University of Trieste: GLOBAL CHANGE ECOLOGY a.a. 2021-2022

Marine Biodiversity and global change

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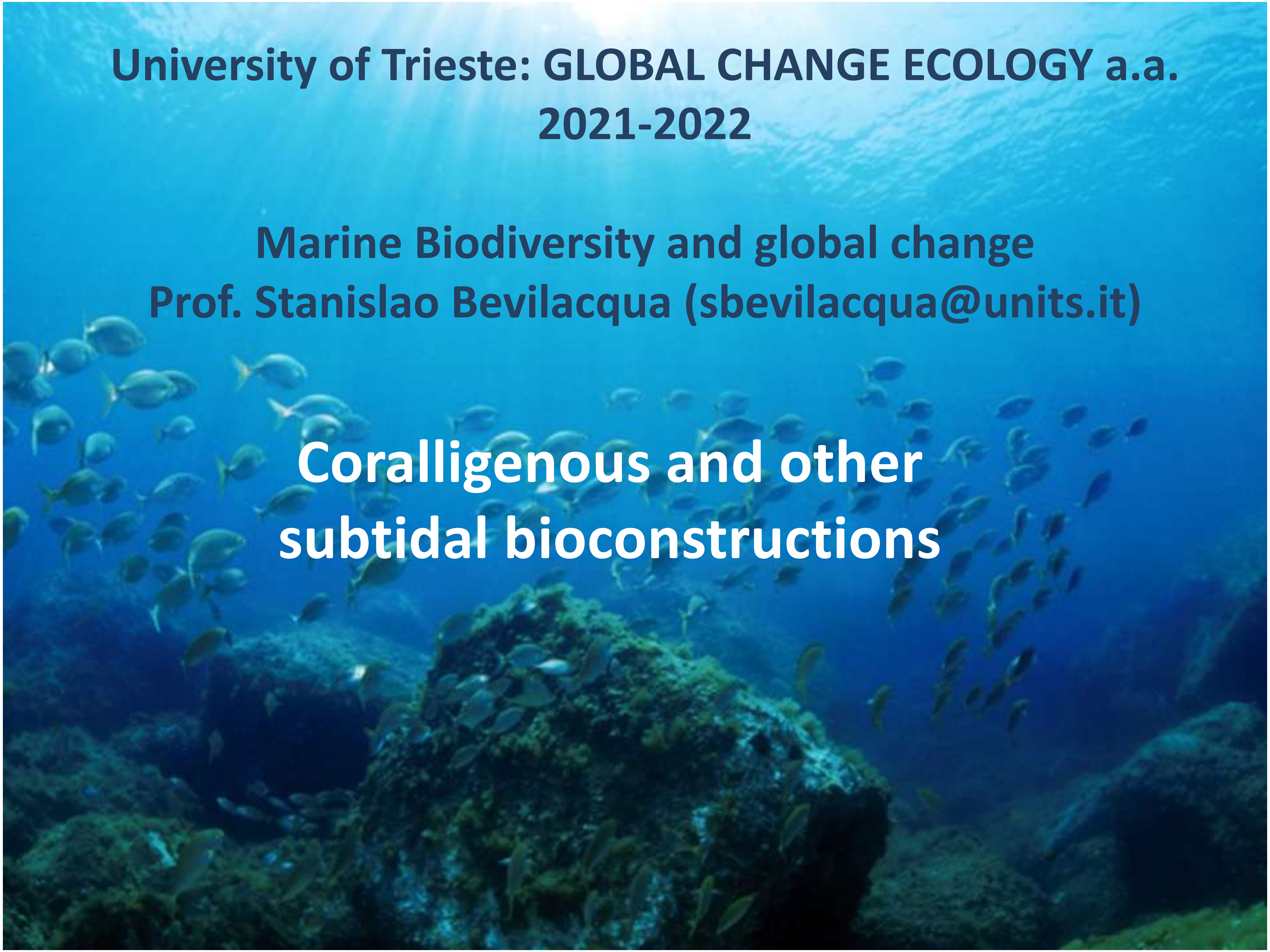
Coralligenous and other subtidal bioconstructions



Bioconstructions

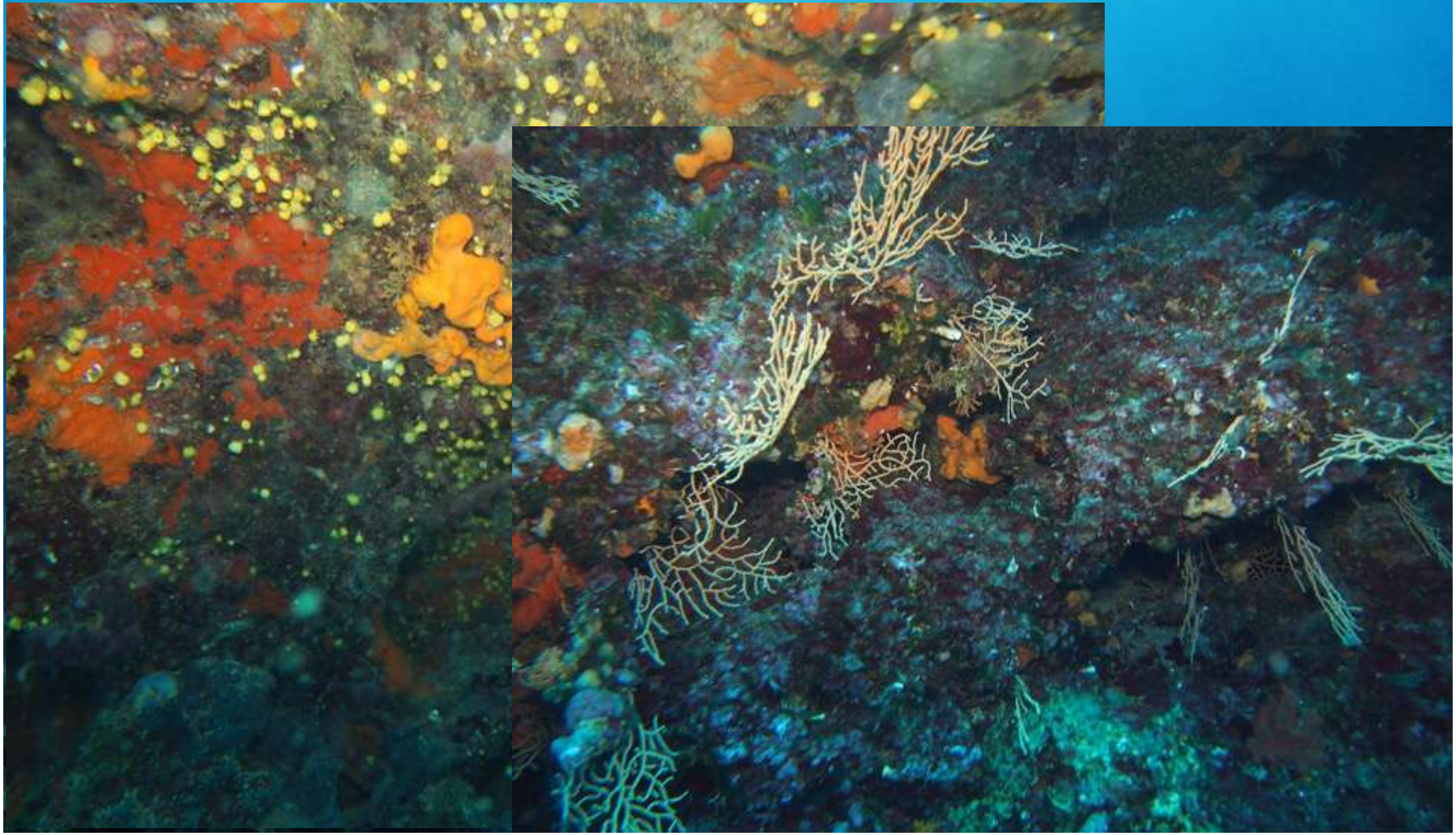
Biogenic reefs are produced by the activity of skeleton producing organisms such as calcareous algae, oysters and corals.

Calcareous sediments deriving from algae, mollusc shells, echinoderms spines, sponge spicules and other skeletal debris often fill the spaces within the reef framework and become consolidated in various ways.

Sponges, zoanthids and certain colonial ascidians can bind reef materials together. Organisms that grow as calcareous sheets can act as biological cementing agents, building permanent bonds that cause the strong adhesion of loose calcareous sediments to the reef frame.

Bioconstructions

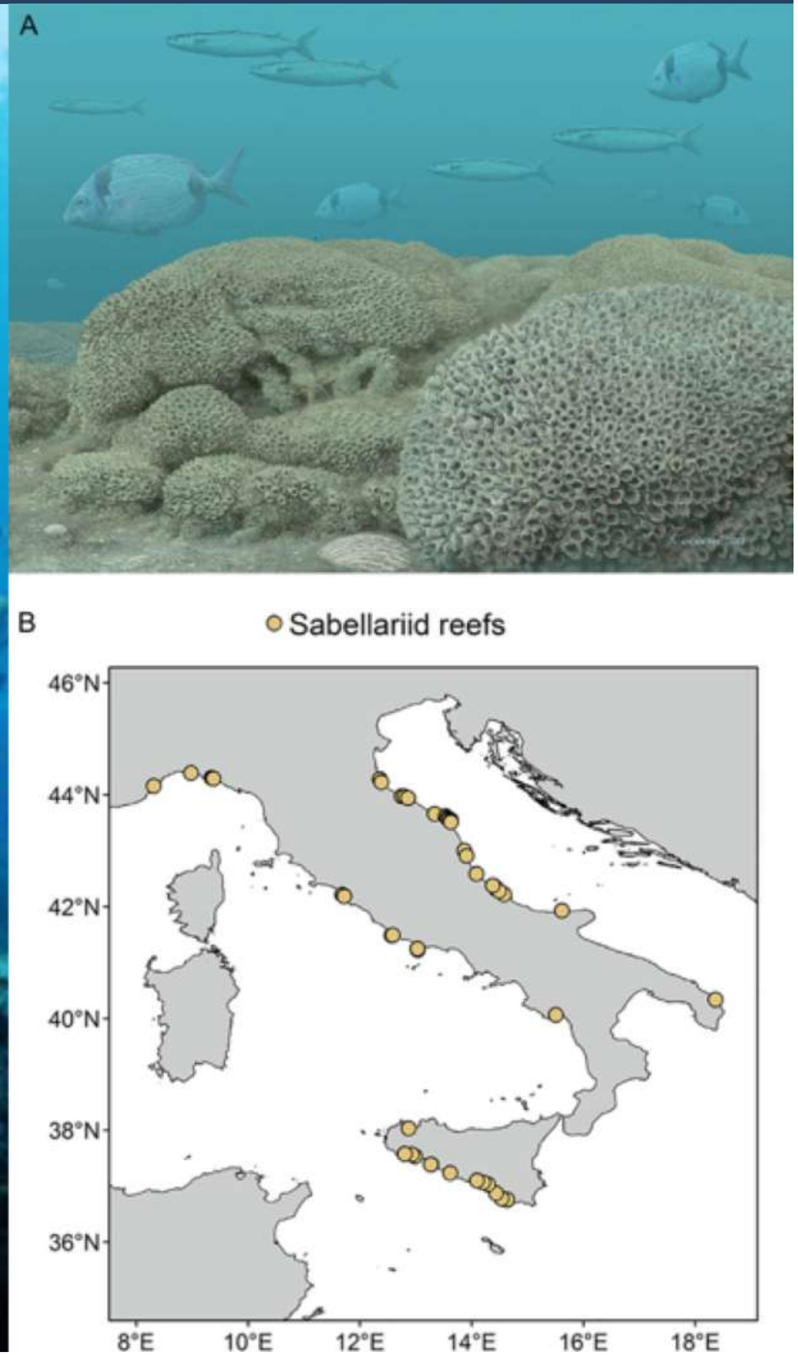
Bioconstructors modify primary (i.e. geological) substrates and provide secondary (i.e. biogenic) substrates for new bioconstructors and for nonbioconstructors who simply inhabit them



Bioconstructions of the Mediterranean Sea

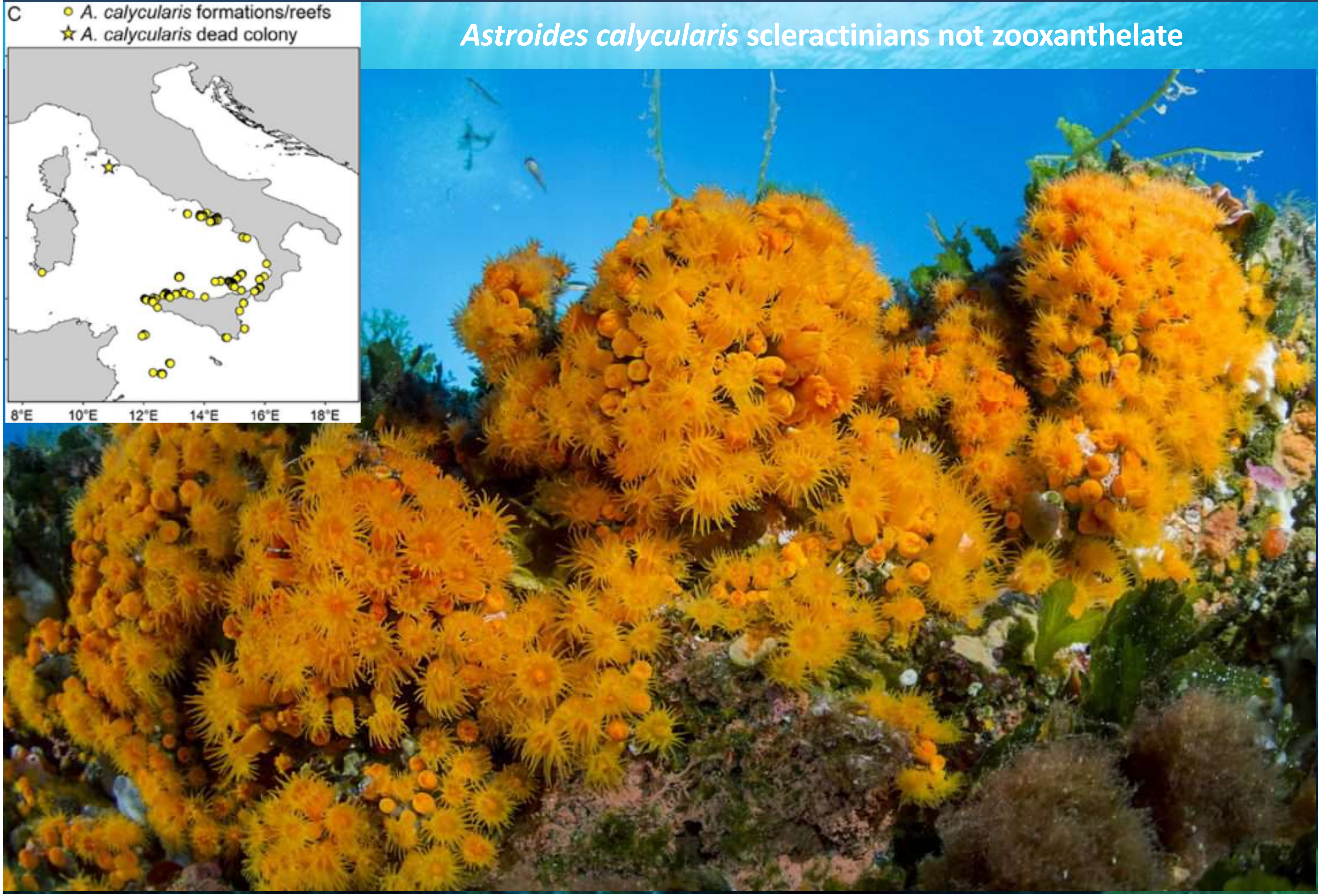
- *Lithophyllum byssoides* concretions/trottoirs
- *Astroides calycularis* formations/reefs
- Coralligenous assemblages
- *Cladocora caespitosa* formations/reefs
- Vermetid reefs
- Sabellariid reefs
- Cold-water corals
- Serpulid reefs, including biostalactites

Sabellariid reefs are compact bioconstructions resulting from the aggregation of tubes made up of sand grains and bioclasts, cemented with mucus, which develop on both solid and soft bottoms. The worms construct these tubes around themselves, in close proximity

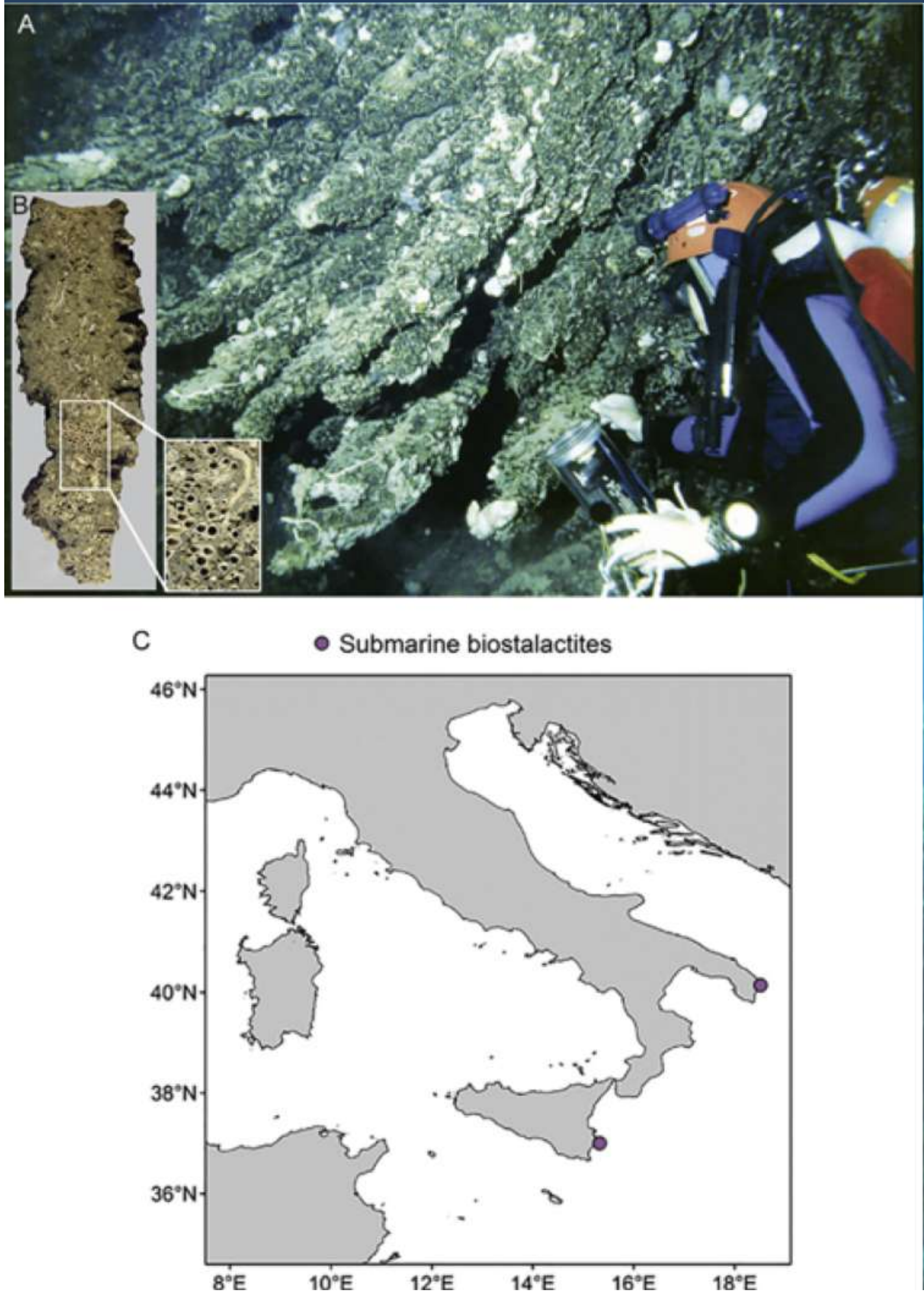


Bioconstructions of the Mediterranean Sea

Astroides calycularis scleractinians not zooxanthelate

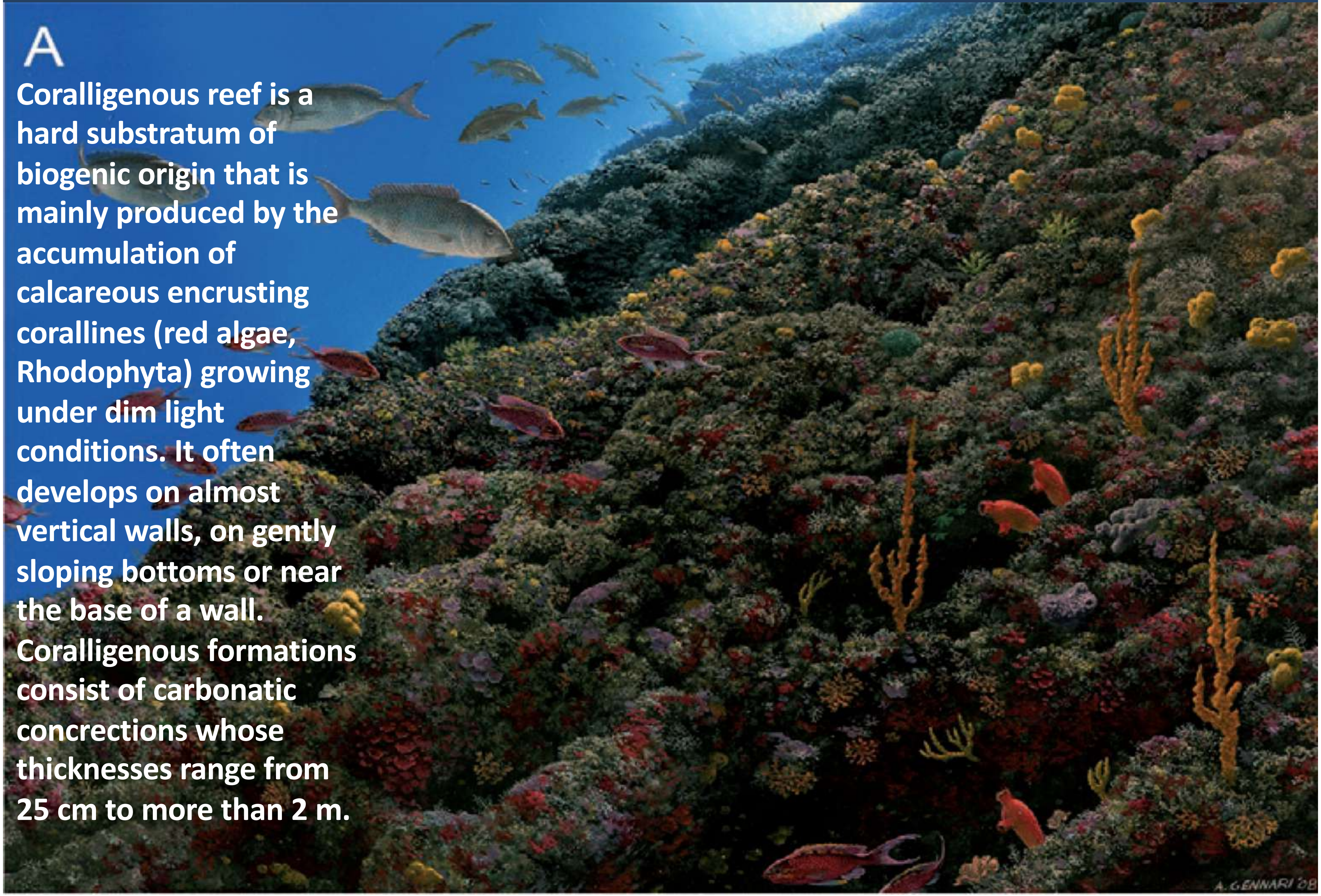


Biostalactites



Particular serpulid structures in submarine caves are the so called biostalactites.
They are formed by single or few serpulid species (mostly *Protula* spp.) whose aggregations become substrate for smaller invertebrates and bacteria.
Biostalactites
can protrude a few cm up to 2 m.

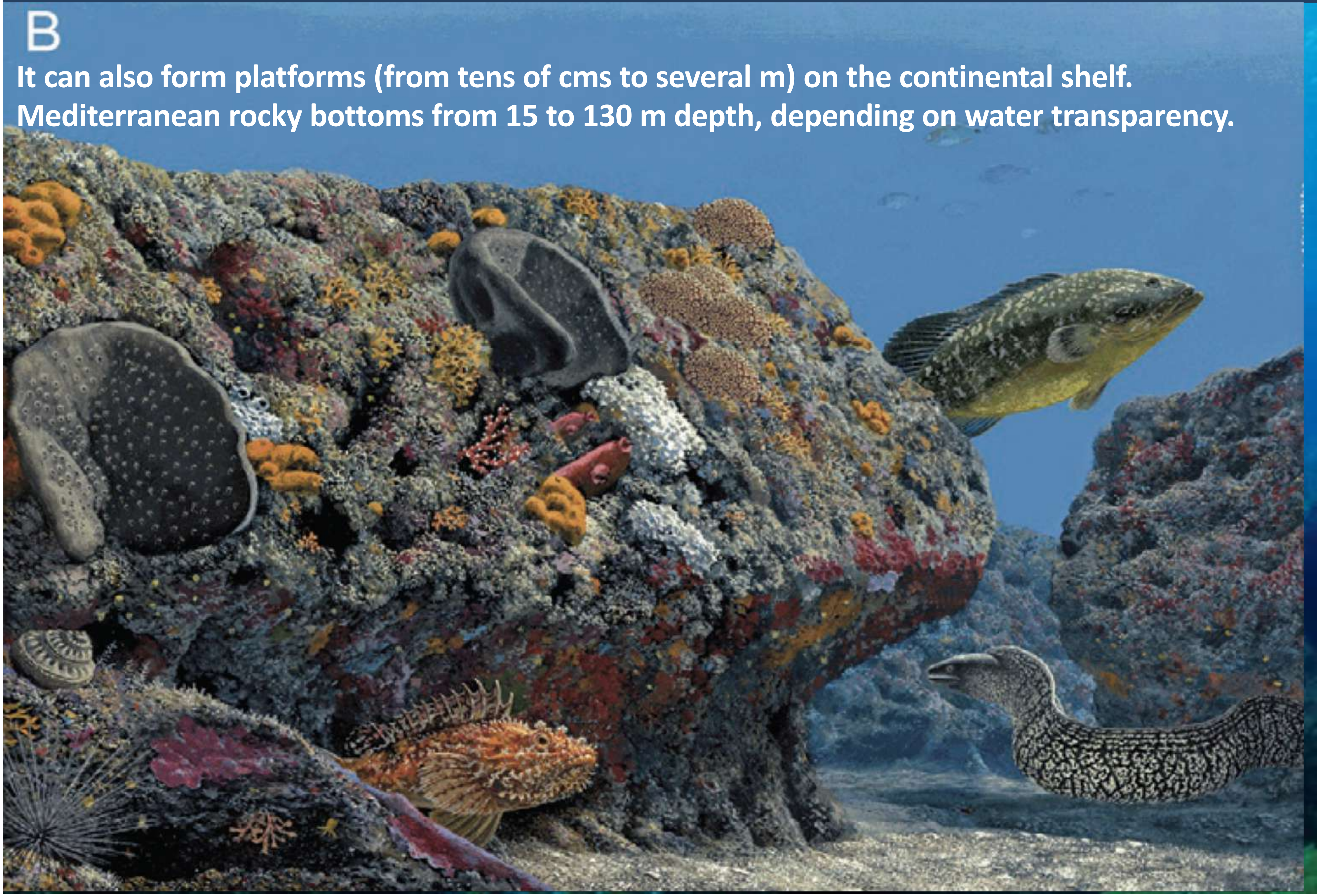
Coralligenous assemblages



Coralligenous reef is a hard substratum of biogenic origin that is mainly produced by the accumulation of calcareous encrusting corallines (red algae, Rhodophyta) growing under dim light conditions. It often develops on almost vertical walls, on gently sloping bottoms or near the base of a wall. Coralligenous formations consist of carbonatic concrections whose thicknesses range from 25 cm to more than 2 m.

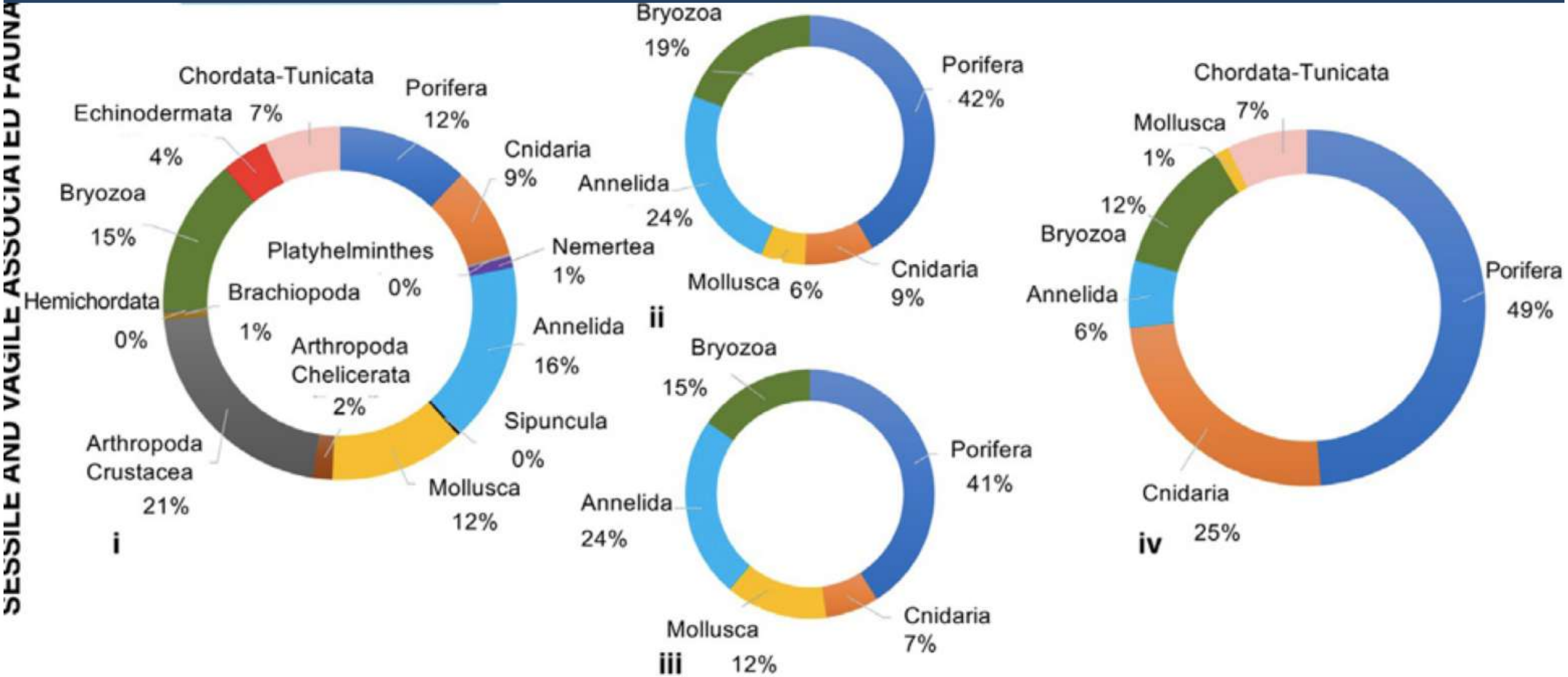
Coralligenous assemblages

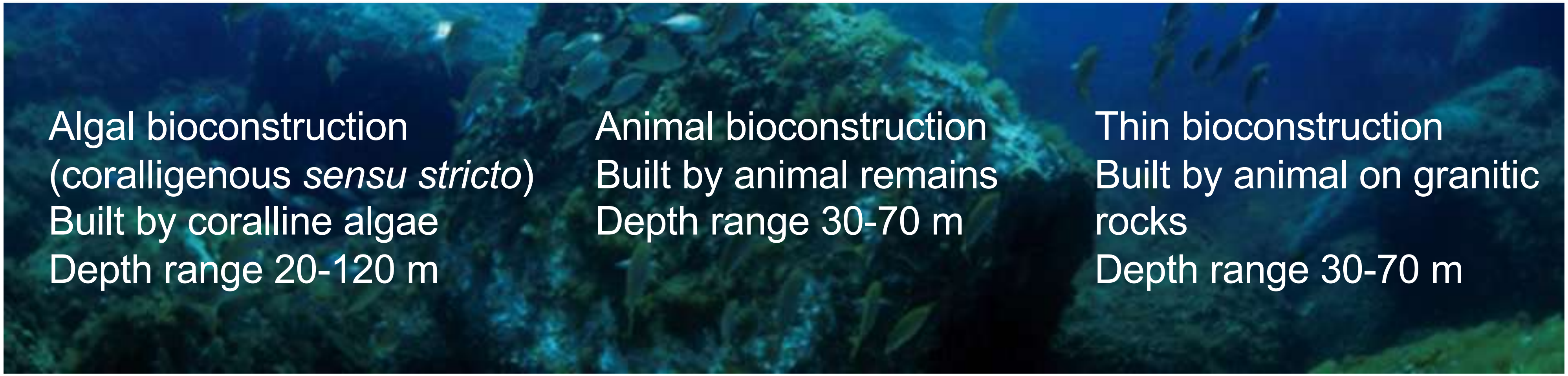
It can also form platforms (from tens of cms to several m) on the continental shelf.
Mediterranean rocky bottoms from 15 to 130 m depth, depending on water transparency.



Coralligenous assemblages

Coralligenous assemblages



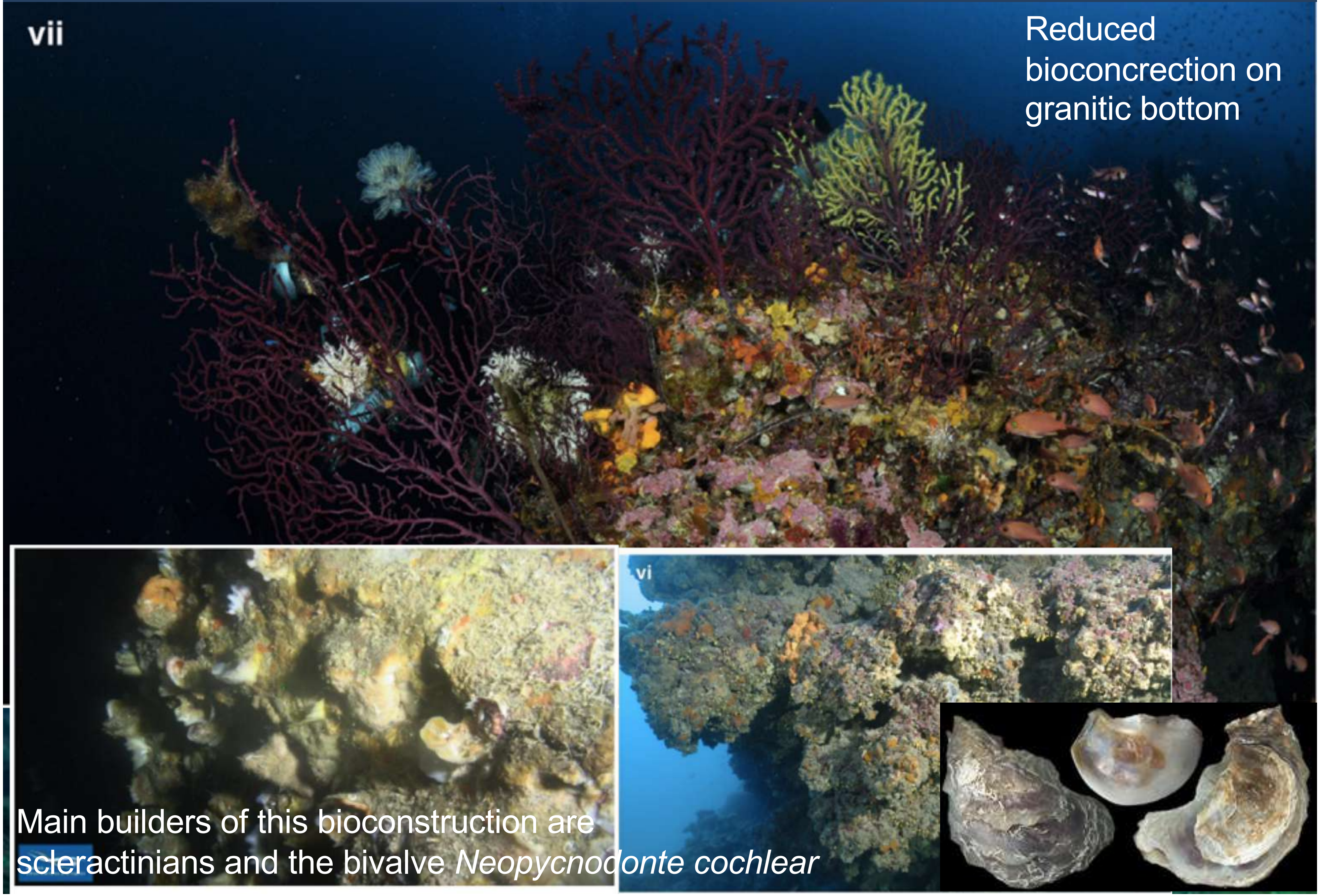


Algal bioconstruction
(coralligenous *sensu stricto*)
Built by coralline algae
Depth range 20-120 m

Animal bioconstruction
Built by animal remains
Depth range 30-70 m

Thin bioconstruction
Built by animal on granitic rocks
Depth range 30-70 m

Coralligenous assemblages

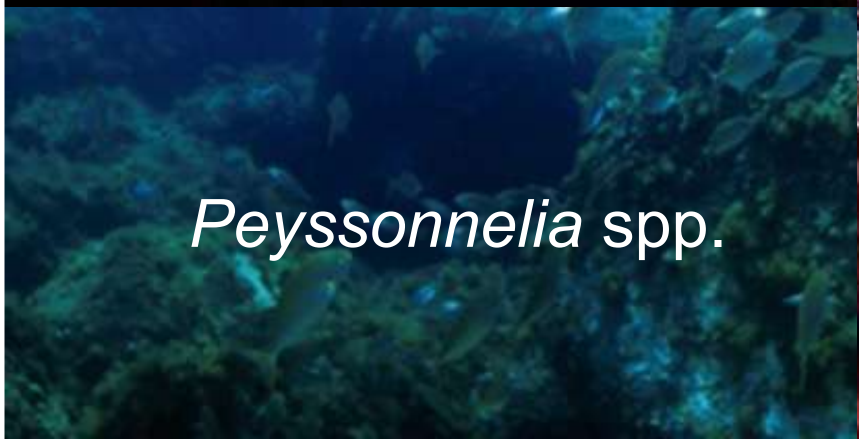


Reduced bioconcrection on granitic bottom

Main builders of this bioconstruction are scleractinians and the bivalve *Neopycnodonte cochlear*

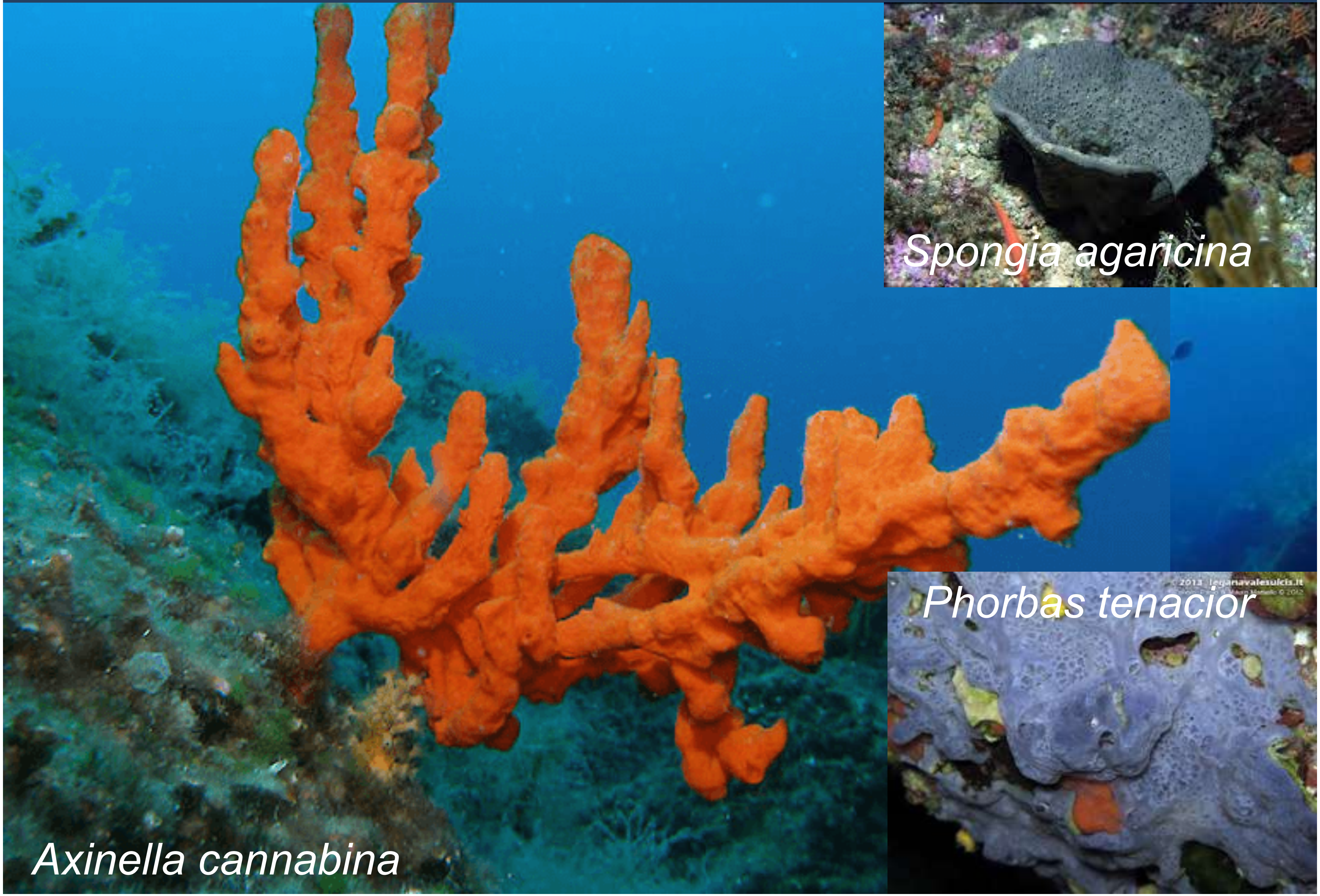
Typical species

Lithophyllum spp.

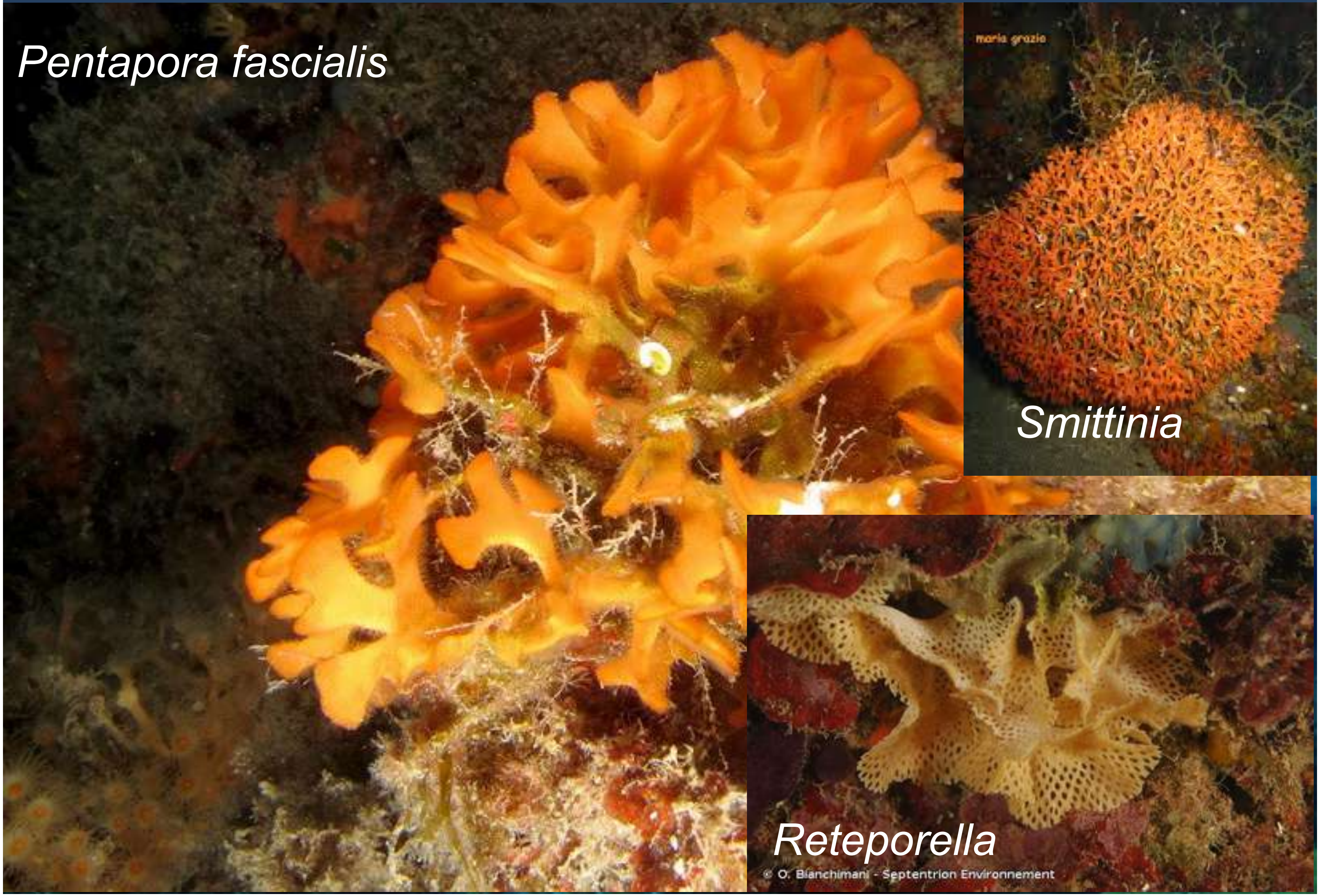


Peyssonnelia spp.

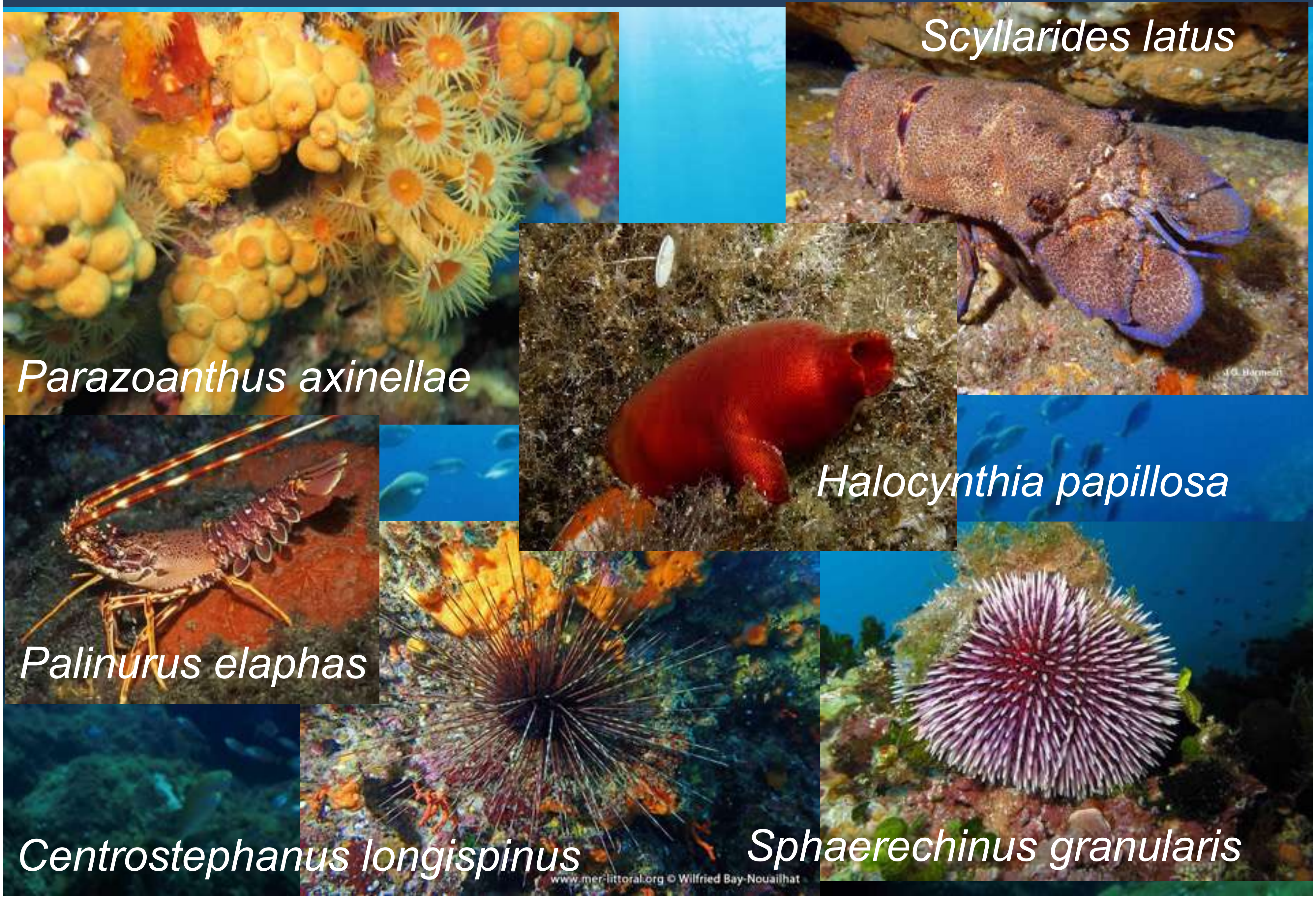
Typical species



Typical species



Typical species



Typical species

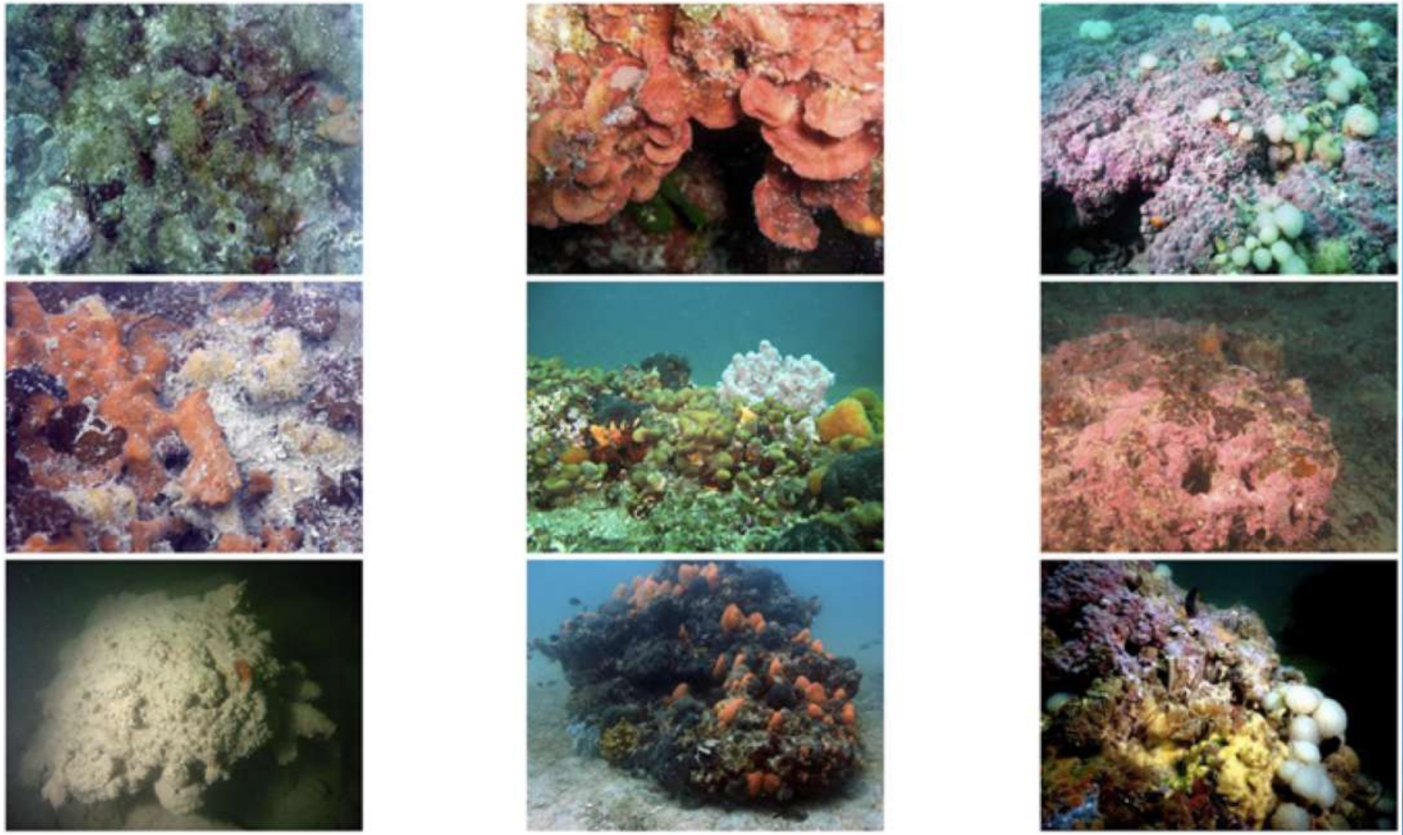

Conger conger


Dentex dentex


Epinephelus marginatus


Muraena helena

Trezze o tegnue



turf
encrusting sponges
bioeroders
sediment

massive sponges
Peyssonnelia spp.
ascidians

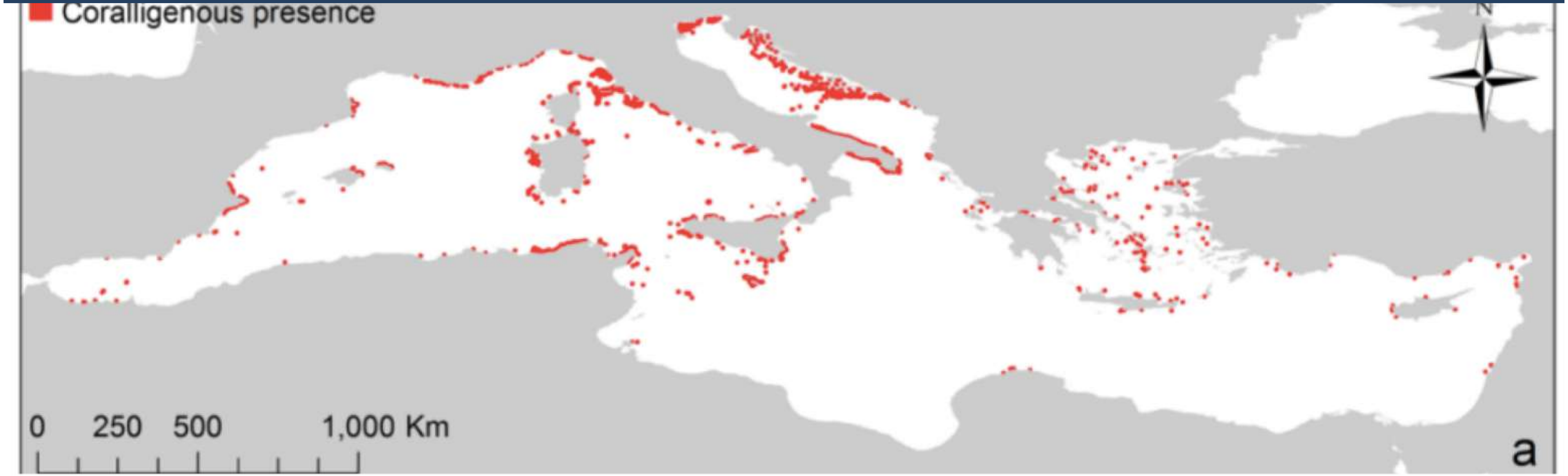
reef builders
Polycitor adriaticus

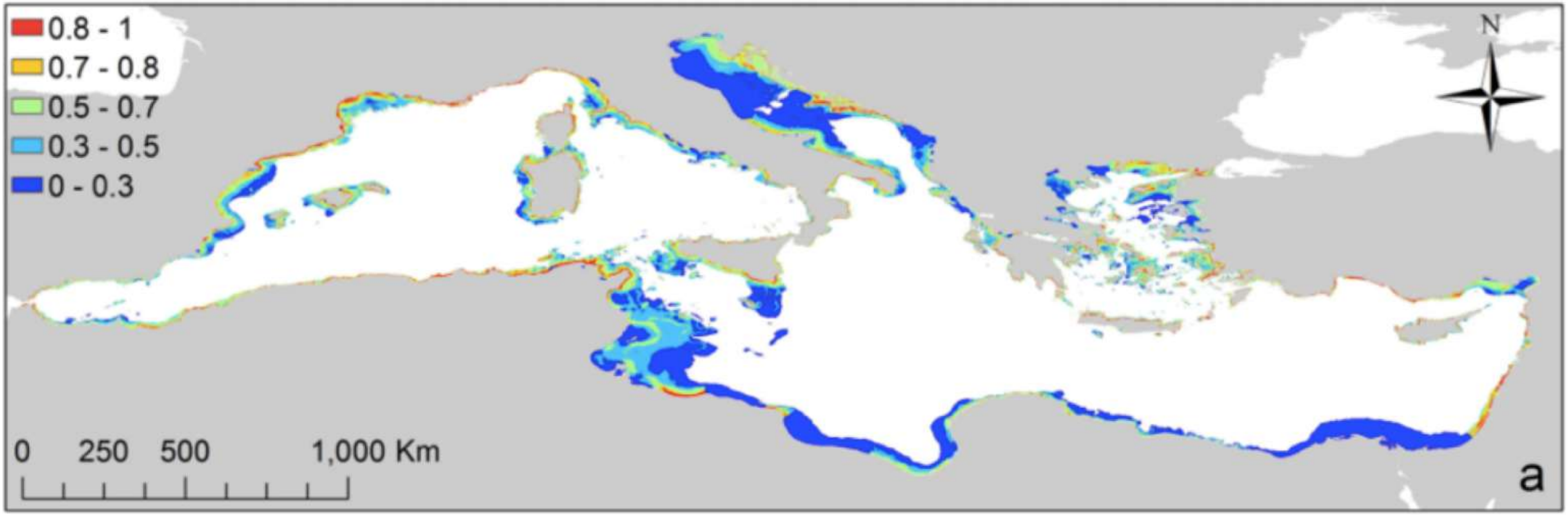
Different types of bioconcrections are present depending on the main components, which in turn, depends on environmental features such as distance from the coasts and human influence

Falace et al., 2015

In the northern Adriatic continental shelf, biogenic frameworks are generally superimposed on hard bottoms. Marine sediments may be consolidated by methane-related calcium carbonate cementation, thanks to seepage of CH_4-rich fluids, observable near many offshore reefs. Pleistocenic rivers, Holocene tidal channels and beach bars which are initial substrate for current coralligenous build-ups.

Distribution





Surface areas reported here for coralligenous outcrops (2,763 km^2) based on data resulting from *in situ* observations limited to the 0 to 200 m depth band. Martin et al. 2014

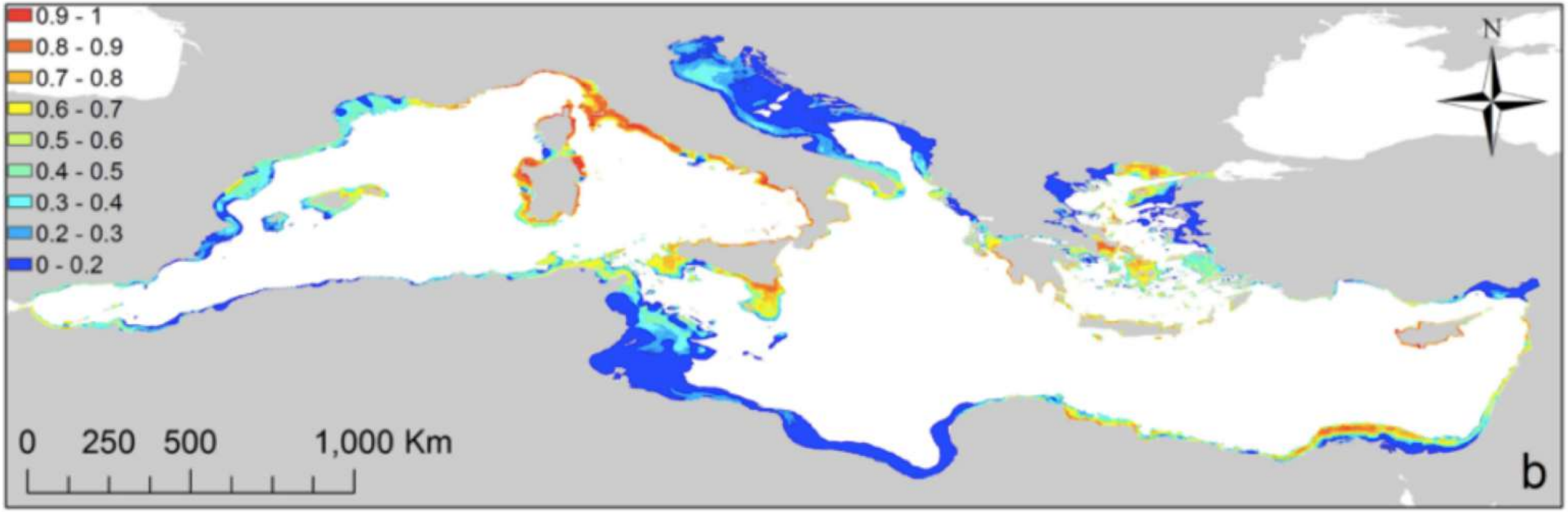
Maërl

Biogenic structure formed by several coralline algae growing and accumulating (dead and alive) on soft bottom, living unattached to the substrate with thalli as nodules of ramified shapes.

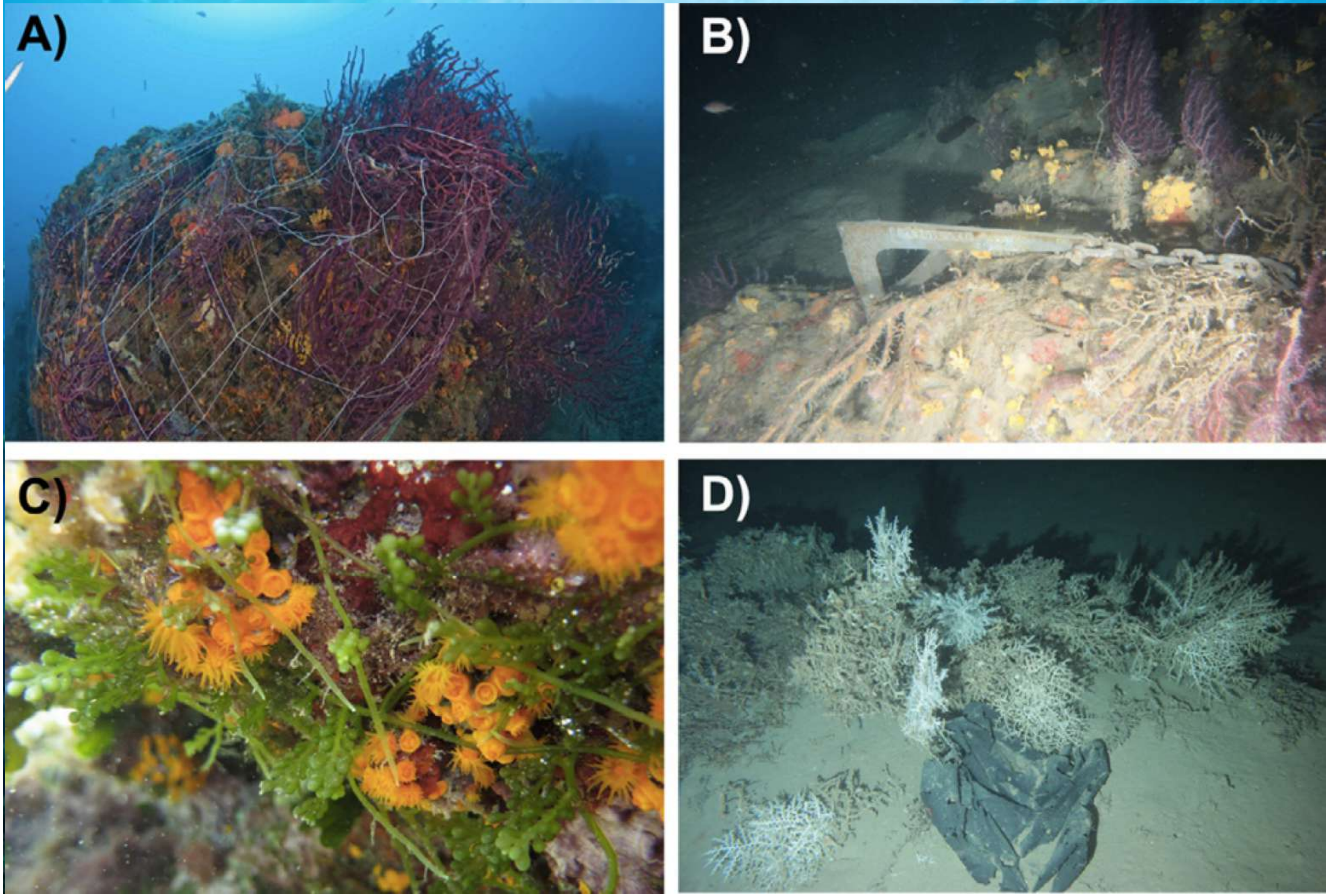
Algae can live >100 y.

Phymatolithon calcareum

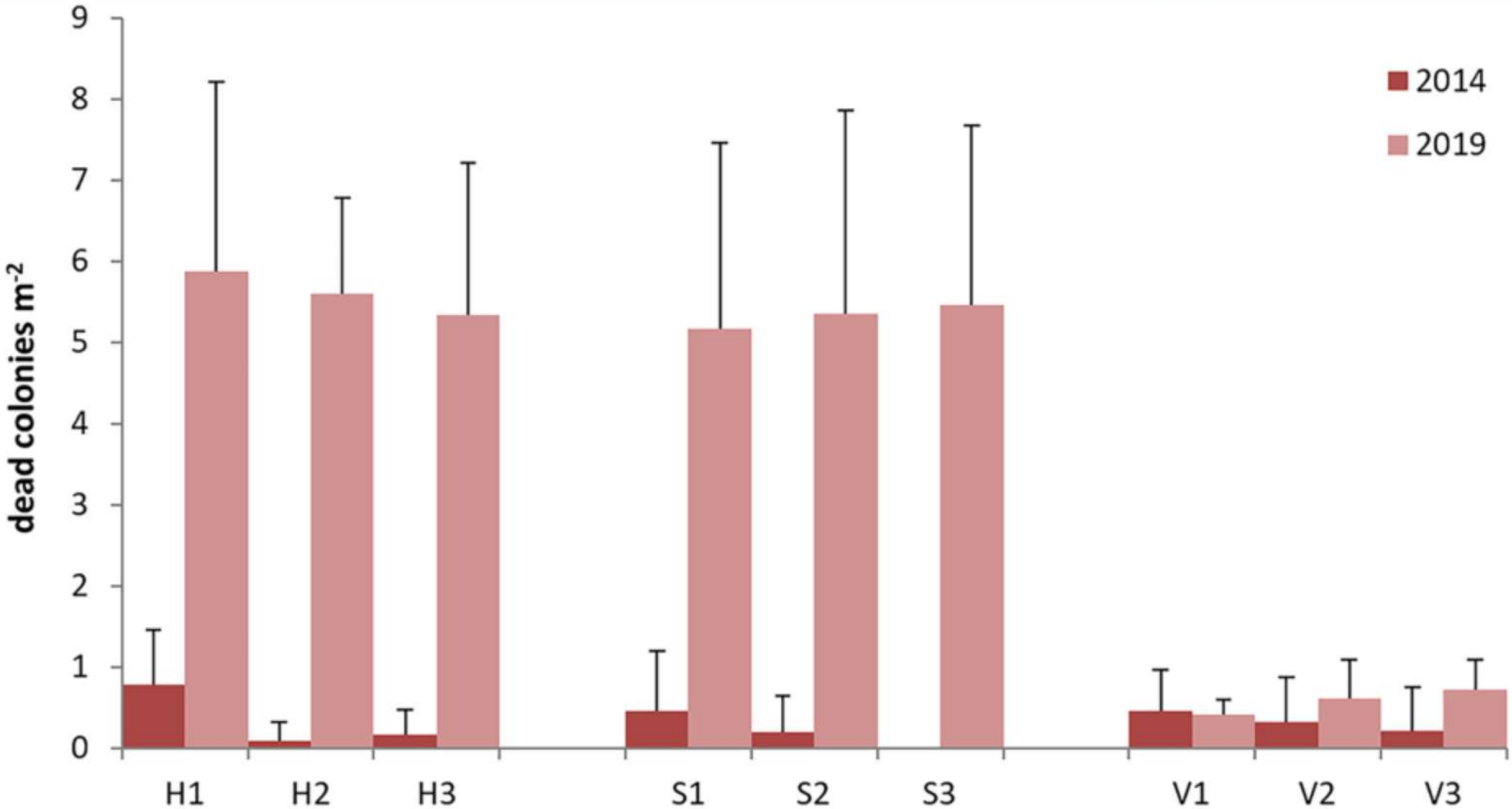
Distribution



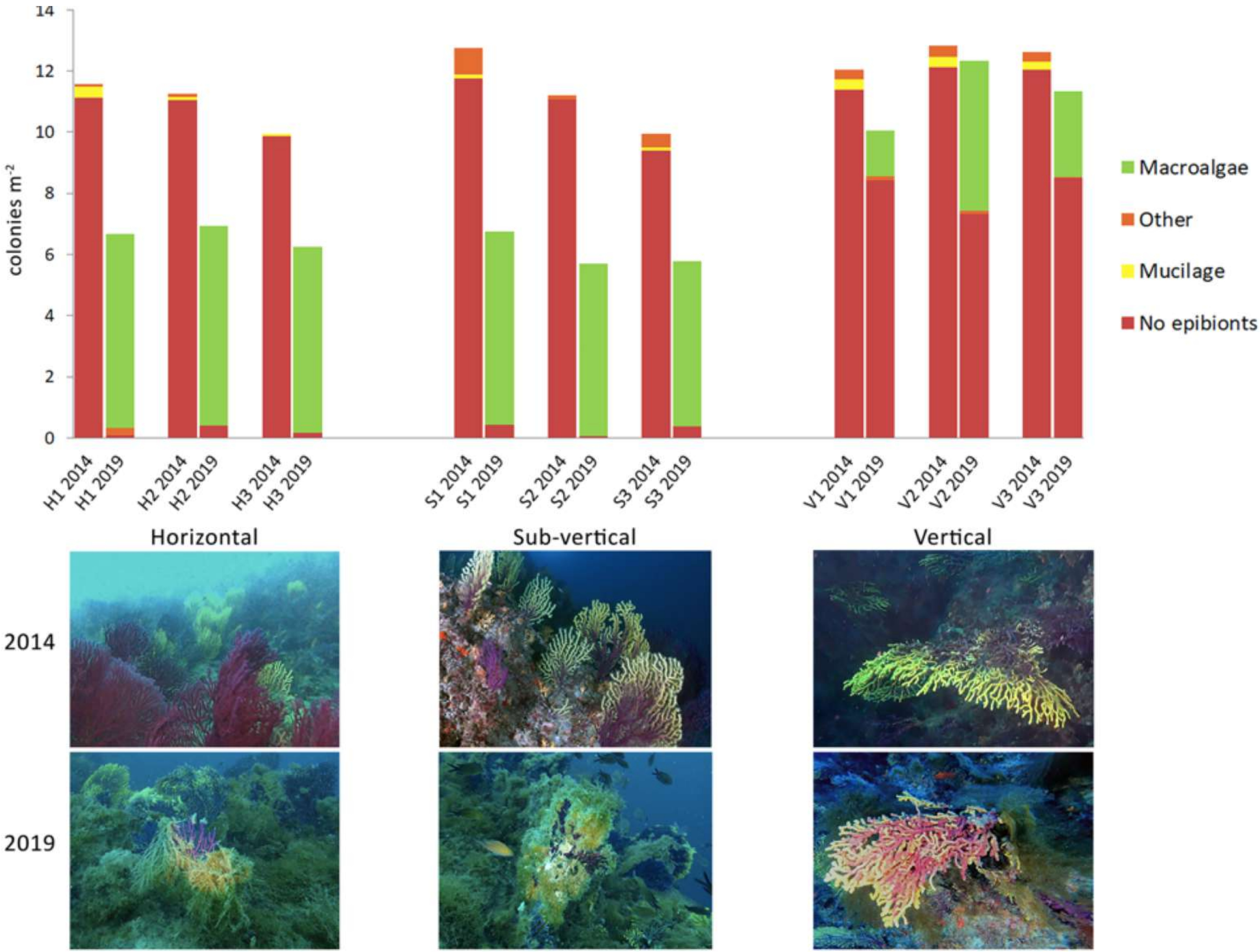
Threats



MMEs

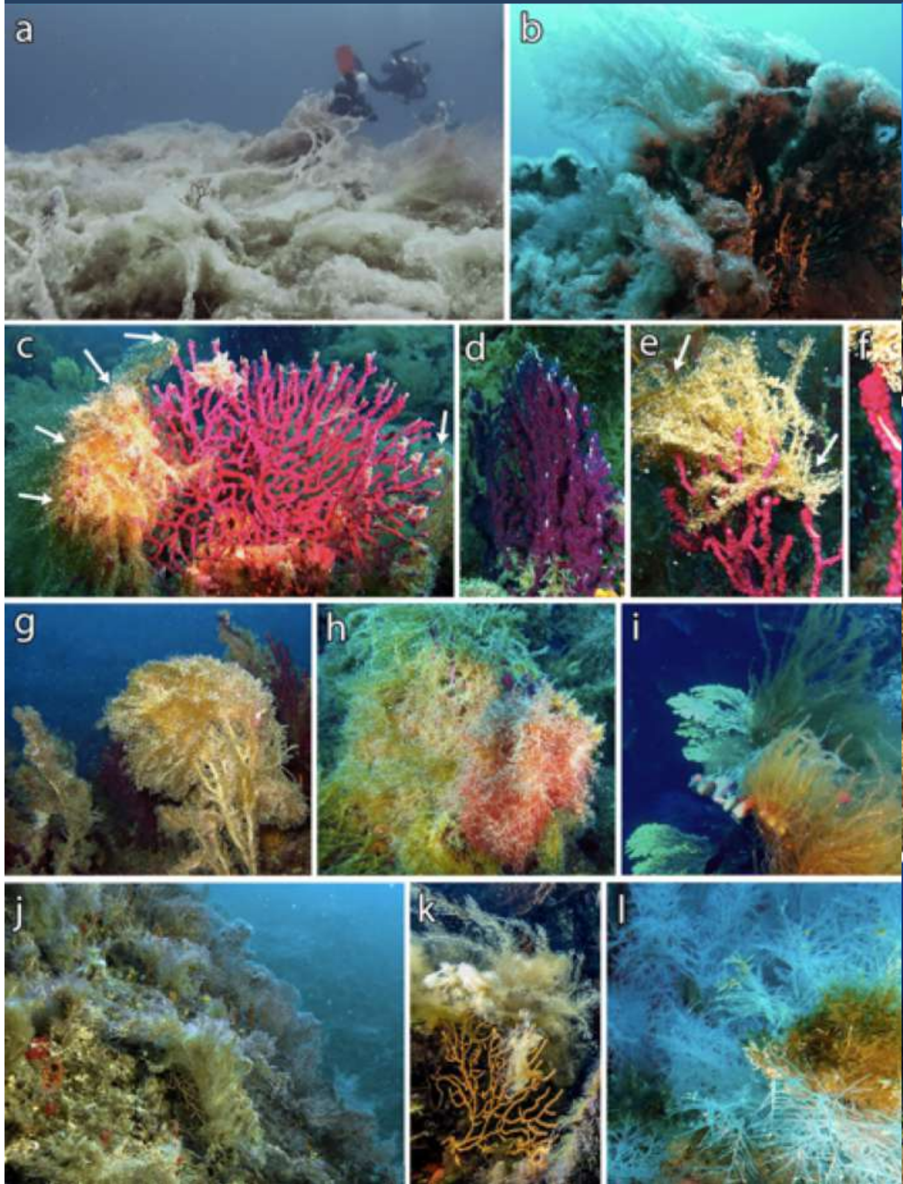


Paramuricea clavata monitored during five years (2014–2019, Tremiti Islands). Massive mucilaginous blooms occurred from 2015 until 2018. The gorgonians at 30-40 m were entirely covered with mucilage. Below 40 m colonies were almost unaffected.

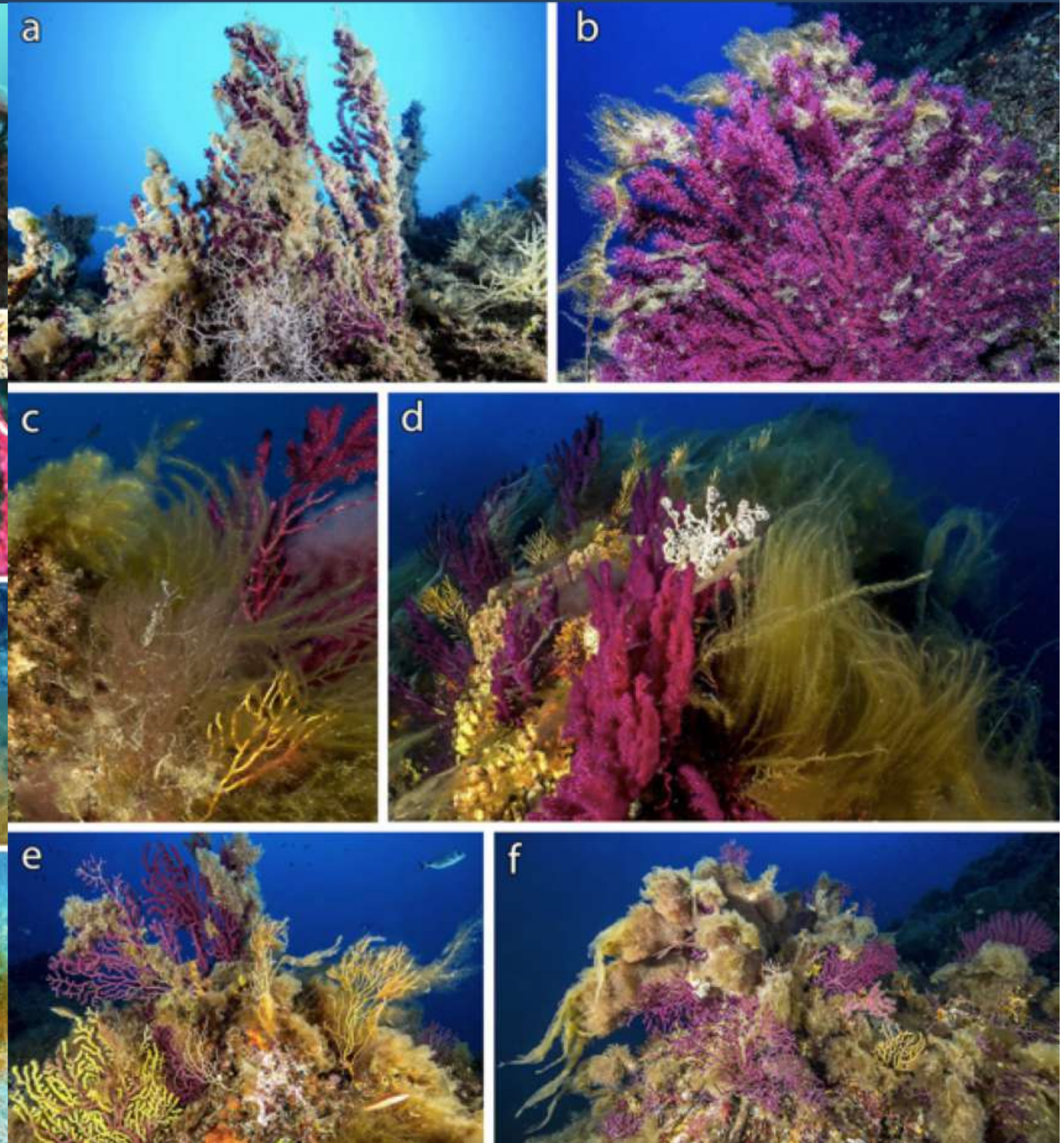


14
12
10
8
6
4
2
0
colonies m-2
Macroalgae
Other
Mucilage
No epibionts
H1 2014
H1 2019
H2 2014
H2 2019
H3 2014
H3 2019
S1 2014
S1 2019
S2 2014
S2 2019
S3 2014
S3 2019
V1 2014
V1 2019
V2 2014
V2 2019
V3 2014
V3 2019
Horizontal
Sub-vertical
Vertical
2014
2019

MMEs

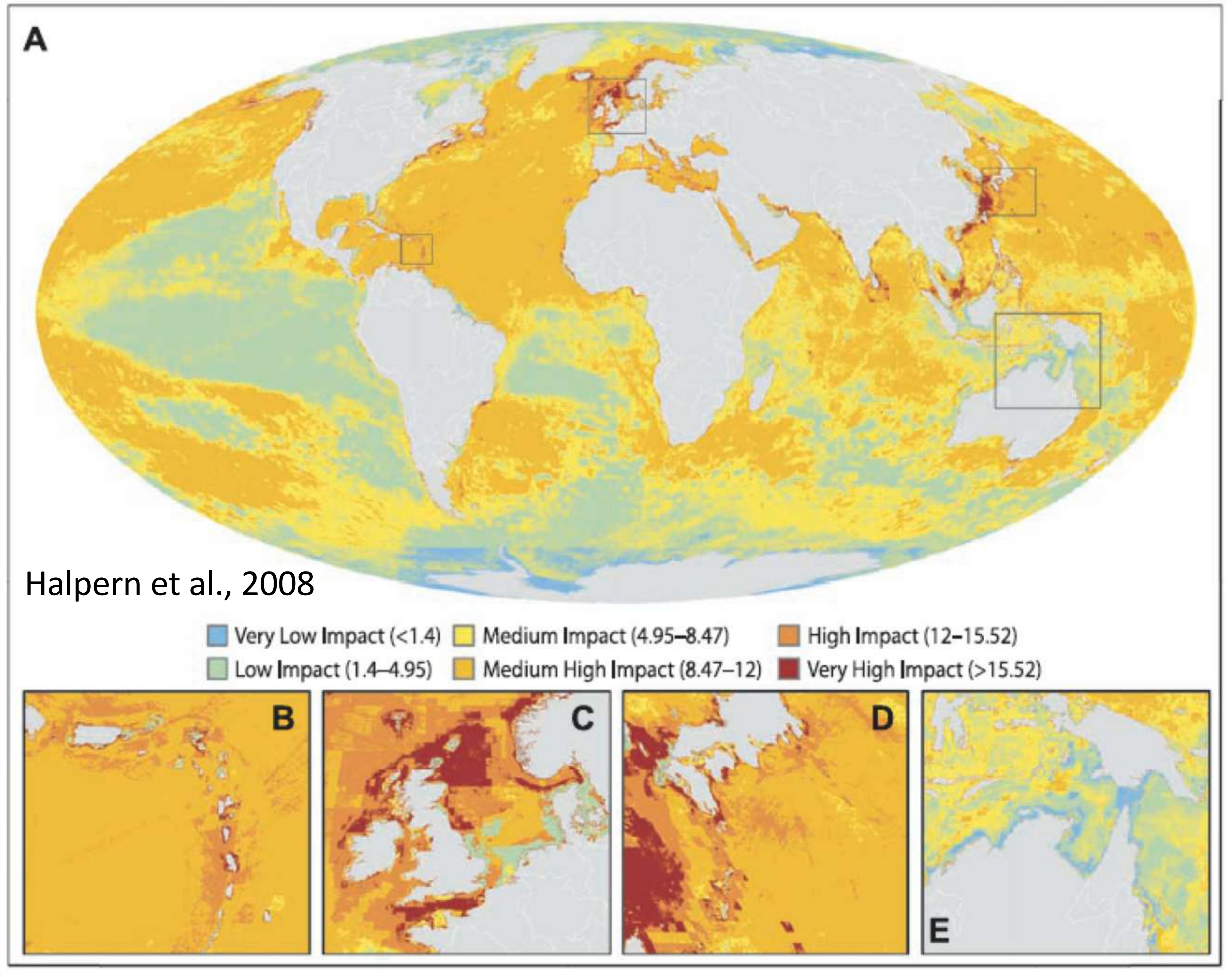


Tremiti Islands

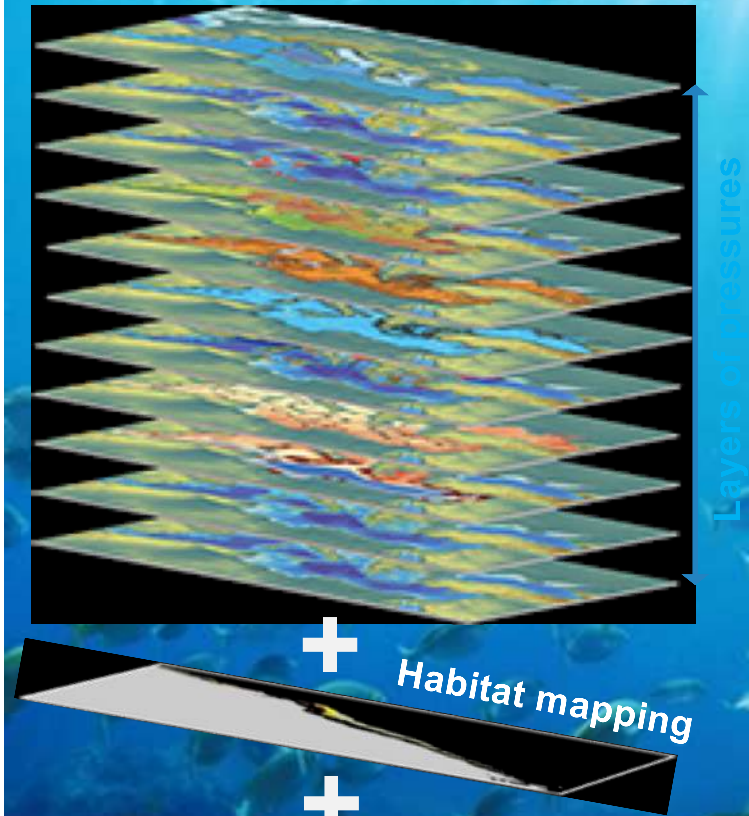


Tuscan Archipelago

Estimating cumulative impacts



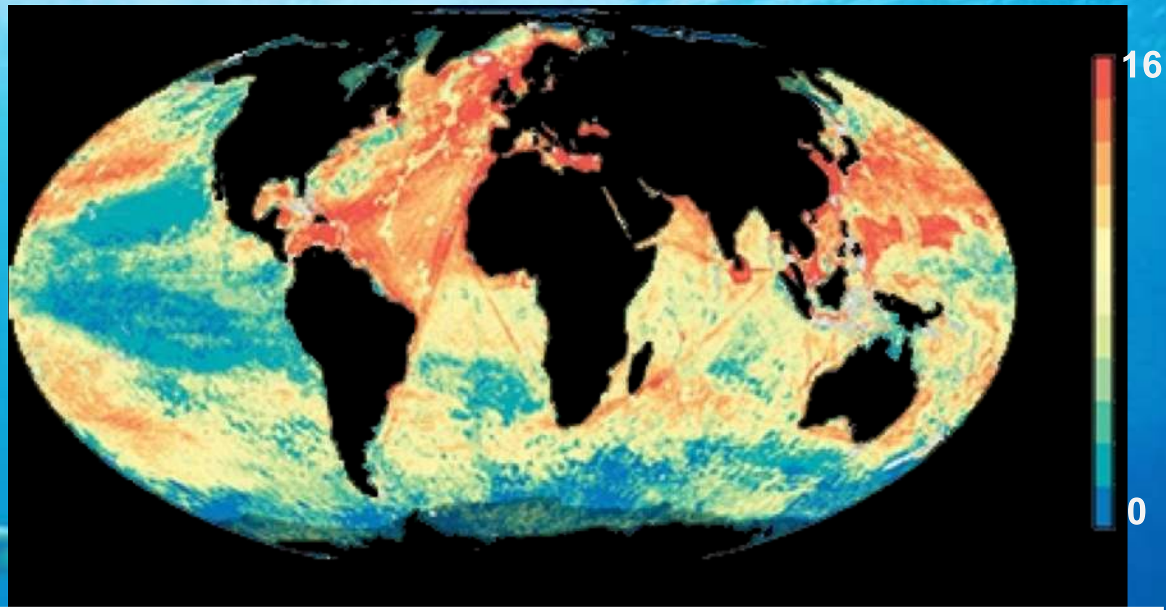
The additive formula



Sensitivity weights by expert opinion

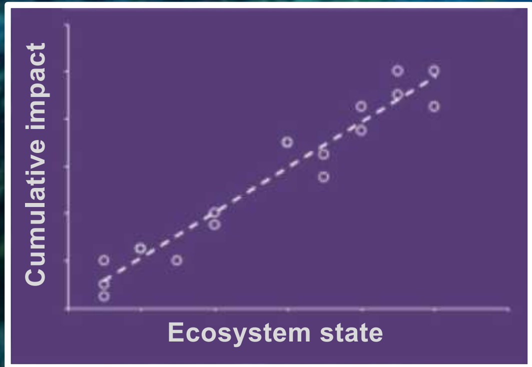
Computing geo-referred impact score

$$I_c = \sum P_i w_i E_j$$



Map of cumulative impact

Cumulative impact score versus ecosystem state



Linear response to pressure

Additivity of impacts

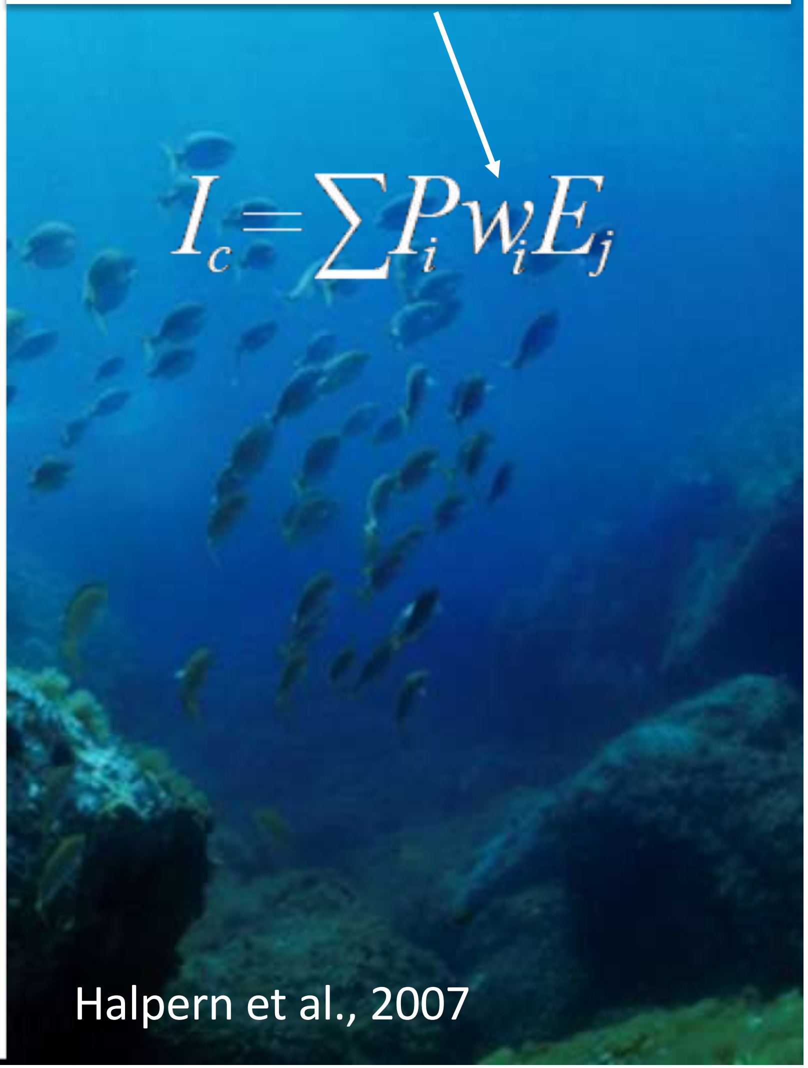
Expert-based sensitivity

Resolution and downscaling

Scores

	Intertidal					*Coastal*				
	Rocky intertidal	*Intertidal mud*	*Beach*	*Mangrove*	*Salt marsh*	*Coral reef*	*Seagrass*	*Kelp forest*	*Rocky reef*	*Suspension-feeder reef*[c]
Threat[b]	13	5	7	7	14	24	6	7	9	5
Freshwater input										
increase	1.6	1.3	0.3	1.8	1.9	1.5	1.6	0.0	1.5	1.7
decrease	1.1	1.1	0.0	2.6	1.9	0.4	1.4	0.0	0.6	1.2
Sediment input										
increase	2.4	2.0	1.1	2.2	2.2	2.8	2.9	1.2	2.0	2.2
decrease	0.6	1.6	0.7	1.3	1.7	0.4	0.5	0.0	0.0	1.5
Nutrient input[d]										
into oligotrophic water	1.8	1.1	0.2	1.4	1.4	2.4	2.1	0.0	1.7	0.0
into eutrophic water	1.3	2.1	0.6	2.1	2.3	1.1	2.0	0.8	1.5	2.8
Pollutant input										
atmospheric	0.8	0.7	0.0	0.9	1.6	0.9	0.6	0.0	0.5	1.8
point, organic	2.4	2.1	1.9	2.0	1.5	2.2	1.9	0.8	2.1	2.4
point, nonorganic	2.2	1.7	0.8	1.1	2.0	1.9	0.4	0.2	1.6	2.4
nonpoint, organic	2.1	2.8	0.1	1.4	1.7	1.2	1.0	1.0	2.2	2.8
nonpoint, nonorganic	2.1	1.6	0.6	0.5	2.0	0.7	0.8	0.0	2.2	2.7
Coastal engineering	2.7	2.1	2.8	3.1	2.3	2.3	2.4	0.0	1.9	3.0
Coastal development	2.7	2.9	3.2	3.4	2.8	2.9	3.3	1.2	2.5	3.2
Direct human	2.8	2.2	2.7	3.3	1.6	2.3	2.5	1.6	2.5	3.0
Aquaculture	2.0	2.0	0.1	3.1	1.7	1.8	2.1	0.0	1.9	1.5
Fishing										
demersal, destructive	1.2	1.4	0.2	0.0	1.0	1.2	0.2	1.5	2.7	3.1
demersal, nondestructive	0.8	1.9	0.9	0.9	1.0	1.6	1.1	2.1	2.9	0.7
pelagic, high bycatch	0.9	0.0	0.1	0.0	0.5	0.5	0.0	0.0	2.6	0.0
pelagic, low bycatch	0.0	0.0	0.0	0.0	0.4	0.7	0.0	0.0	2.6	0.0
aquarium	1.4	0.0	0.0	0.7	0.5	1.6	0.4	0.0	1.8	0.0
illegal/unregulated/unreported	1.2	0.0	0.7	0.0	0.4	1.0	0.6	0.0	1.2	0.0
artisanal, destructive	1.1	0.5	0.8	1.2	0.5	2.0	0.0	1.5	2.3	1.2
artisanal, nondestructive	1.4	0.3	0.5	2.2	0.6	2.5	0.6	0.0	2.1	0.7
recreational	2.0	1.7	0.4	2.1	0.5	2.1	2.2	2.3	2.6	1.3
Climate change										
sea level	2.5	1.9	2.1	3.0	3.1	2.4	2.6	1.6	1.5	1.8
sea temperature	2.8	1.4	0.6	2.4	1.4	2.8	2.1	2.0	1.9	0.8
ocean acidification	0.9	1.0	0.0	1.2	1.3	1.1	1.4	0.0	1.1	0.7
ozone/UV	0.9	1.3	0.0	0.2	1.1	0.8	0.5	0.1	0.7	0.0
Species invasion	2.8	2.9	0.9	1.0	2.8	1.5	1.2	1.3	2.5	2.6
Disease	1.3	1.8	0.0	1.7	1.1	2.2	1.0	0.7	1.8	2.1
Harmful algal blooms	1.9	2.2	0.9	1.6	2.0	1.8	2.3	0.4	1.7	2.5
Hypoxia	1.2	2.1	0.6	0.6	1.9	0.8	1.3	1.0	1.6	2.9
Ocean-based pollution	1.3	0.8	0.5	1.2	1.2	1.2	0.5	0.1	1.7	0.0
Commercial activity	0.3	1.9	1.9	2.0	1.4	1.5	1.9	0.0	1.4	0.0
Ocean mining	0.9	0.0	0.3	0.0	1.1	0.8	0.4	0.0	1.3	0.0
Offshore development	0.7	0.0	0.4	0.0	0.7	0.2	0.0	0.5	0.7	0.0
Benthic structures	1.0	0.9	0.8	1.3	0.9	0.5	1.6	0.0	1.7	0.4
Ecotourism	1.6	0.0	1.0	2.3	1.3	1.8	1.5	0.8	1.7	0.3
Summed threat	58.9	51.4	28.4	55.7	54.9	57.2	48.9	22.4	66.6	53.2
Average threat	1.5	1.4	0.7	1.5	1.4	1.5	1.3	0.6	1.8	1.4

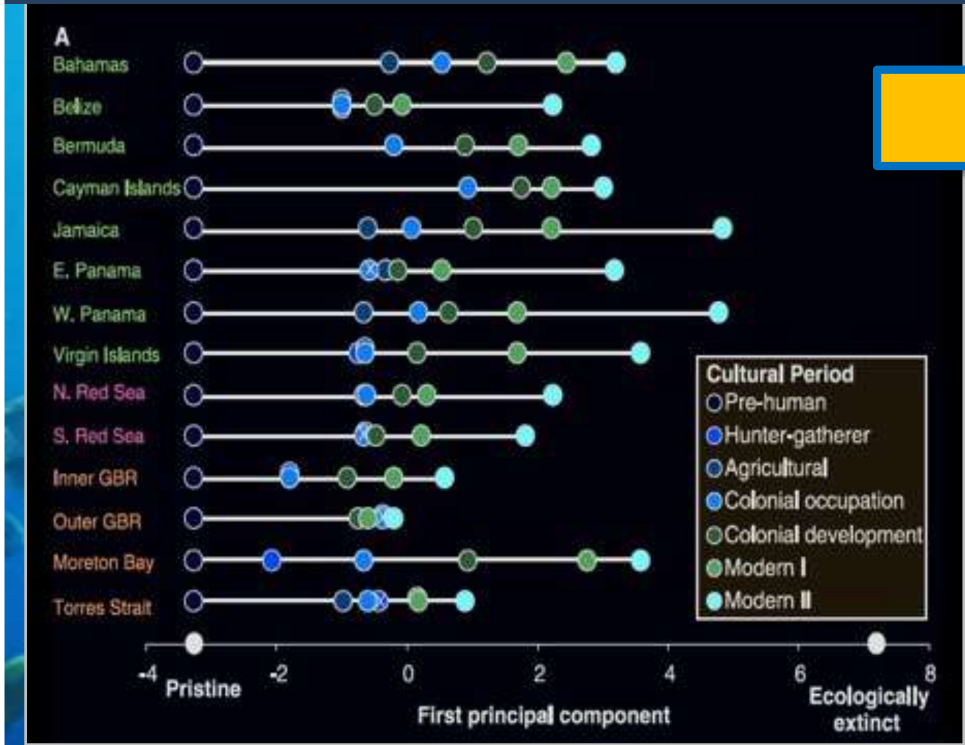
Score from expert opinion. For each ecosystem and each threat a sensitivity score has been assigned



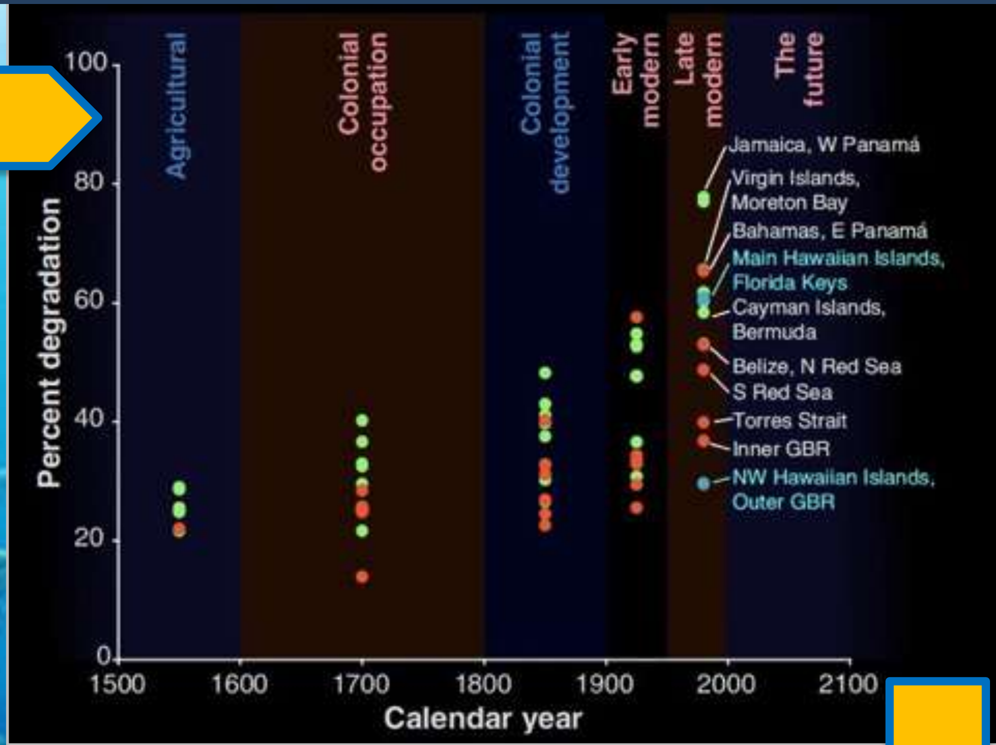
$$I_c = \sum P_i w_i E_j$$

Halpern et al., 2007

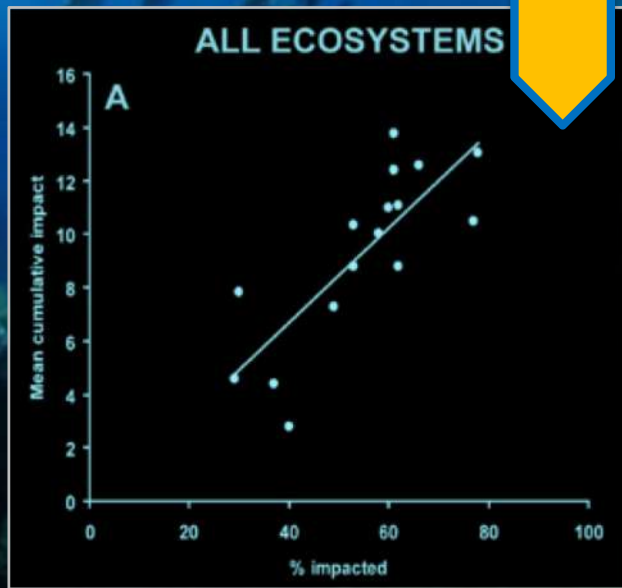
Pressure response relationship



Pandolfi et al., 2003. Science



Pandolfi et al., 2005. Science



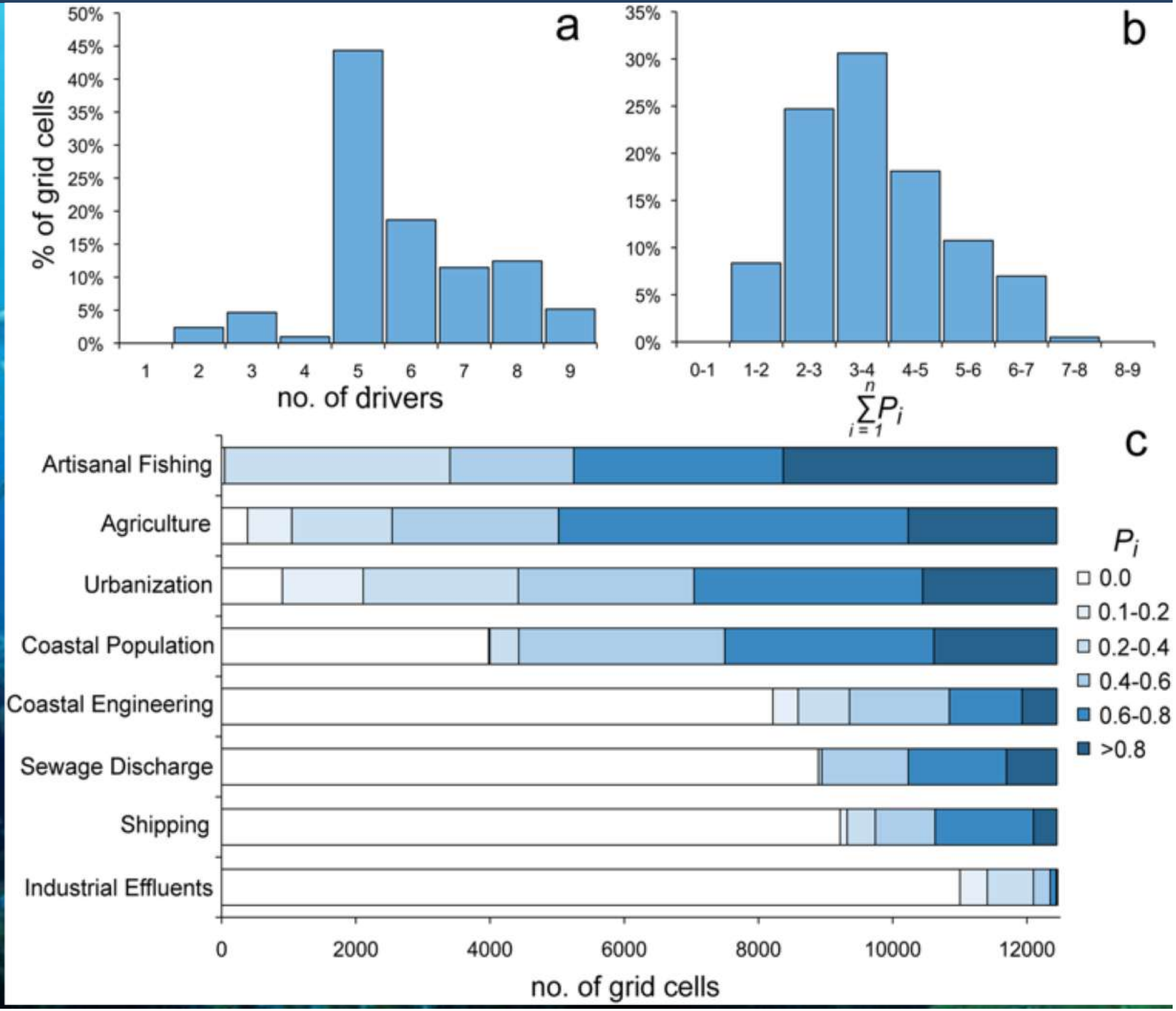
$I_c = 0.1762 \times$ [level of system degradation] $- 0.3381$

Halpern et al., 2008. Science

<10%	very low	(<1.4)
10-30%	low	(1.45-4.95)
30-50%	medium	(4.95-8.47)
50-70%	medium-high	(8.47-12)
70-90%	high	(12-15.52)
>90%	very high	(>15.52)

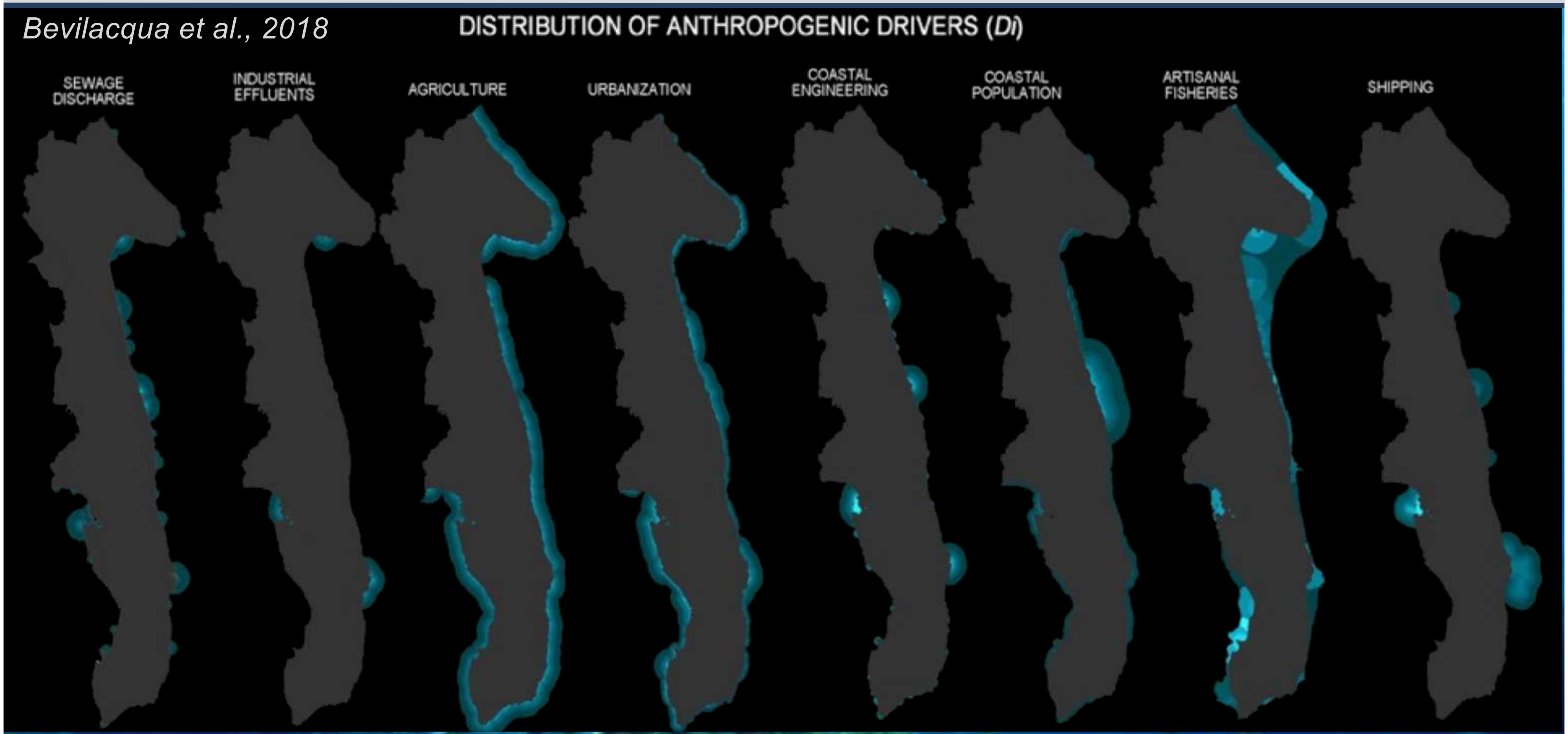
A case study on coralligenous outcrops

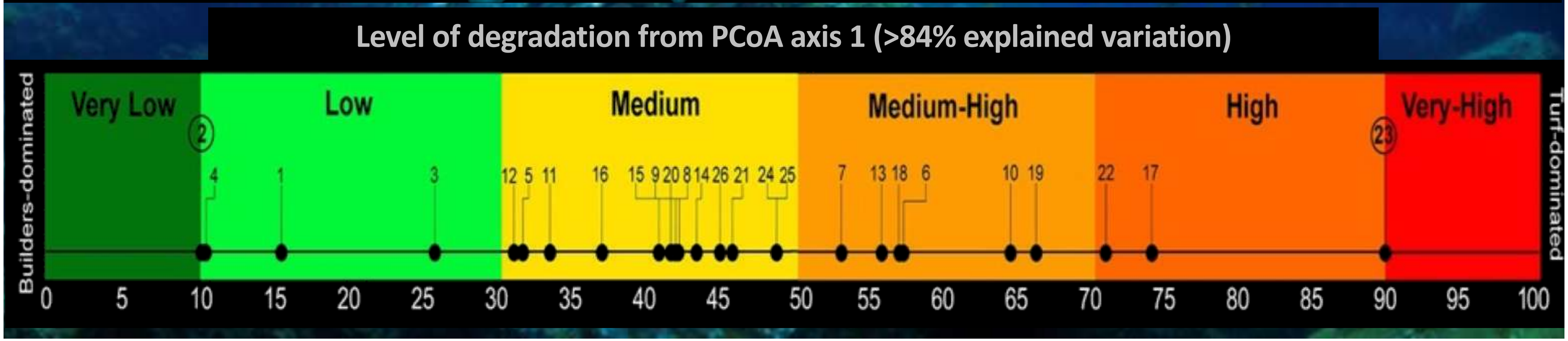
Bevilacqua et al., 2018



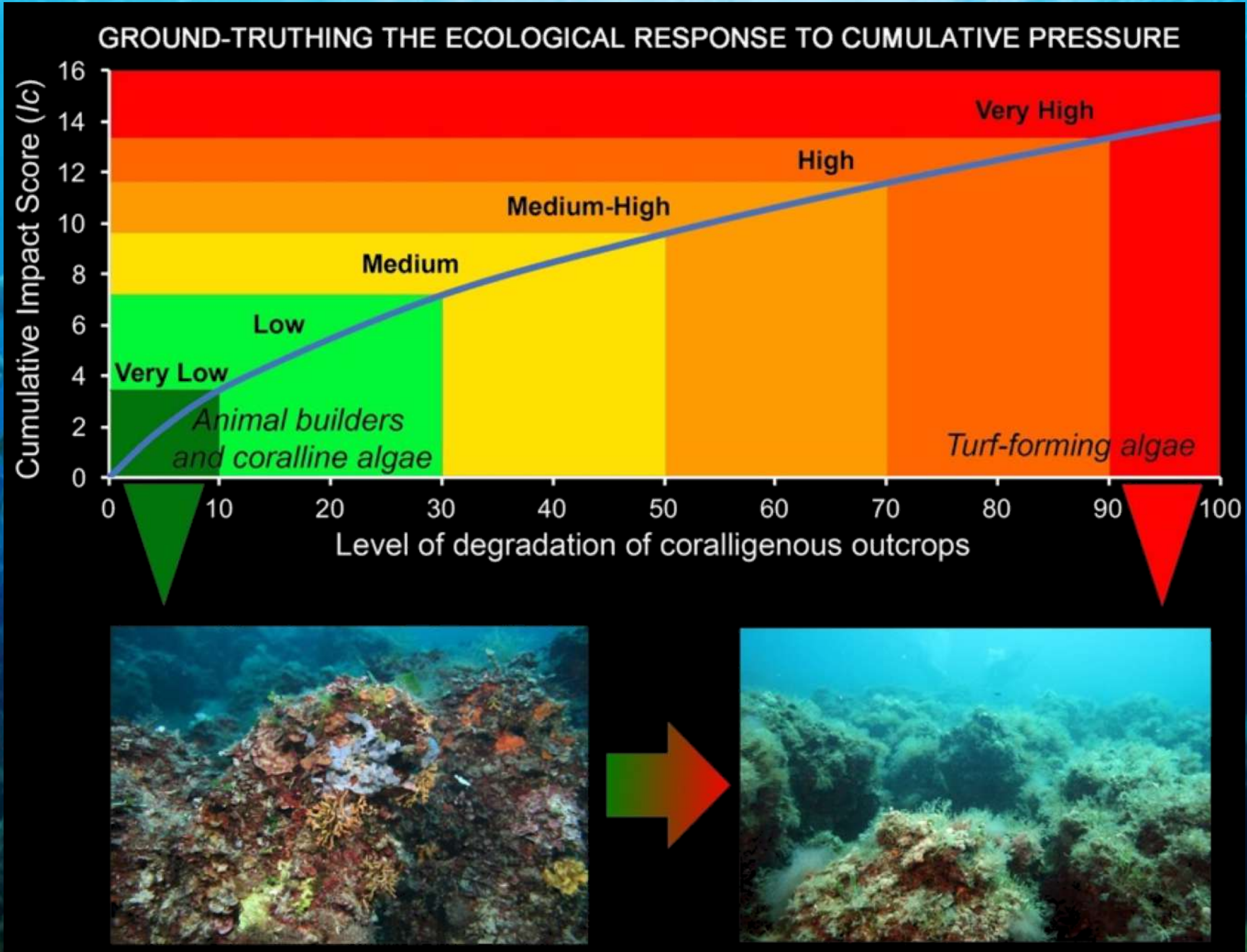
Pressures

Bevilacqua et al., 2018

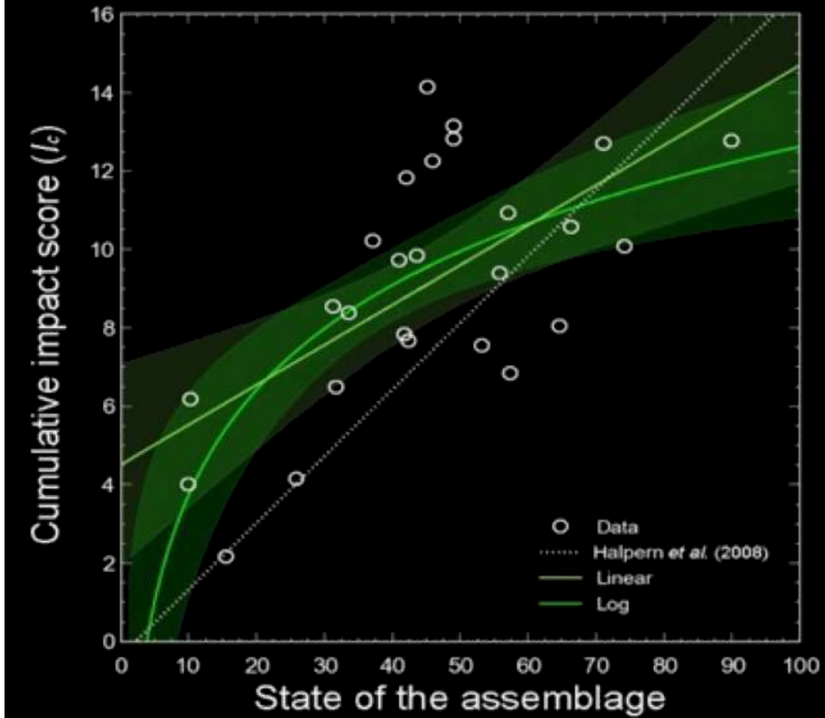




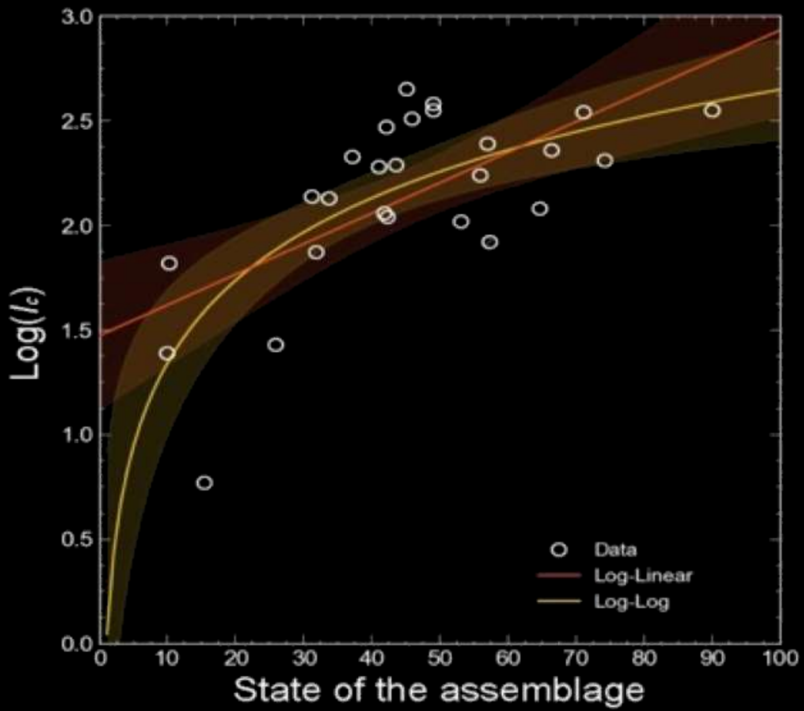
Status of coralligenous



Pressure-response relationship

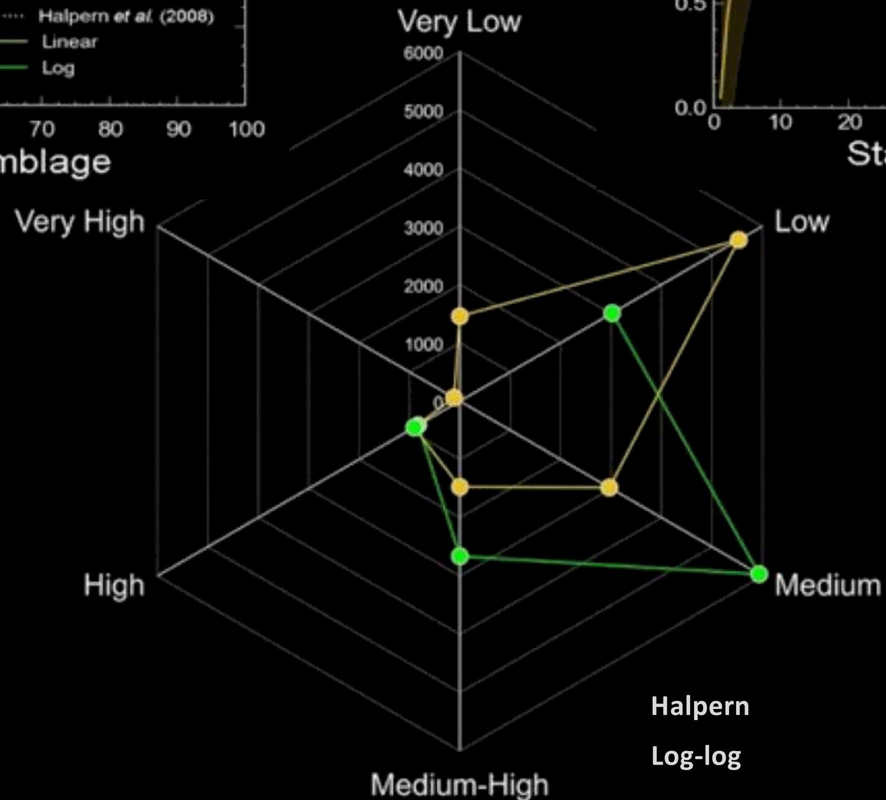


A log-log model best fitted the pressure-response relationship
Halpern's linear model was unlikely



Thresholds from Halpern's linear model

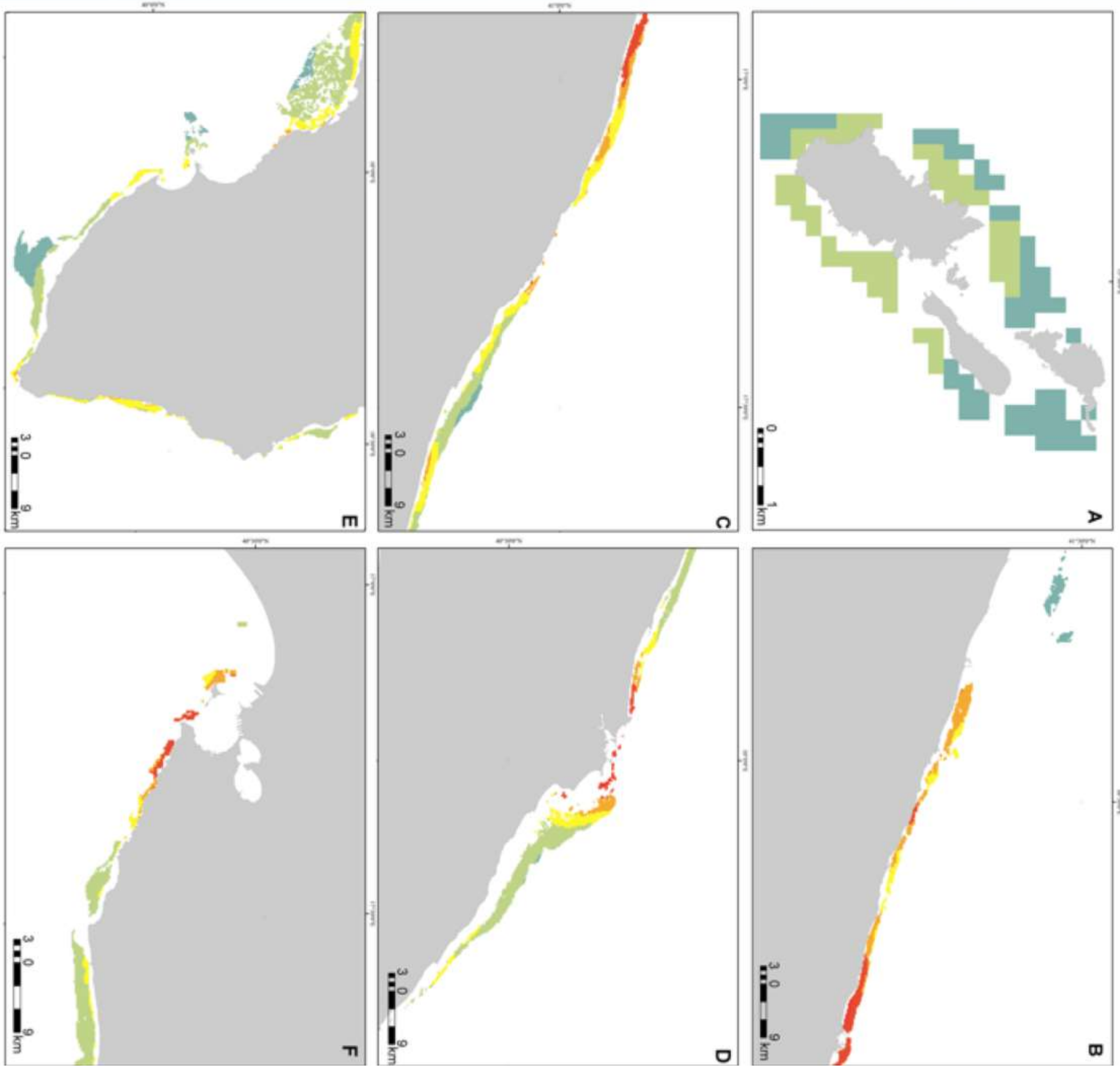
very low	(<1.4)
low	(1.45-4.95)
medium	(4.95-8.47)
medium-high	(8.47-12)
high	(12-15.52)
very high	(>15.52)

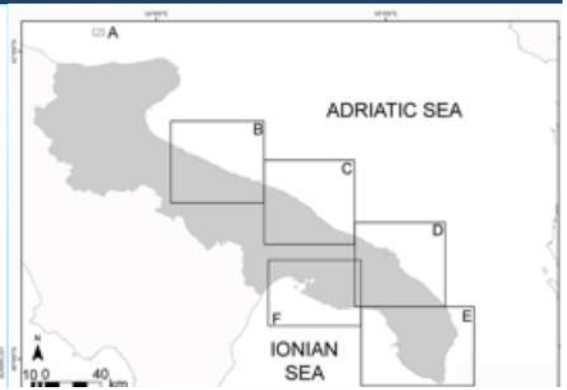


Thresholds from log-log model

very low	(<3.86)
low	(3.86-7.19)
medium	(7.19-9.59)
medium-high	(9.59-11.6)
high	(11.6-13.37)
very high	(>13.37)

A case study on coralligenous outcrops





- Very low (< 3.86)
- Low (3.86 - 7.19)
- Medium (7.19 - 9.59)
- Medium-High (9.59 - 11.60)
- High (16.60 - 13.37)
- Very high (> 13.37)