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

Marine Biodiversity and global change Prof. Stanislao Bevilacqua (sbevilacqua@units.it)

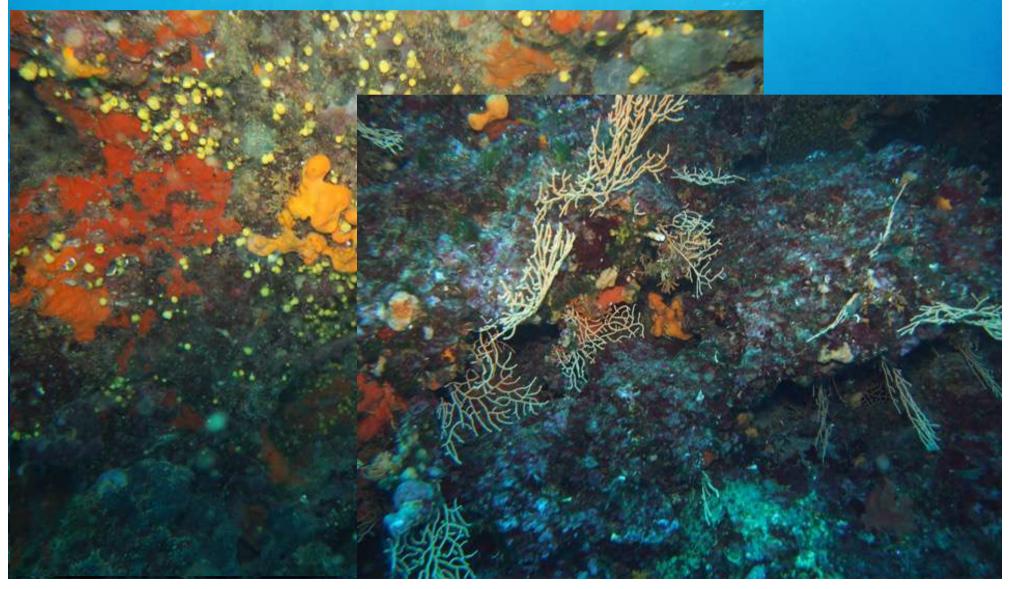
> **Coralligenous and other subtidal bioconstructions**

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

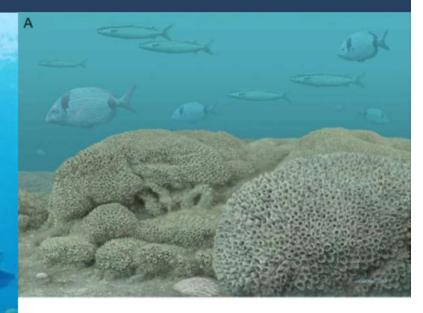
Bioconstructors modify primary (i.e. geological) substrates and provide secondary (i.e. biogenic) substrates for new bioconstructors and for nonbioconstructors who simply inhabit them

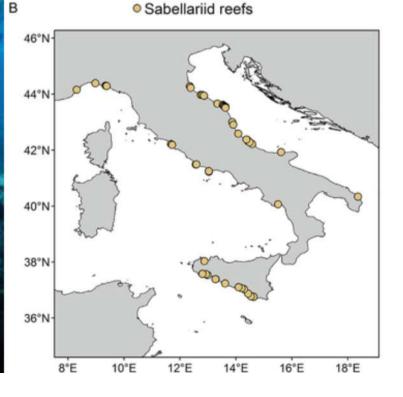


Bioconstructions of the Mediterranean Sea

- 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



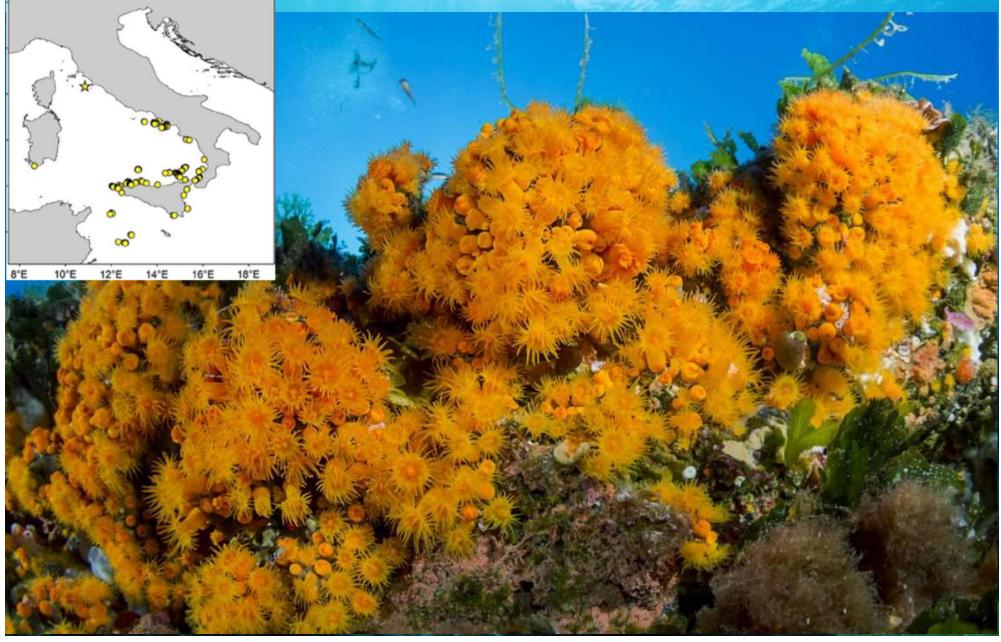


Bioconstructions of the Mediterranean Sea

A. calycularis formations/reefs
 A. calycularis dead colony

C

Astroides calycularis scleractinians not zooxanthelate



Biostalactites



C • Submarine 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.

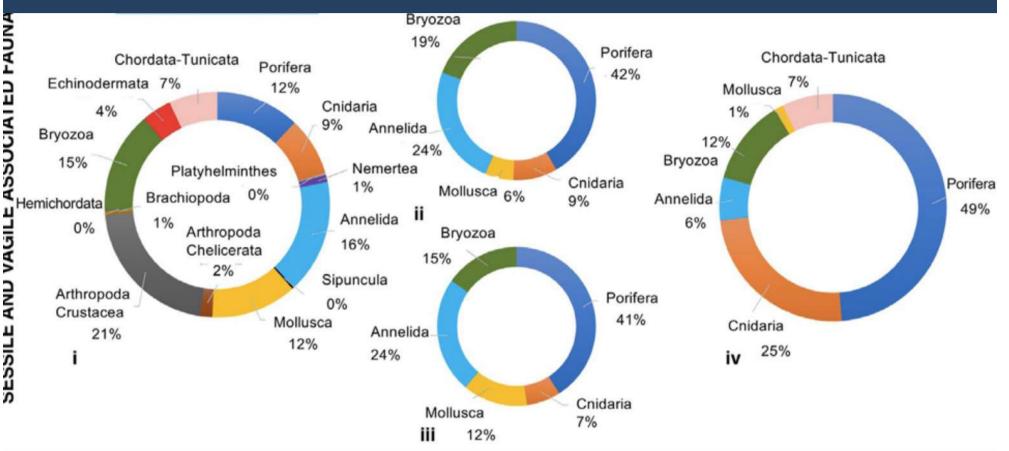
A

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.

В

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.





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

vii

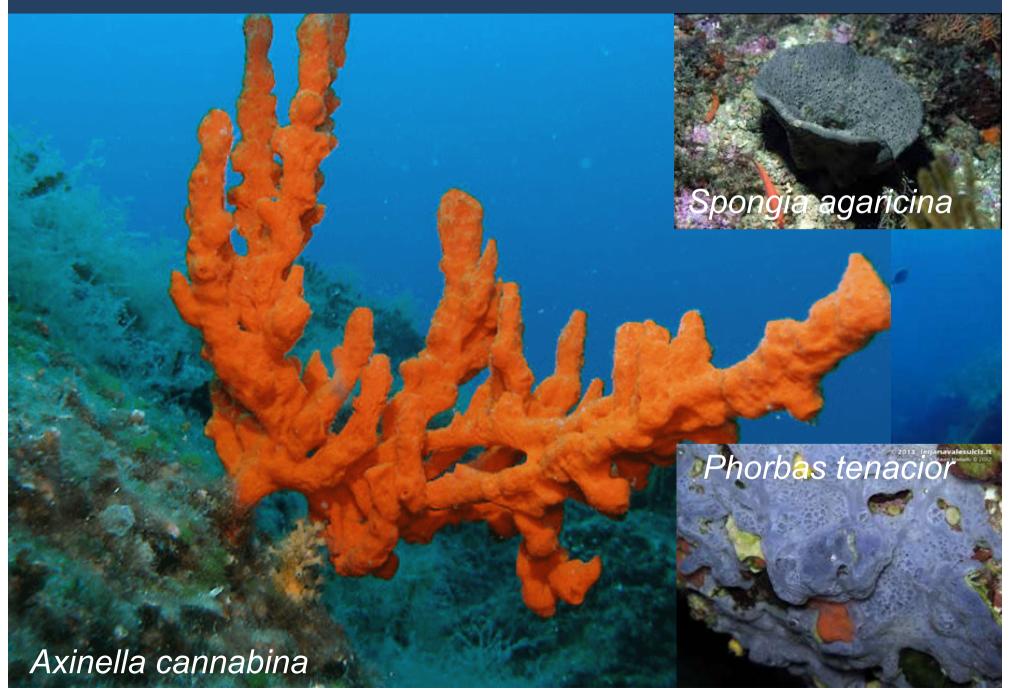
Reduced bioconcrection on granitic bottom

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

Lithophyllum spp.

www.mer-littoral.c

Peyssonnelia spp.



Pentapora fascialis

Smittinia

maria grazia

Reteporella

Parazoanthus axinellae

Palinurus elaphas

Centrostephanus longispinus

Halocynthia papillosa

Scyllarides latus

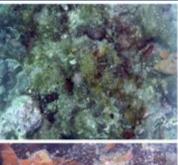
Sphaerechinus granularis



Muraena helena

Dentex dentex

Trezze o tegnue







turf encrusting sponges bioeroders sediment







massive sponges *Peyssonnelia* spp. ascidians







reef builders Polycitor adriaticus

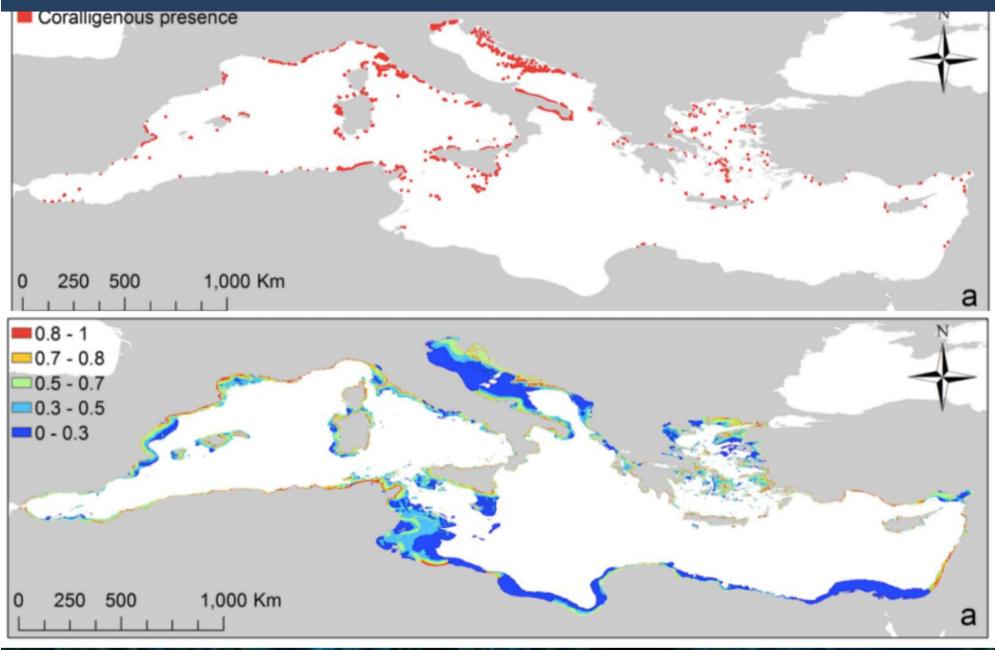
Different types of bioconcrections are present depending on the main components, which in turn, depends on environmental features such as distance from the coasts and human influence

Falace et al., 2015

In the northern Adriatic continental shelf, biogenic frameworks are

generally superimposed on hard bottoms. Marine sediments may be consolidated by methanerelated calcium carbonate cementation, thanks to seepage of CH₄-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

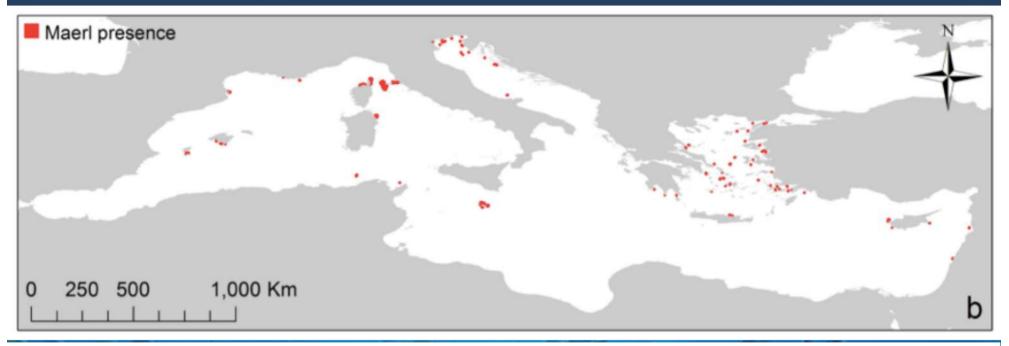


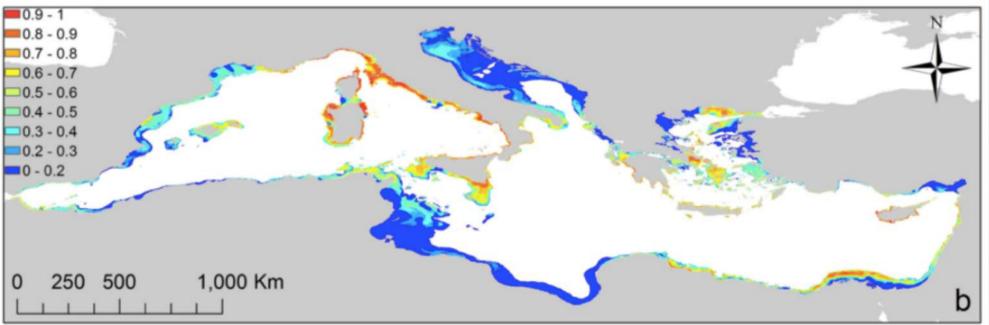
Surface areas reported here for coralligenous outcrops (2,763 km²) based on data resulting from *in situ* observations limited to the 0 to 200 m depth band. Martin et al. 2014

Maërl

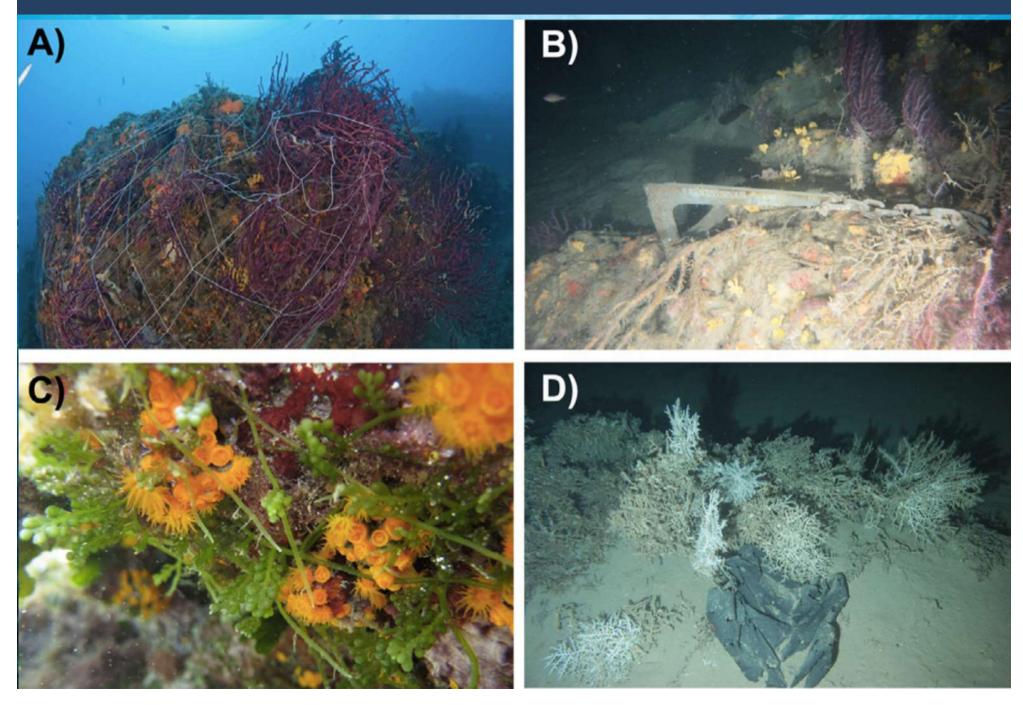
Biogenic structure formed by several coralline algae growing and accumulating (dead and alive) on soft bottom, living unattached to the substrate with thalli as nodules of ramified shapes. Algae can live >100 y. *Phymatolithon calcareum*

Distribution

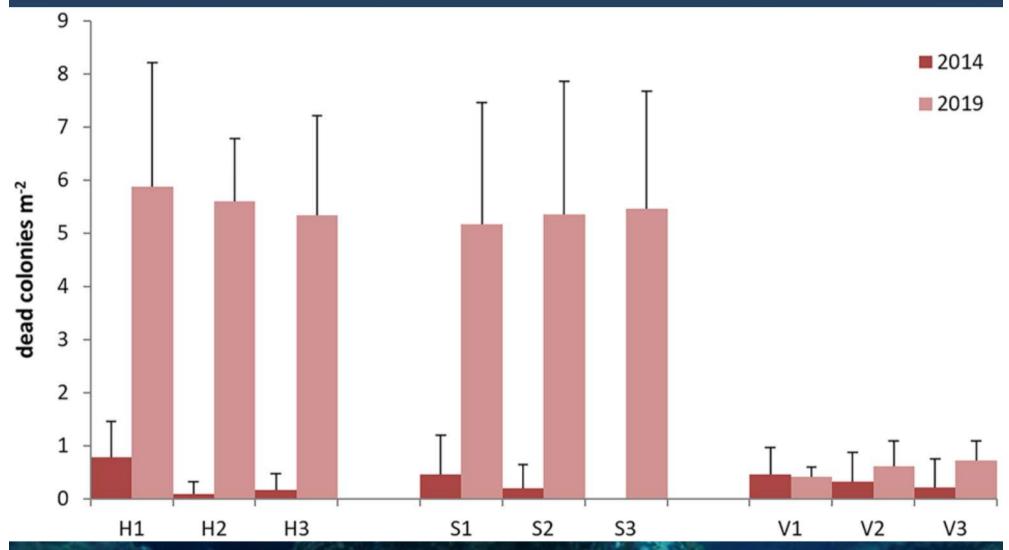




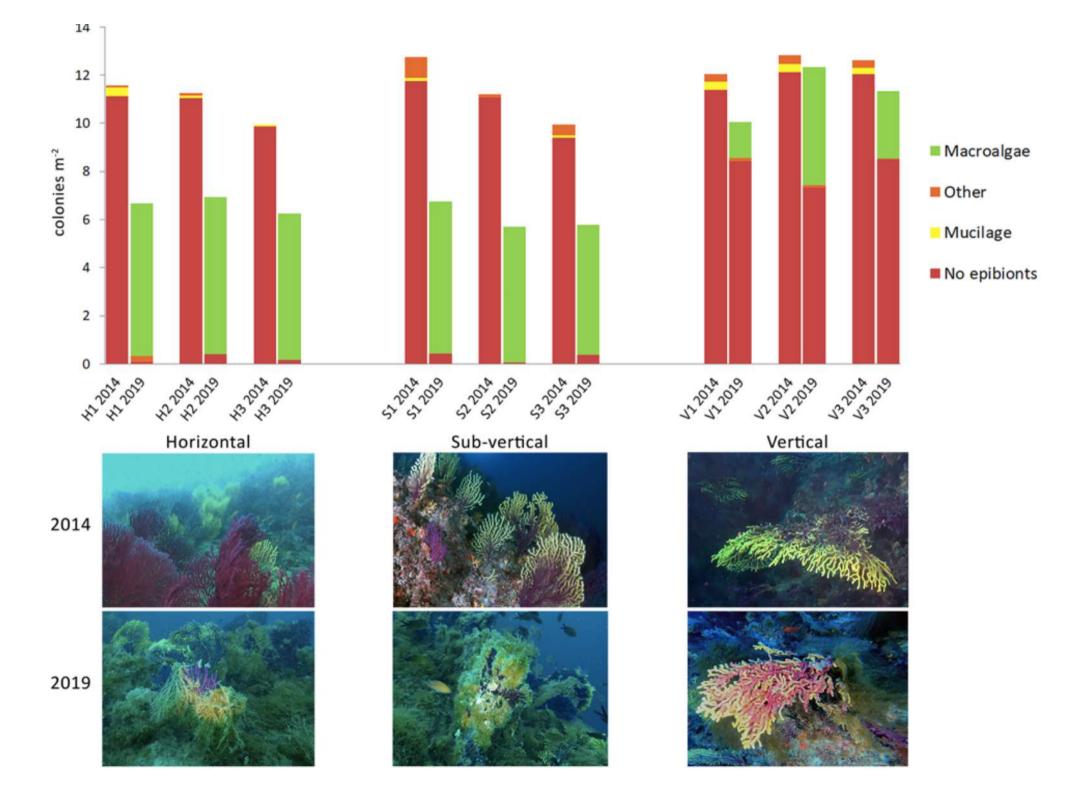
Threats



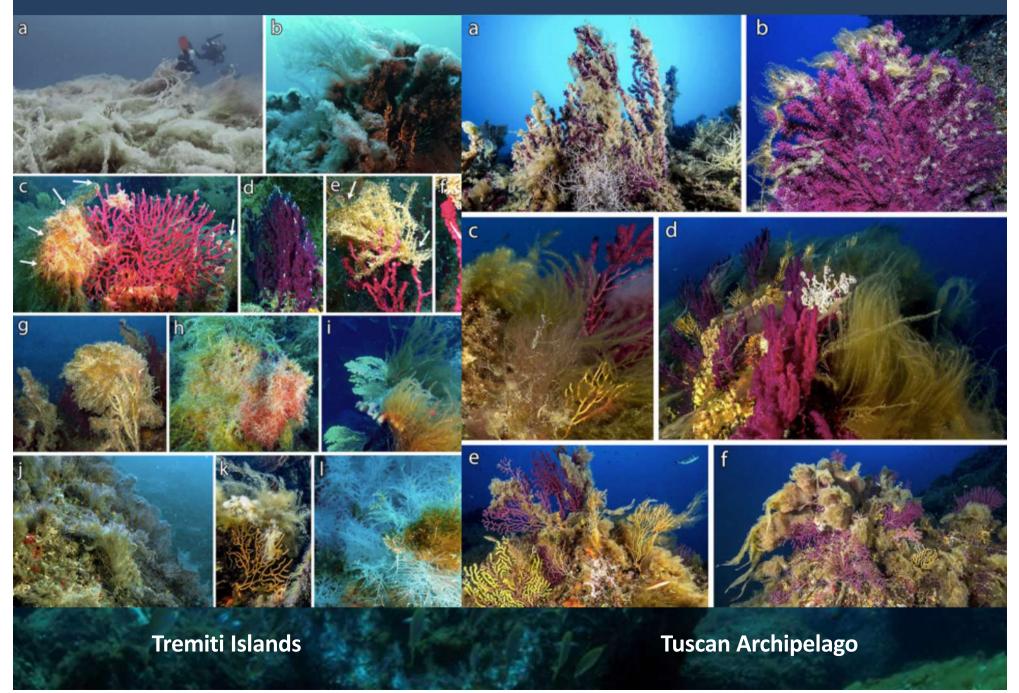
MMEs



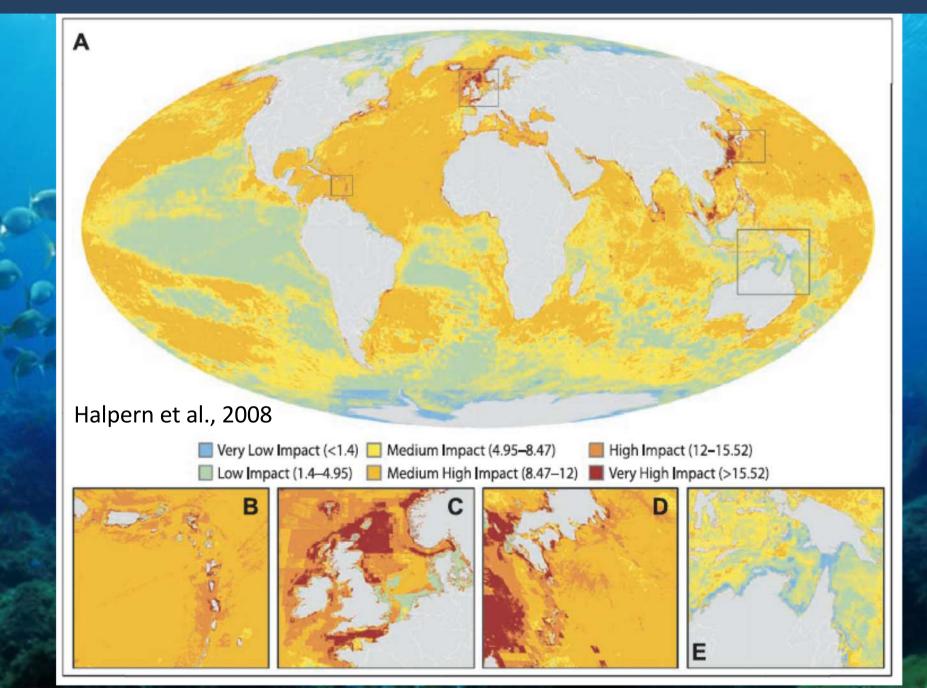
Paramuricea clavata monitored during five years (2014–2019, Tremiti Islands). Massive mucilaginous blooms occurred from 2015 until 2018. The gorgonians at 30-40 m were entirely covered with mucilage. Below 40 m colonies were almost unaffected.



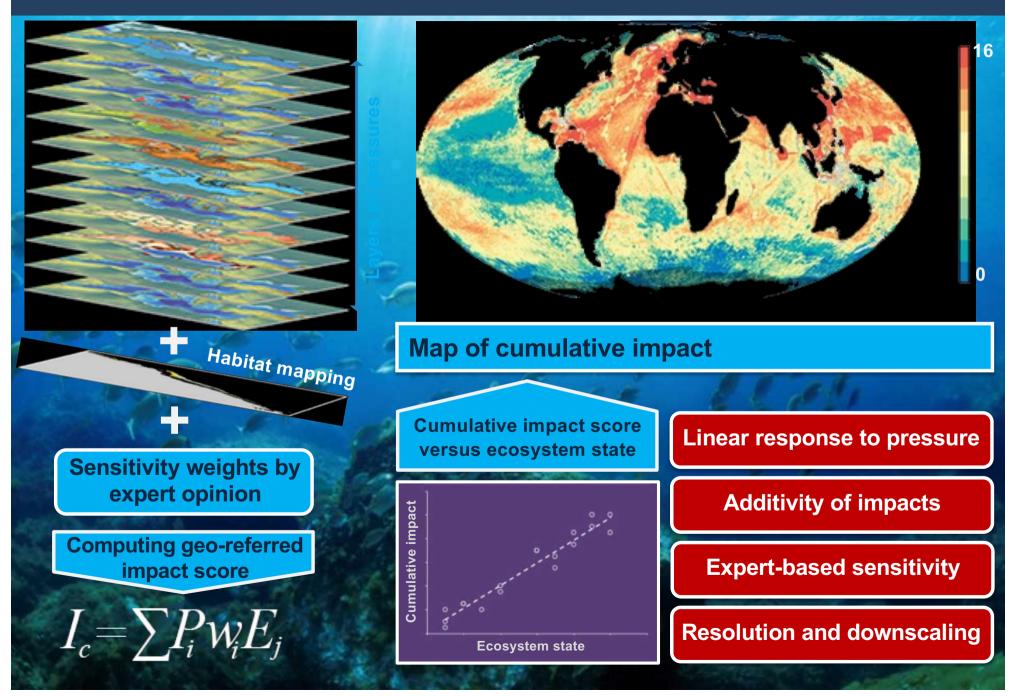
MMEs



Estimating cumulative impacts



The additive formula



Scores

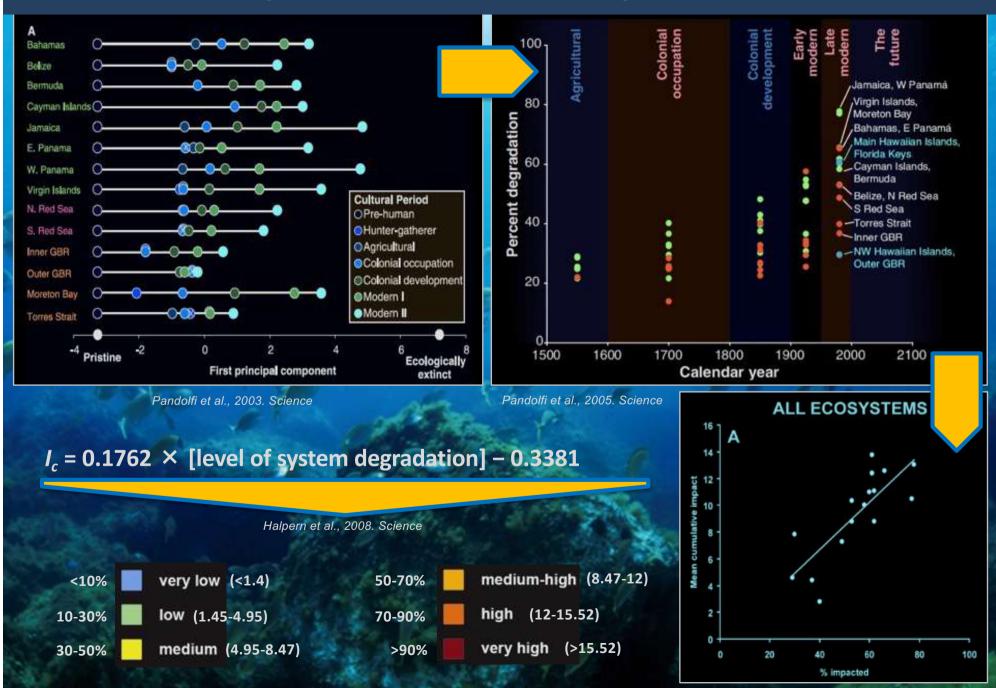
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$\begin{array}{c c c c c c c c c c c c c c c c c c c $	point, nonorganic			0.8	1.1	2.0	1.9	0.4			
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Coastal development 2.7 2.9 5.2 5.4 2.8 2.9 3.5 1.2 2.5 3.5 Direct human 2.8 2.2 2.7 3.3 1.6 2.5 2.5 1.6 2.5 3.4 Aquaculture 2.0 2.0 0.1 3.1 1.7 1.8 2.1 0.0 1.9 1.5 Fishing $$	nonpoint, nonorganic		1.6	0.6	0.5	2.0	0.7	0.8	0.0	2.2	2.7
$\begin{array}{c ccccc} Coastal development \\ Direct human \\ 28 & 22 & 27 & 33 \\ 28 & 22 & 27 & 33 \\ 20 & 0.1 & 3.1 & 1.7 & 1.8 & 2.1 & 0.0 & 1.9 & 1.5 \\ \hline \\ Fishing \\ demersal, destructive \\ demersal, nondestructive \\ 0.8 & 1.9 & 0.9 & 0.9 & 1.0 & 1.2 & 0.2 & 1.5 & 2.7 & 3.4 \\ demersal, nondestructive \\ 0.8 & 1.9 & 0.9 & 0.9 & 1.0 & 1.6 & 1.1 & 2.1 & 2.9 & 0.5 \\ pelagic, high bycatch & 0.9 & 0.0 & 0.1 & 0.0 & 5 & 0.5 & 0.0 & 0.0 & 2.6 & 0.0 \\ pelagic, kow 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 & 0.5 & 1.6 & 0.4 & 0.0 & 1.2 & 0.0 \\ artisanal, destructive & 1.1 & 0.5 & 0.8 & 1.2 & 0.5 & 2.0 & 0.0 & 1.5 & 2.5 & 1.0 \\ artisanal, destructive & 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 & 2.5 & 2.5 & 1.2 \\ caracter berature & 2.8 & 1.4 & 0.6 & 2.4 & 1.4 & 2.8 & 2.1 & 2.0 & 1.9 & 0.0 \\ occan acidification & 0.9 & 1.0 & 0.0 & 1.2 & 1.3 & 1.1 & 1.4 & 0.0 & 1.1 & 0.7 & 0.0 \\ species invasion & 2.8 & 2.9 & 0.9 & 1.0 & 2.8 & 1.5 & 1.2 & 1.5 & 2.5 & 2.0 \\ Discase & 1.3 & 1.8 & 0.0 & 1.7 & 1.1 & 2.2 & 1.0 & 0.7 & 1.8 & 2.5 \\ Harmful algal blooms & 1.9 & 2.2 & 0.9 & 1.6 & 2.0 & 1.8 & 2.5 & 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 & 2.2 \\ Ocean-based pollution & 1.3 & 0.8 & 0.5 & 1.2 & 1.2 & 1.5 & 2.5 & 2.0 \\ Discase & 1.3 & 1.8 & 0.0 & 1.7 & 1.1 & 2.2 & 1.0 & 0.7 & 1.8 & 2.5 & 2.0 \\ Discase & 1.3 & 1.8 & 0.0 & 1.7 & 1.1 & 0.8 & 0.4 & 0.0 & 1.1 & 0.7 & 0.0 \\ Ocean mining & 0.9 & 0.0 & 0.3 & 0.0 & 1.1 & 0.8 & 0.4 & 0.0 & 1.3 & 0.0 \\ Ocean mining & 0.9 & 0.0 & 0.3 & 0.0 & 1.1 & 0.8 & 0.4 & 0.0 & 1.3 & 0.0 \\ Ocean mining & 0.9 & 0.0 & 0.3 & 0.0 & 1.1 & 0.8 & 0.4 & 0.0 & 1.3 & 0.0 \\ Ocean mining & 0.9 & 0.0 & 0.3 & 0.0 & 1.1 & 0.8 & 0.5 & 0.1 & 0.7 & 0.0 \\ Benthic structures & 1.0 & 0.9 & 0.8 & 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.$	Coastal engineering		2.1	2.8	3.1		23	2.4	0.0	1.9	3.0
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sea temperature ocean acidification 2.8 1.4 0.6 2.4 1.4 2.8 2.1 2.0 1.9 0.5 ocean acidification ozone/UV 0.9 1.0 0.0 1.2 1.3 1.1 1.4 0.0 1.1 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 2.5 0.4 1.7 2.1 2.5 0.4 1.7 2.1 2.2 1.0 0.7 1.8 2.5 0.4 1.7 2.1 2.2 1.0 0.7 1.8 2.4 0.6 0.6 1.9 0.8 1.3 1.0 1.6 2.4 Harmful algal blooms 1.2 2.1 0.6 0.6 1.9 0.8 1.3 1.0 1.6 2.4 Ocean-based pollution 1.3 0.8											
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Harmful algal blooms 1.9 2.2 0.9 1.6 2.0 1.8 2.3 0.4 1.7 2.4 Hypoxia 1.2 2.1 0.6 0.6 1.9 0.8 1.3 1.0 1.6 2.3 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 0.3 0.0 1.1 0.8 0.4 0.0 1.3 0.0 Benthic structures 1.0 0.9 0.8 1.3 0.9 0.5 1.6 0.0 1.7 0.4 Benthic structures 1.6 0.0 1.0 2.3 1.3 1.8 1.5	Species invasion	2.8	2.9			2.8			1.3		2.6
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 Summed threat 58.9 51.4 28.4 55.7 54.9 57.2 48.9 22.4 66.6 53.3	Discase	1.3	1.8	0.0	1.7		22	1.0	0.7	1.8	
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 Summed threat 58.9 51.4 28.4 55.7 54.9 57.2 48.9 22.4 66.6 53.3	Harmful algal blooms	1.9	2.2	0.9	1.6	2.0	1.8	2.3	0.4	1.7	
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 Summed threat 58.9 51.4 28.4 55.7 54.9 57.2 48.9 22.4 66.6 53.3	Hypoxia	1.2	2.1	0.6	0.6	1.9	0.8	1.3	1.0	1.6	2.9
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 0.7 Scotourism 1.6 0.0 1.0 2.3 1.3 1.8 1.5 0.8 1.7 0.7 Summed threat 58.9 51.4 28.4 55.7 54.9 57.2 48.9 22.4 66.6 55.3	Ocean-based pollution	1.3	0.8	0.5	1.2	1.2	1.2	0.5	0.1	1.7	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 53.3			1.9	1.9	2.0		1.5	1.9	0.0		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 2.4 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 53.3					and the second se		1.000				0.0
Benthic structures 1.0 0.9 0.8 1.3 0.9 0.5 1.6 0.0 1.7 0.7 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 53.3			0.0			and the second se					0.0
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 53.3											0.4
Summed threat 58.9 51.4 28.4 55.7 54.9 57.2 48.9 22.4 66.6 53.							1.				0.3
					and the second se						
	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

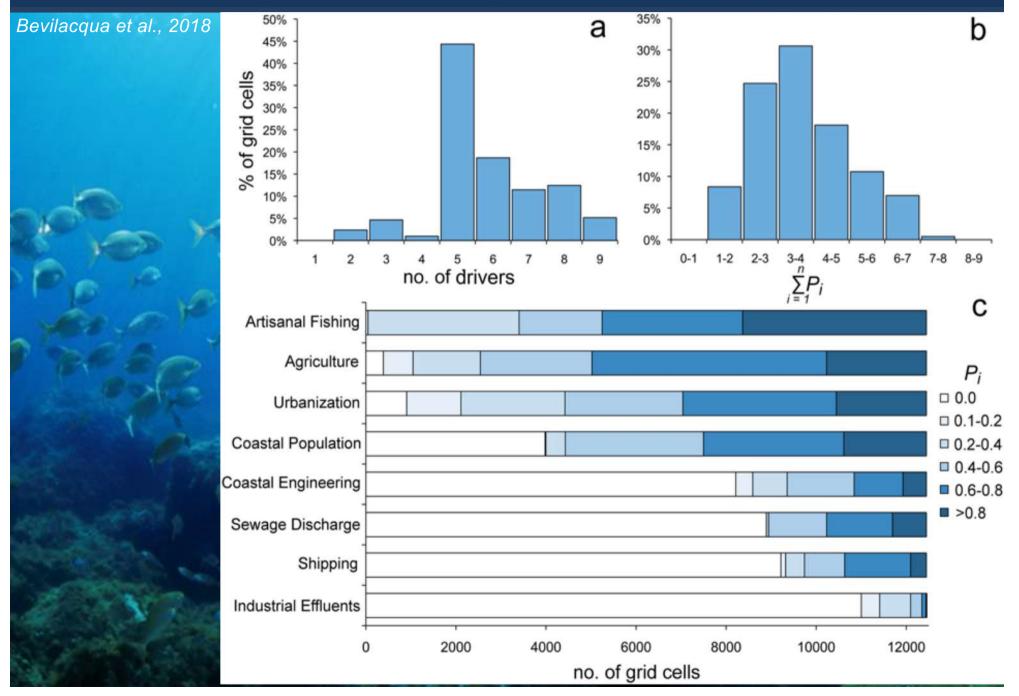
 $I_c = \sum P_i w_i E_j$

Halpern et al., 2007

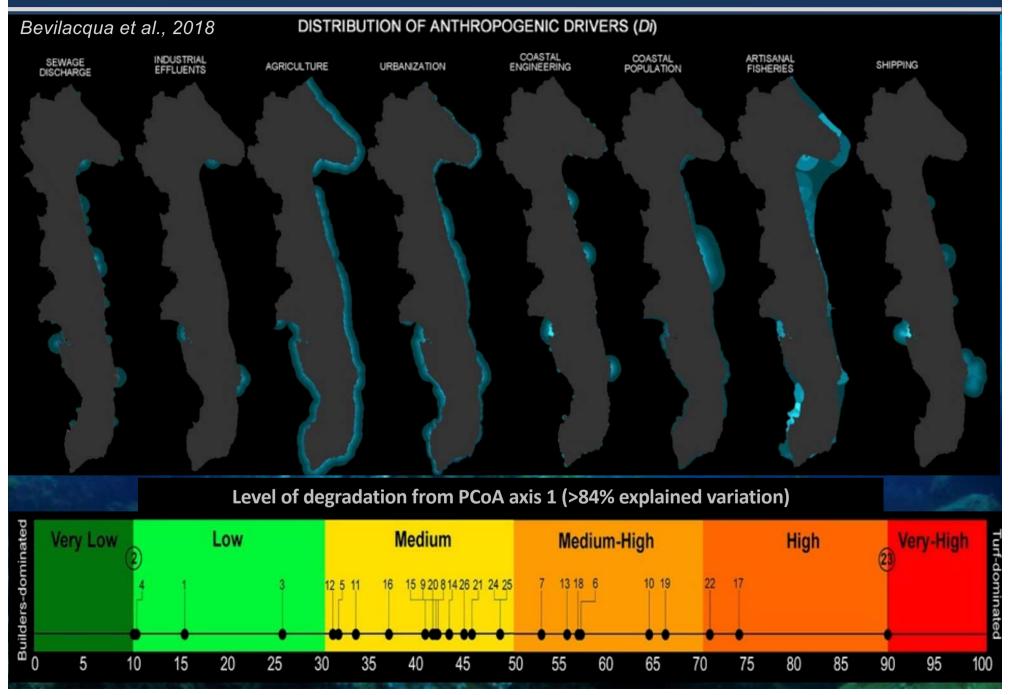
Pressure response relationship



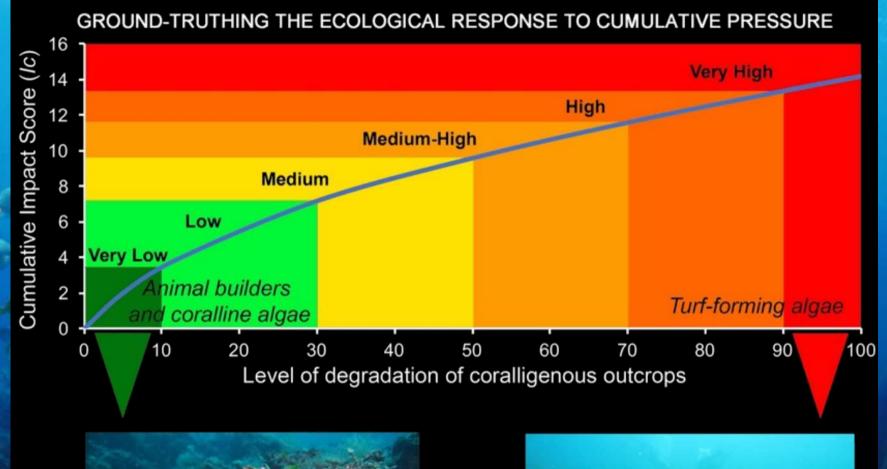
A case study on coralligenous outcrops



Pressures



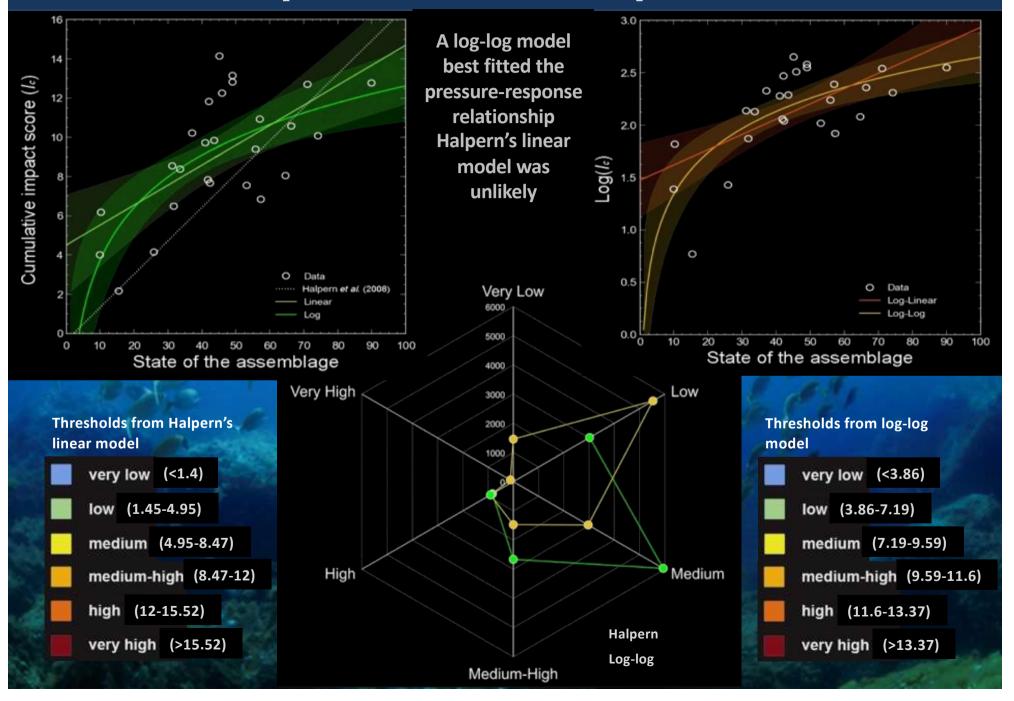
Status of coralligenous







Pressure-response relationship



A case study on coralligenous outcrops

