

An underwater photograph showing a large school of small, silvery fish swimming in clear blue water. The fish are positioned in the middle ground, moving towards the right. Below them, a dark, rocky seabed is visible, covered with green algae and other marine life. Sunlight rays filter down from the surface, creating a bright, shimmering effect at the top of the frame.

**GLOBAL CHANGE ECOLOGY AND SUSTAINABILITY**  
**a.a. 2024-2025**

**Conservation and Management of Marine Ecosystems**  
**Prof. Stanislao Bevilacqua ([sbevilacqua@units.it](mailto:sbevilacqua@units.it))**

**Intertidal and subtidal rocky habitats**



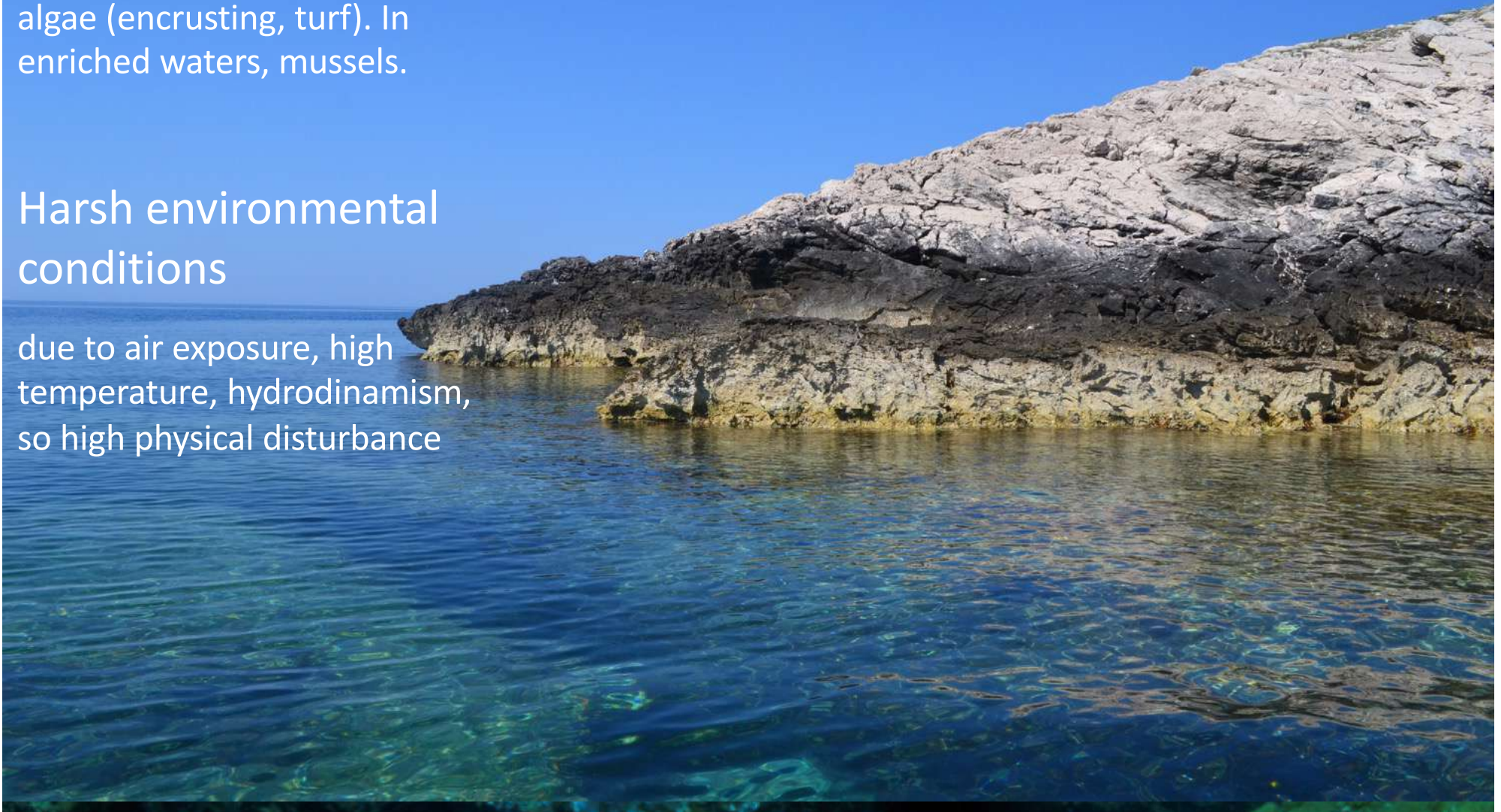
# Intertidal rocky reefs

## Reduced diversity

Barnacles, littorinids, limpets, cyanobacteria, anthozoans, algae (encrusting, turf). In enriched waters, mussels.

## Harsh environmental conditions

due to air exposure, high temperature, hydrodynamism, so high physical disturbance

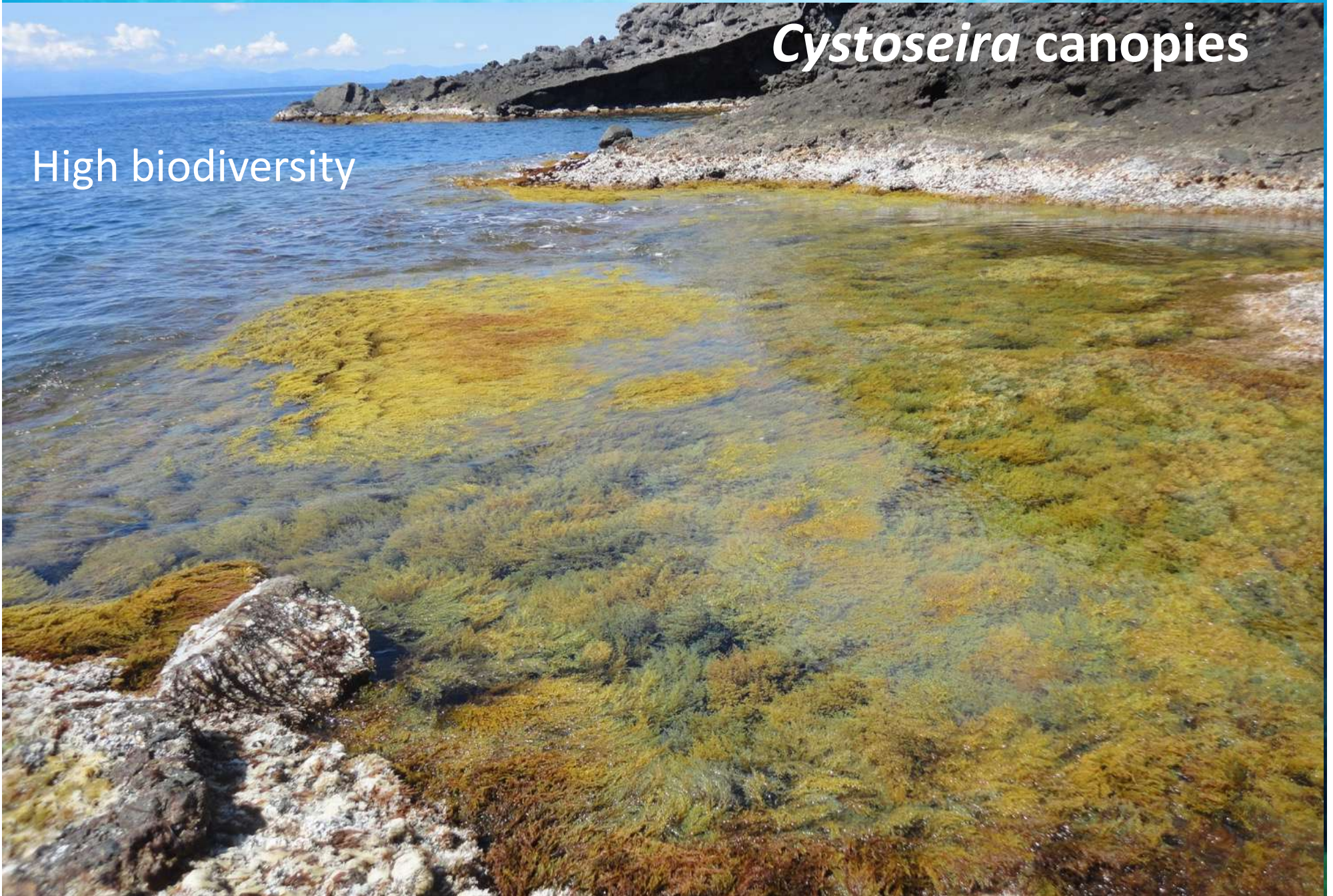




# Intertidal rocky reefs

*Cystoseira* canopies

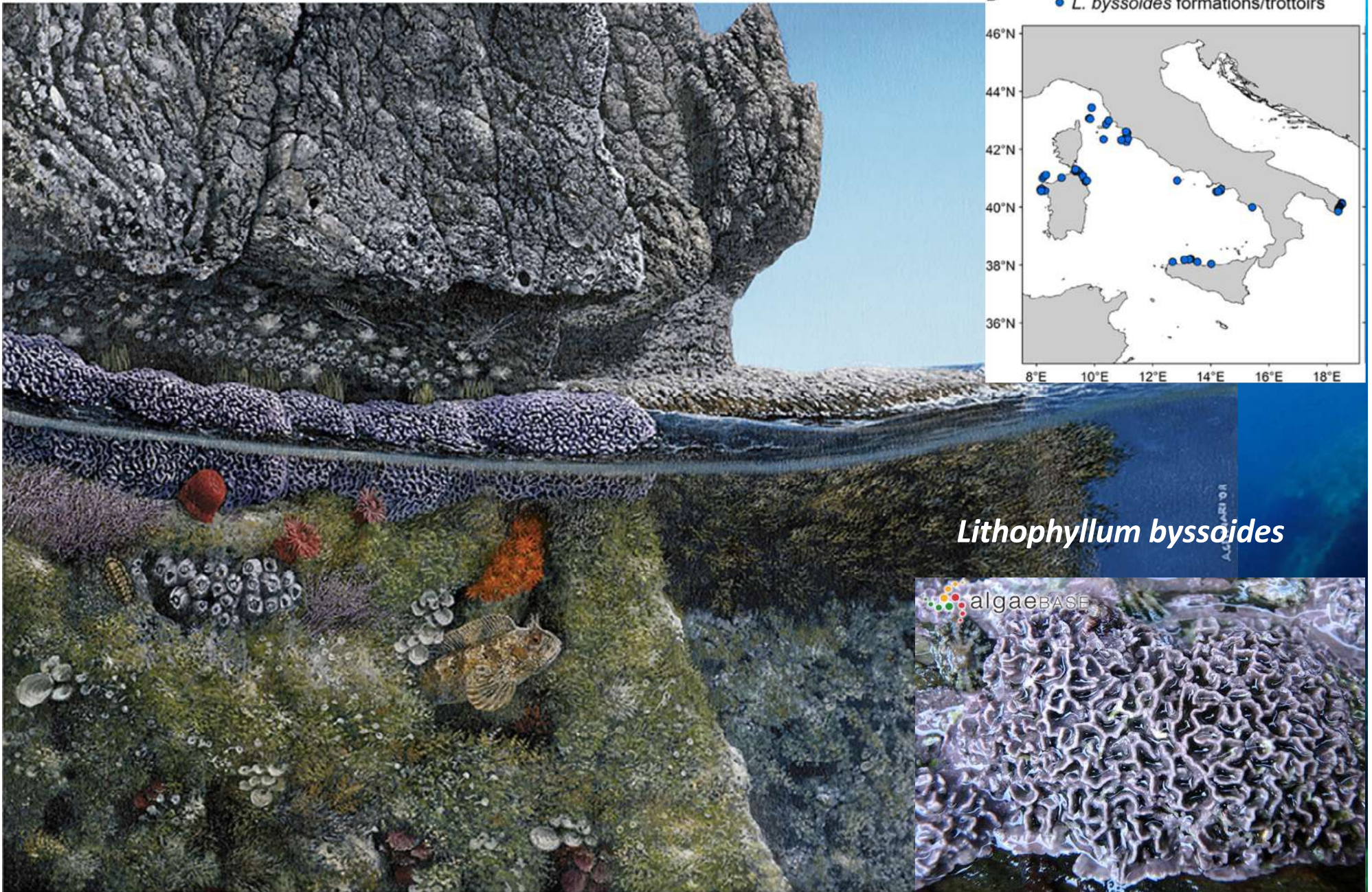
High biodiversity





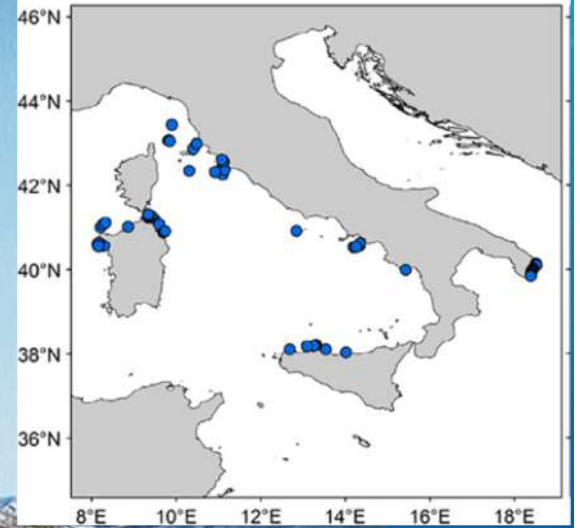
# *Lithophyllum* rims

A



B

• *L. byssoides* formations/trottoirs



*Lithophyllum byssoides*





# *Lithophyllum* rims

Bioconstructions





# Vermetid reefs



*Lithophyllum incrustans*



*Dendropoma (Novastoa) petraeum*



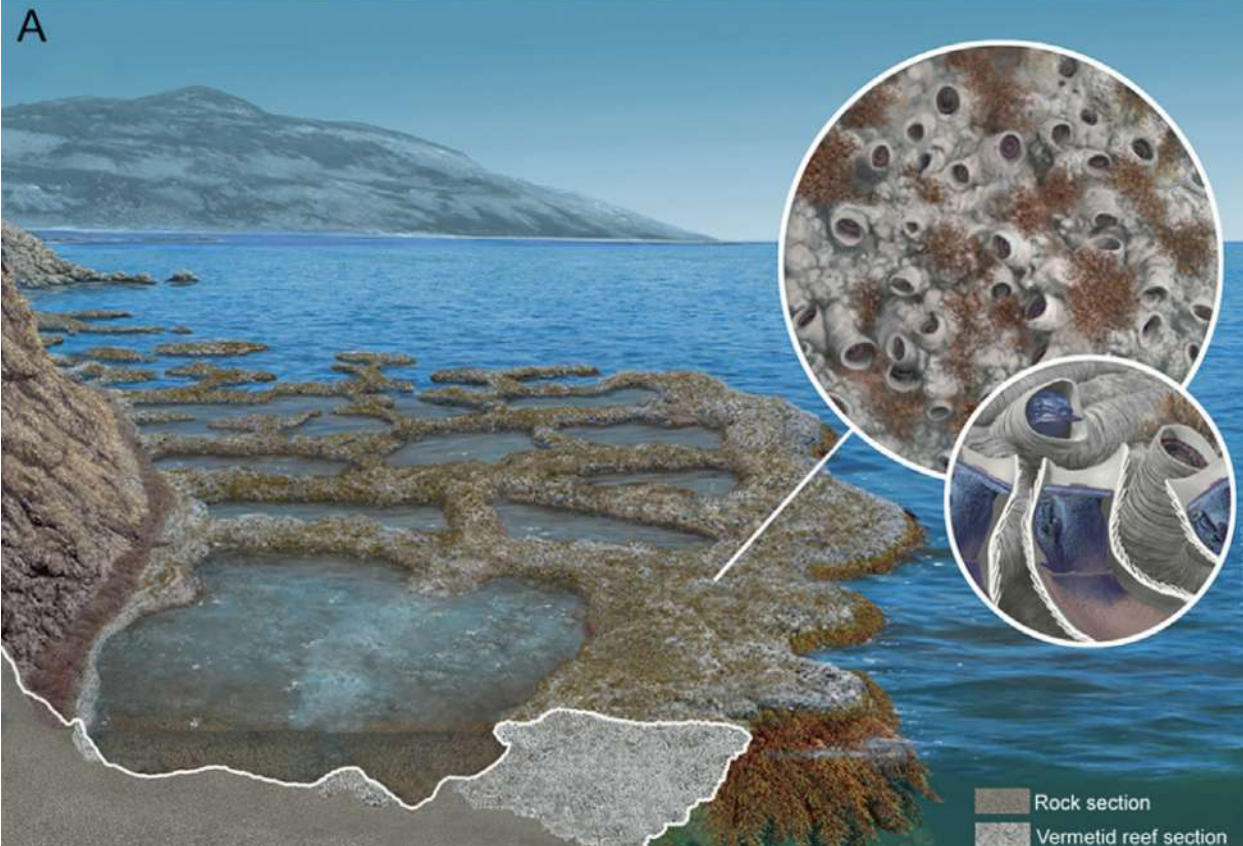
*Lithophyllum byssoides*



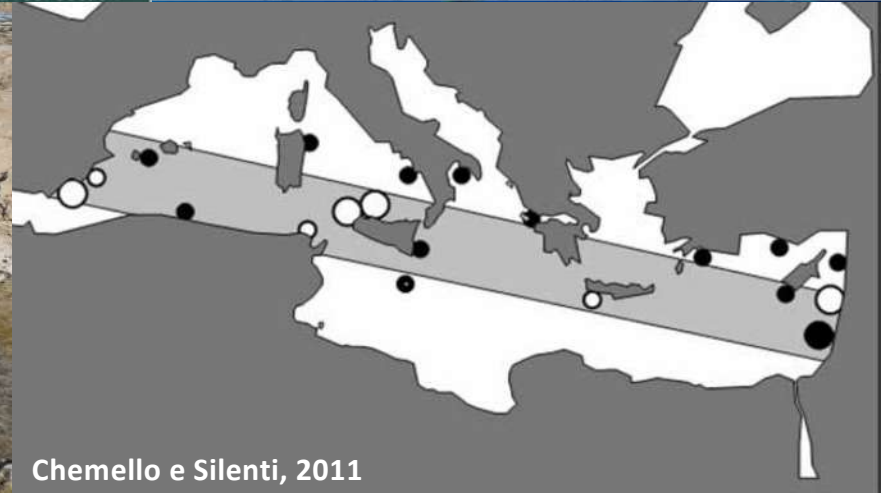
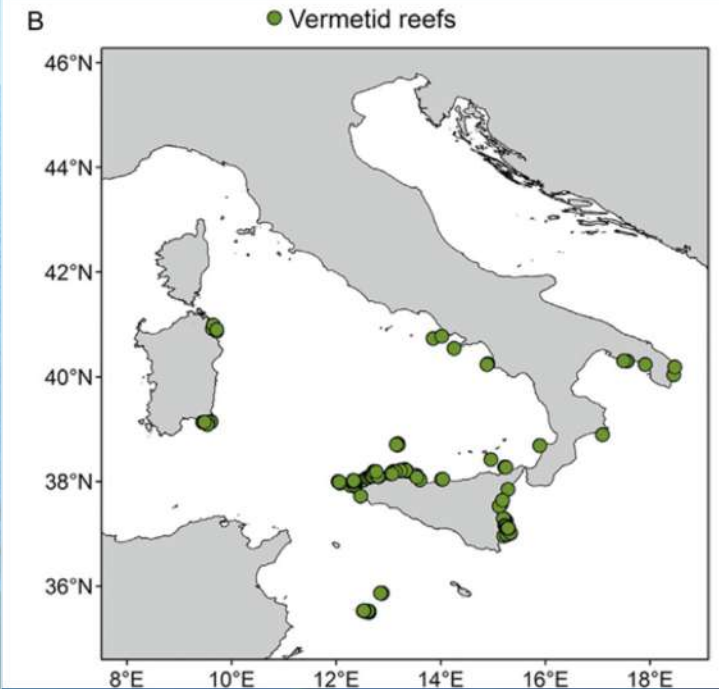
*Neogoniolithon brassica-florida*



# Vermetid reefs



## Distribution in Italy and the Mediterranean Sea



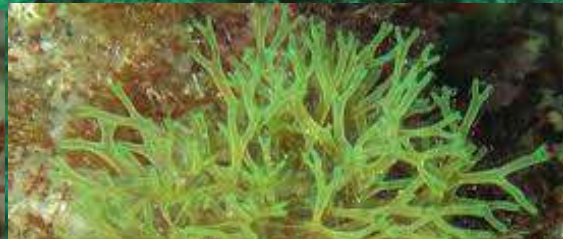


# Vermetid reefs





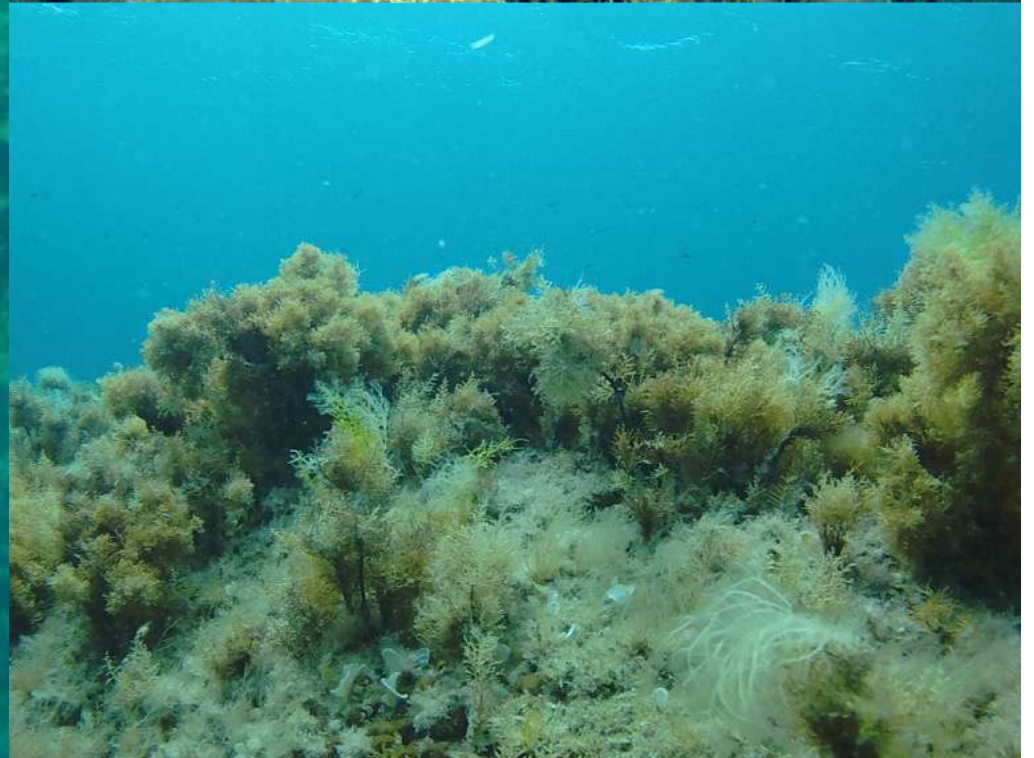
# Subtidal macroalgal stands





# *Cystoseira s.l.* forests

Fucales (*Ericaria*, *Gongolaria*, *Cystoseira*)





# Subtidal macroalgal stands





# Subtidal rocky cliffs



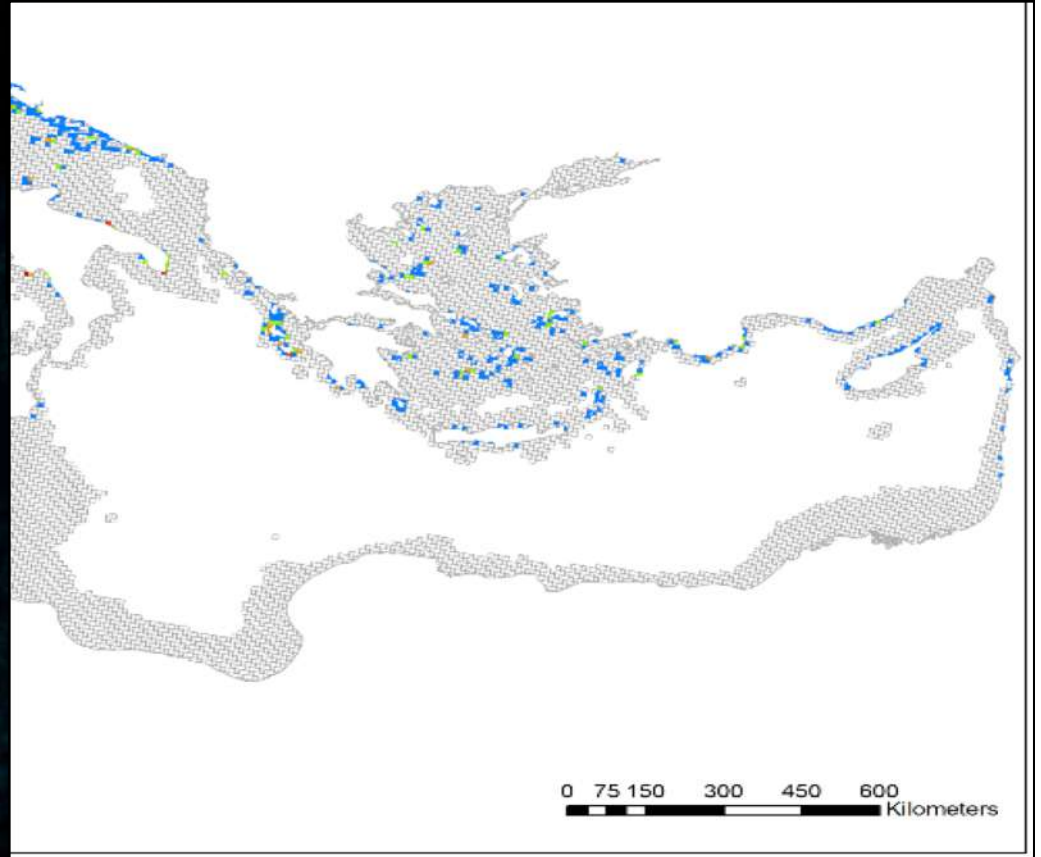
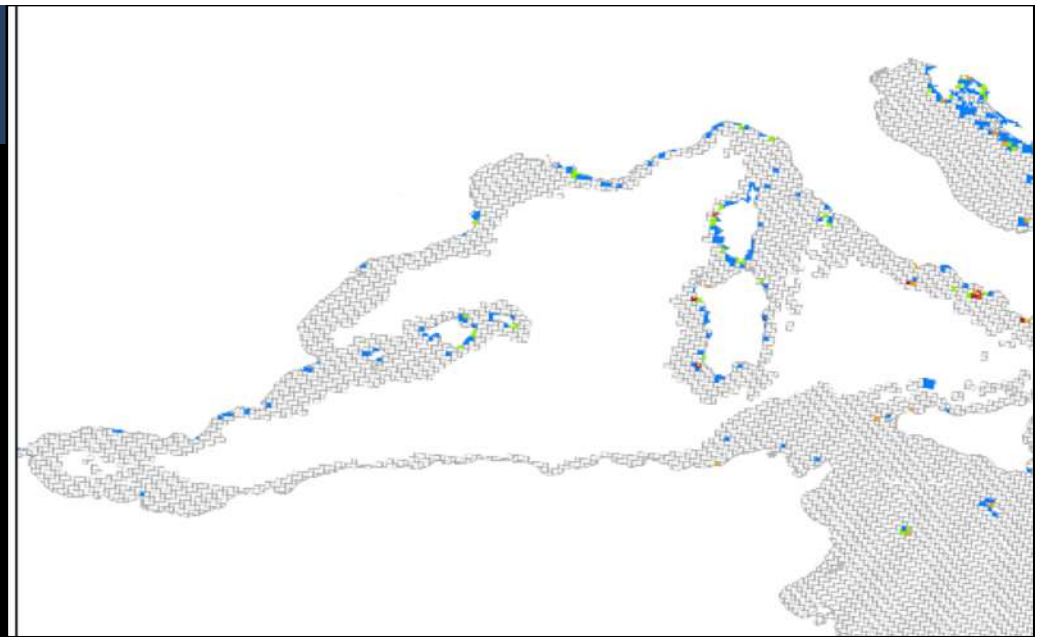


# Subtidal rocky cliffs





# Submarine caves





# Fish assemblages





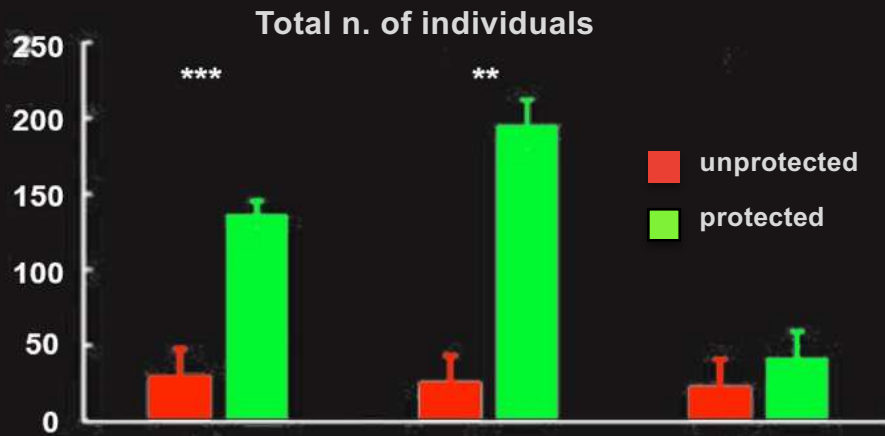
# Main human threats

- Pollution
- Direct physical habitat disruption and artificialisation
- Overfishing
- Bioinvasions
- Climate change

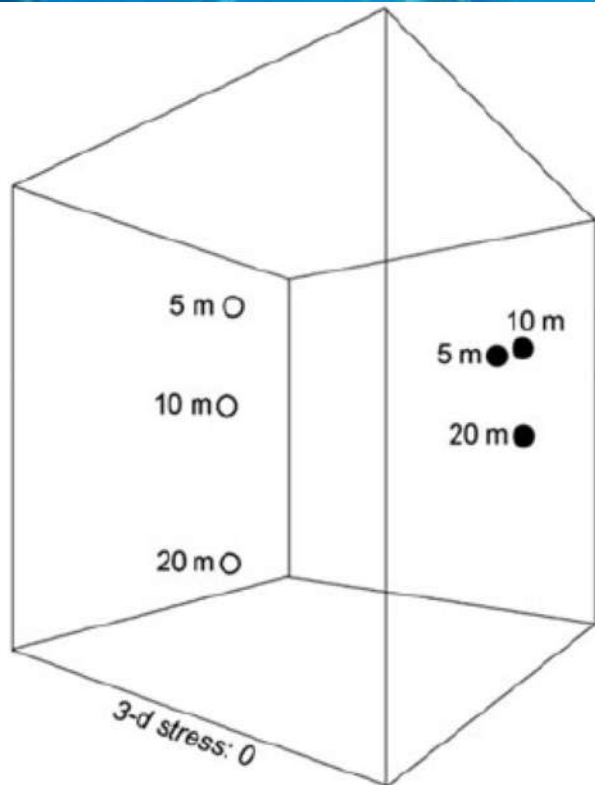
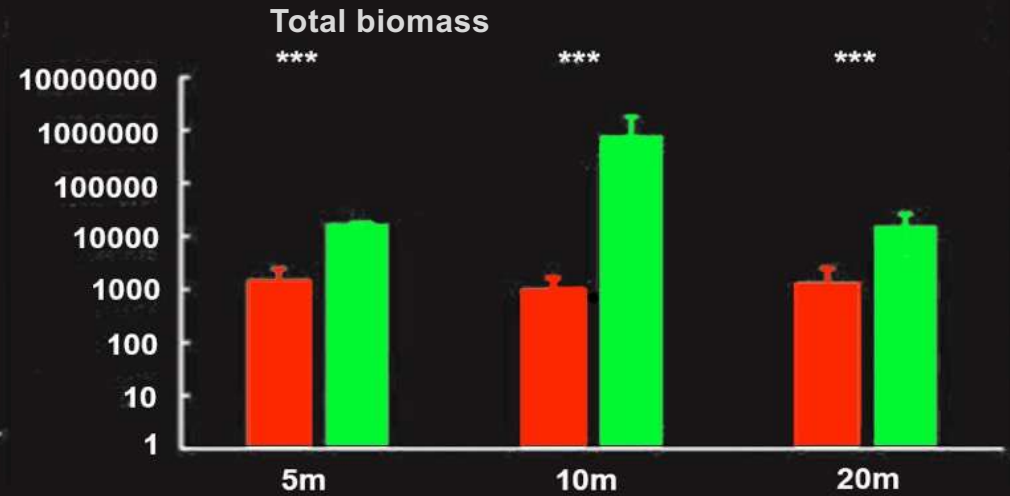




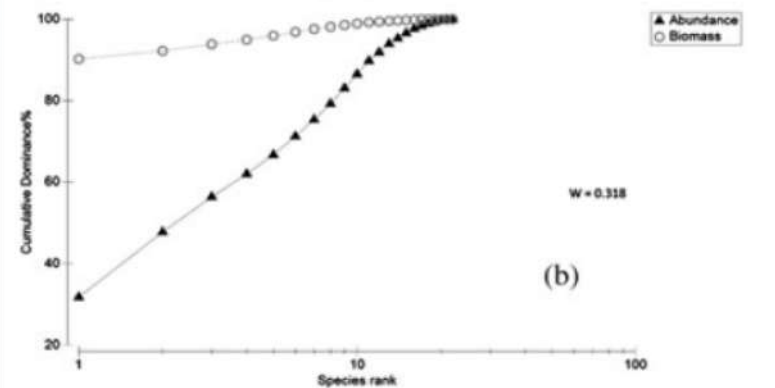
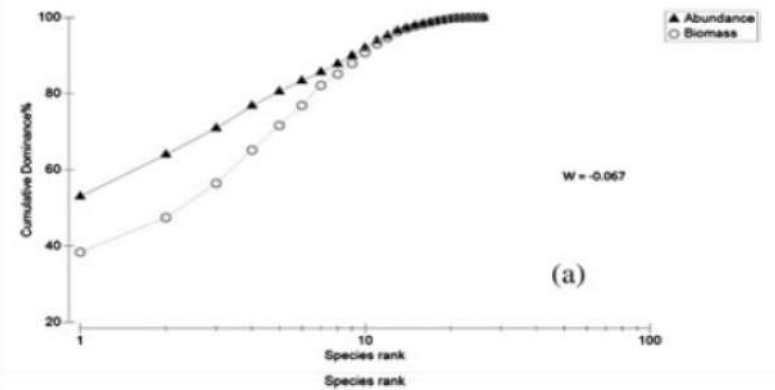
# Effects of overfishing



*Appolloni et al., 2017.*

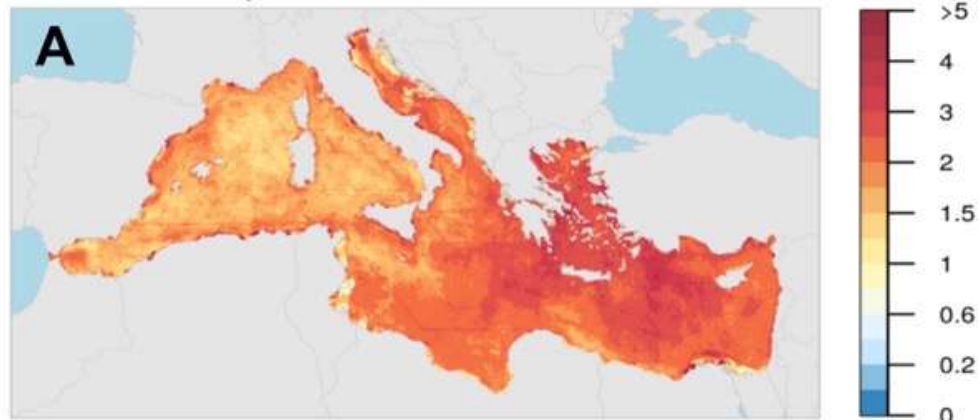


Maintainance of depth structure in fish assemblages. Abundance-biomass patterns typical of healthy conditions





# Trends in cumulative impact



Climate drivers are the main contributors to increased cumulative impact to rocky reefs, but overfishing and pollution are also key drivers of increased Impact. Rocky reefs are impacted by the largest suite of different stressors

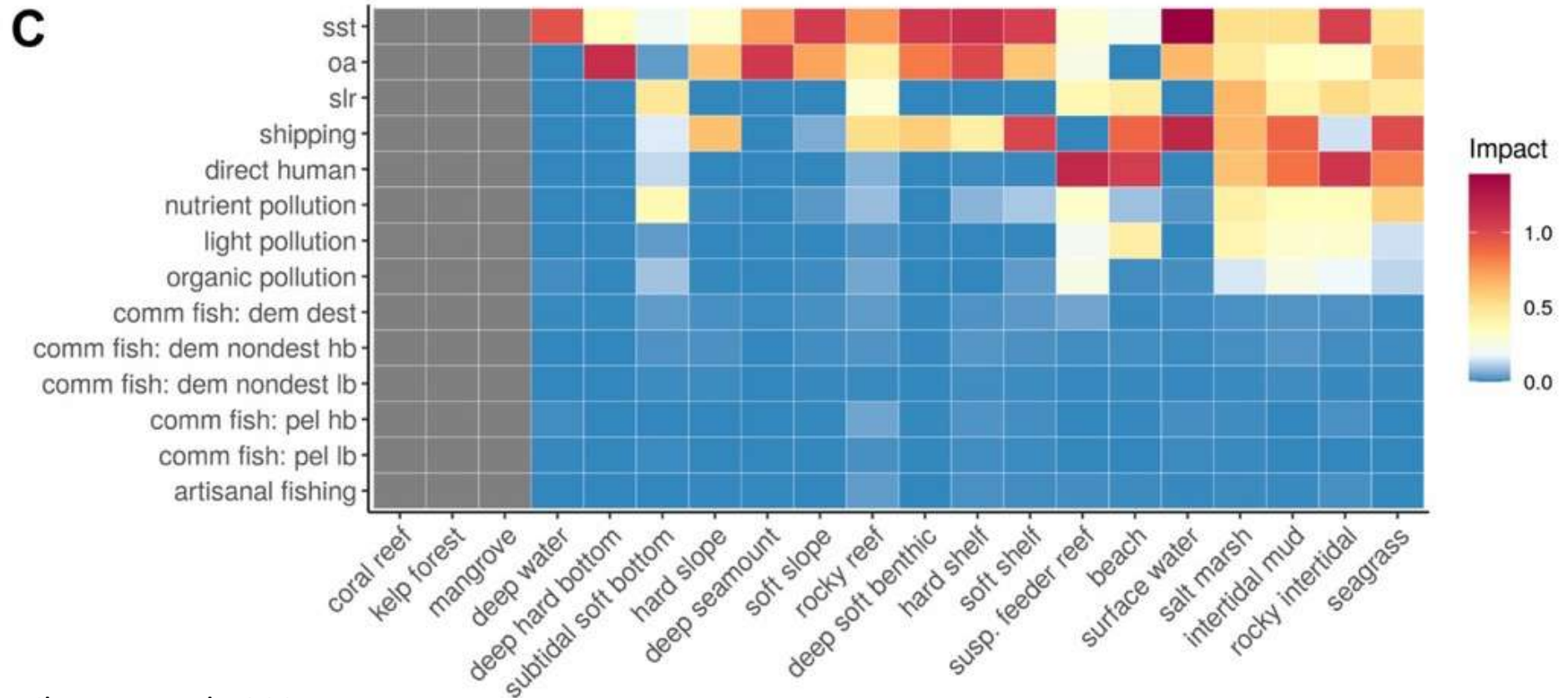




Table 1  
Summarized description and sensitivity levels of the main community categories distinguished in the monitored coasts

Category	Description	Sensitivity level
<i>Cystoseira mediterranea</i> 5	Continuous belt of <i>C. mediterranea/stricta</i>	20
<i>Cystoseira crinita</i>	Populations of <i>C. crinita</i>	20
<i>Cystoseira balearica</i>	Populations of <i>C. balearica</i>	20
<i>Cystoseira sheltered</i>	Populations of <i>Cystoseira foeniculacealbarbatalspinosa</i> v. <i>tenuior/compressav.pustulata</i>	20
<i>Posidonia</i> reef	Barrier and fringing reefs of <i>Posidonia oceanica</i>	20
<i>Cymodocea nodosa</i>	<i>Cymodocea nodosa</i> meadows	20
<i>Zostera noltii</i>	<i>Zostera noltii</i> meadows	20
Trottoir	Build-ups of <i>Lithophyllum byssoides</i>	20
<i>Cystoseira mediterranea</i> 4	Almost continuous belt of <i>C. mediterranea/stricta</i>	19
<i>Cystoseira mediterranea</i> 3	Abundant patches of dense stands of <i>C. mediterranea/stricta</i>	15
<i>Cystoseira mediterranea</i> 2	Abundant scattered plants of <i>C. mediterranea/stricta</i>	12
<i>Cystoseira compressa</i>	Populations of <i>C. compressa</i> v. <i>compressa</i>	12
<i>Cystoseira mediterranea</i> 1	Rare scattered plants of <i>C. mediterranea/stricta</i>	10
<i>Corallina</i>	Belt of <i>Corallina elongata</i> without <i>Cystoseira</i>	8
<i>Haliptilon</i>	Belt of <i>Haliptilon virgatum</i> , without <i>Cystoseira</i>	8
<i>Mytilus</i>	Mussel ( <i>Mytilus galloprovincialis</i> ) beds, without <i>Cystoseira</i>	6
Encrusting corallines	Belt of <i>Lithophyllum incrustans</i> , <i>Neogoniolithon brassica-florida</i> and other encrusting corallines	6
Green algae	Upper sublittoral belts of <i>Ulva</i> and <i>Cladophora</i>	3
Blue greens	Communities dominated by Cyanobacteria and <i>Derbesia tenuissima</i>	1

Index of ecological status of intertidal rocky fringe based on sensitivity levels (SL) of different macroalgae associations and their abundance. Value calculated as the ratio between the weighted mean of SL and the reference value for the area.

Ballesteros et al. 2007

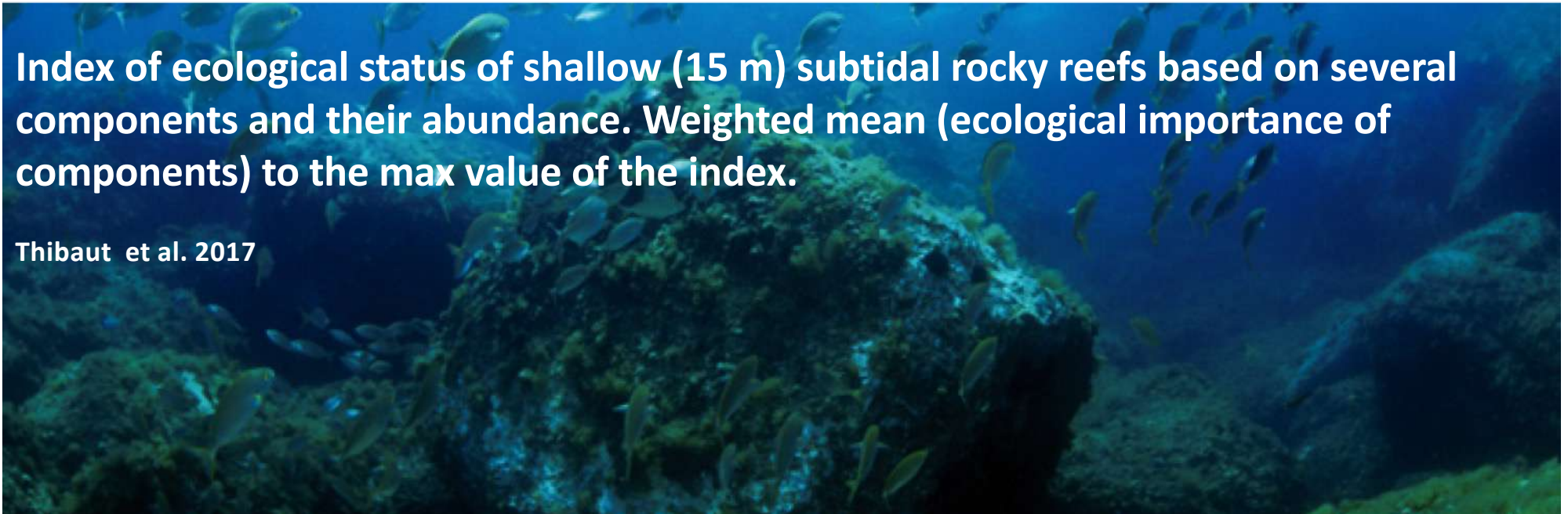


# Reef-EBQI

Functional compartment	Weighting (W)	Parameter	4	3	2	1	0
1- MPOs	15	Cover type	Arborescent perennial $\geq 50\%$	Arborescent perennial 5 to $<50\%$	Shrubby $\geq 50\%$	Shrubby 5 to $<50\%$	Turf Encrusting
2- Detritus-feeders	3	Density (individuals $10\text{ m}^{-2}$ )	$<0.5$	0.5 to 1.0	1.1 to 2.0	2.1 to 5.0	$>5.0$
3- Filter- and suspension-feeders	2	Density (individuals $10\text{ m}^{-2}$ )	$<2.5$	2.5 to 5.0	5.1 to 10.0	10.1 to 20.0	$>20.0$
4- Sea urchins	10	Density (individuals $\text{m}^{-2}$ )	0.05 to 1.0	$<0.05$	1.1 to 5.0	5.1 to 10.0	$>10.0$
5- Invertivorous invertebrates	3						
- <i>Octopus vulgaris</i> , <i>Marthasterias glacialis</i>		Density (individuals $200\text{ m}^{-2}$ )	$>1.0$	0.6 to 1.0	0.3 to 0.5	0.1 to 0.2	$<0.1$
- <i>Hexaplex trunculus</i>		Density (individuals $10\text{ m}^{-2}$ )	$<0.5$	0.6 to 1.0	1.1 to 2.0	2.1 to 4.0	$>4.0$
6- Herbivorous teleosts	4	Biomass kg teleosts WM $100\text{ m}^{-2}$	1.1 to 3.0	3.1 to 4.0	$>4.0$	0.25 to 1.0	$<0.25$
7-8- Omnivorous and Invertivorous teleosts	4	Biomass kg teleosts WM $100\text{ m}^{-2}$	$>3.5$	2.6 to 3.5	1.6 to 2.5	0.8 to 1.5	$<0.8$
9- Piscivorous teleosts	7	Biomass kg teleosts WM $100\text{ m}^{-2}$	$>5.0$	1.0 to 5.0	0.5 to 0.9	0.4 to 0.1	$<0.1$
10- Planktivorous teleosts	1	Biomass kg teleosts WM $100\text{ m}^{-2}$	$>2.0$	2.0 to 1.5	1.5 to 0.9	0.9 to 0.3	$<0.3$
11- Sea birds	1						
- <i>Phalacrocorax</i> spp.		Distance to the nearest nesting site (km)	$<4.0$	4.0 to 7.9	8.0 to 12.9	13.0 to 17.0	$>17.0$
- <i>Pandion haliaetus</i>		Distance to the nearest nesting site (km)	$<4.0$	4.0 to 7.9	8.0 to 12.9	13.0 to 17.0	$>17.0$

Index of ecological status of shallow (15 m) subtidal rocky reefs based on several components and their abundance. Weighted mean (ecological importance of components) to the max value of the index.

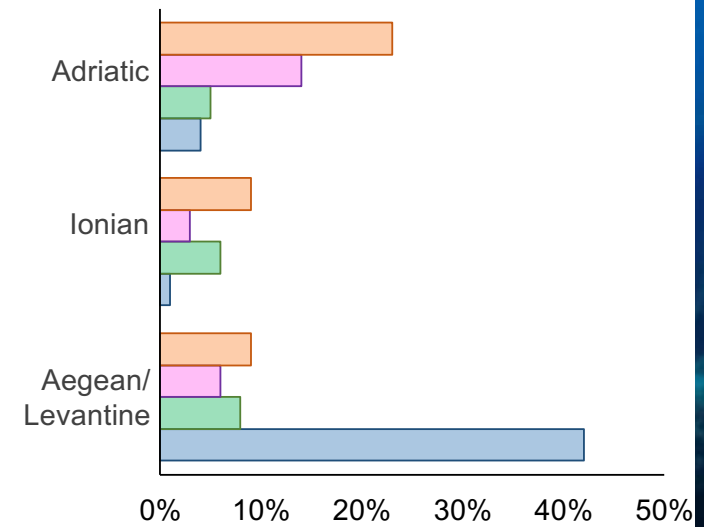
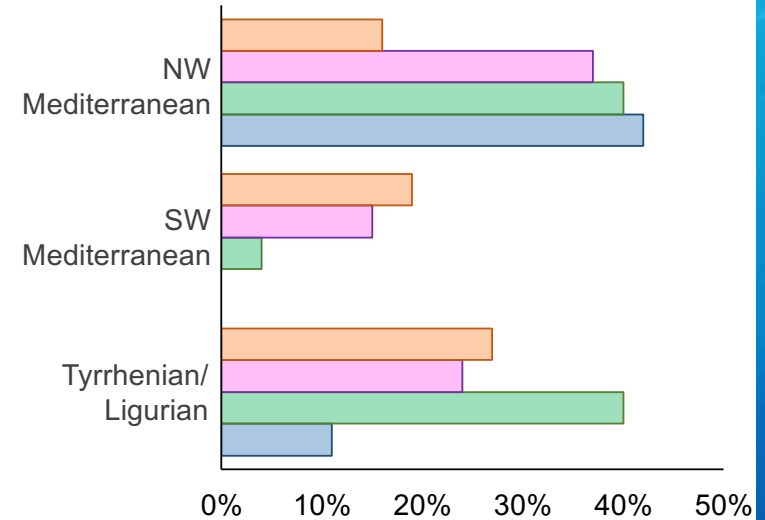
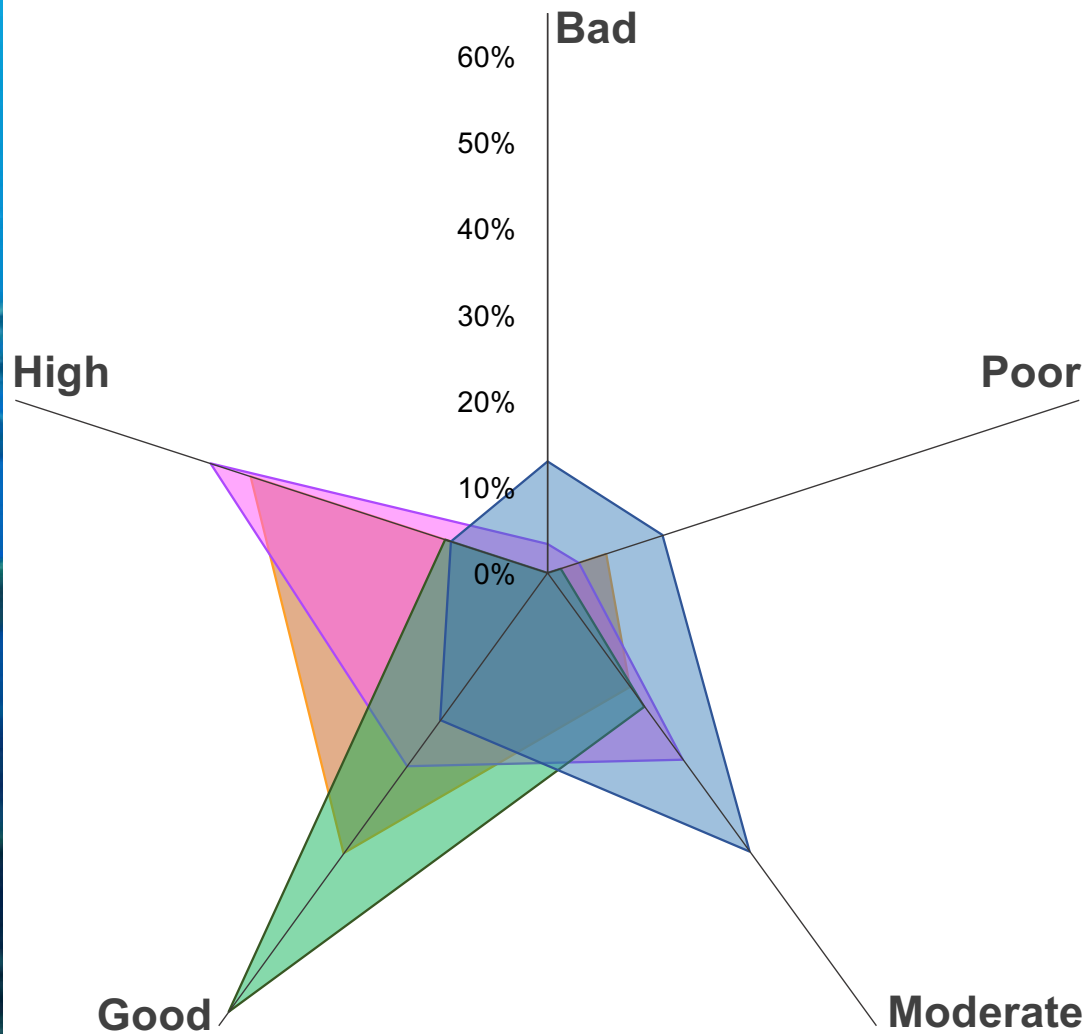
Thibaut et al. 2017





# Ecological status

Bevilacqua et al., 2020



Coastal soft bottoms (CSB)

Rocky intertidal fringe (RIF)

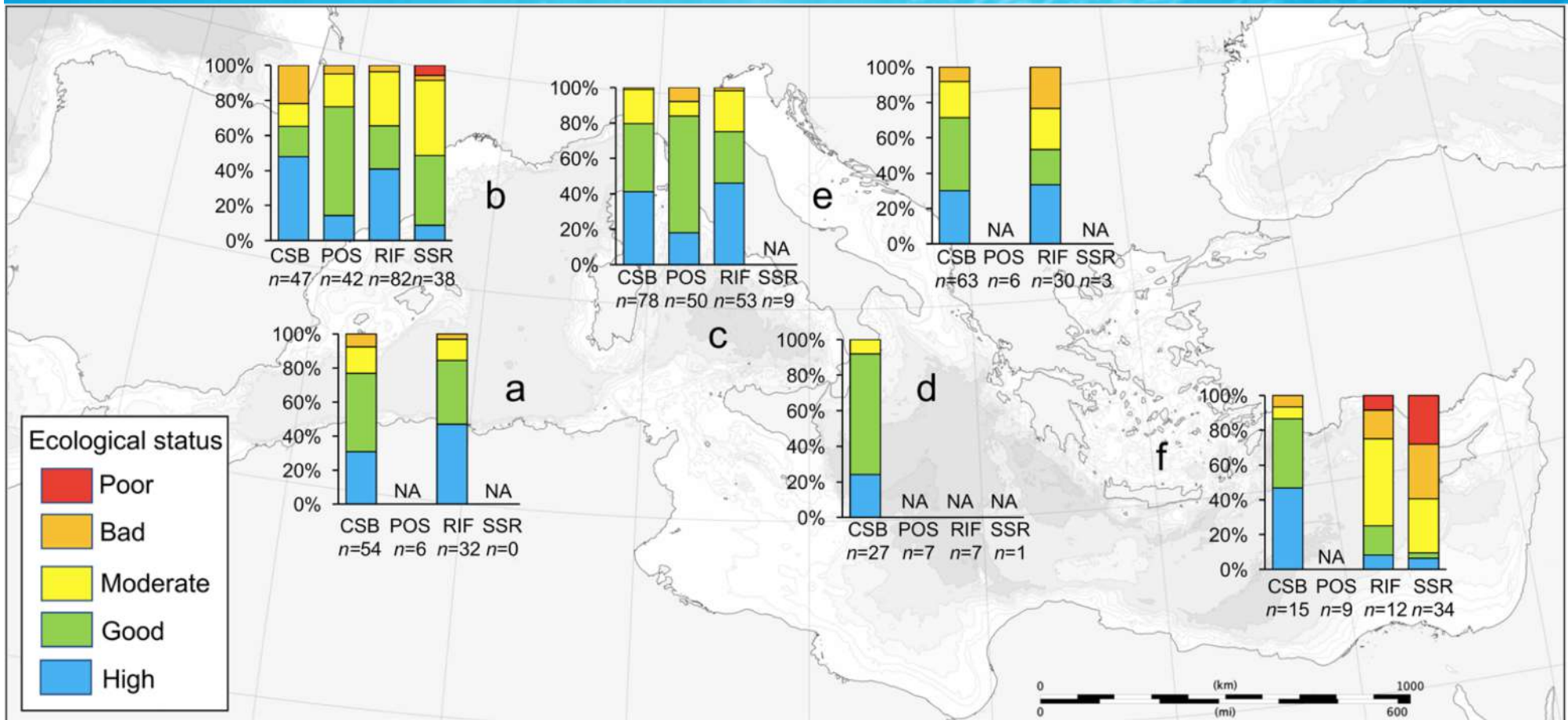
*P. oceanica* beds (POS)

Shallow subtidal reefs (SSR)





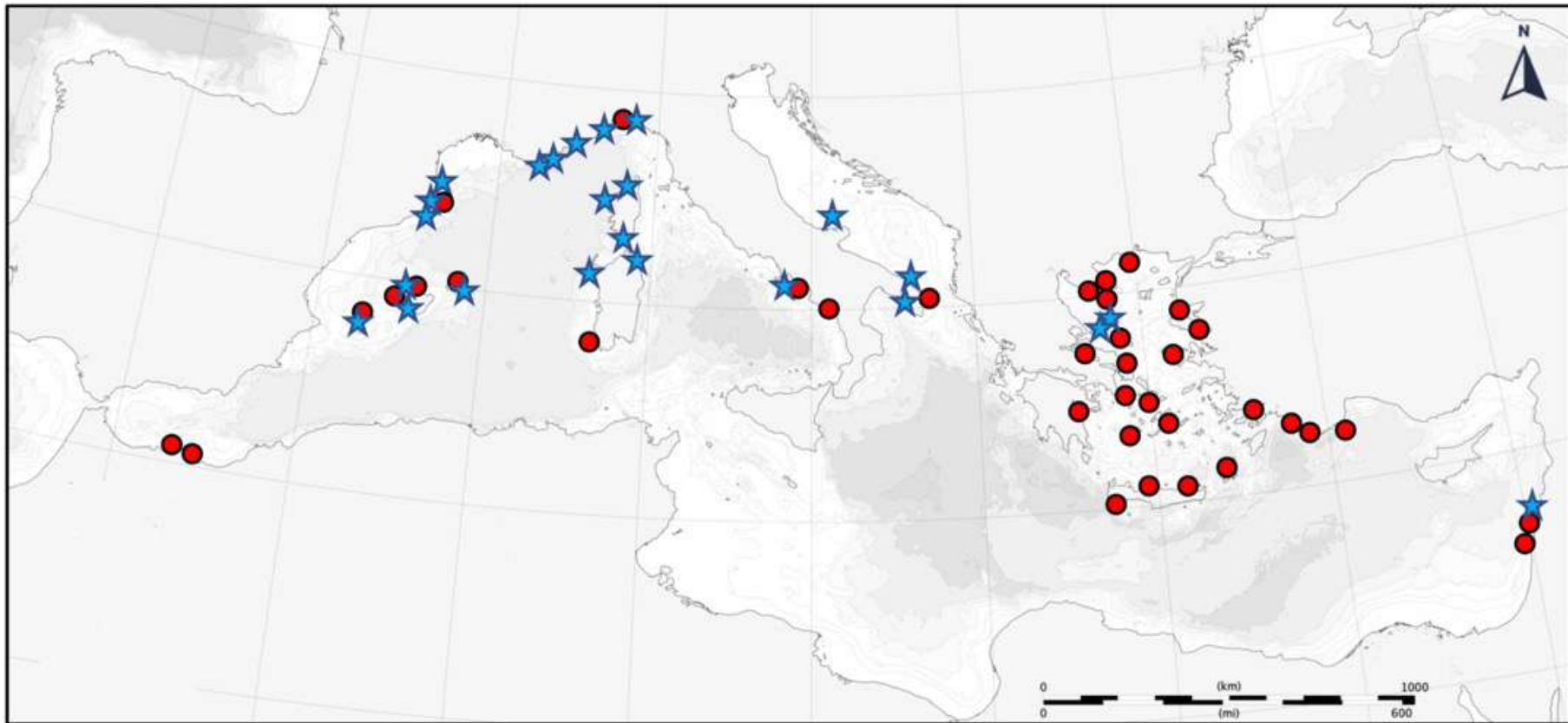
# Ecological status



Lack of data in several areas. Apparently, rocky reefs in the Levantine basin are those in worse conditions



# Ecological status



## Ecological status

Poor

Bad

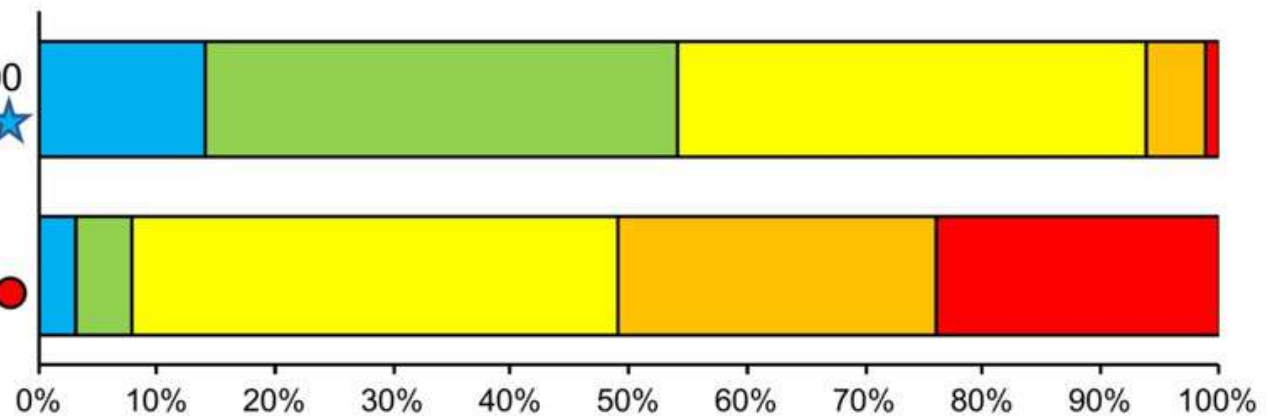
Moderate

Good

High

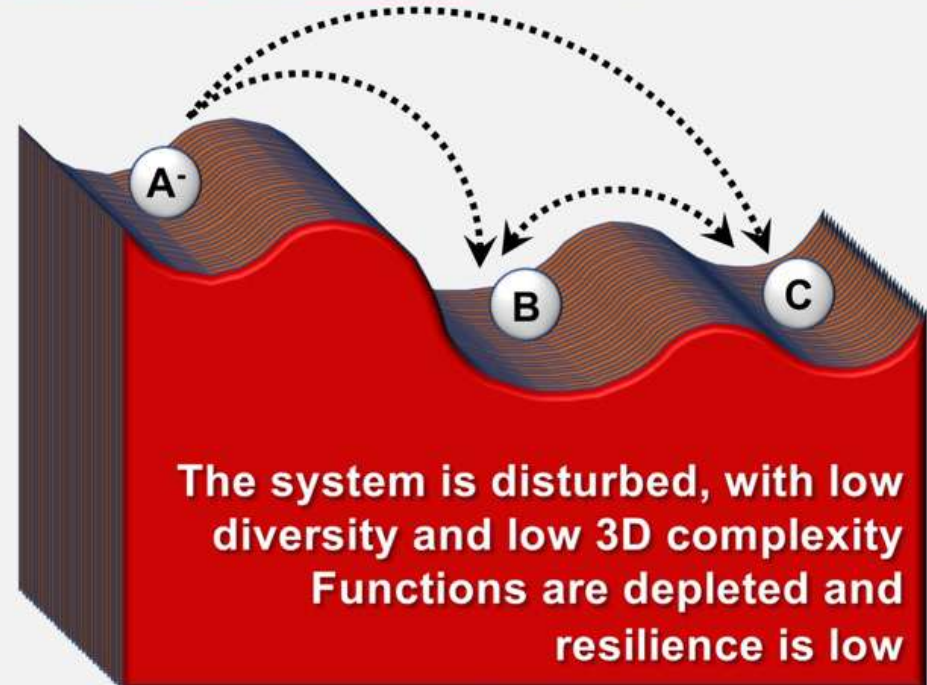
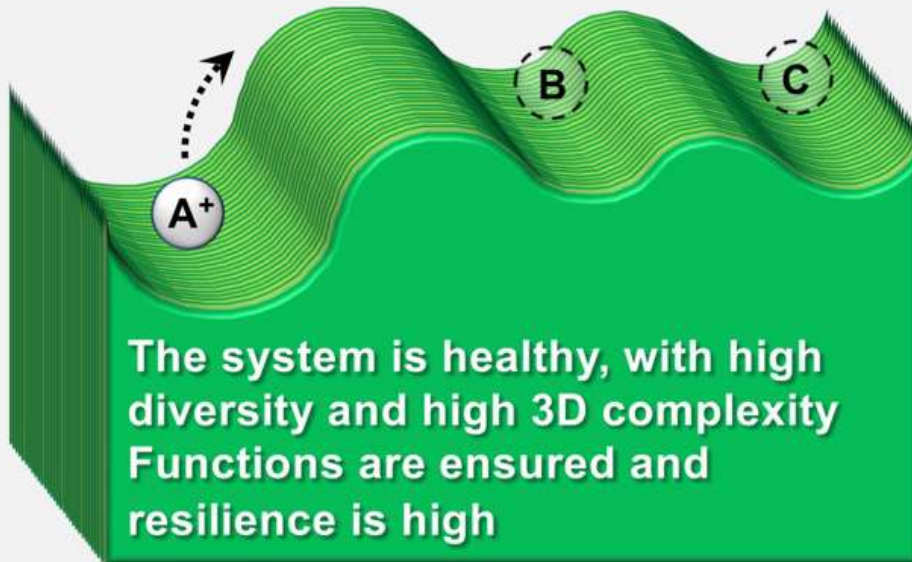
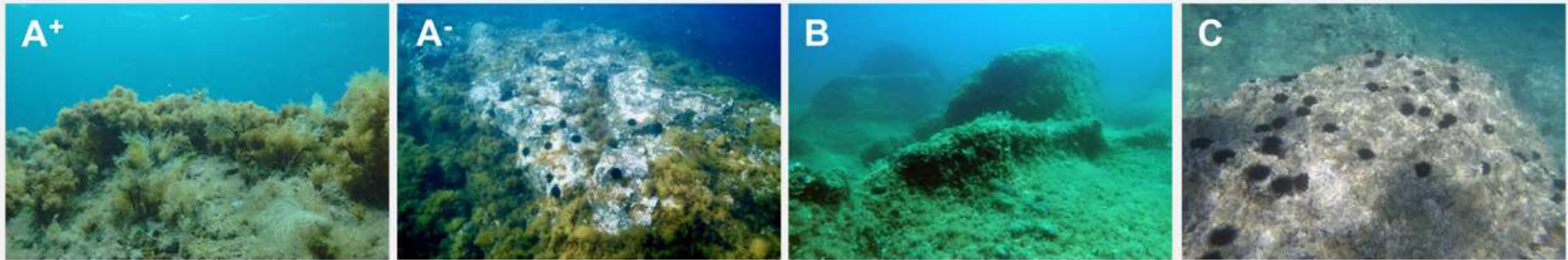
MPAs or N2000  
Sites ( $n = 44$ ) ★

Unprotected  
Sites ( $n = 41$ ) ●





# Phase shifts



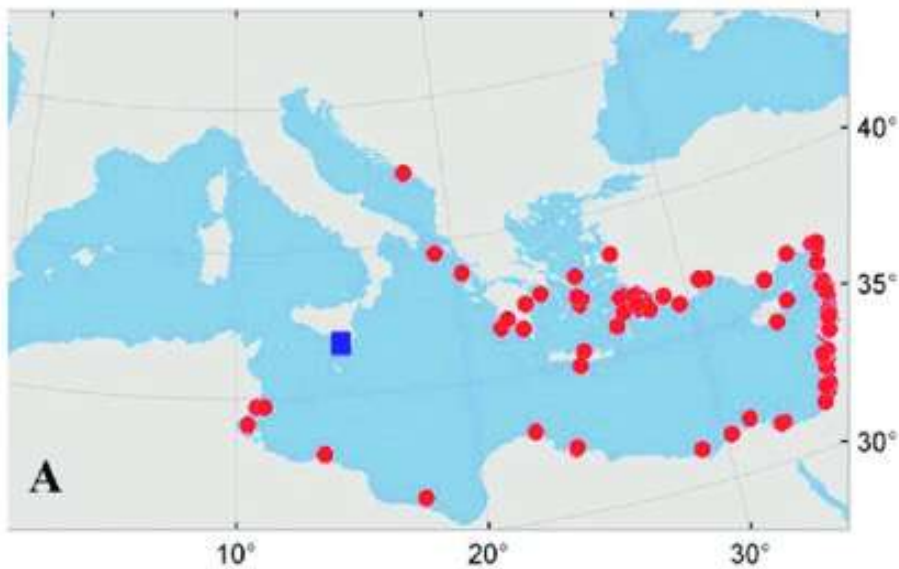
Deterioration of environmental conditions and biological components



# The role of climate change: invasions



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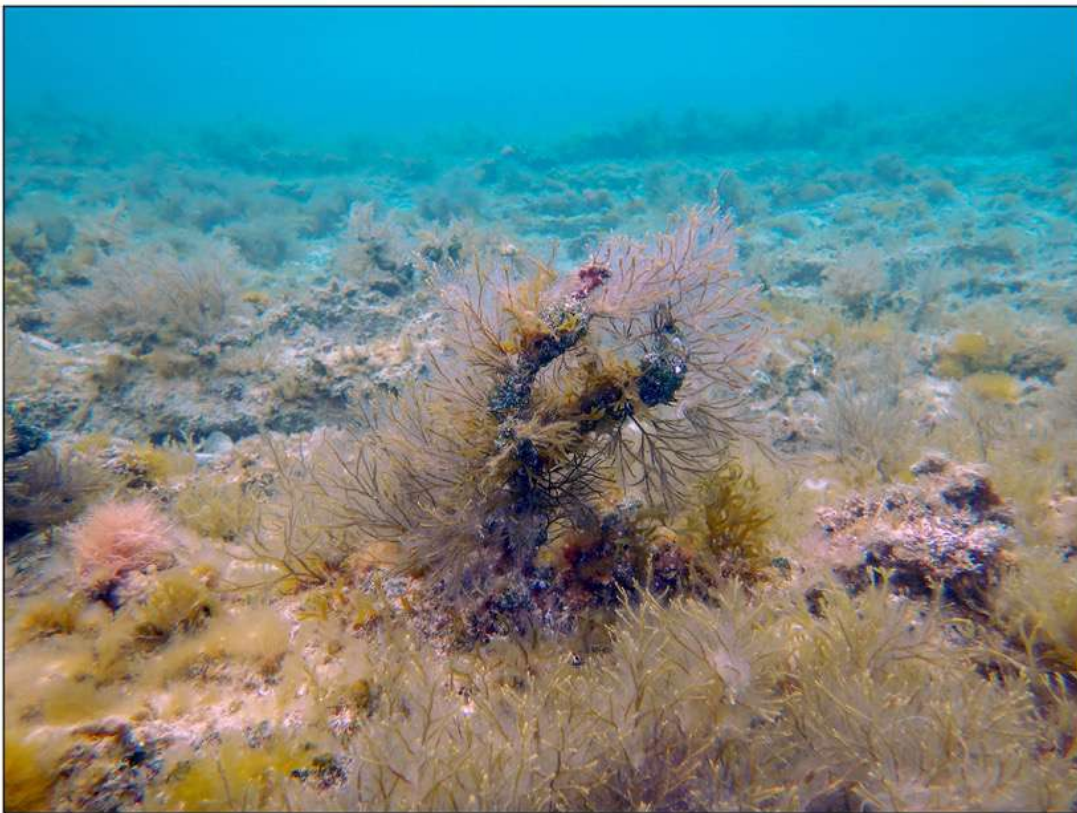




# The role of climate change: heatwaves



a

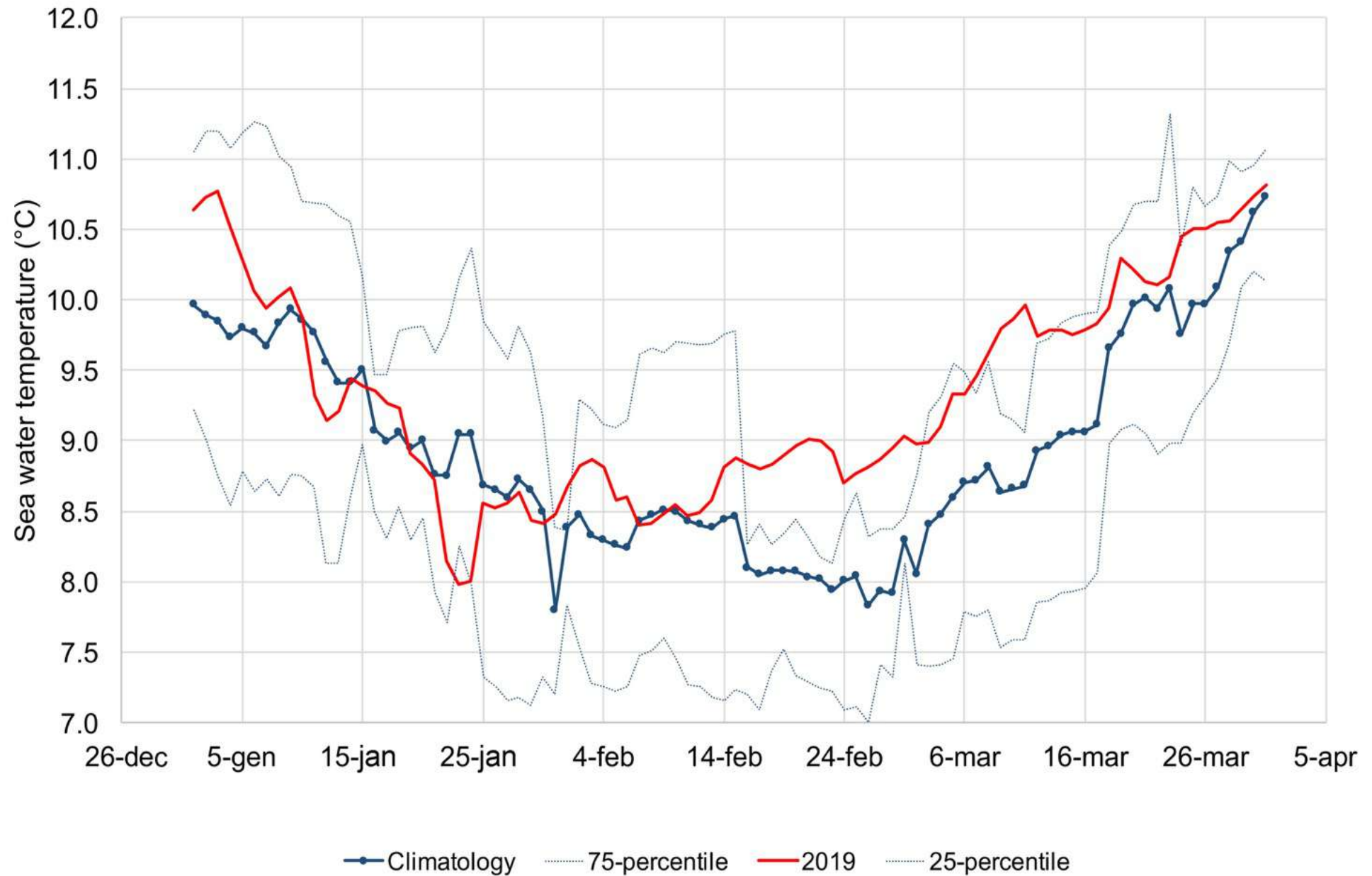


b



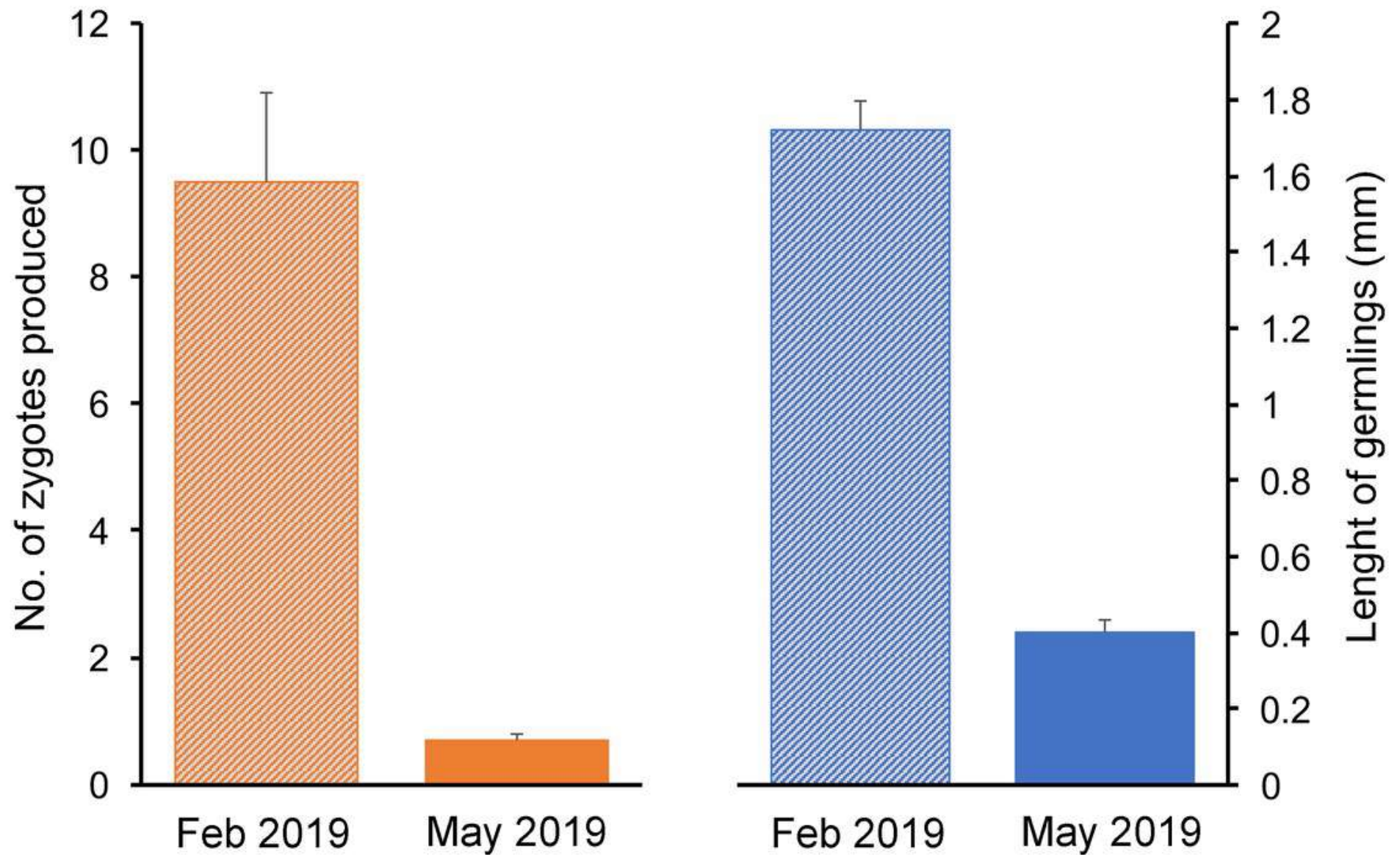


# The role of climate change





# The role of climate change





# The role of climate change

