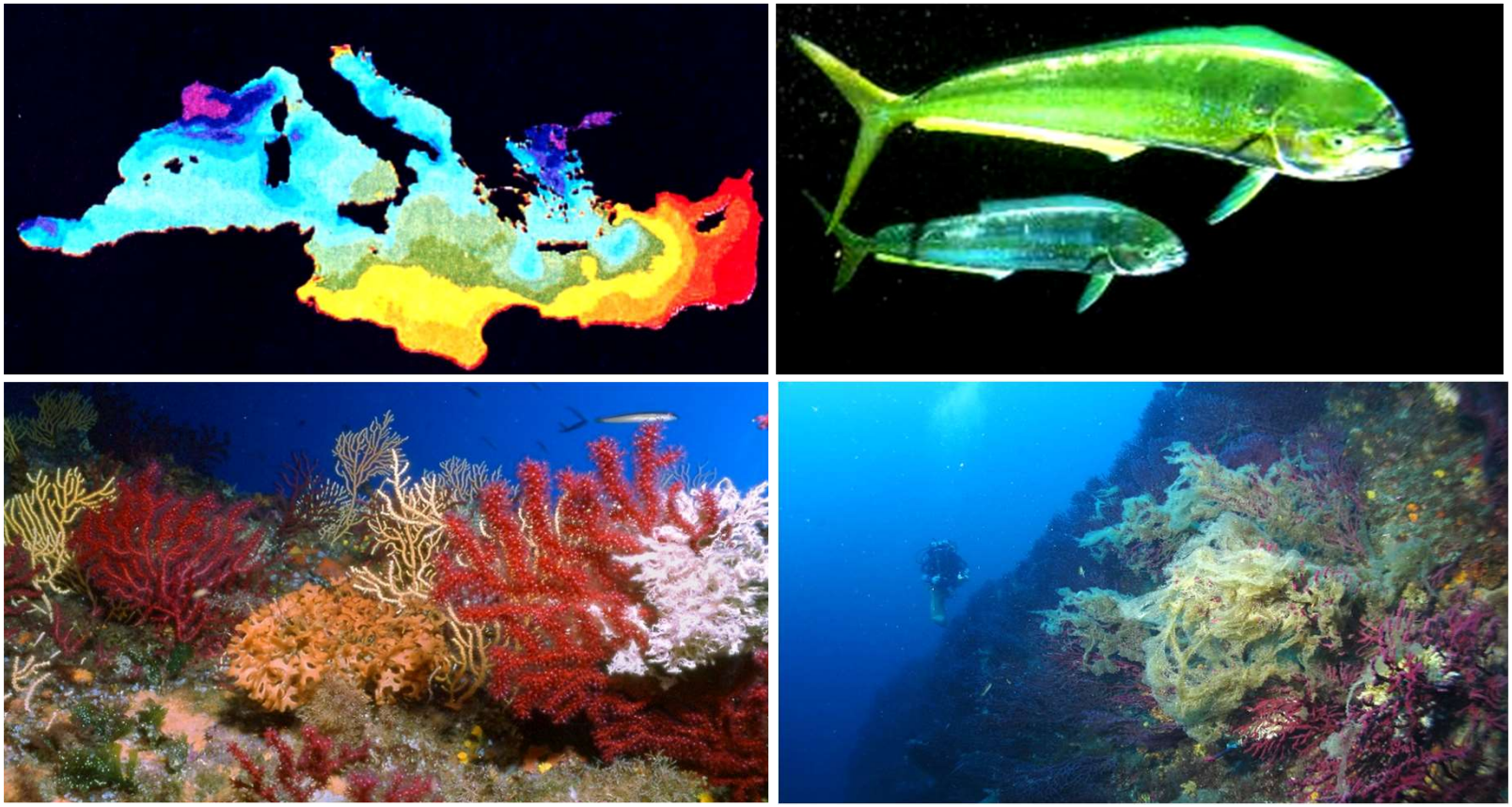
Effect of the climate change on the marine biodiversity

Examples in the Mediterranean Sea



Thierry PEREZ

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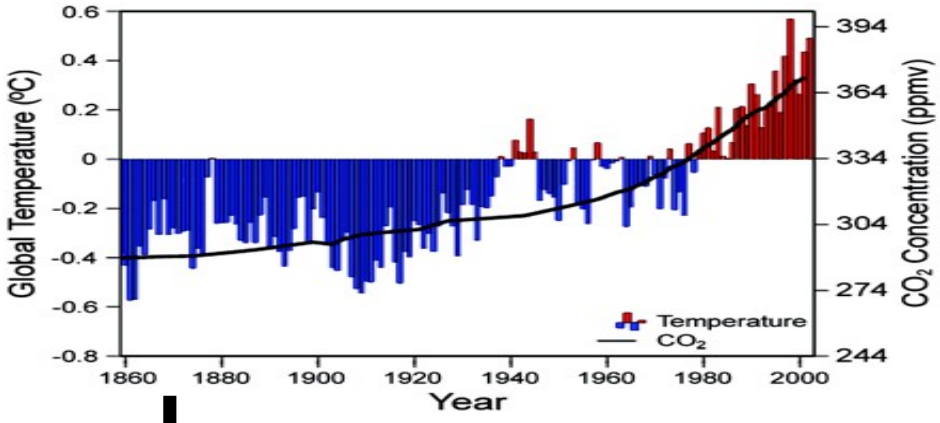
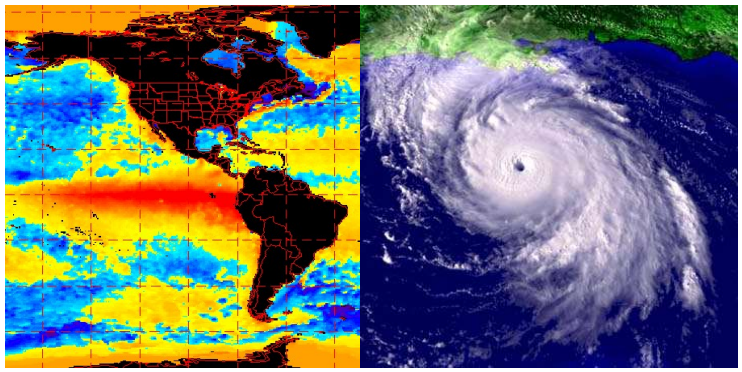
Institut Pythéas
Observatoire des Sciences de l'Univers
Aix*Marseille Université

Impact of the global change on the biological systems

Global warming



Occurrence of extreme events



Cascading biological responses

Physiological stress, disease, mortality

Shift in distribution, local extinction

Effect on life cycle, Adaptations

Effect on biodiversity Ecosystem functioning

? Combined effect ?

Local disturbances:

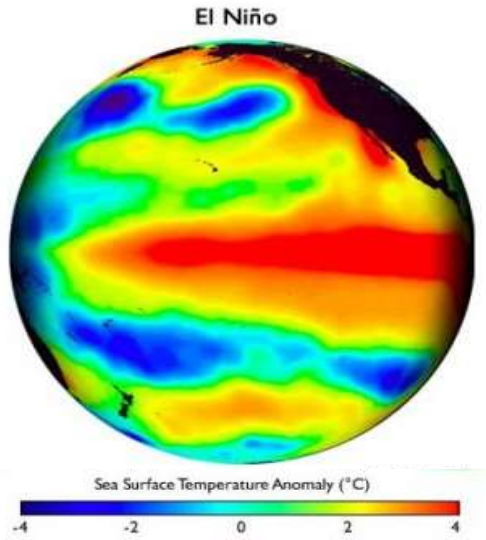
- **terrigenous inputs**
- **pollutants**
- **biological invasions**

« Heat waves » in the Ocean

- Long periods, from several days to several months, of surface water warming, which can extend over thousands of kilometers

- Poor knowledge of past occurrences of these thermal anomalies and their evolution in the future

Frolicher et al. 2018 Nature

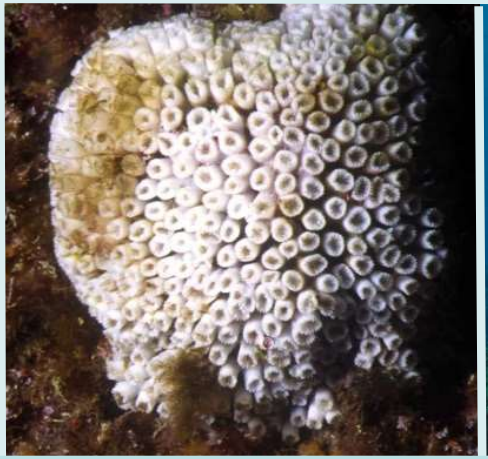


Hobday et al. 2016 Prog. Oceaogr.









« Heat waves » in the Ocean

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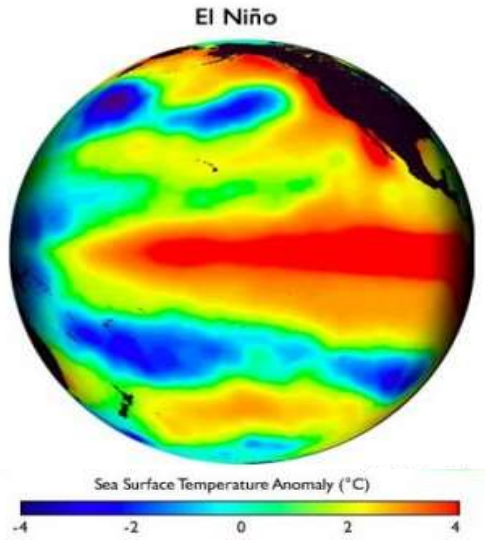


No type configuration, No typology.
Not only at the ocean surface

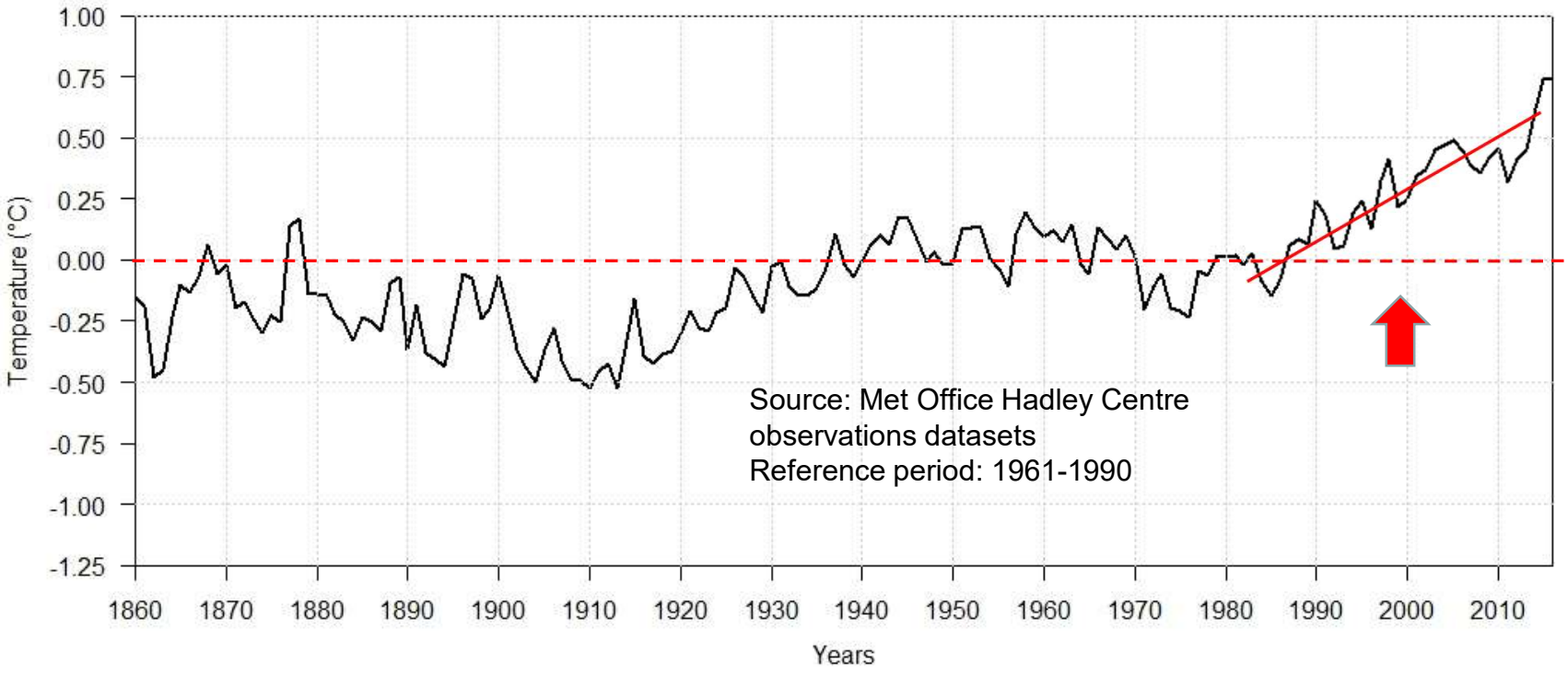
Not necessarily
« marine heat-waves »

Depending on the recording methods,
some undetectable events

Hobday et al. 2016 Prog. Oceaogr.

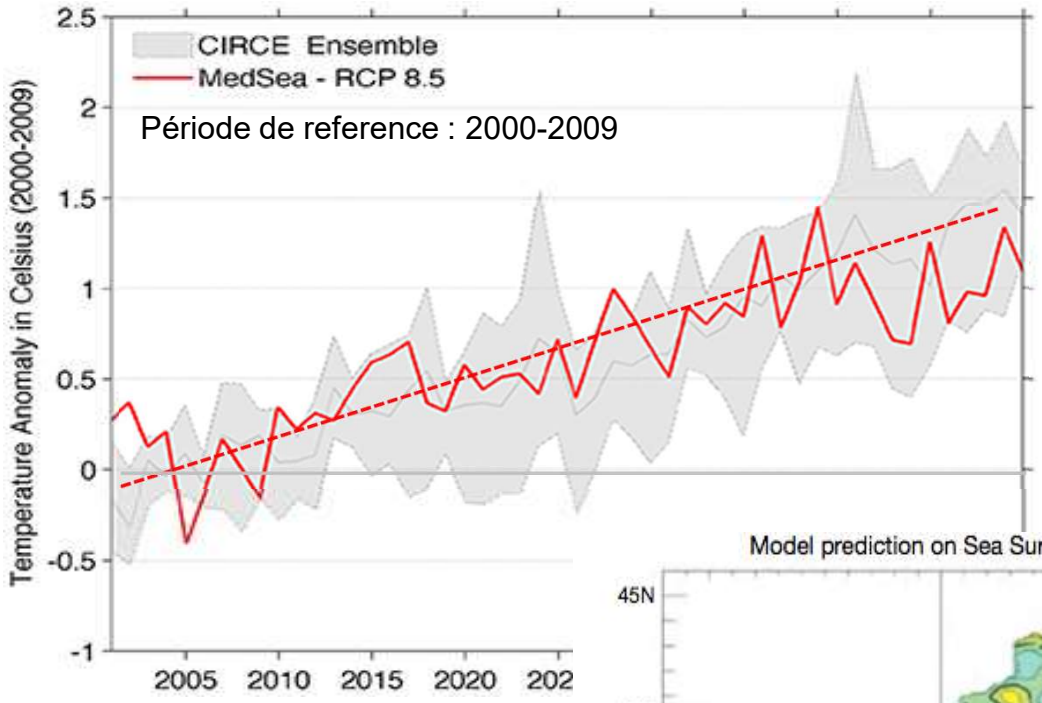
Recording of « Heat waves » in the Ocean

Thermal anomalies recorded at the ocean surface, Northern Hemisphere



At the global scale, a continuous regime of positive thermal anomalies since the 1980's

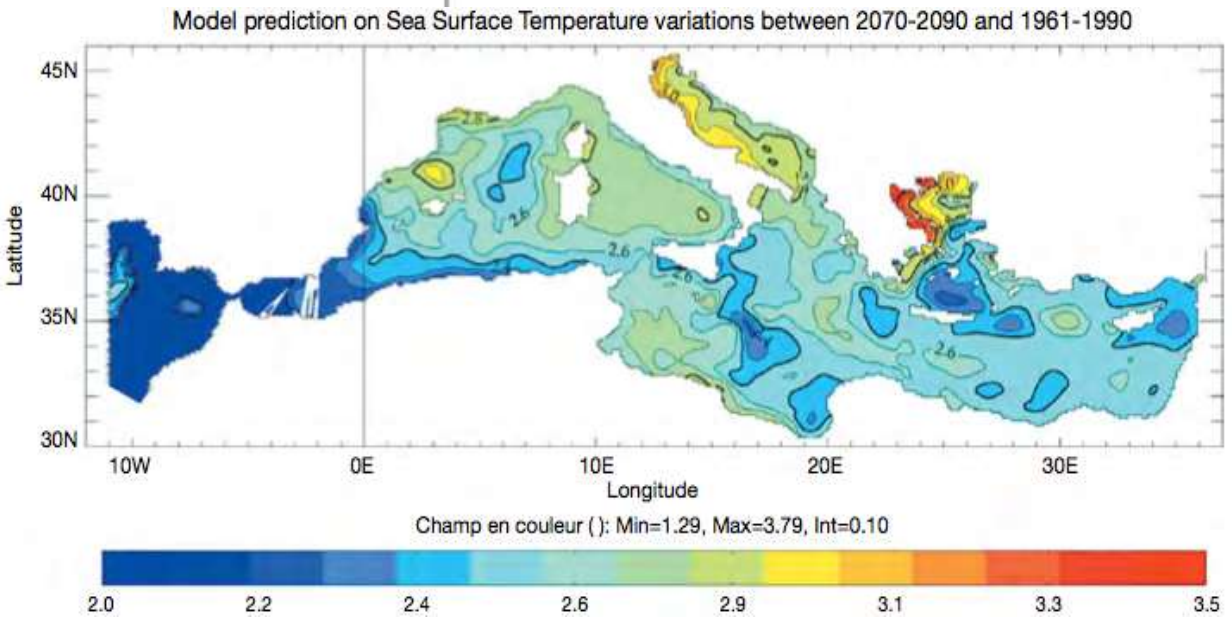
Prediction of Sea Surface Thermal anomalies in the Mediterranean



Galli et al. 2017 Front. Mar. Sci.

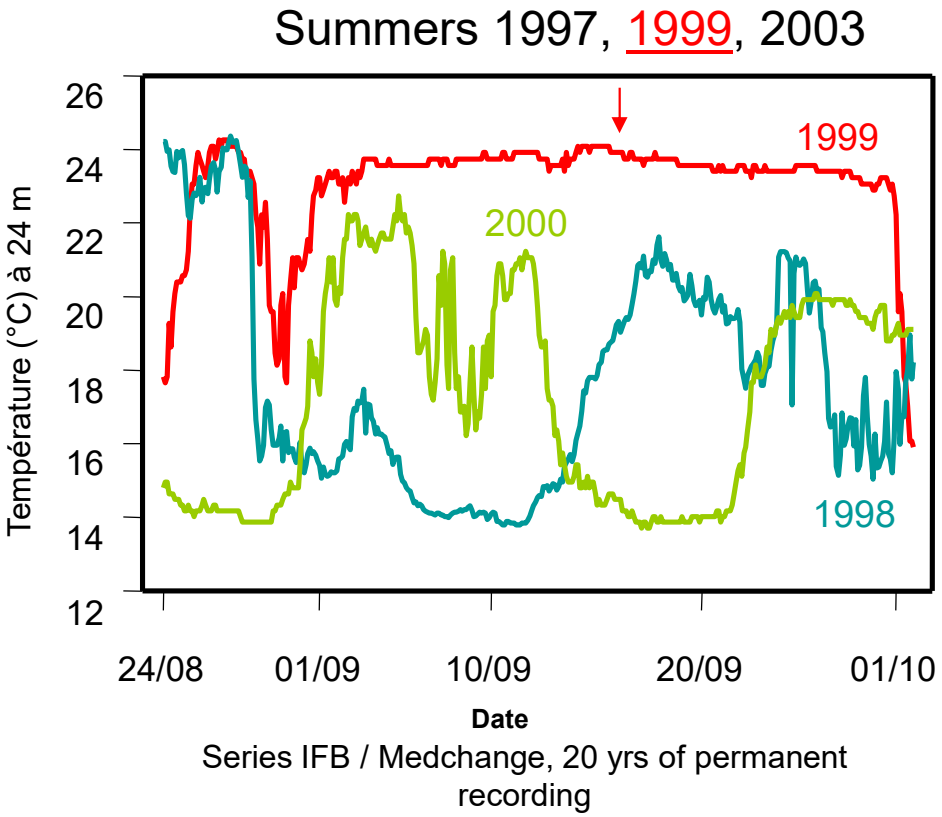
A trend that is not about to reverse

Some will like it hot !

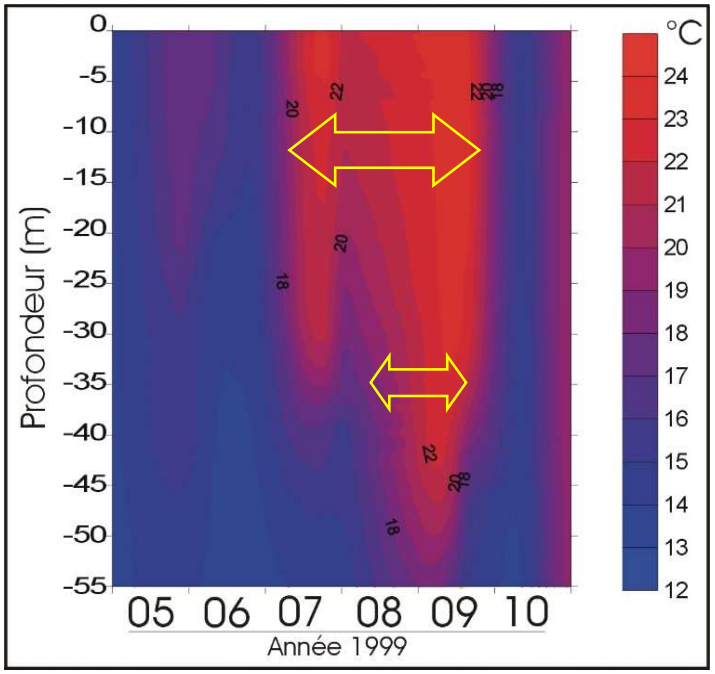


Lionello (Ed.) 2012

The first events investigated in details



Series IFB / Medchange, 20 yrs of permanent recording

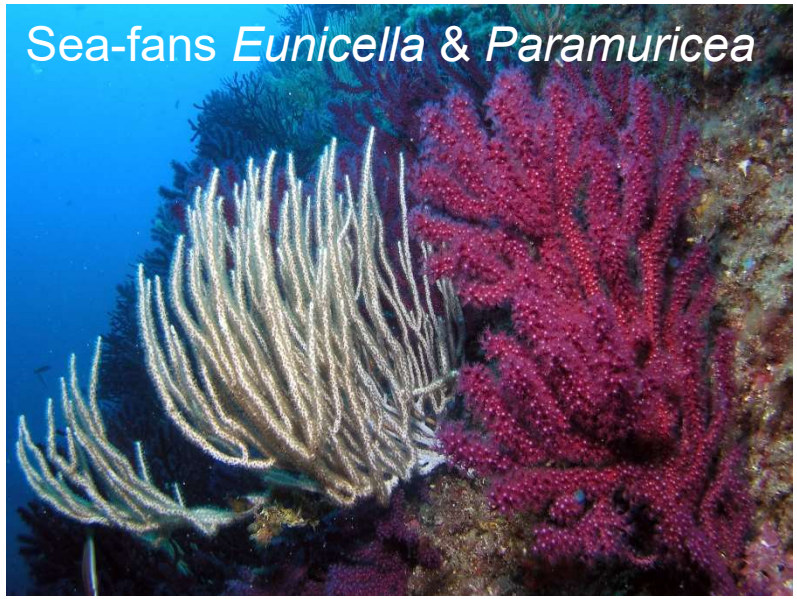


1999 : Poorly detectable in models

2003 : Record of high temperature, but restricted to 15m depth

2018, 2019 : SST records !

Disease outbreaks and invertebrates mass mortality events

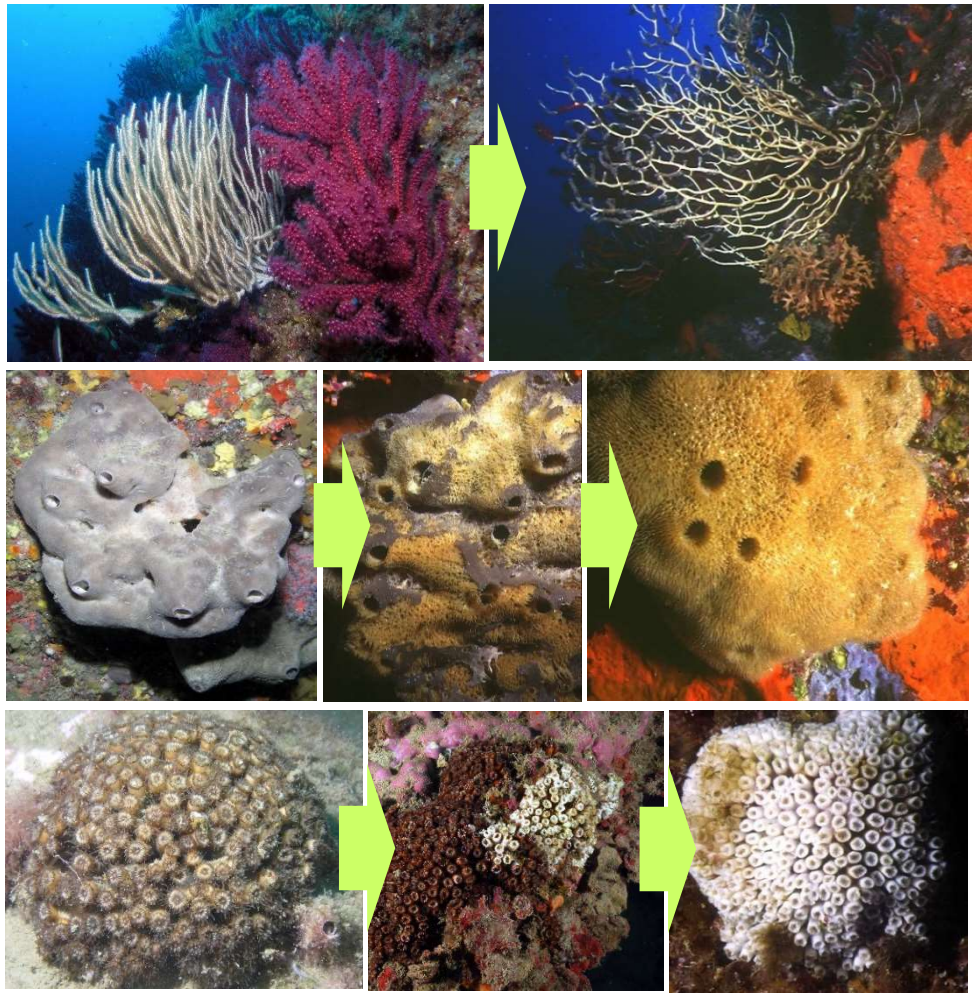


Sessile, endemic, keystone species

Disease outbreaks and invertebrates mass mortality events

Numerous reports from 1999 and 2003

Two unprecedented extreme events



Increasing frequency and +++ large areas

Frontiers in Marine Science, Nov. 2019

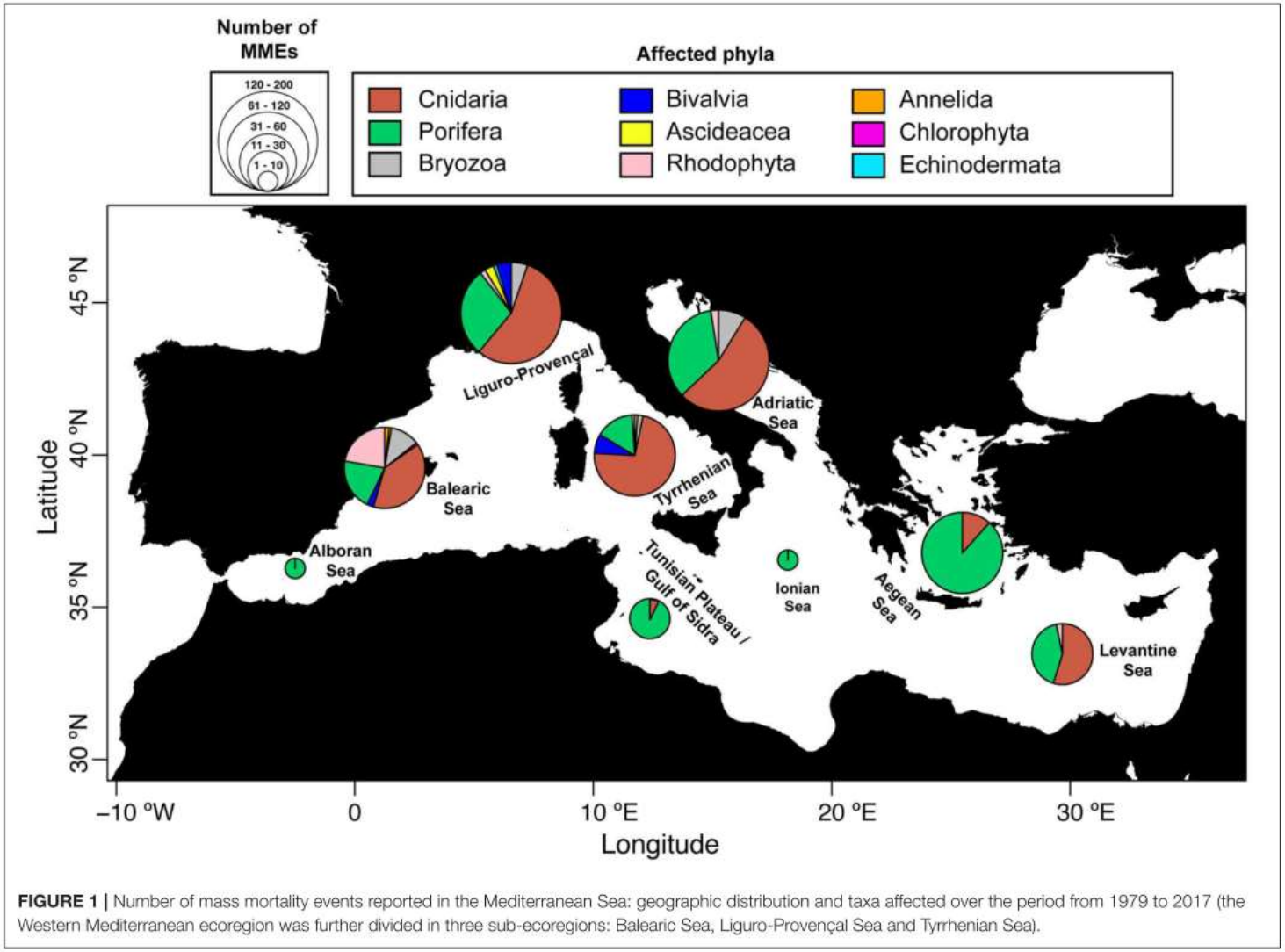
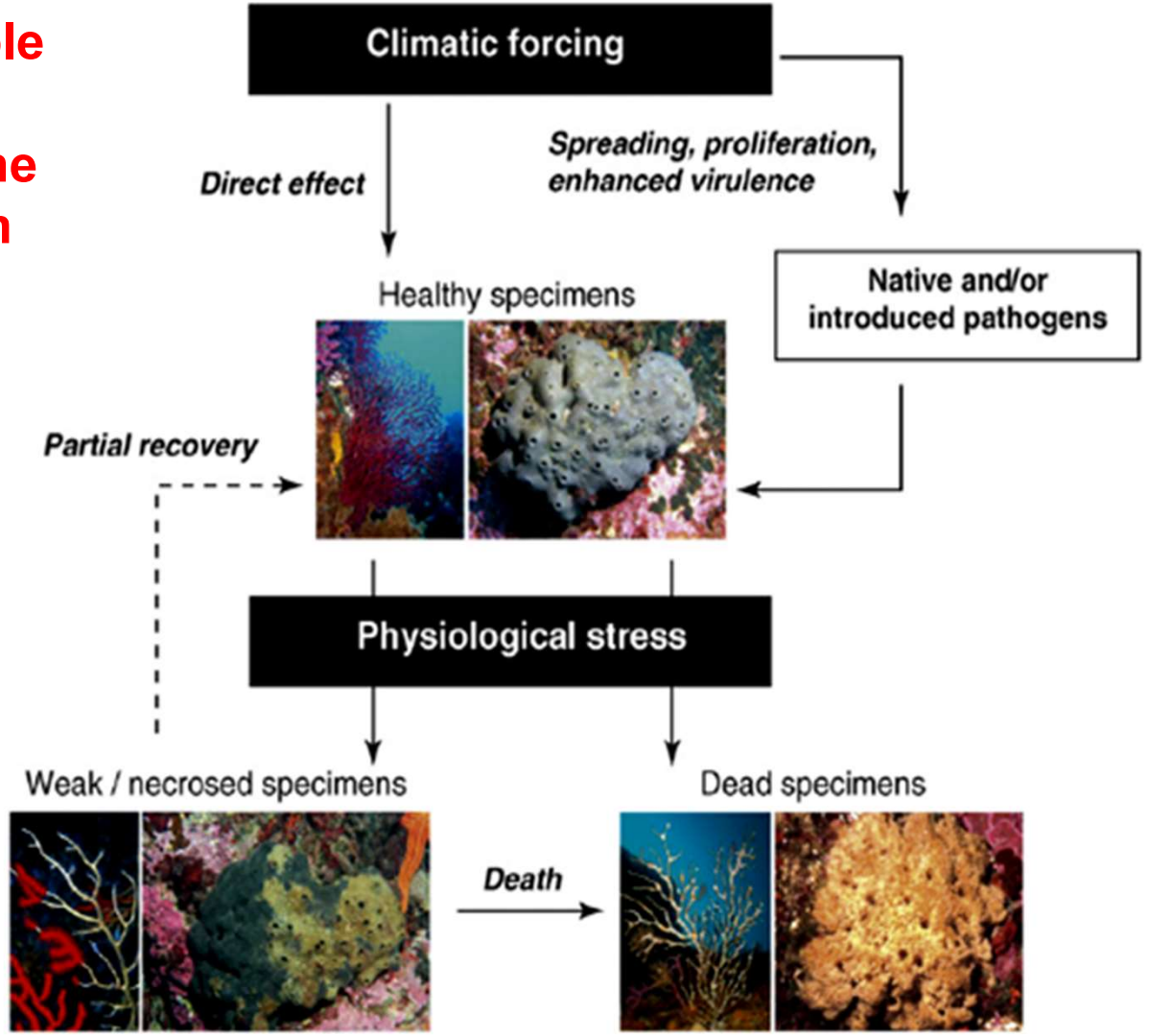


FIGURE 1 | Number of mass mortality events reported in the Mediterranean Sea: geographic distribution and taxa affected over the period from 1979 to 2017 (the Western Mediterranean ecoregion was further divided in three sub-ecoregions: Balearic Sea, Liguro-Provençal Sea and Tyrrhenian Sea).

Disease outbreaks and invertebrates mass mortality events:
Mechanisms : physiological stress, infectious diseases, both?

Most probable combined effect : on the metabolism and of pathogens



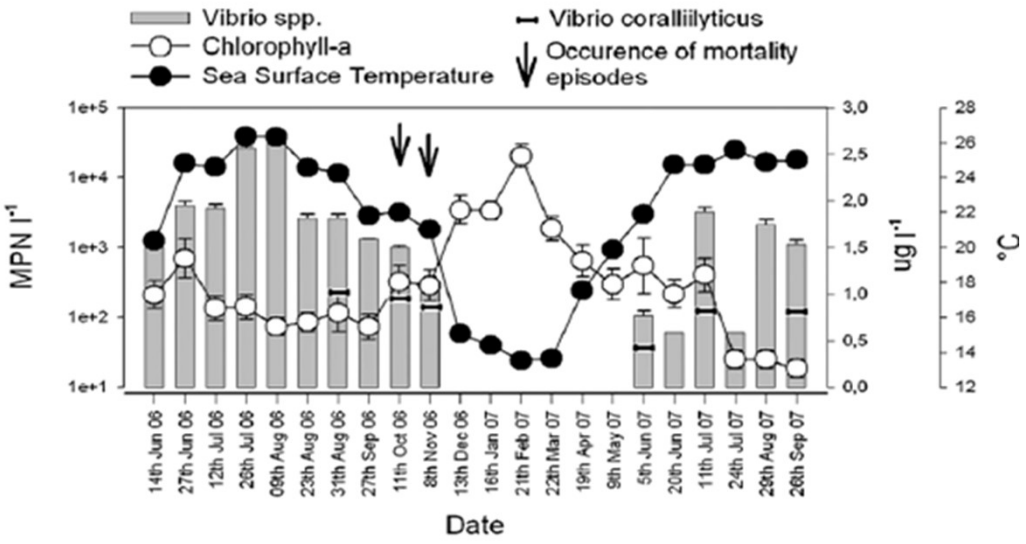
Lejeusne et al. 2010 TREE

Disease outbreaks and invertebrates mass mortality events

Emerging of thermodependent bacterial pathogens

Monitoring

Vezzulli et al. 2010

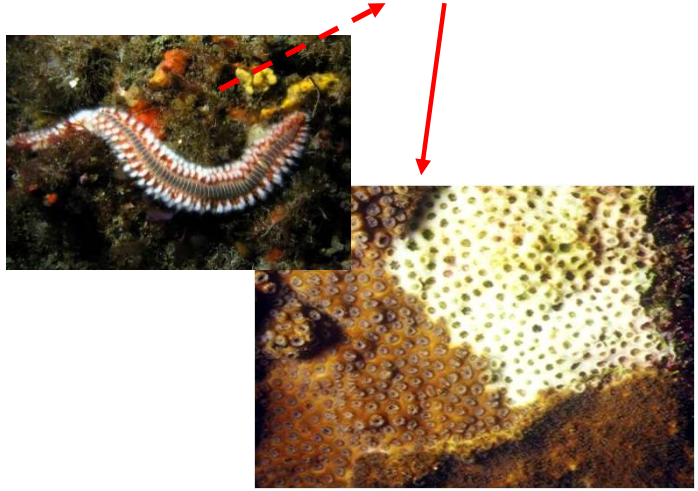


Experimental works

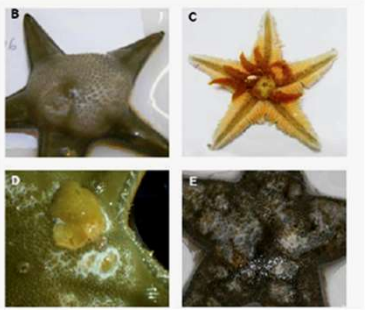
Verify the Koch's postulate

Effect of temperature on bleaching of the coral *Oculina patagonica* by *Vibrio* AK-1

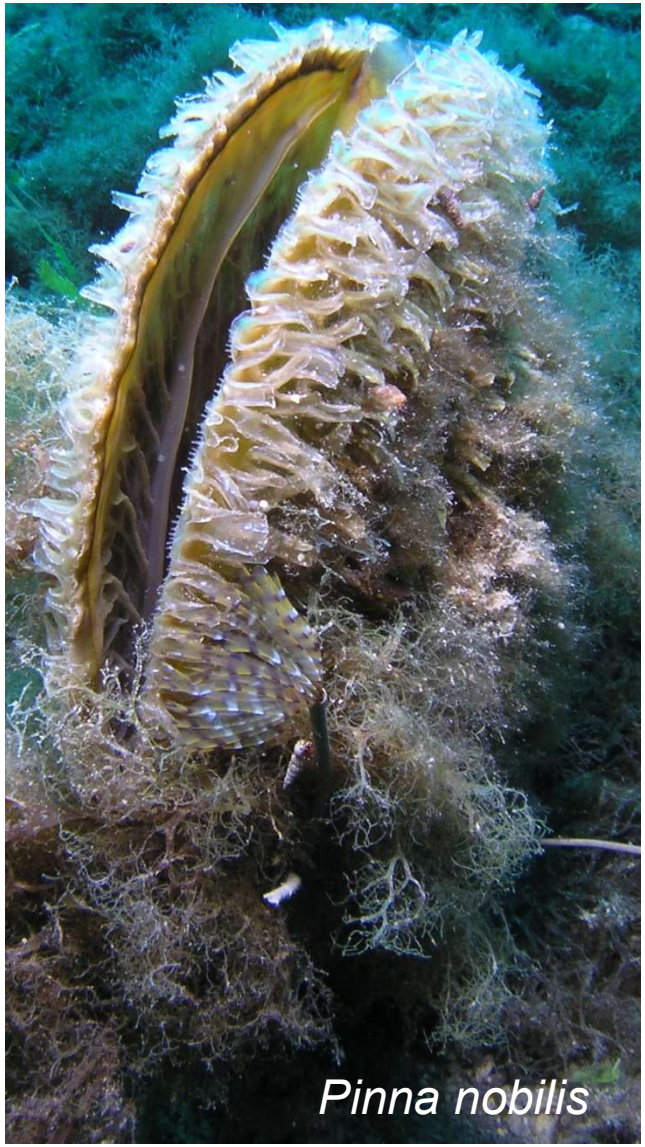
A. Kushmaro[1], E. Rosenberg[2], M. Fine[1], Y. Ben Haim[2], Y. Loya[1,*]

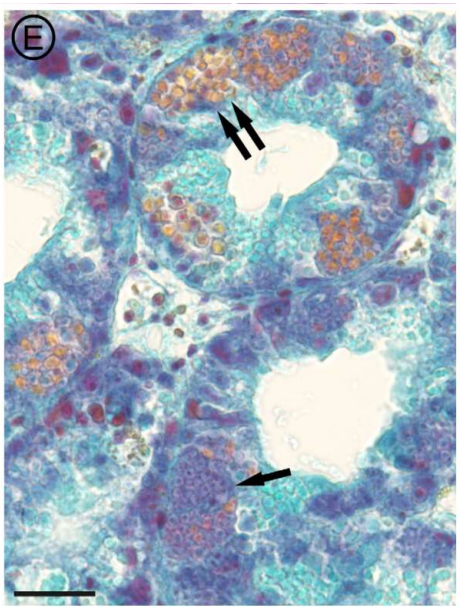


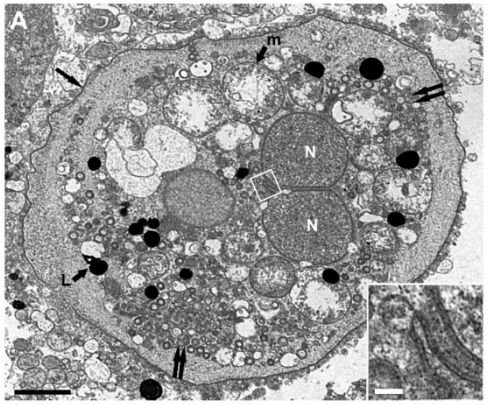
Temperature induced disease in the starfish *Astropecten jonstoni*



Disease outbreaks and invertebrates mass mortality events







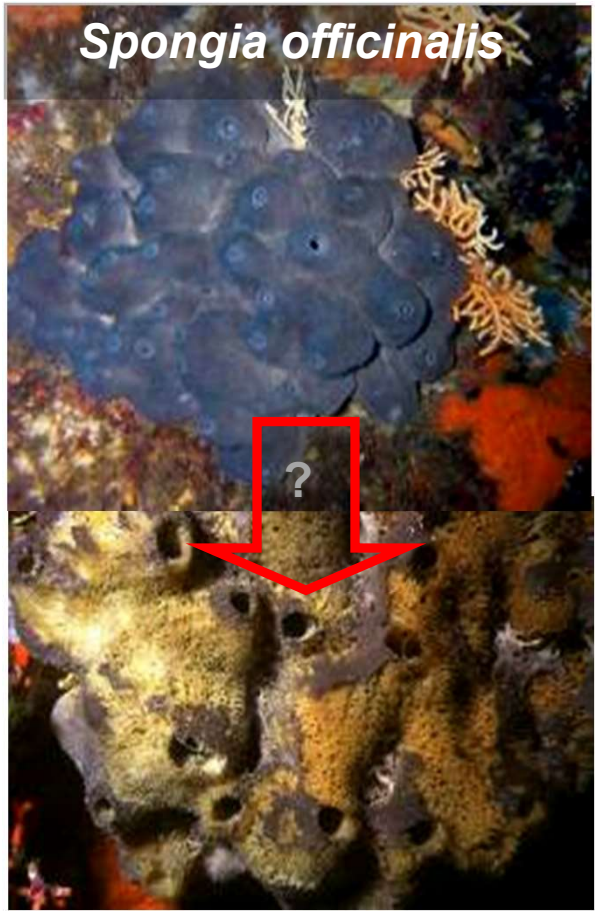
Haplosporidium pinnae sp. nov.

Well-known pathogens of other mollusks

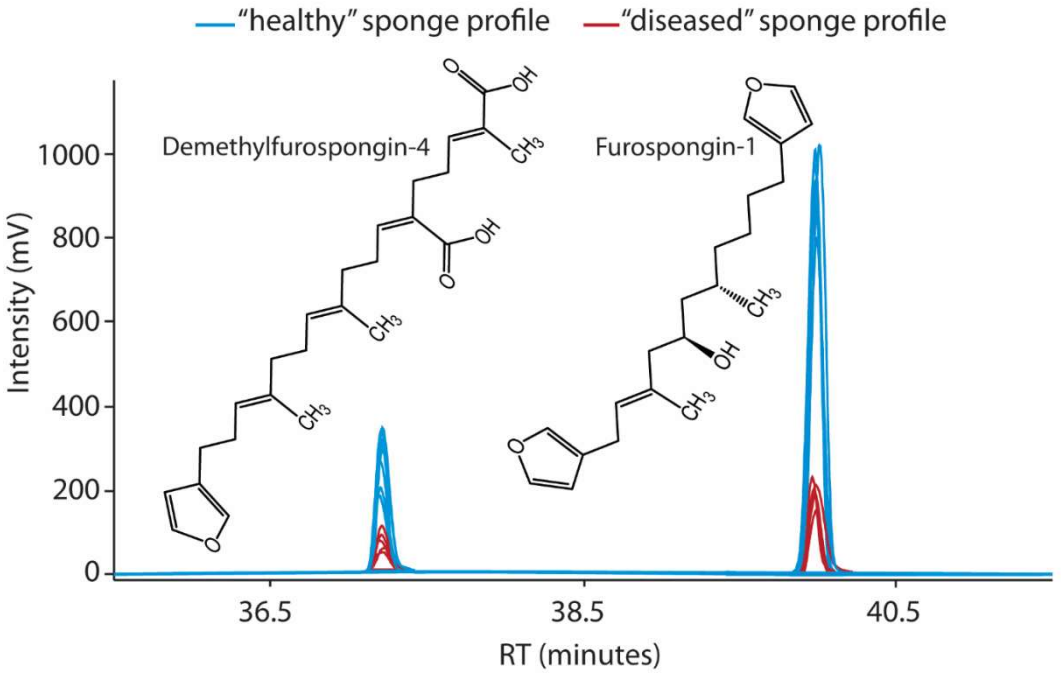
Virulence triggered by high temperature

Catanese et al. 2018 J. Invert. Path.

Disease outbreaks and invertebrates mass mortality events



Sponge mass mortality

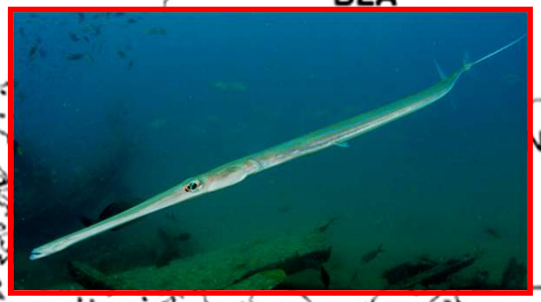


- **Collapse of some chemical defenses**
- **Anti-proliferative property supressed = a gate wide open !**

Some indicators of a « meridionalisation » of the Mediterranean sea: homogenisation of the Mediterranean biota with thermophilic species

Main routes of species range expansion

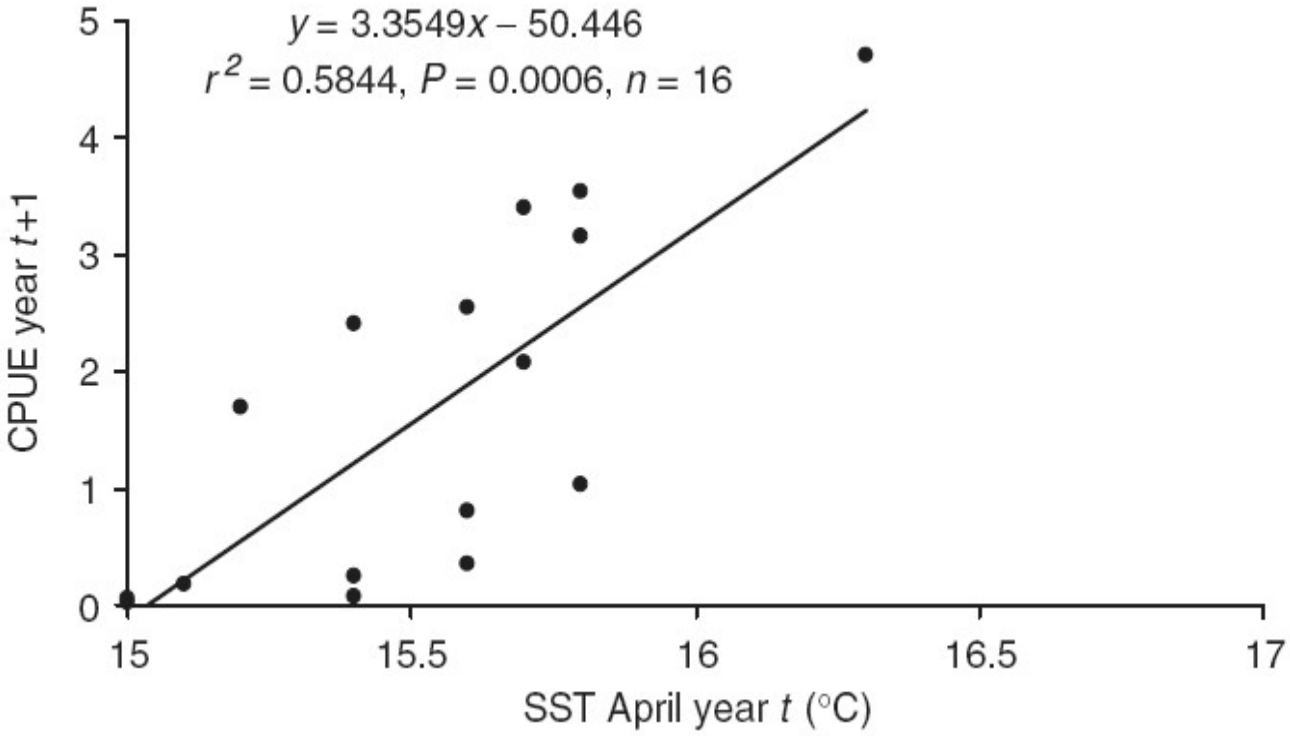
→ mediterranean natives → atlantic migrants → lessepsian migrants



TRENDS in Ecology & Evolution

Some effect on Mediterranean fisheries

Case of the small pelagic fish, *Sardinella aurita*, in the western Med



- landings catches in relation to air temperature anomalies (1950-2003)
- the maximal catches are related to the Sea Surface Temperature of April the year before (Sabates et al. 2006)

Negative effects on « cold stenotherm » pelagic species

Examples:

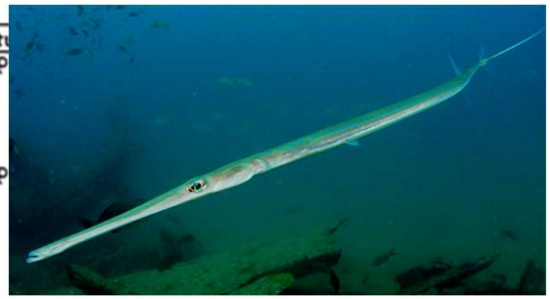
- **Sprat** in the Adriatic and Gulf of Lion
- **Anchovies** in Adriatic

Francour et al 1994; Bonbace 2001

Mediterranean Sea warming and biological invasions

Alien species

Fistularia commersonii



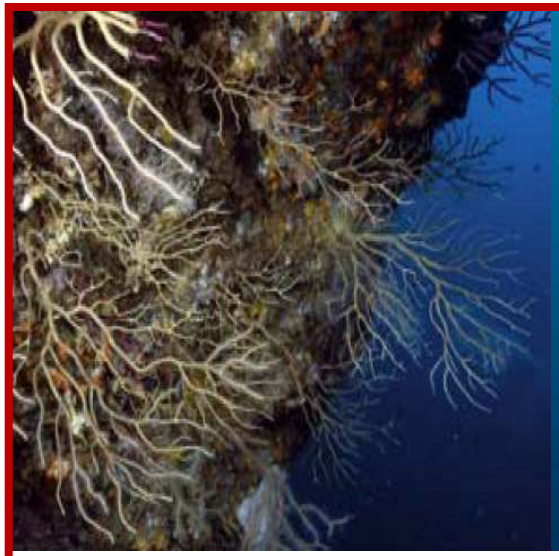
		Place	Number	Size (cm)	Depth (m)	Pictu	
		lles Island (Var)	1	90	20	P	
		zara (Corsica)	2	47 and 55	30		
		Islands (Corsica)	2				
		-Mer (Alpes-Maritimes)	Several individuals				
		-Mer (Alpes-Maritimes)	1		10	P	
		-Mer (Alpes-Maritimes)	1	100	4-6		
		Gulf (Corsica)	1 to 5		1-5		
8	4-8/10/2010	Ajaccio Harbour (Corsica)	1	75	6		
9	4-8/10/2010	South Gulf of Ajaccio (Corsica)	1	80	5-6		
10	4-8/10/2010	Gulf of Ajaccio (Corsica)	1	92	22		Net
11	16/10/2010	South Bastia (Corsica)	1	70-80	10		Free diving
12	17/10/2010	Porto Gulf (West Corsica)	4	78-85	25		Net
13	22/10/2010	Agriate (North Corsica)	2	100-110	17		Net
14	23/10/2010	Solenzara (Corsica)	2	100	50	P	Net
15	23/10/2010	Barcaggio (North Corsica)	3		30		Net
16	24/10/2010	Antibes (Alpes-Maritimes)	1	70		P	Spear fishing
17	24/10/2010	Antibes (Alpes-Maritimes)	1				Net
18	25/10/2010	Giraglia (North Corsica)	4	80		P	Net
19	27/10/2010	Cap d'Ail (Alpes-Maritimes)	3	95	23	P	
20	29/10/2010	Capu Cavallo (Corsica)	1	125	9		
21	30/10/2010	Calvi (Corsica)	2	92	15	P	
22	02 /11/2010	Dramont (Var)	2		25		
23	02 /11/2010	Boulouris (Var)	1				
24	02 /11/2010	Saint-Raphaël (Var)	1	88	35	P	
25	03/11/2010	Cargese (Corsica)	3	75-80	3		
26	07/11/2010	Isolella-Ajaccio (Corsica)	1	90			
27	09/11/2010	Saint-Raphaël (Var)	2	One of 70			
28	13/11/2010	Planier (Marseille)	1	80-90	8	P	
29	15/11/2010	Rondinara (Corsica)	1	80	1		

Merci d'envoyer toutes nouvelles observations à Patrice Francour (francour@unice.fr) en donnant le plus de préc
Si un exemplaire peut être conservé, il serait important de garder la tête, jusqu'aux nageoires pectorales (incluse

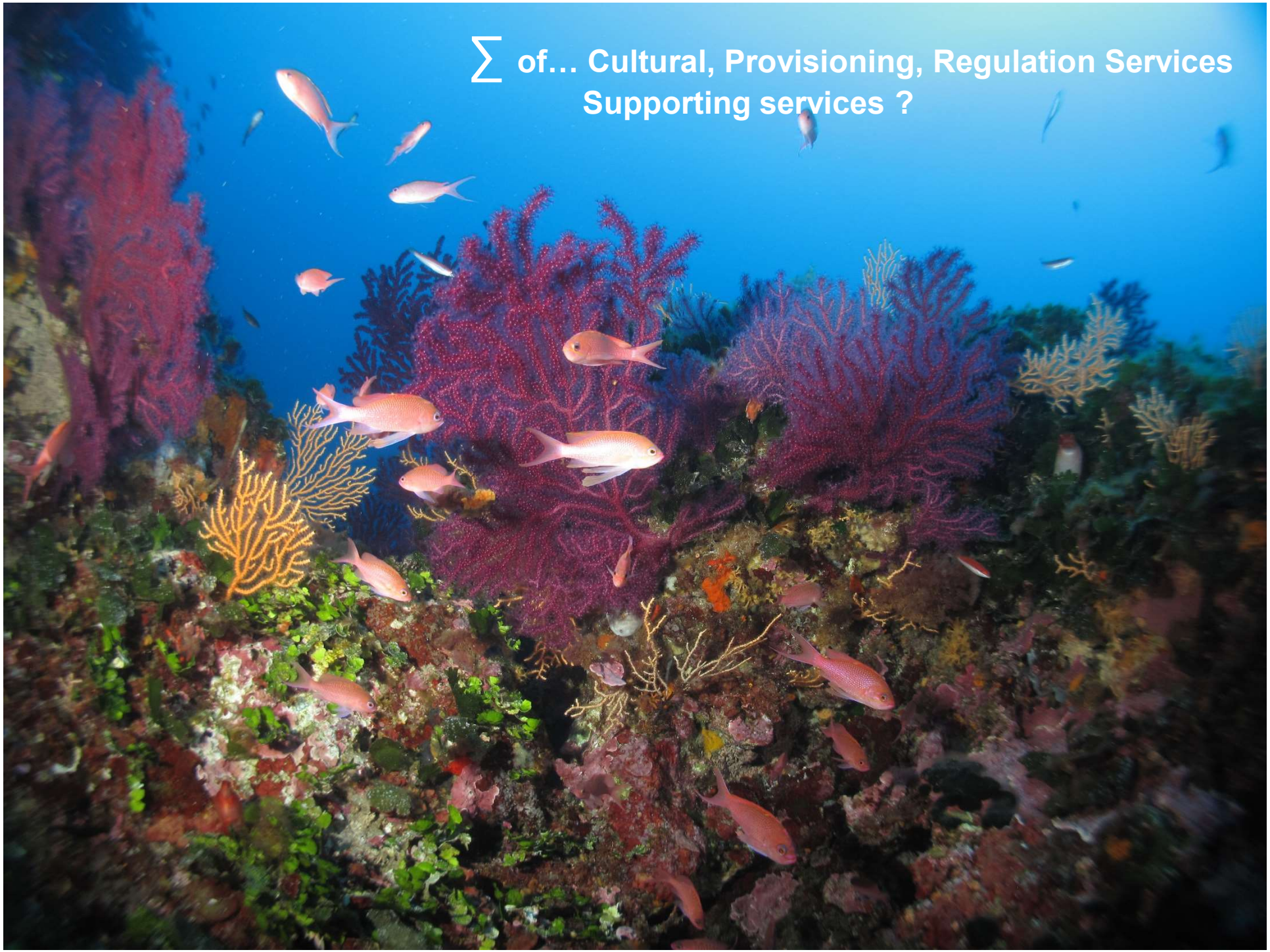
Effects on the ecosystem functioning and ecosystem services?

Cascading effect after successive NAO+ at the end of the 80's: 30 yrs monitoring, bloom of gelatinous triggered by NAO+, increasing of predation on copepodes, Indirect effect of pelagic fish stocks

?



- Consequences of the top predators change in distribution on the trophic network ?
- Consequences of the suspension feeders mass mortality on the bentho-pelagic couplings ?


∑ of… Cultural, Provisioning, Regulation Services
Supporting services ?

Ceci n’est pas un jeu « *cherchez l’erreur* » !

This is not a game « find the mistake » !

Impact of Climate Change on the Mediterranean Sea

Further reading

• Plateforme Océan-Climat: https://ocean-climate.org/?lang=en

• MEDECC 1st Report https://www.unep.org/unepmap/fr/resources/medecc-mar1-climate-and-environmental-change-mediterranean

•UNEP-MAP-RAC/SPA 2008 (http://www.rac-spa.org/)

•The MERMEX group 2011. **Marine ecosystems' responses to climatic and anthropogenic forcings in the Mediterranean**. Progress in Oceanography

• LEJEUSNE et al. 2010 **Climate change effects on a miniature ocean: the highly diverse, highly impacted Mediterranean Sea**. Trends in Ecology and Evolution

•COLL et al. 2010. **The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats**. PLOSOne

Sea-level rise may affect biodiversity