13TH INTERNATIONAL TEMPERATE REEFS SYMPOSIUM
HOBART, UNIVERSITY OF TASMANIA

Mega-fires in the Mediterranean Sea: an exploratory study of indirect effects on rocky reef communities in Sardinia Island (Italy)

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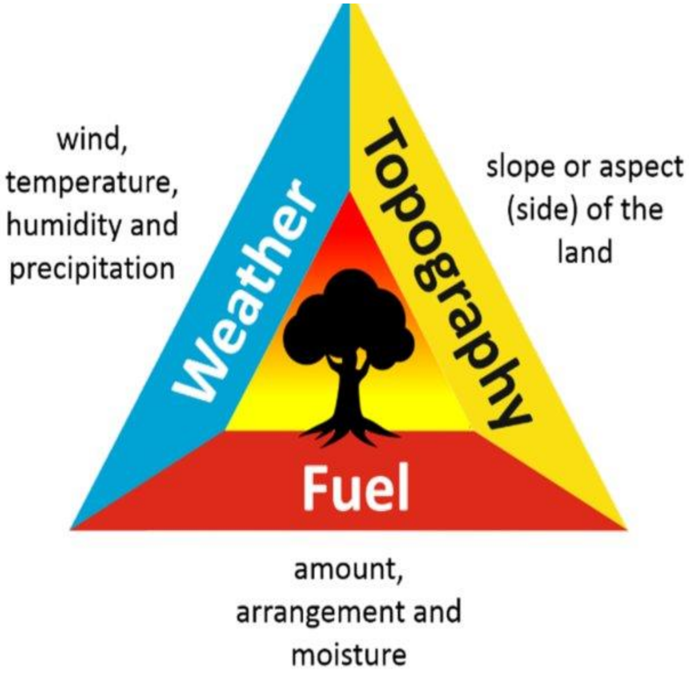
Fire is an important natural phenomenon for the healthy functioning of the ecosystems

Source: Civil Eats 2015

Climate Change fuels wildfires

The weather conditions favourable to fires have become more frequent (hot, drought and windy)

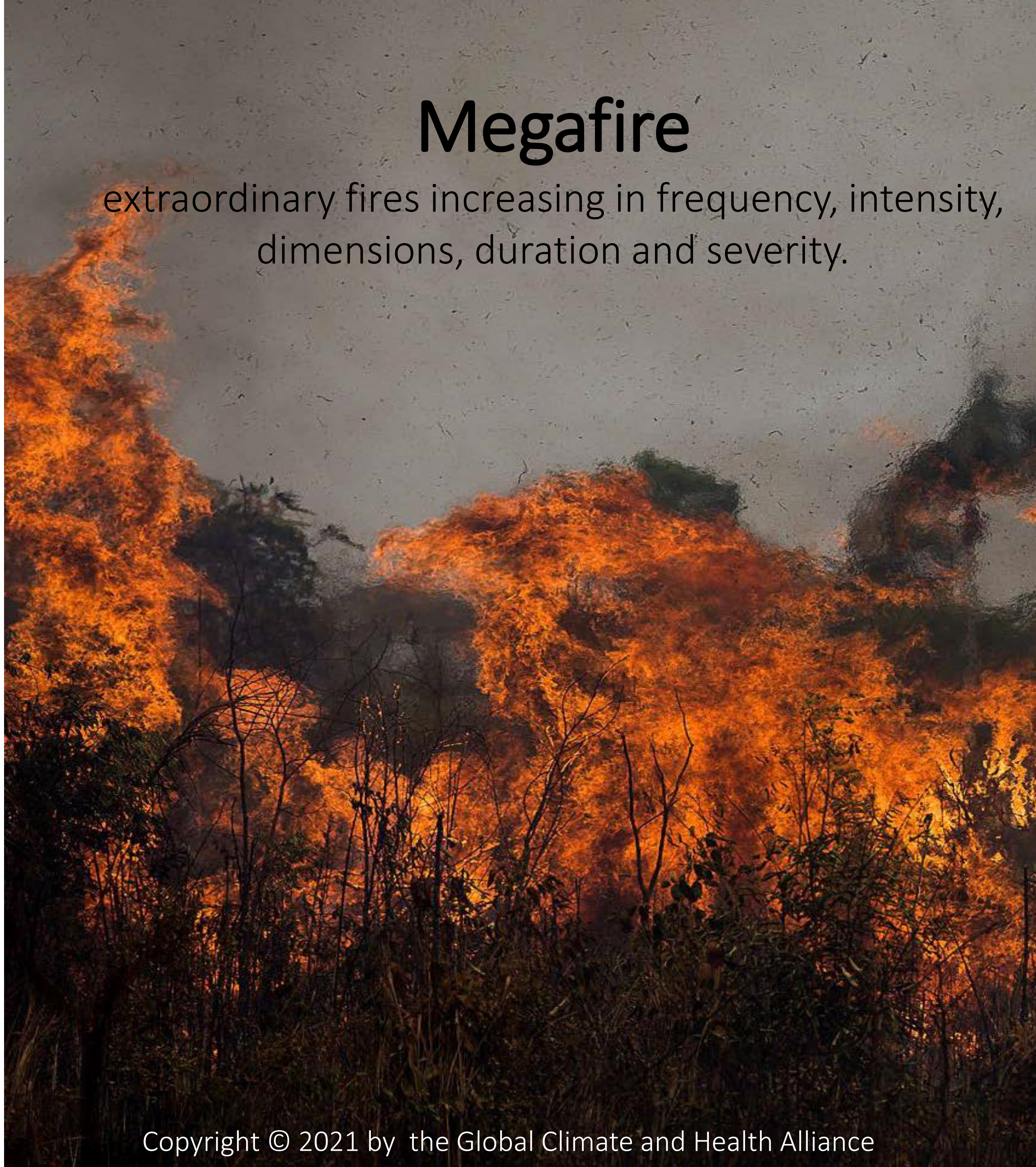


(Wildfire Triangle, Barrows 1951)

IPCC, 2021. doi:10.1017/9781009157896.

Megafire

extraordinary fires increasing in frequency, intensity, dimensions, duration and severity.



Burning changes the chemical-biological composition of the soil

- N:P:C ratio drastically changes
- carbon compounds derived from combustion ('black carbon’) are deposited on the ground
- concentration of hydrocarbons and metals increases
- microbial decomposition activity drastically decreases
- Soil becomes water-repellent

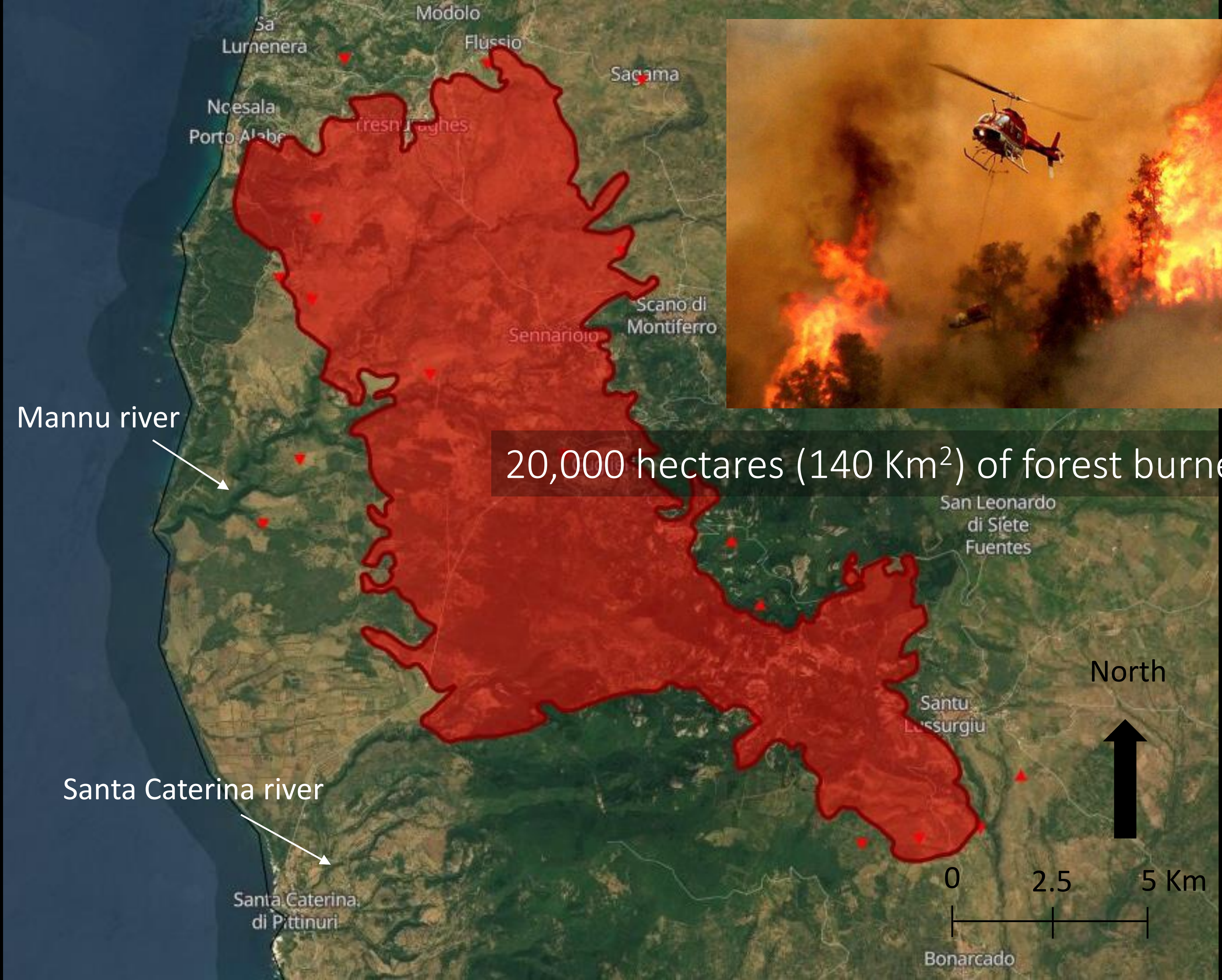
(e.g. Certini et al. 200

Which are the consequences for marine ecosystems?

Fire produces debris, ash, biogenic elements (e.g. carbon, nutrients and metals) that flow into the Ocean through atmospheric and river inputs.

- Smoke haze and ash layer into the water reduce sunlight and can compromise photosynthesis on the sea bottom
  e.g. Indonesian coral reef, after tropical wild fire of 1997 - Abram et al. 2003.
- Debris and ash can mechanically compromise respiration of fish and filter-feeding animals such as shellfish
  e.g. Galician coast wildfires during 2013-14 affected local market of mussels, and clams - Duran-Medrano 2017
- The surplus of nutrient input can fertilize the water column determining phytoplankton blooms with dangerous effects for marine life.
  e.g. low level of oxygen in the water during the bushfire ”Black Summer” 2019/20 - Sydney Institute of Marine Science 2020.
- Metals and other contaminants can change the physiology and behaviour of marine animals and enter in the food chain
  e.g. reaction to organic exposure, malignant transformation, susceptibility to disease of sea otters during the “Thomas Fire” 2017/18 - Bowen et al. 2015.

A case of megafire in the Mediterranean Sea (wildfire 23-25 July 2021, Sardinia, Italy)



20,000 hectares (140 Km^2) of forest burned in 3 days

Strong flood events occurred in winter 2021-22

Wildfire area	Total rain	Rainy days
Year	647 mm	65
January	352 mm	26

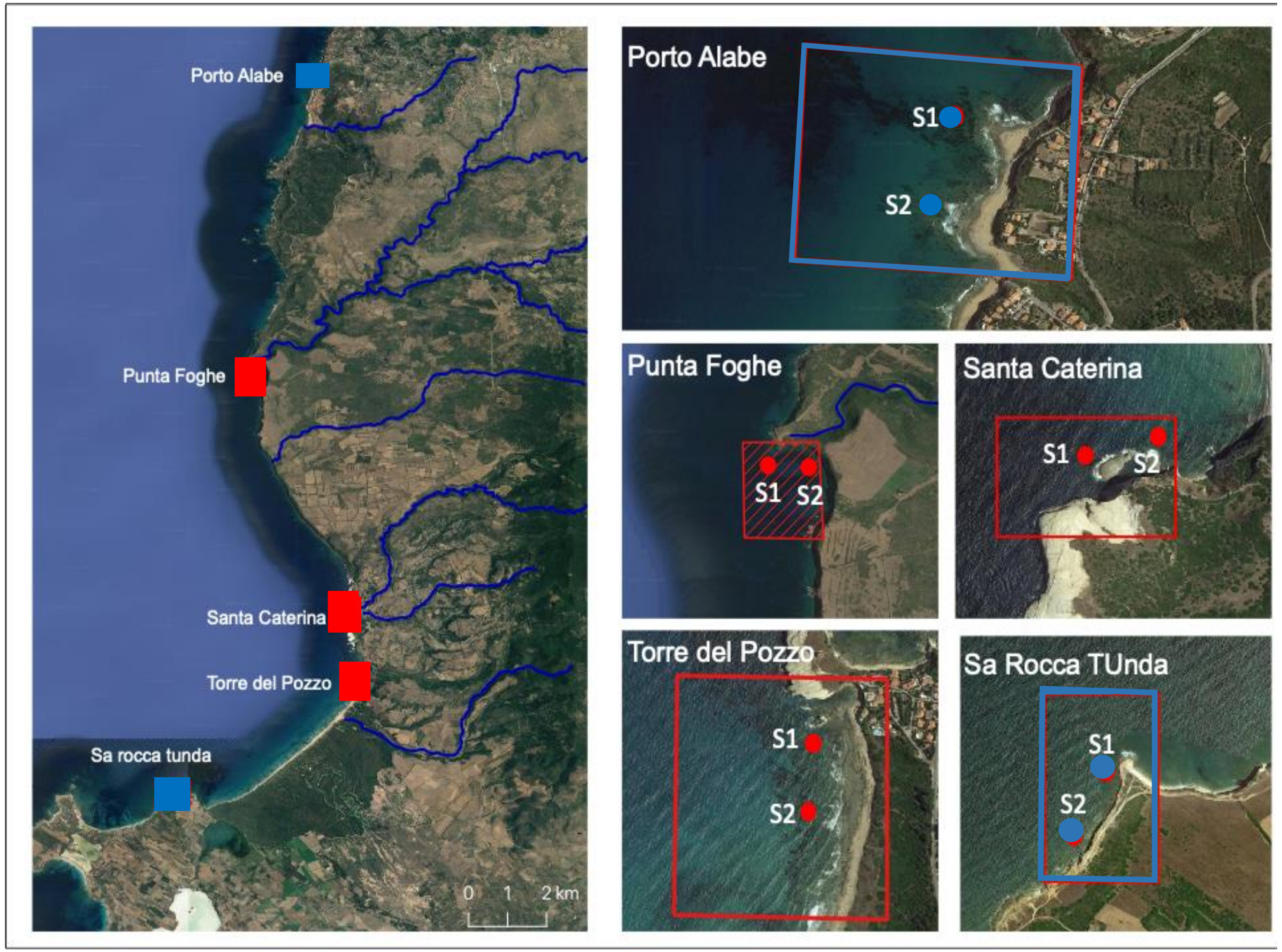
Source: hydrological yearbook of Arpa Sardegna

Santa Caterina Bay, winter 2021-22

Aim of the study

To assess the mid- and long-term effects of the megafire on shallow benthic ecosystems

multi-scale experimental design (B.A.C.I.)



Impacted (burned) area

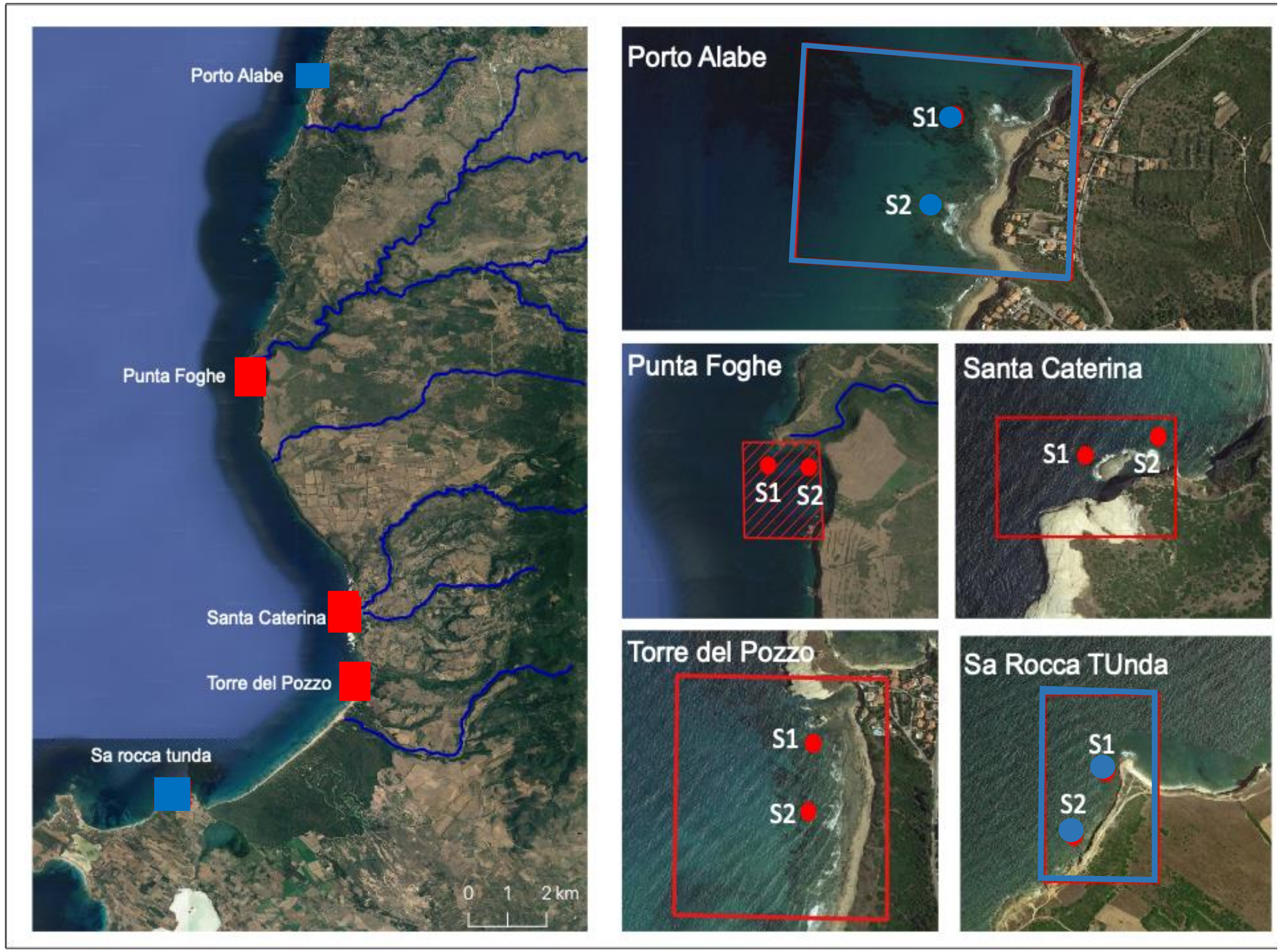
Localities 2-10 km	P.ta Foghe	S.ta Caterina	Torre del Pozzo
Sites ∼100 m	S1 S2	S1 S2	S1 S2
Replicates ∼1 m	1 5 1 5	...	1 5 1 5

Control areas

Localities 2-10 km	P.to Alabe	Sa Roca Tunda
Sites ∼100 m	S1 S2	S1 S2
Replicates ∼1 m	...	1 5 1 5

Aim of the study

To assess the mid- and long-term effects of the megafire on shallow benthic ecosystems



Sampling time

Megafire: 23-25 July 2021

↓ summer

T0 (Oct 21) : pre-flooding sampling

↓ winter (rains)

T1 (May 22): 1st post-flooding sampling

↓ summer

T2(Oct 22): 2nd post-flooding sampling

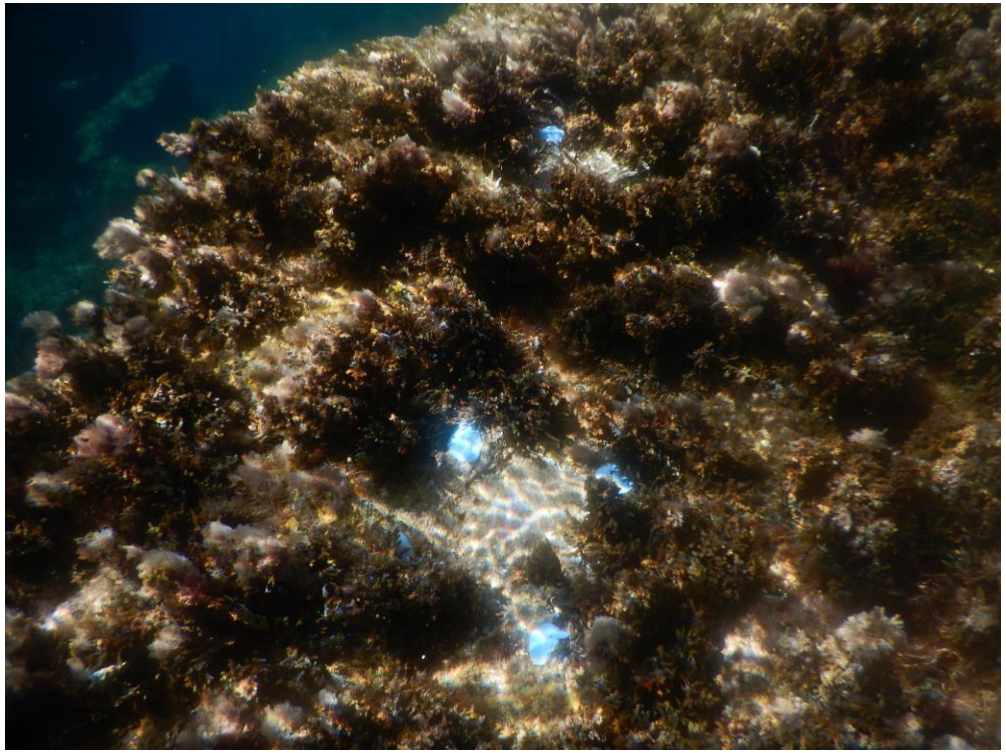
↓ winter (rains)

T3(May 23): 3rd post-flooding sampling

Objectives

Intertidal

- Evaluation of the resilience of the marine forests formed by *Ericaria crinita* and *E. amentacea* (habitat-forming species protected by Barcelona Convention 1995) through the recolonization of disturbed fixed squares.



Objectives

Subtidal (5m depth)

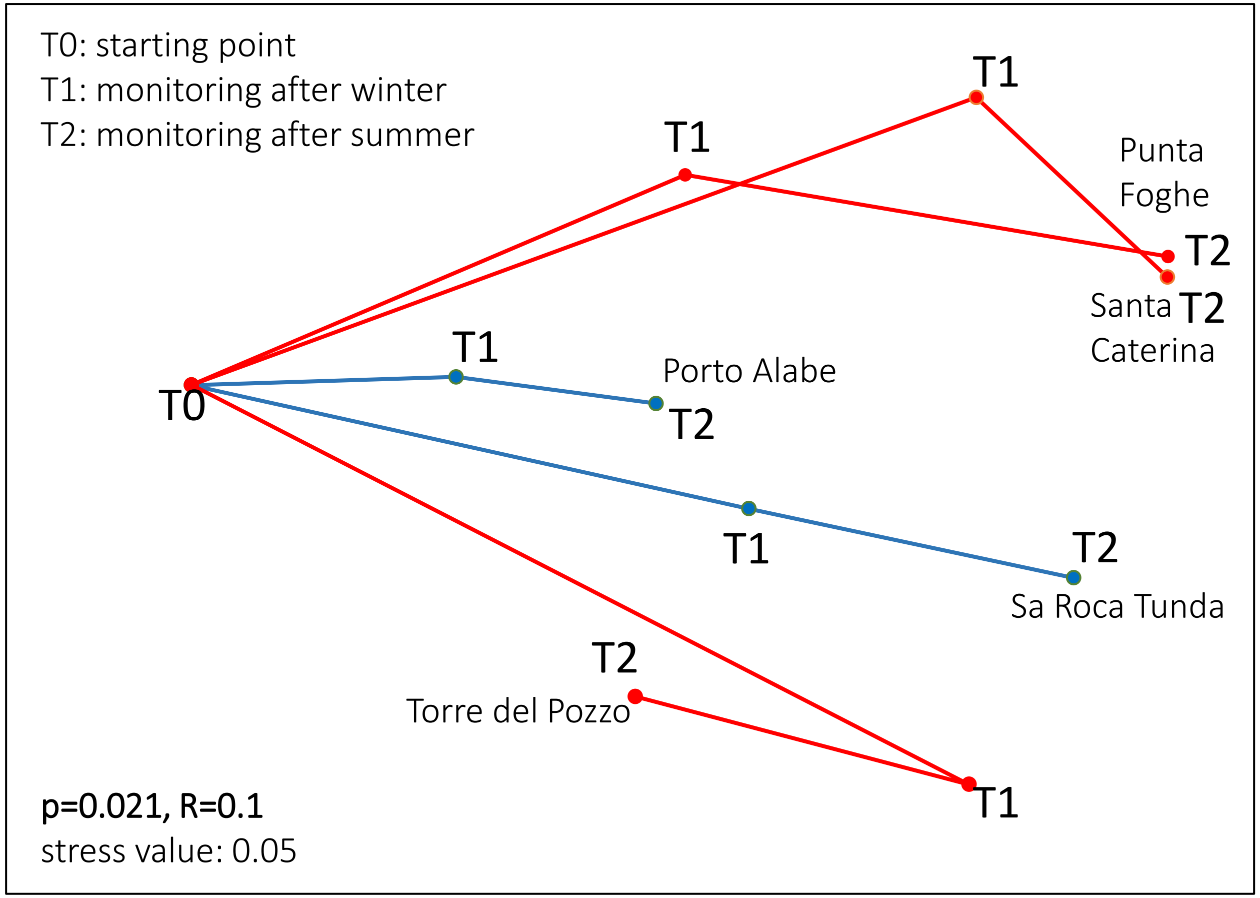
- Evaluation of the benthic community structure through visual sampling.
- Evaluation of the sea urchin population structure through abundance counting and size frequency estimation.

Results

Intertidal

Recovery capacity of algal populations

Comparison of the temporal recovery trajectories between Impact and Control areas.



Second Stage Analysis

there is little but significant difference between Impact and Control areas.

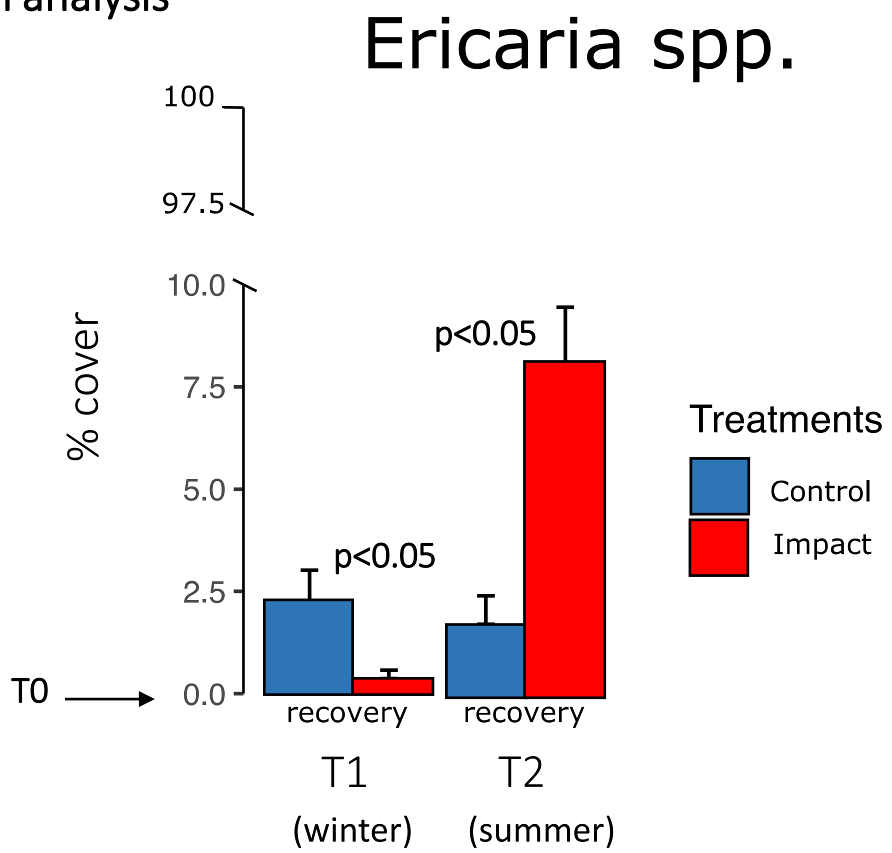
Results

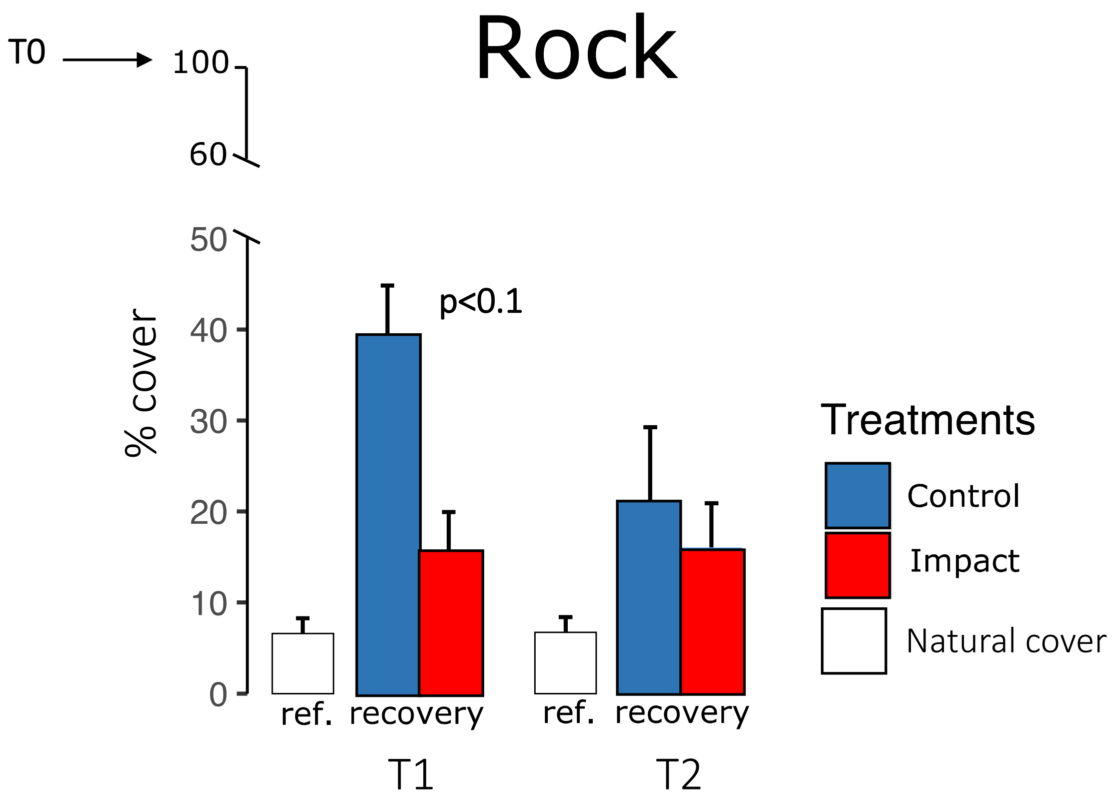
Intertidal

Recovery capacity of the habitat forming species and loss of bare rock

Comparison of the percent cover between
Impact and Control areas at the different times (T1 and T2 after flooding).

GLMM analysis



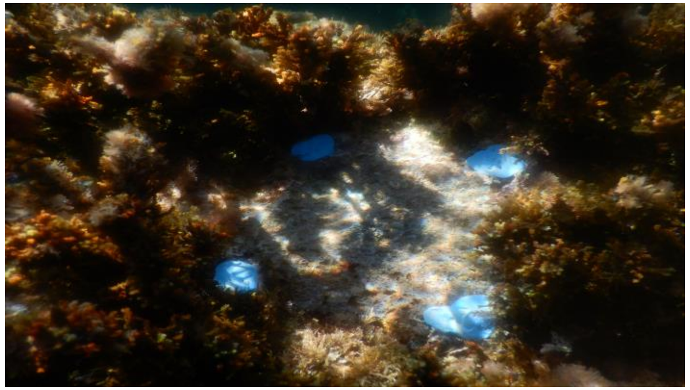


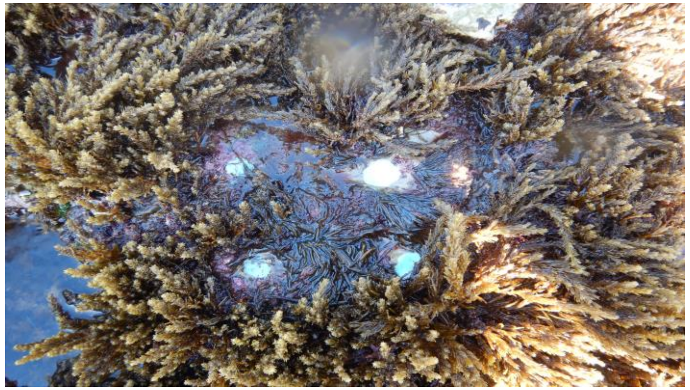
Results

Intertidal

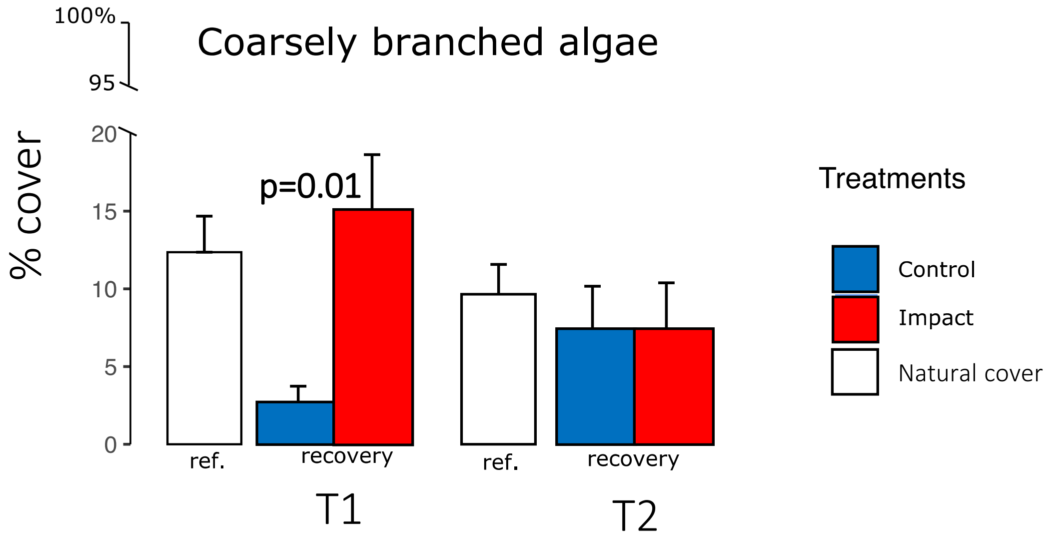
Significant recovery capacity of other algal groups

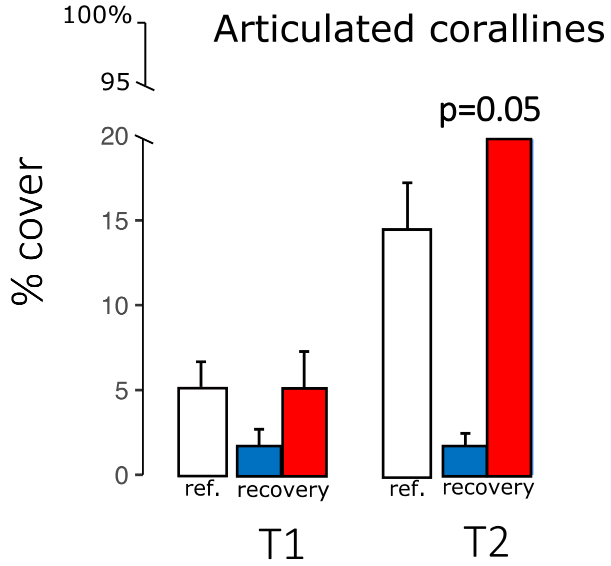
Comparison of the percent cover between Impact and Control areas at the different times (T1 and T2 after flooding)

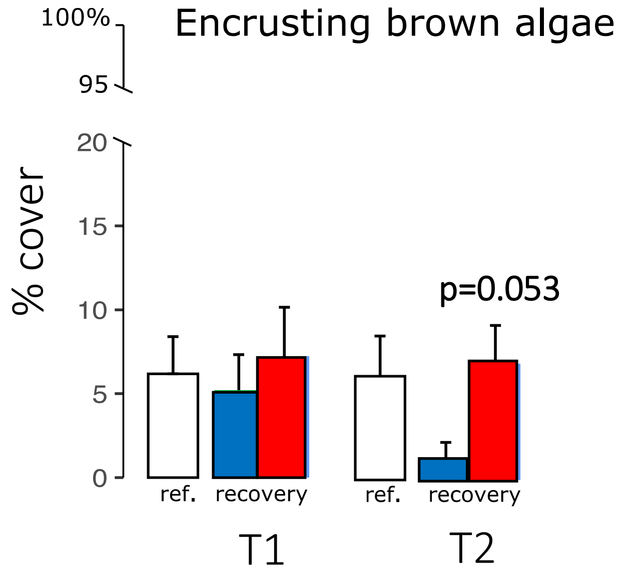




GLMM analysis





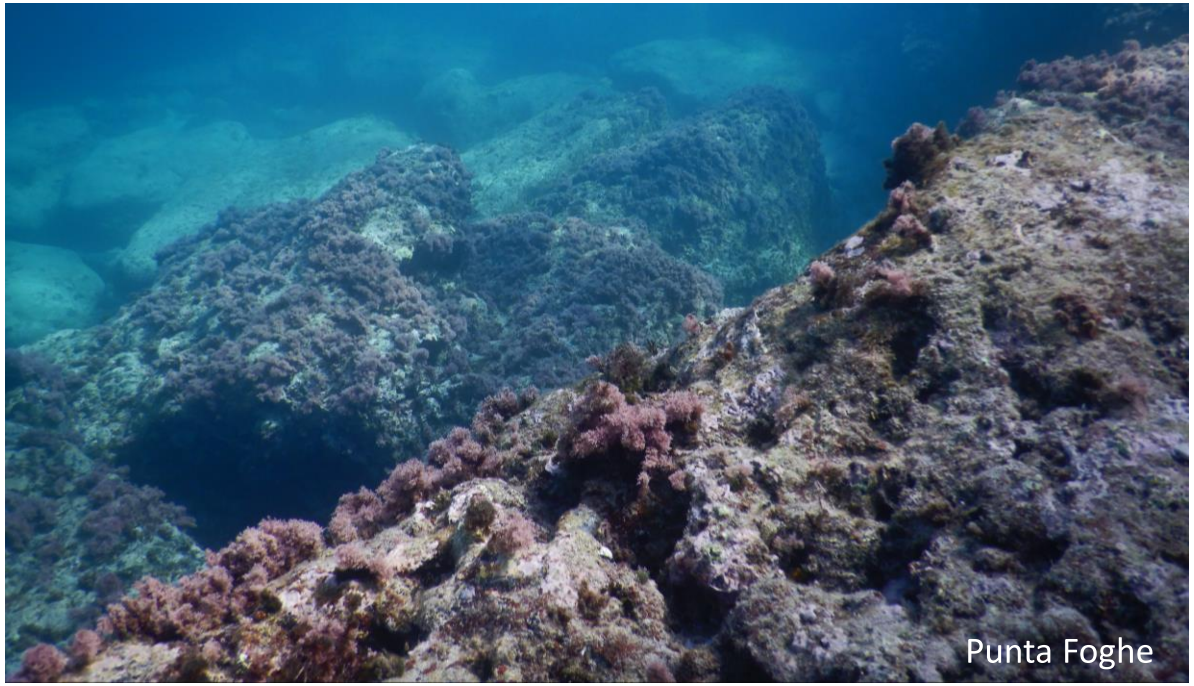


Results

Subtidal

Benthic community structure

Comparison between Impact and Control areas
and across Time (T0 before and T1, T2 after floodings).



Permanova analysis

Source	df	SS	MS	Pseudo-F	P(perm)
Before vs After	1	3660.6	3660.6	0.45529	0.8792
Time(Before vs After)	1	10998	10998	2.7392	0.1385
Control vs Impact	1	10891	10891	0.5758	0.7381
Location(Control vs Impact)	**3**	**77966**	**25989**	**3.839**	**0.0049**
Site(Location(C vs I)	5	16853	3370.6	1.3037	0.2755
B vs A x C vs I	1	2006.1	2006.1	0.47806	0.856
Time(B vs A) x C vs I	1	5316.6	5316.6	1.3242	0.3591
B vs A x Location(C vs I)	2	14102	7051	1.4868	0.1823
Time(B vs A) x Location(C vs I)	2	8030.2	4015.1	1.6072	0.1857
B vs A x Site(Loc(C vs I))	4	8744.6	2186.1	0.85558	0.6251
Time(B vs A) x Site(Loc(C vs I))	**4**	**9992.6**	**2498.2**	**1.6096**	**0.0242**
Results	114	1.77E+05	1552		
Total	139	3.59E+05			

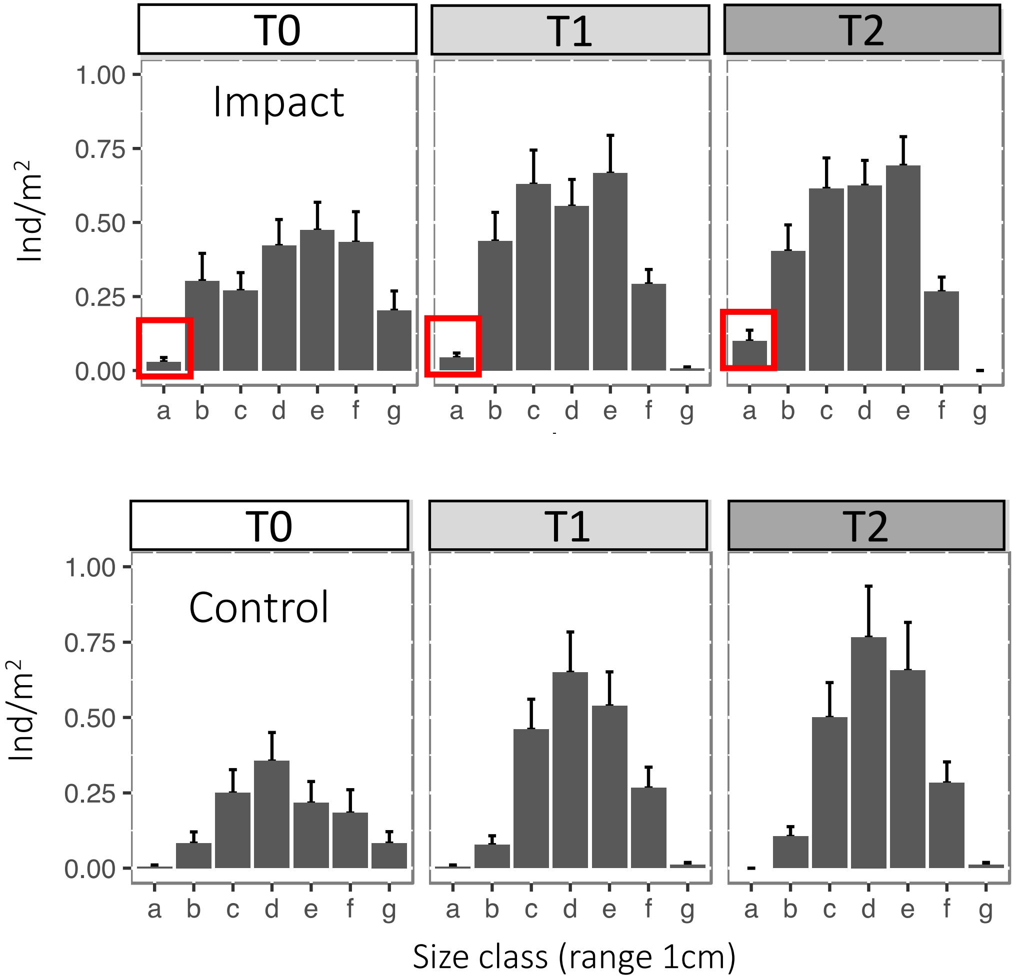
→ No significant differences at community level

Results

Subtidal

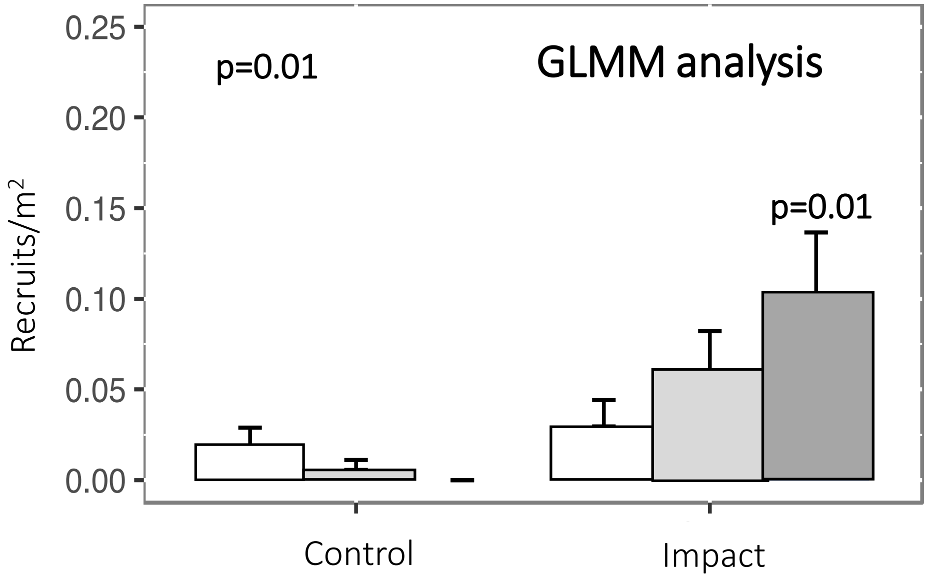
Sea urchin population structure in
the Impact and Control areas and across Time

Time
T0 Pre-flooding
T1
T2
post-flooding



Recruit density (a=0-1cm)

Comparison between Impact and Control areas and across Time (T0, T1, T2) is significant

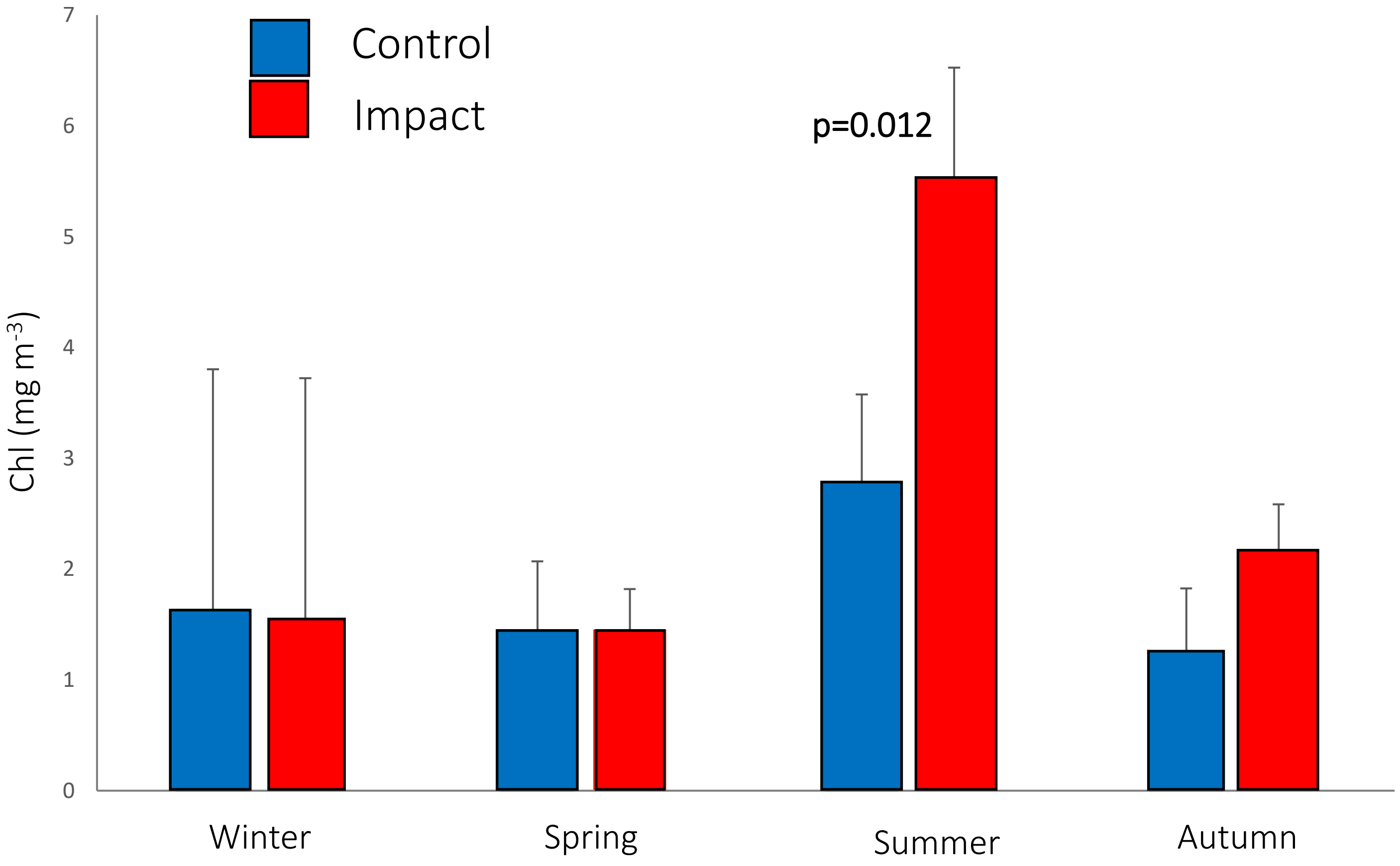


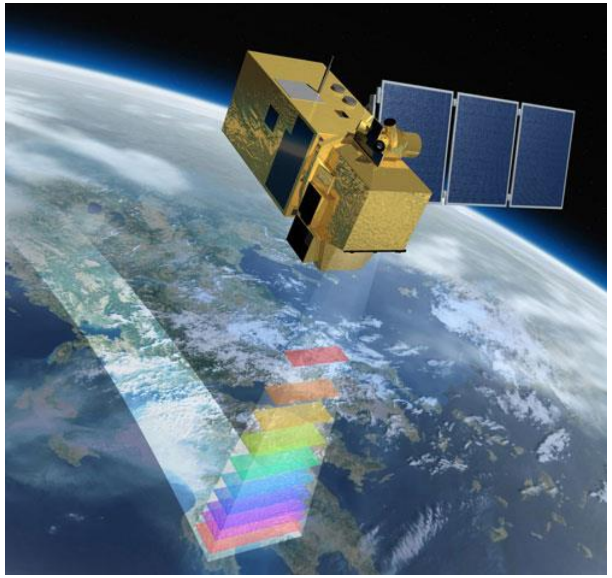
Results

Sea surface

preliminary data analysis of seasonal average of chlorophyll concentration

Chlorophyll concentration during 2022 (GLMM analysis)

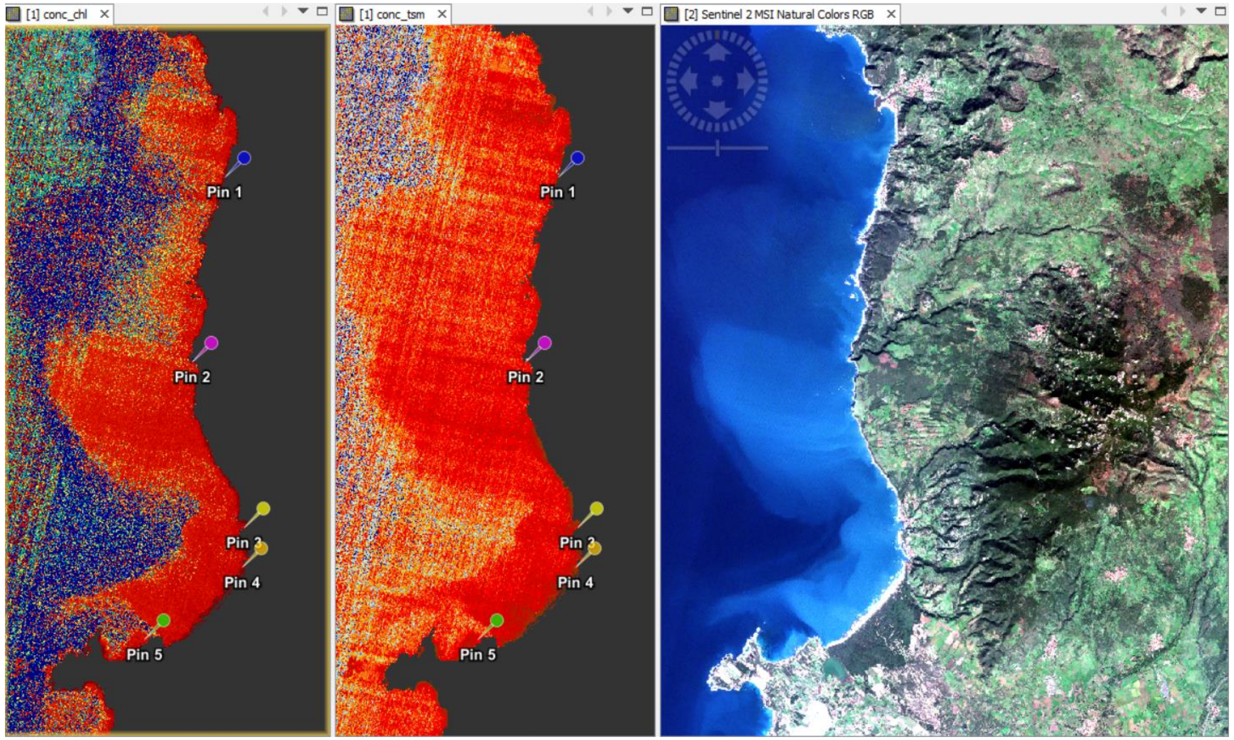




data source: Copernicus Sentinel-2
(size cell resolution $10x10m^2$)

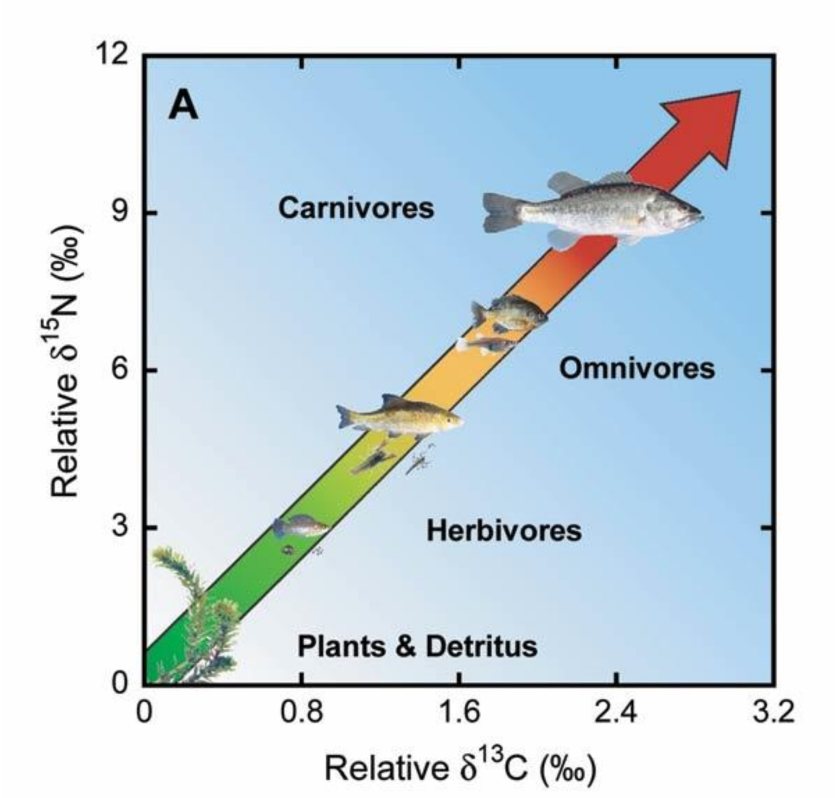
abiotic variables analysis (in progress)

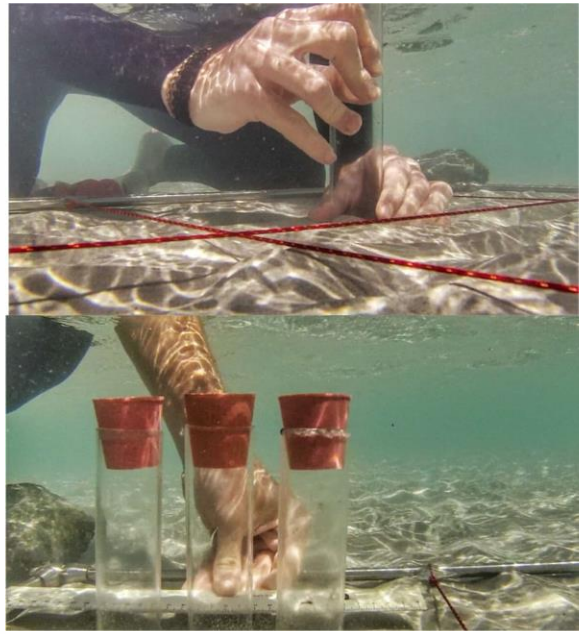
- Fresh and sea water samples: organic material (including black carbon), nutrients, metals, sediment structure.
- Water turbidity and chlorophyll concentration from satellite data.



More biotic variables analysis (in progress)

- δ15N, δ13C isotopic composition of primary producers and consumers (invertebrate herbivores and predators).
- Trace element of heavy metals and black carbon in coralline algae.
- Enzymatic activity in the bottom sediment.
- Evaluation of nutrient and metal accumulation in *P. oceanica* meadows.





Preliminary conclusions

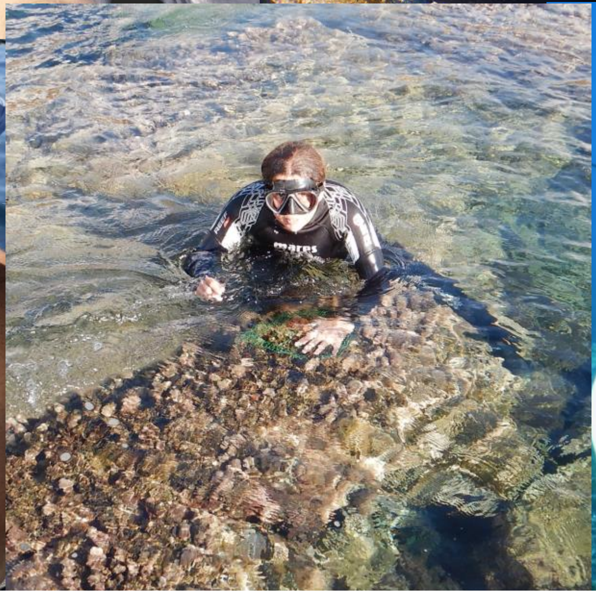
- This megafire seems to be an extra source of nutrients (natural fertilization) for the benthic community playing an important role in high oligotrophic conditions.

- No shifts in mature benthic assemblages of the subtidal or the intertidal.

- Analysis in progress of sea, fresh water and sediment samples may provide clear evidence of nutrient or other biogenic elements transfer from the burned area to marine habitats.





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Thanks to all

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