which is limited in the Mediterranean, between high- and low-tide levels. The infralittoral goes from the part of the coast which is always submerged to the line where the Neptune grass disappears and the circumlittoral is the deepest area, stretching on average from 35-40 meters depth to 80-100.



The illustration summarises all the main types of sea bottom which a diver would see in an ideal dive in a small bathyscaph, from the surface down to depths of 400-500 meters, the limit of the upper part of the bathyal plane which then descends to 3,000 meters, the average depth of the Mediterranean. To facilitate identification, a different color corresponds to each of the several environments.

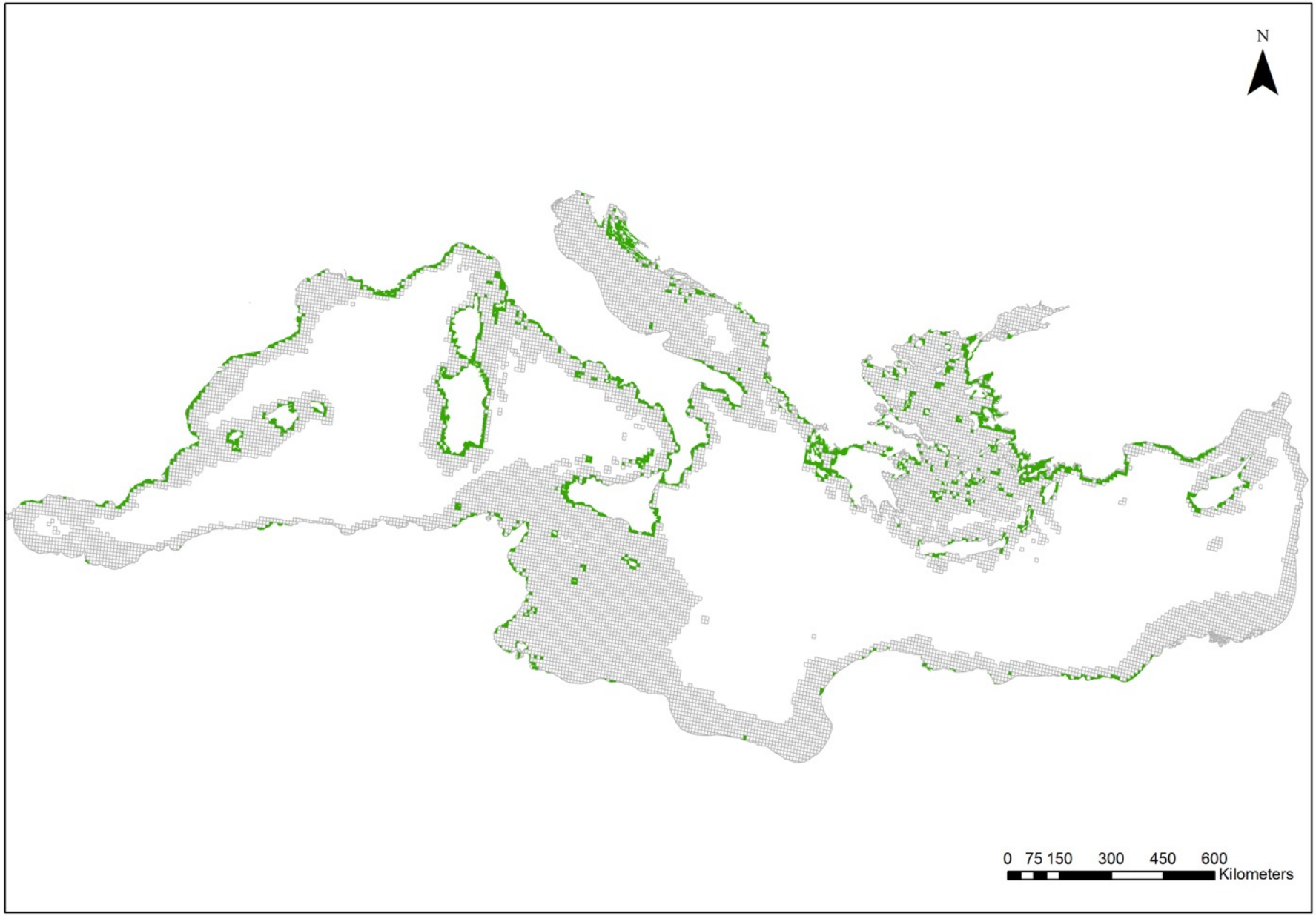
1) Rocky coastline above the water line
2) Sandy plains
3) Submerged mobile bottoms
4) Rocky bottoms with rich algal population
5) Posidonia meadows
6) Coralligenous bottom
7) Detritus and mud bottoms
8) Steeply shelving detrital bottoms
9) Bathyal mud
10) Deep-water coral formations

What is the Mediterranean? In the previous chapters I have tried to reconstruct its past, to draw a profile of it and to explain the mechanisms which make it unique. But faced with such an exceptional sea the answer becomes a very complex one. If the sea is unique for everyone, then everyone sees it with different eyes and a different soul. It is rather like what happens when visiting a museum and that, for once, is how I should like to present my Mediterranean, imagining it as a living museum with grandiose galleries, where you can invent your own, interweaving, itineraries with by the sounds of this sea as leitmotivs. There are no compulsory itineraries here in the Mediterranean and what follows is only a series of suggestions, whether for a leisurely stroll or a journey of cultural discovery. Everyone is free to choose their starting point and where to linger and look more carefully.

1) Barnacle (Chtamalus sp.)
2) Limpet (Patella sp)
3) Mussel (Mytilus galloprovincialis)
4) Lithophyllum lichenoides
5) Cistoseira (Cystoseira sp.)
6) Beadlet anemone (Actinia equina)
7) Barnacle (Balanus sp.)
8) Cerithium
9) Jania rubens
10) Corallina elongata
11) Dictyota sp.
12) Peacock's tail (Padina pavonica)
13) Black sea urchin (Arbacia lixula)
14) Rock crab (Pacygrapsus marmoratus)
15) Codium sp.
16) Common red star (Echinaster sepositus)
17) Codium bursa
18) Sargassum sp
19) Posidonia oceanica
20) Sea anemone (Anemonia sulcata)
21) Purple sea urchin (Spaerechinus granularis)
22) Crinoid (Antedon mediterranea)
23) Holothuria polii
24) White sea fan (Eunicella singularis)
25) Aplysina aerophoba
26) Alcyonium palmatum
27) False coral (Myriapora truncata)
28) Halimeda tuna
29) Udotea petiolata
30) Smittina cervicornis
31) Axinella sp.
32) Spirastrella cunctatrix
33) Halocibthya papillosa
34) Pentapora fascialis
35) Haliclona mediterranea
36) Sea lace bryozoan (Sertella septentrionalis)
37) Anchinoe sp.
38) Red coral (Corallium rubrum)
39) Yellow sea fan (Eunicella cavolinii)
40) Yellow zoanthid (Parazoanthus axinellae)
41) Ophiothrix sp.
42) Red sea fan (Paramuricea clavata)
43) Pareythropodium coralloides
44) Tube coral (Cladocora caespitosa)
45) Warty sea fan (Eunicella verrucosa)

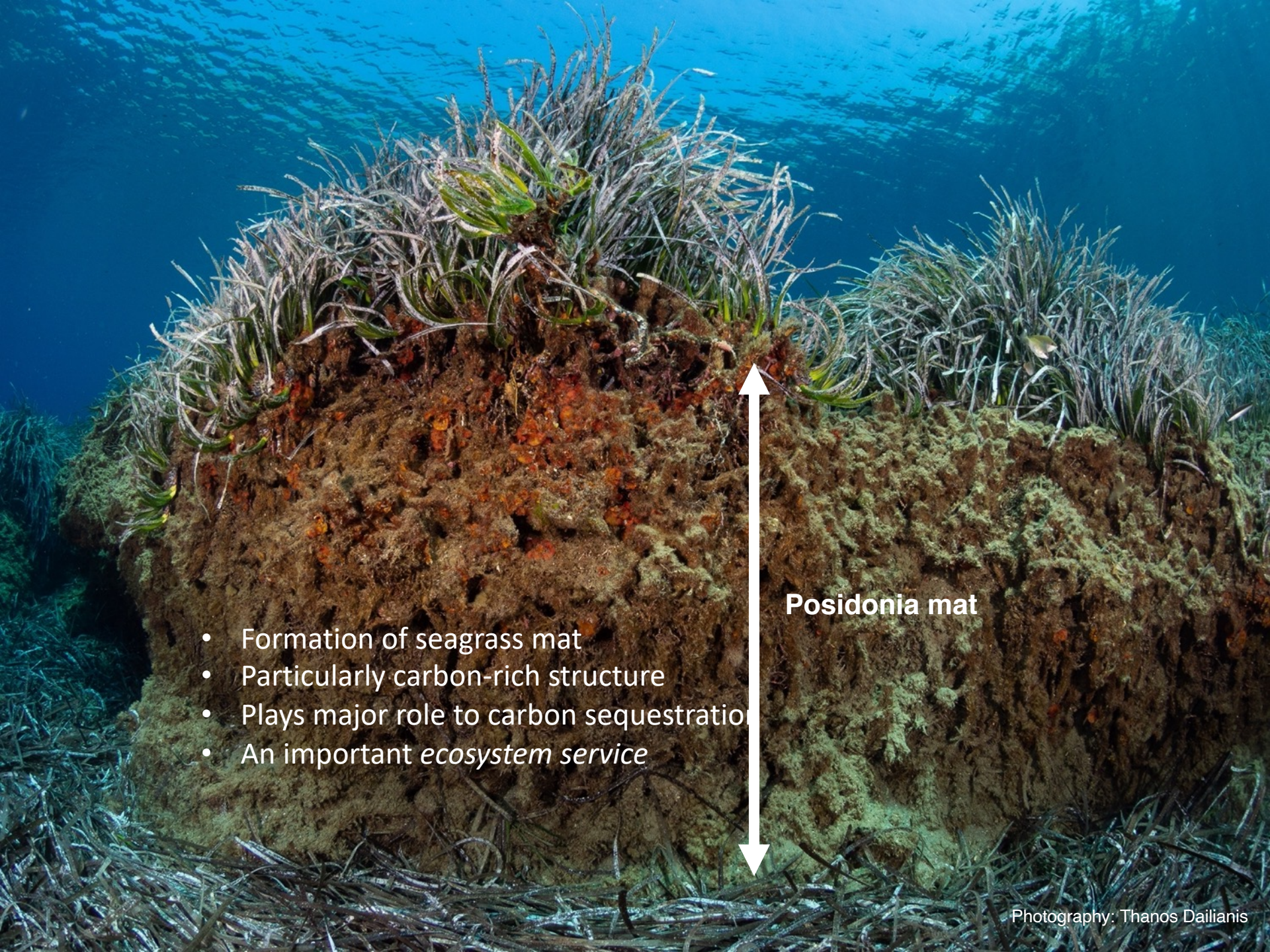
Source: Mojetta (2005)


Posidonia oceanica
Seagrass meadows
Photos: Thanos Dailianis

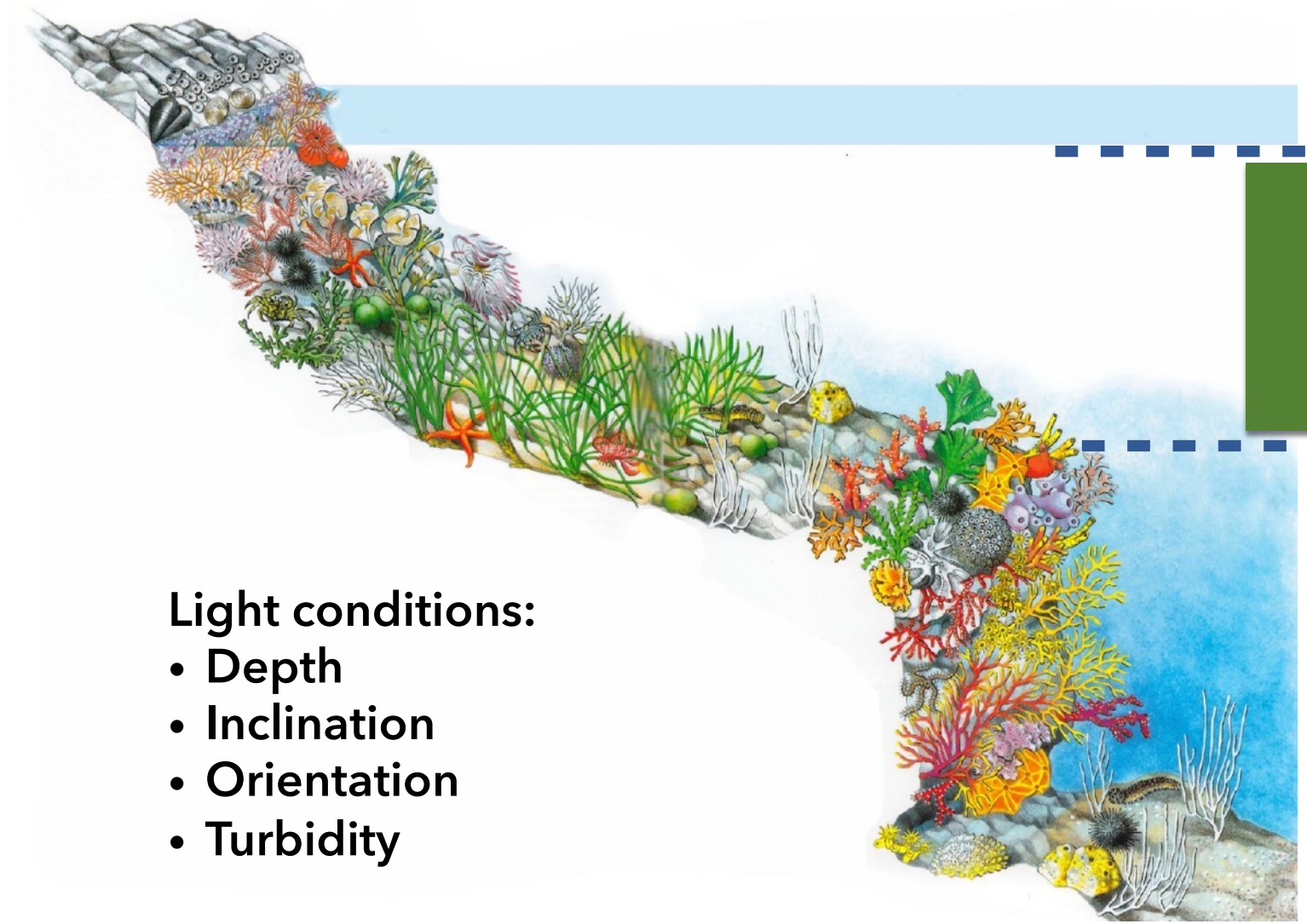


Source: Giakoumi et al. (2013)

Source: Mojetta (2005)


Posidonia mat
• Formation of seagrass mat
• Particularly carbon-rich structure
• Plays major role to carbon sequestratio
• An important *ecosystem service*
Photography: Thanos Dailianis

Photophilic algae communities



1 m

≈20 m

Lower depth down to 40-50 m depending on environmental conditions

Light conditions:

- Depth
- Inclination
- Orientation
- Turbidity

Source: Mojetta (2005)

ALGAL FORMATIONS:

- Canopy-forming
- Provision of habitat supporting biodiversity
- Also known as “marine forests”

Photography: Thanos Dailianis


Photography: Thanos Dailianis

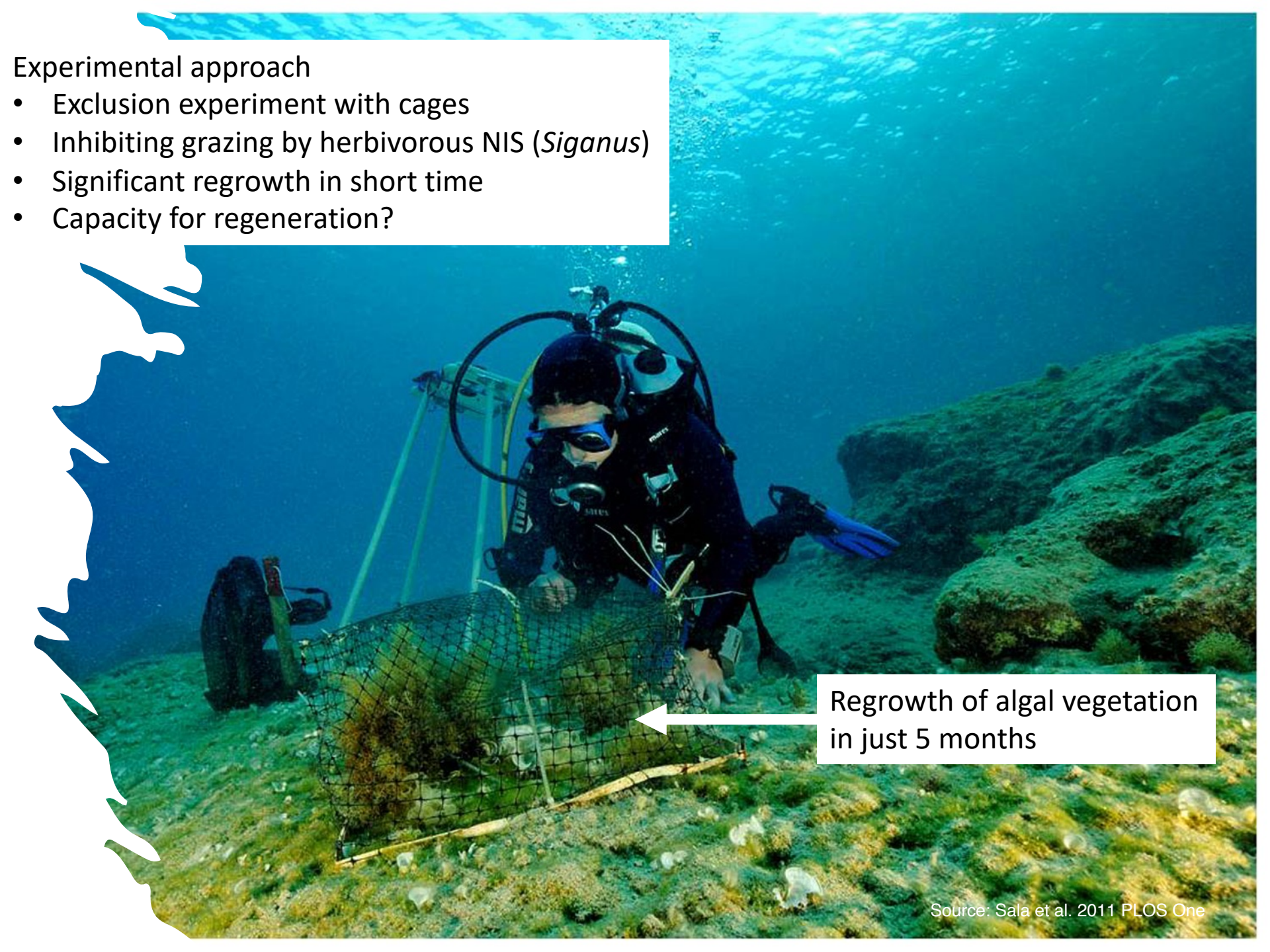
Marine ”deforestation”?

- Disappearance of erect algal formations
- Extensive formations of rocky barrens
- Lower complexity >> less biodiversity

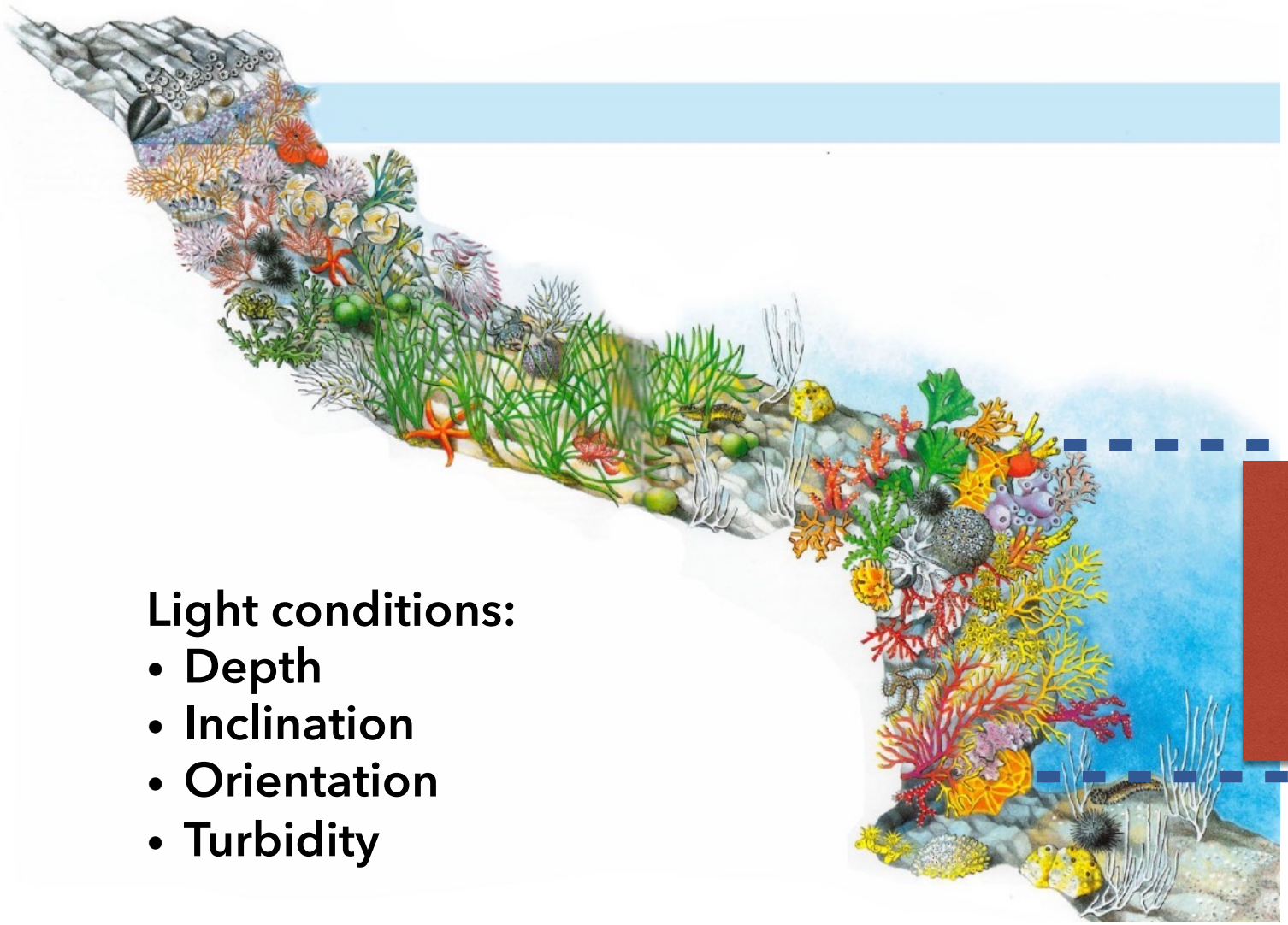
Photography: Vasilis Gerovasileiou

Experimental approach

- Exclusion experiment with cages
- Inhibiting grazing by herbivorous NIS (*Siganus*)
- Significant regrowth in short time
- Capacity for regeneration?



Sciaphilic reef communities



15 m

120 m

Light conditions:

- Depth
- Inclination
- Orientation
- Turbidity

Source: Mojetta (2005)

The coralligenous habitat

Mediterranean coralline reefs

- native Mediterranean seascape
- biogenic construction (coralline algae under dim-light conditions)
- complex in structure

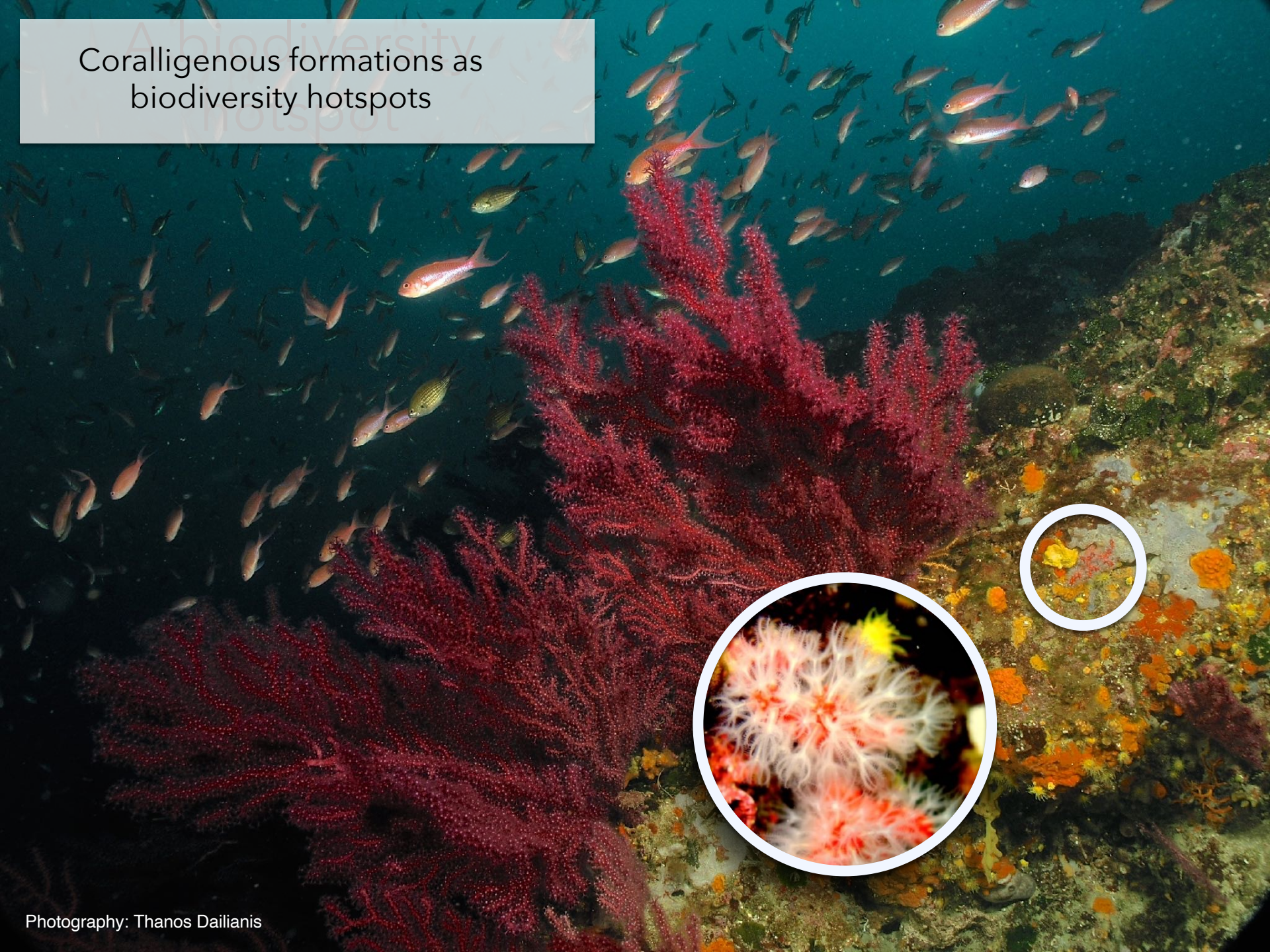
Drawing from Ballesteros 2006

Photography: Thanos Dailianis

Coralligenous formations as biodiversity hotspots

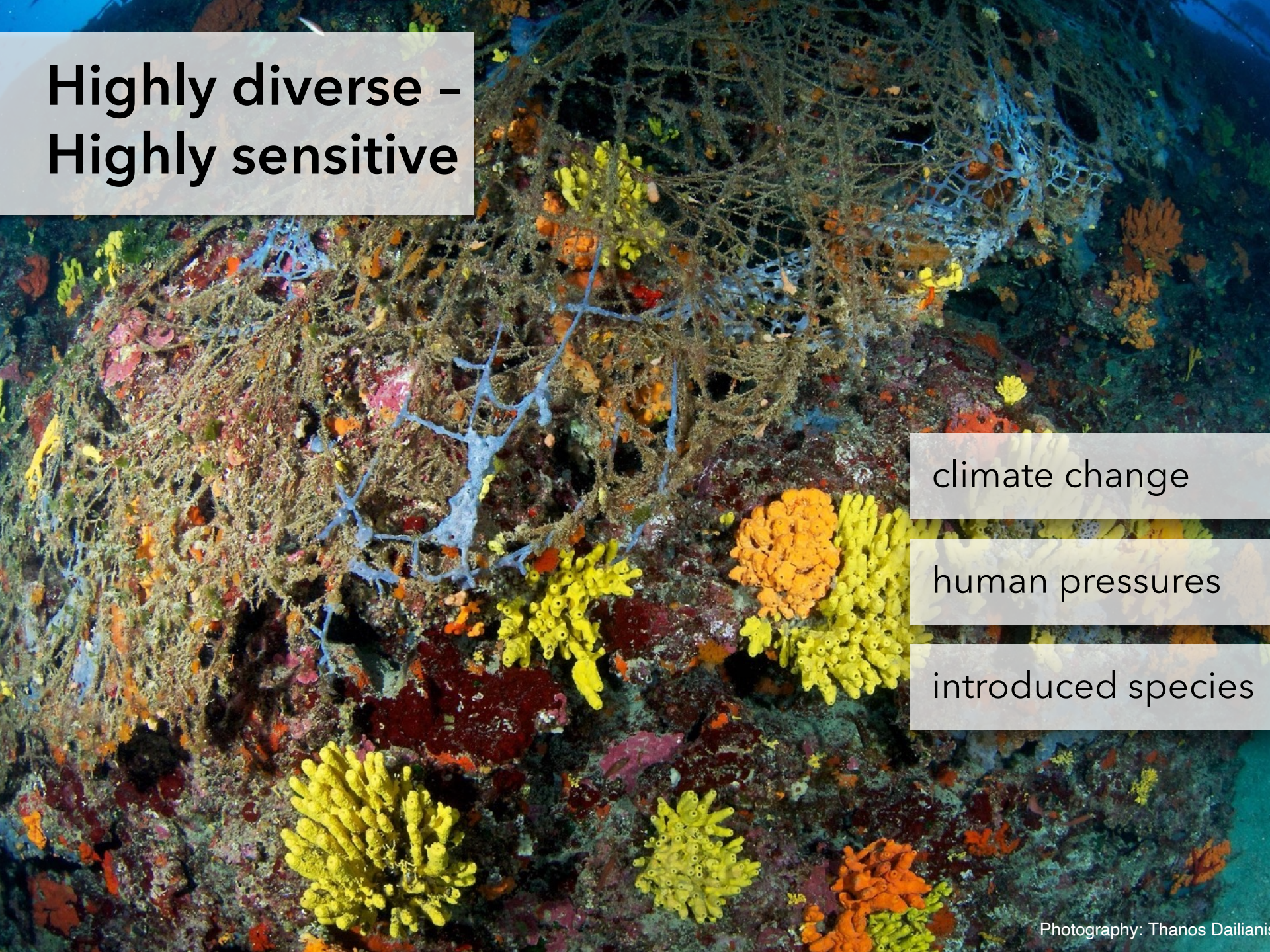
Photography: Yiannis Issaris

Coralligenous formations as biodiversity hotspots



Photography: Thanos Dailianis

Photography: Thanos Dailianis


Highly diverse –
Highly sensitive
climate change
human pressures
introduced species
Photography: Thanos Dailiani

Marine caves in the Mediterranean Sea

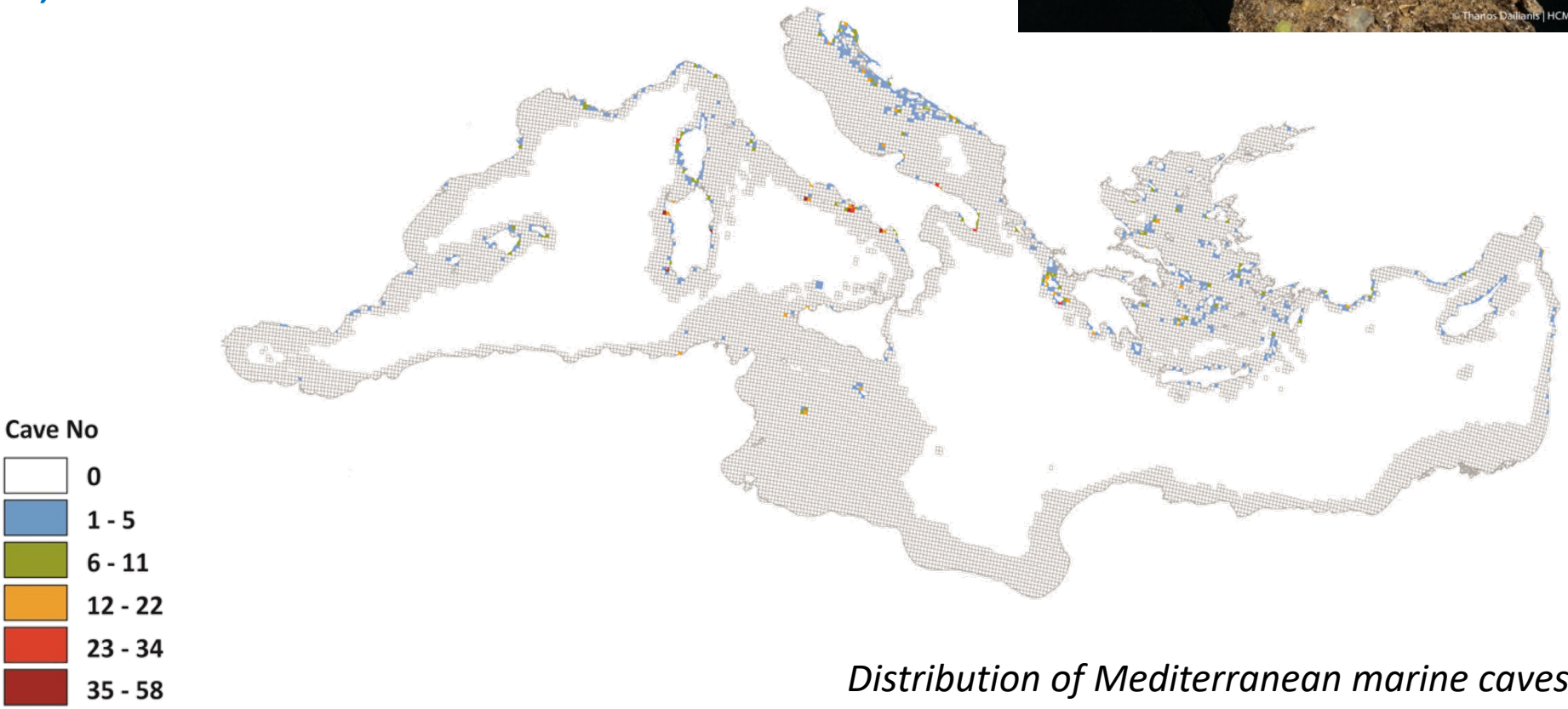
OPEN ACCESS Freely available online

PLOS ONE

Ecoregion-Based Conservation Planning in the Mediterranean: Dealing with Large-Scale Heterogeneity

Sylvaine Giakoumi[1,2*], Maria Sini[3], Vasilis Gerovasileiou[4], Tessa Mazor[2], Jutta Beher[2], Hugh P. Possingham[2], Ameer Abdulla[2,5], Melih Ertan Çinar[6], Panagiotis Dendrinos[7], Ali Cemal Gucu[8], Alexandros A. Karamanlidis[7], Petra Rodic[9], Panayotis Panayotidis[10], Ergun Taskin[11], Andrej Jaklin[12], Eleni Voultsiadou[4], Chloë Webster[13], Argyro Zenetos[1], Stelios Katsanevakis[14]

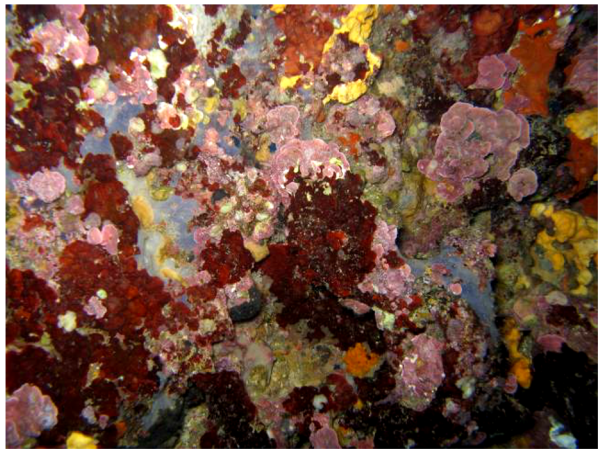
3,000 marine caves known so far…



Distribution of Mediterranean marine caves

Ecological zonation

Photography: Vasilis Gerovasileiou



Coralligenous community

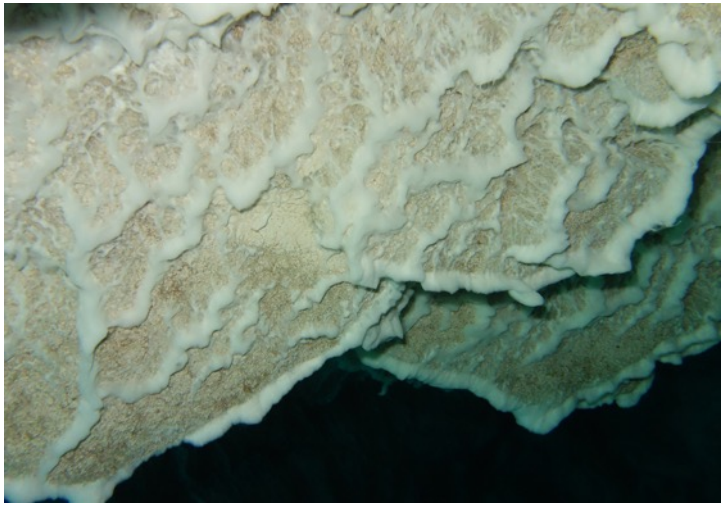
Semi-dark cave community

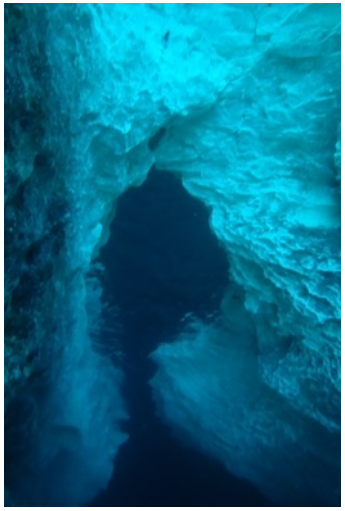
Dark cave community

Unique diversity, assemblages & structures

Photography: Vasilis Gerovasileiou

Serpulid & bryozoan bio-stalactites (Sanfilippo et al., 2017 JMBA UK)





Bacterial structures (Polymenakou et al., 2018 Mediterranean Marine Science)

Marine caves as “biodiversity reservoirs”

Refuge for several rare, protected and threatened species

Monachus monachus

IUCN Red List status

Corallium rubrum

IUCN Red List status

3. Threats, challenges and conservation

Coastal development and infrastructure construction

- Space is at premium in the coastal zone
- Attracts many economic activities
- High demand for settlement
- Important part for everyday lives

Photography: Vasilis Gerovasileiou


Photo: Thanos Dailianis

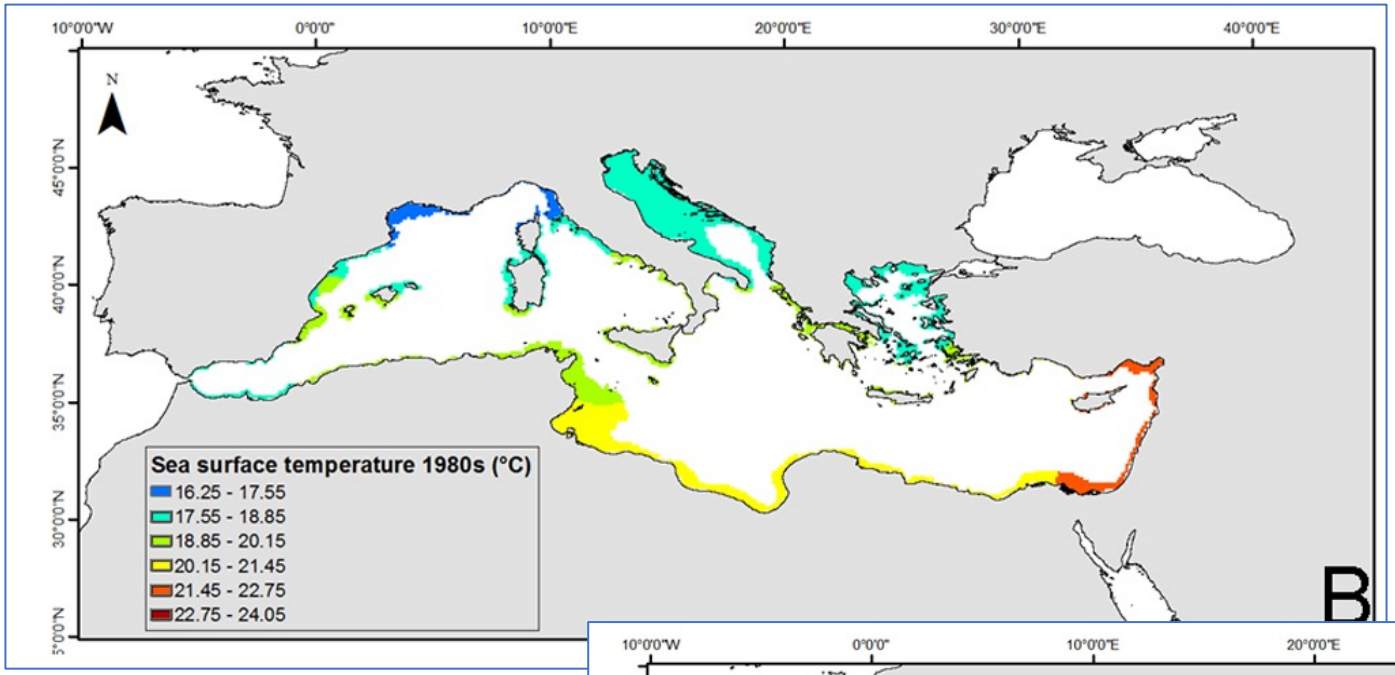

Credit: Rob Faulkner, flickr

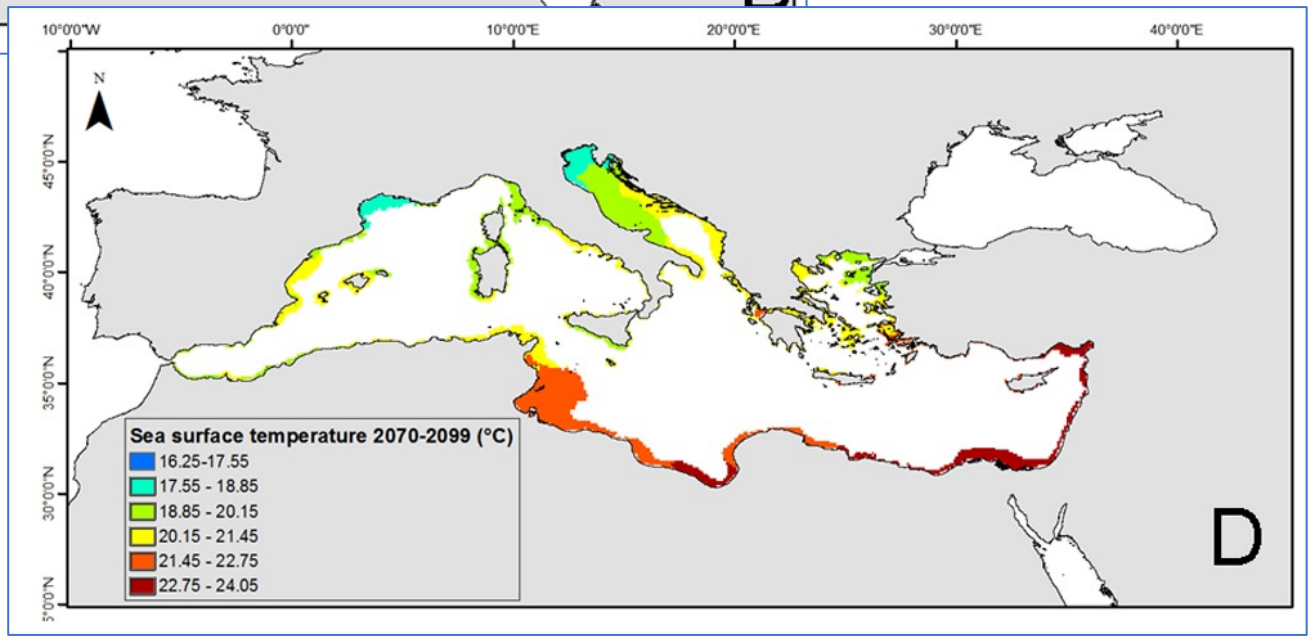

Credit: Jay Yeary, flickr


Photo: Thanos Dailianis


Photo: Thanos Dailianis

Water temperature rise

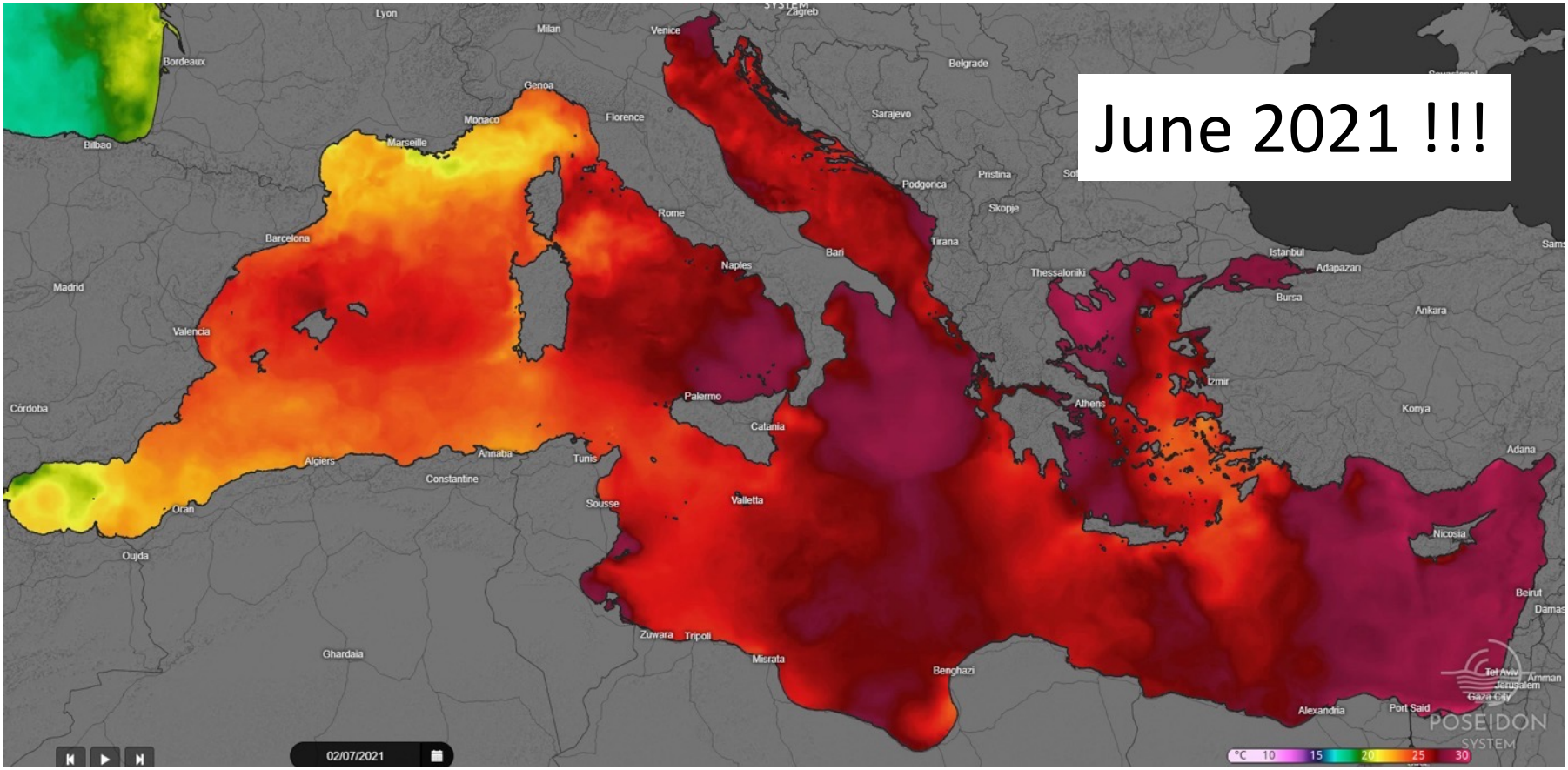




Source: Coll et al. (2010) PLOS ONE

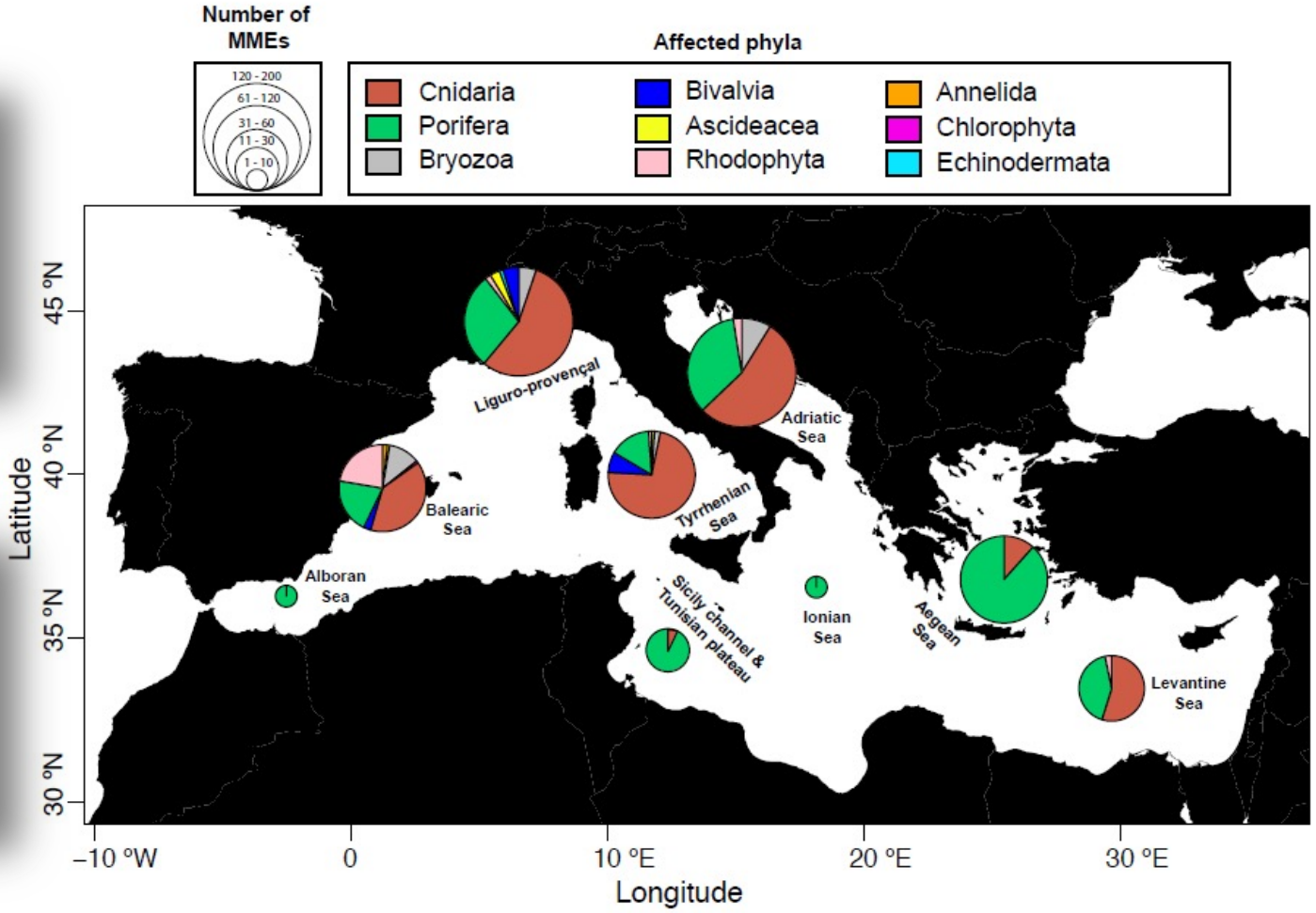
Extreme climatic events

- Marine heatwaves
- Usually accompany atmospheric heatwaves
- Increased frequency and duration of extreme events



Source: Denaxa and the HCMR POSEIDON team 2021

Mass mortality events



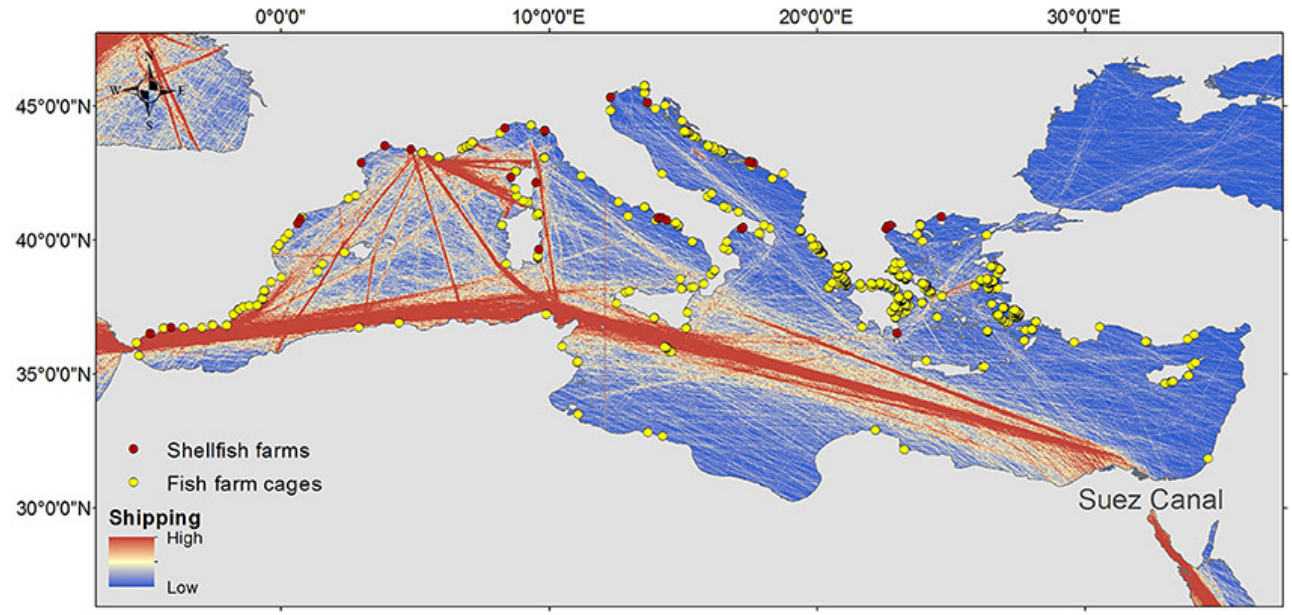
676 mass mortality events from 1979 to 2017

MME-T-MEDNet

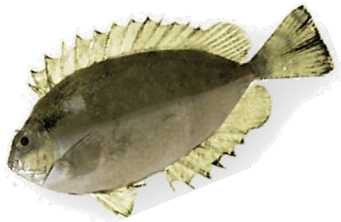
http://www.t-mednet.org/

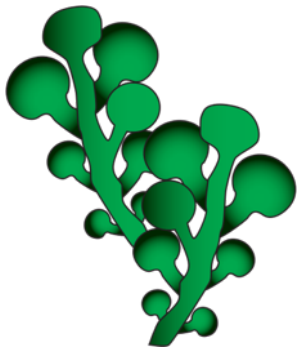
Source: Garrabou et al. 2019, Frontiers in Marine Science

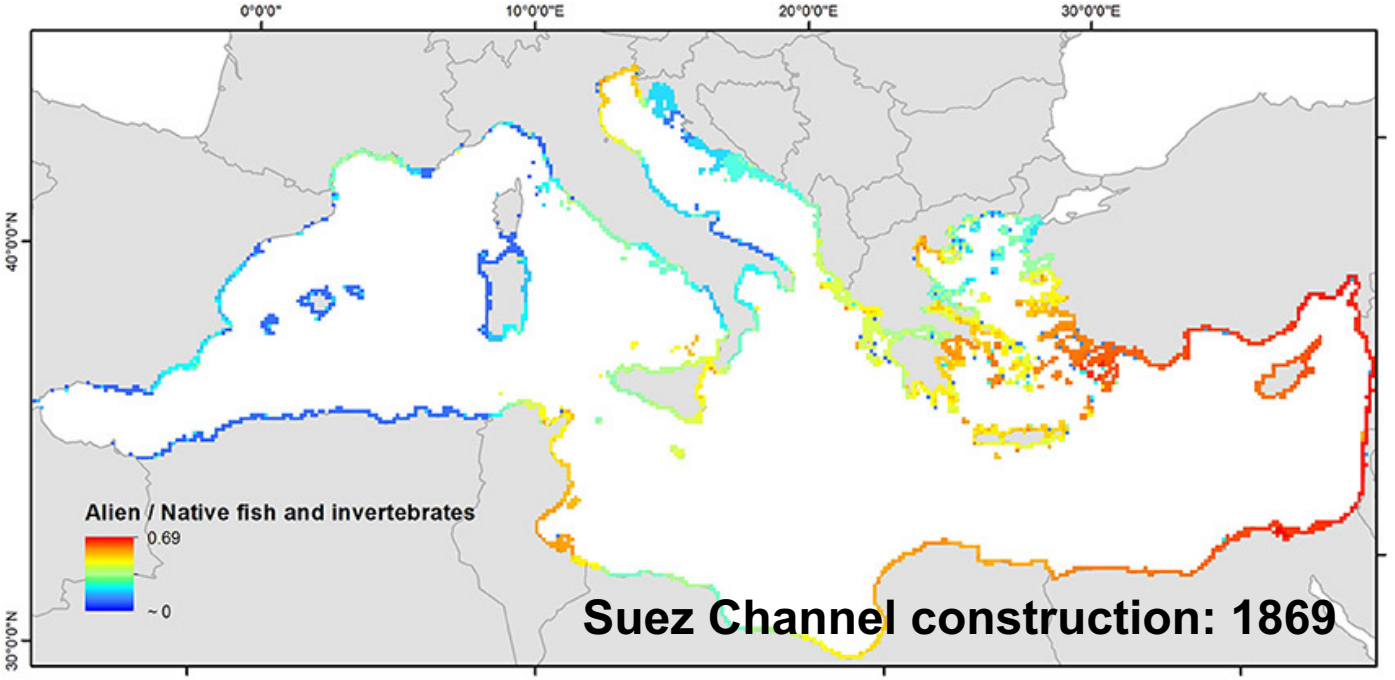
Non-indigenous species (NIS)



Nearly 1000 NIS!







Source: Katsanevakis et al. (2014) Frontiers in Marine Science

The invasion of the Lionfish in the Mediterranean

>> First observation in the Mediterranean (coast of Lebanon) in 2013

Short Communication

Mediterranean Marine Science
Indexed in WoS (Web of Science, ISI Thomson) and SCOPUS
The journal is available on line at http://www.medit-mar-sc.net
DOI: http://dx.doi.org/10.12681/mms.428

The presence of the invasive Lionfish *Pterois miles* in the Mediterranean Sea

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Handling Editor: Argyro Zenetos

Received: 12 April 2013; Accepted: 9 May 2013; Published on line: 4 June 2013

>> First observation in the Aegean Sea (Rhodes) in 2014

4.3 First occurrence of the invasive lionfish *Pterois miles* in Greece and the Aegean Sea

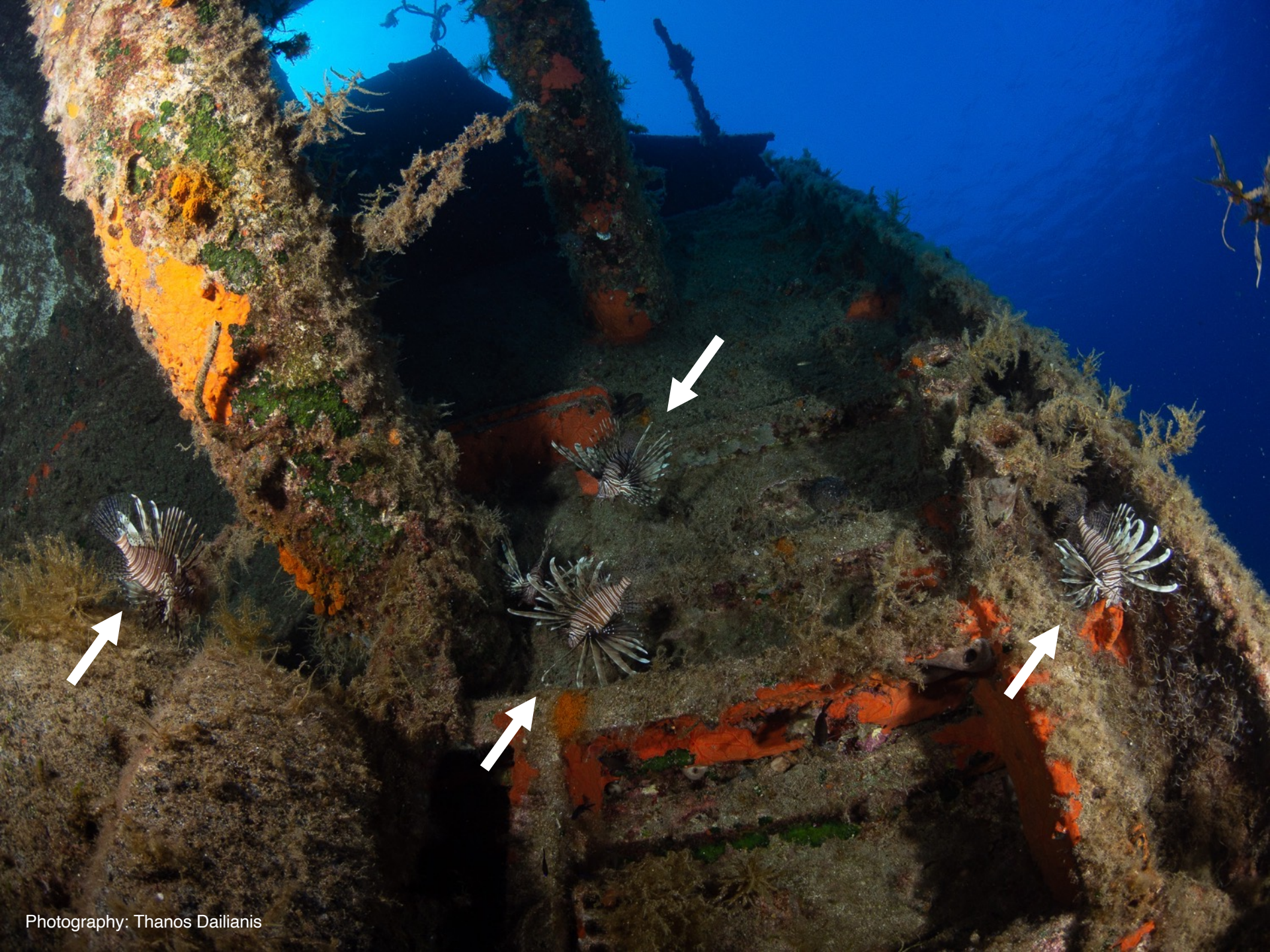
M. Corsini-Foka & G. Kondylatos

Pterois miles (Bennett, 1828) (Actinopteri: Scorpaeniformes: Scorpaenidae) is a species native to the Indian Ocean, from the Red Sea to Sumatra, and invasive to the Atlantic Ocean. Its occurrence has also been ascertained along the eastern Levantine Sea coasts, first in Israel in 1991 (Golani & Sonin, 1992), later in Lebanon in 2012 (Bariche *et al*., 2013), along the northeastern Mediterranean coasts of Turkey in 2014 (Turan *et al*., 2014) and in Cyprus in 2013 and 2015 (see Oray *et al*., 2015).

A single lionfish specimen was photographed by divers on 15th July 2015 in Kallithea (Rhodes Island) (36.3855° N - 28.2458° E), at 7 m depth under a large rock covered by vegetation on a sandy bottom (Fig. 11). On 2nd August 2015, a lionfish was also observed by divers in the shipwreck of Plimmiri Bay (35.9194° N - 27.8566° E), about one kilometer off the southeastern coasts of the island, while another specimen was sighted by a swimmer on 23rd September 2015 at 2 m depth in Psaropoula, Rodos town (approximate coordinates 36.4539° N - 28.2181° E). At the moment, the available photographic material is not sufficient for distinguishing *P. miles* from its congeneric *Pterois volitans* (Linnaeus, 1758), as the two species are morphologically similar (Bariche *et al*., 2013). Nevertheless, it is reasonable and highly probable that the specimen of the lionfish reported here belongs to *P. miles*, since the marine environment of the island is suitable for the introduction and establishment of alien biota of Indo-Pacific origin, generally, after their spread along the Levantine Mediterranean coasts (Corsini-Foka *et al*., in press). Therefore, our findings constitute the first not only in Greece, but also the entire Aegean Sea.

Fig. 11: The invasive lionfish *Pterois miles* from Kallithea. Photo by Antonis Kantaros.

P. miles is considered to be one of the most successful invasive aquatic species globally; the frequency of records in the last three years at various eastern Mediterranean locations may suggest that this alien fish has recently found environmental conditions that are favourable for its invasive character, after twenty years since its first finding in the basin (Golani & Sonin, 1992). Being dangerous for humans also, due to highly venomous fin spines (Bariche *et al*., 2013), we suggest that the wider community is informed and authorities alerted as early as possible as regards the presence of this fish in the region. Finally, these records confirm the importance of citizen scientists in providing information on biological invasions and monitoring alien dispersion (Zenetos *et al*., 2013, 2015b).



Photography: Thanos Dailianis

Invasive species

Cyprus begins lionfish cull to tackle threat to Mediterranean ecosystem

Voracious fish are bleeding into ocean 'like a cut artery', says top marine biologist

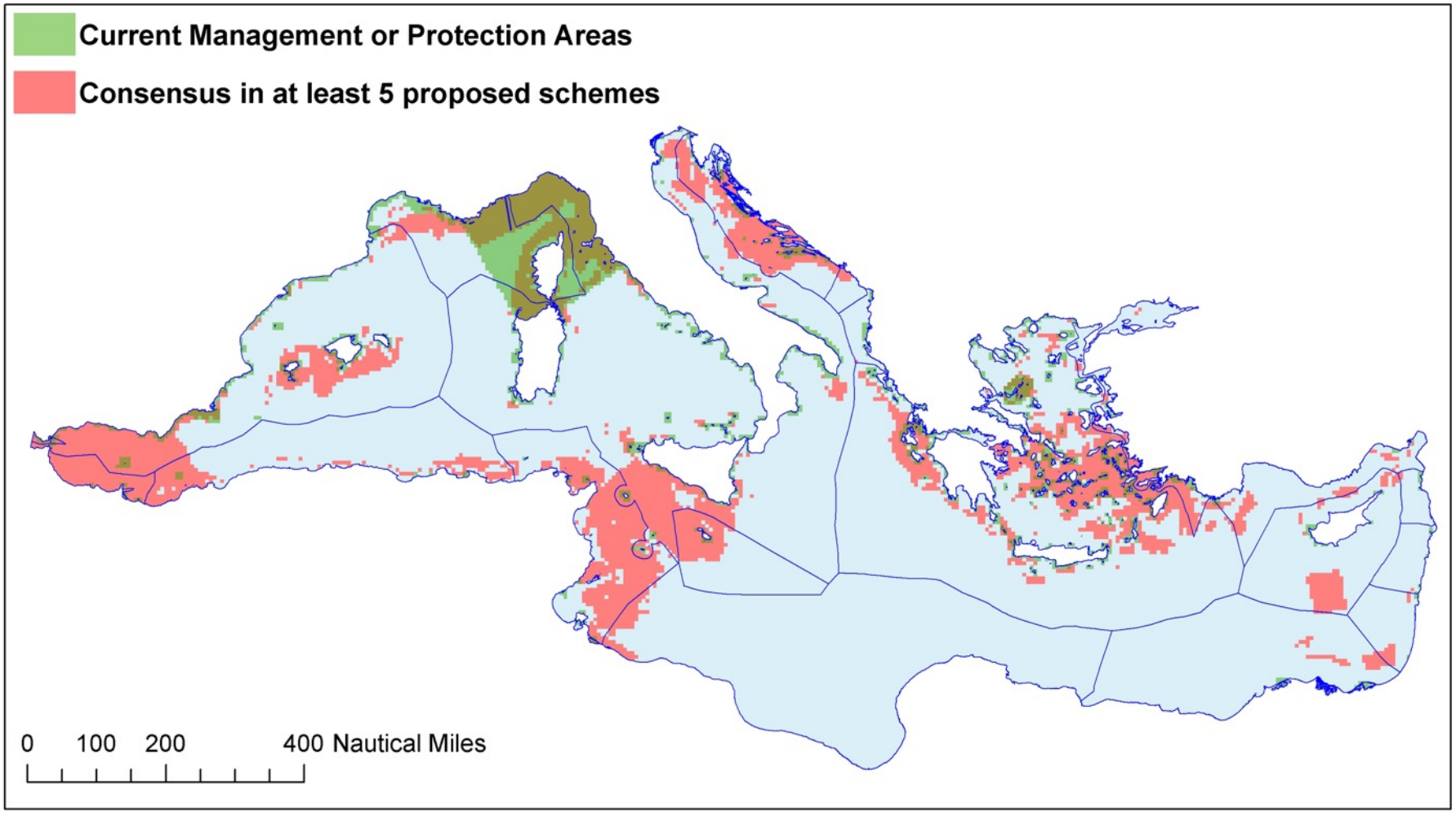
Helena Smith *in Nicosia*

Wed 29 May 2019 12.25 BST

▲ Lionfish, armed with venomous dorsal spines that enable them to deter predators, are more normally associated with warm tropical waters. Photograph: Andre Seale/VWPics/Alamy Stock Photo

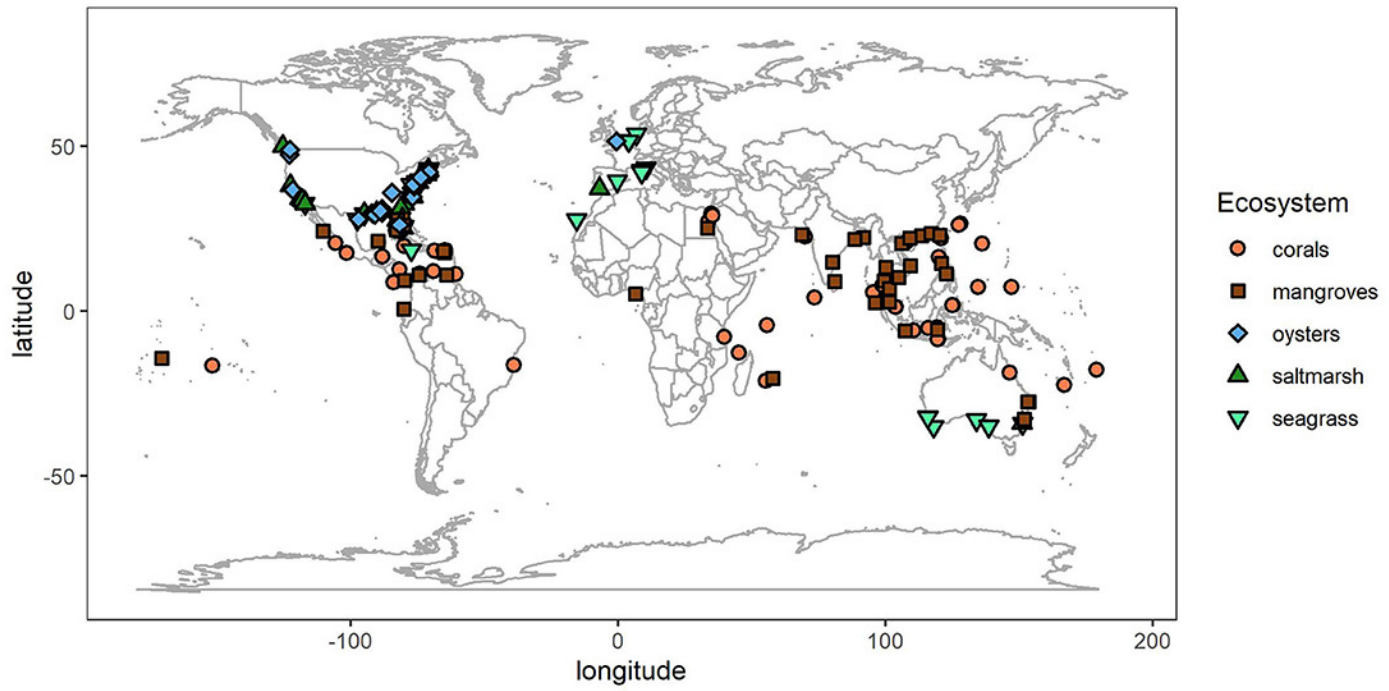
Marine conservation

MPAs cover only 0.1% - 3.8% of the MED



Source: Micheli et al. (2013) PLOS ONE

Marine Ecosystem Restoration



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