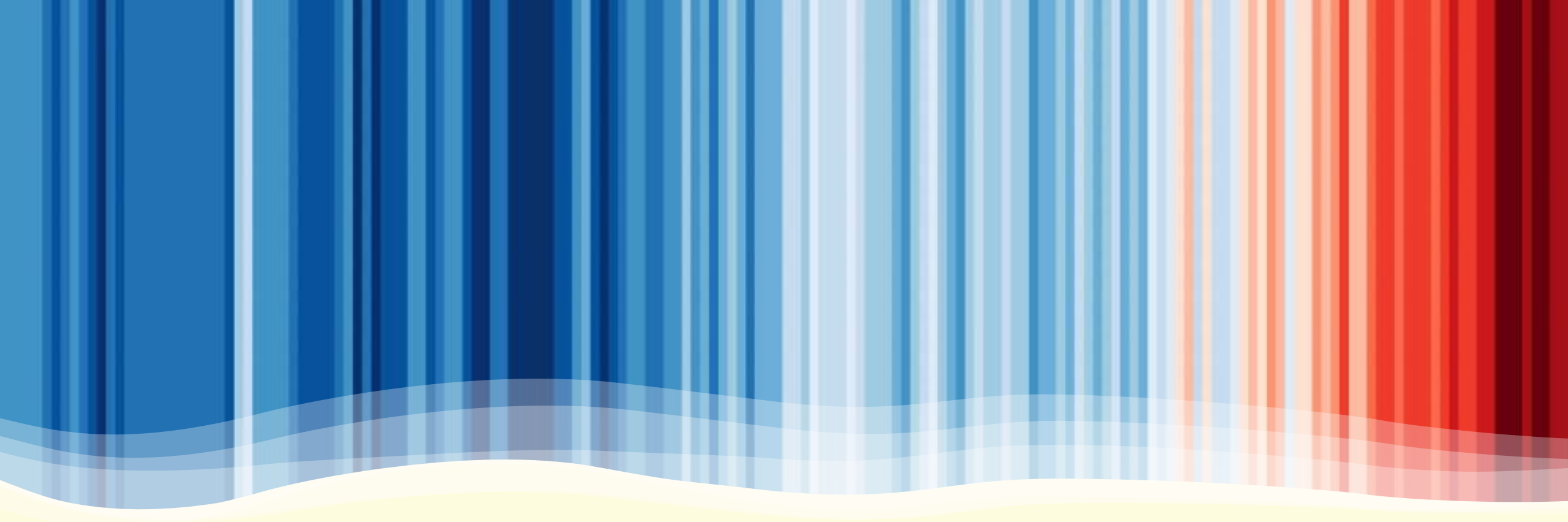

Marine Heat Waves

by Aigerim Sagidulla, Anja Pansegrau, Lilly Kitzinger & Enja Stürtz

Content

1. Introduction (Enja)
2. Physics of Heat Waves (Anja)
3. Biology of Heat Waves (Hera)
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Introduction

What are marine heatwaves?

Periods of unusually high ocean temperatures lasting days to months

Can occur in different regions of the world's oceans

Have increased in frequency, duration, and intensity in recent decades

Impact marine ecosystems, fisheries, tourism, and coastal communities

Expected to become more common due to climate change

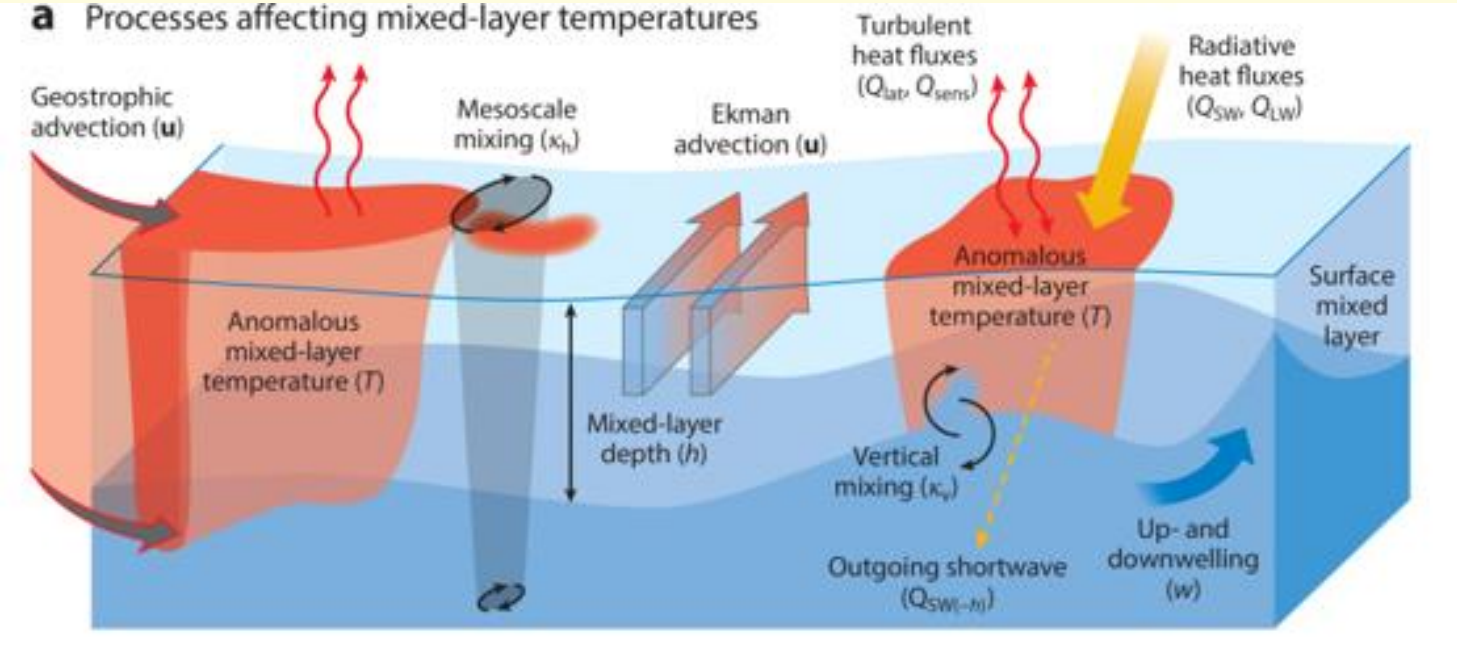
Introduction

- The Mediterranean Sea is one of the most affected regions
- The number of marine heatwave events has doubled since 1982
- The total number of MHW days worldwide has increased by about 50% over the last century

Key historical MHWs

Physics of Heat Waves

- mixed-layer temperature budget used to describe the processes of MHW formation, evolution, and decay



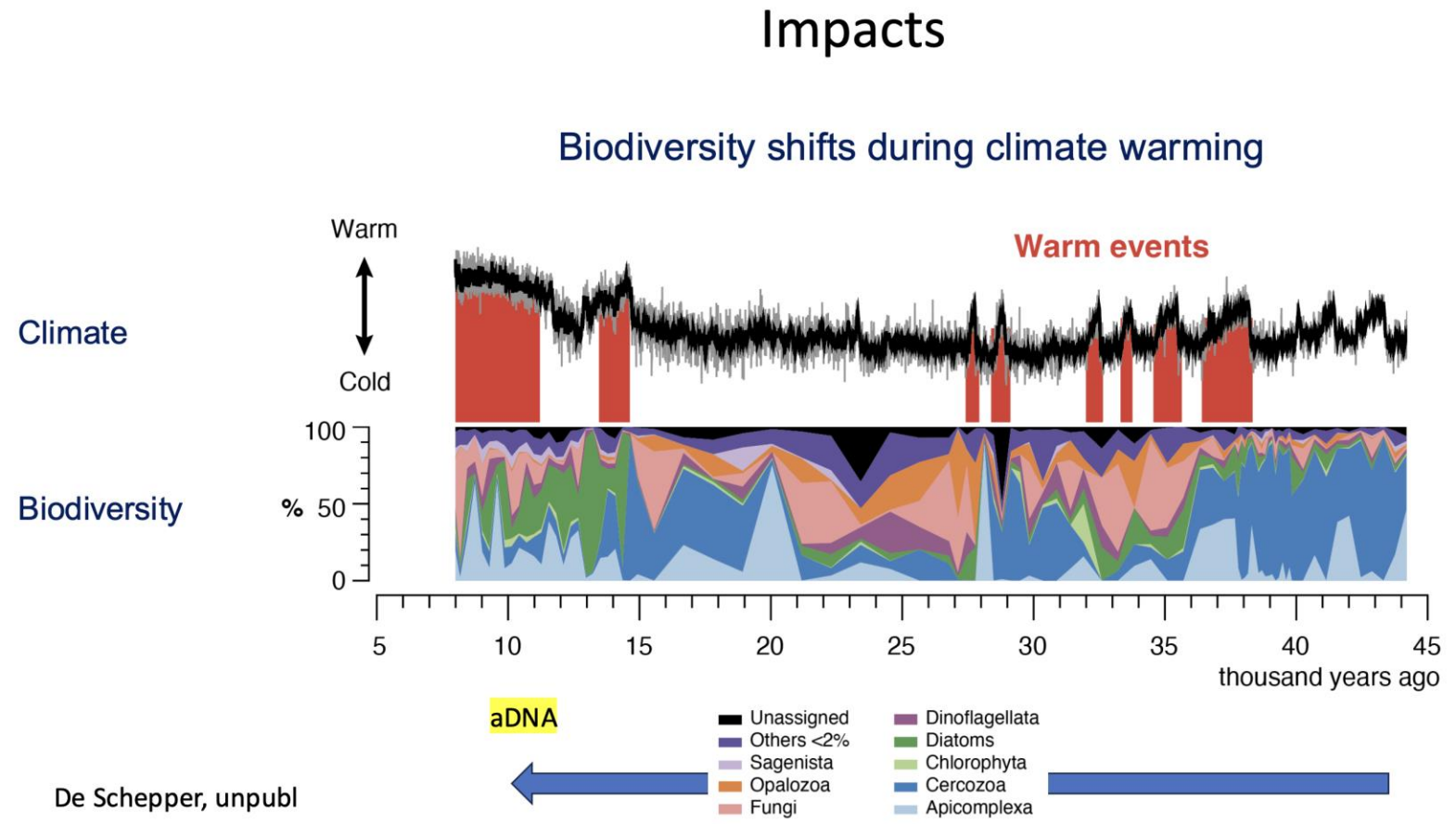
$$temperature\ tendency = -horizontal\ advection + horizontal\ mixing\ - vertical\ mixing - entrainment + air\ sea\ heat\ flux$$

Physical Drivers of Heat Waves

- **Increased solar radiation** (clear skies, high pressure)
- **Reduced heat loss** (less wind → less evaporation & sensible heat loss)
- **Suppressed vertical mixing** (calm winds → less cold water from below, suppressed upwelling)
- **Warm water advection** (e.g. currents like El Niño bring warm water)
- **Sea Surface Height (SSH) Anomalies** (thermal expansion → can influence local currents and indicate accumulated heat and mass)
- **Sea ice loss** (More solar absorption, less albedo → amplifies warming)
- **Increased stratification** (traps heat near the surface by suppressing vertical mixing and dampening internal waves)

Biology of Heat Waves

Changes in Biodiversity



1. Strong biodiversity reorganization
2. Increased ecosystem instability
3. Opportunistic species benefit
4. Loss of ecological balance

Biology of Heat Waves
Effect of CC on MCEs

Marine & Coastal Ecosystems Mediterranean	RESPONSE VARIABLE CATEGORIES	CLIMATE CHANGE								
		Warming / heat waves	Extreme weather events	Atmospheric CO_2 concentration	Ocean acidification	Sea level rise	Salinity (hyper)	Cooling	Rainfall regimes	Inundation
 CORALS *Cladocora caespitosa*	Density/Abundance	45%								
	Distribution									
	Growth	18%			66%					
	Habitat structure									
	Metabolism	9%								
	Photosynthesis/Respiration	9%			33%					
	Reproduction	9%								
	Other	9%								
	Total number of studies	11			3					
 SEAGRASS BEDS *Posidonia oceanica*	Density/Abundance	18%	100%		22%		8%			
	Distribution	5%				50%	8%			
	Growth	23%			11%		16%			
	Habitat structure	3%			11%	50%	15%			
	Metabolism	28%			22%		39%			
	Photosynthesis/Respiration	18%			22%		15%			
	Reproduction	5%								
	Other	3%			11%					
	Total number of studies	40	2		9	2	13			

Response Legend: Fully / Mostly Negative; Fully / Mostly Positive; Fully / Mostly Neutral; Fully / Mostly Unclear; Mixed; Not tested

Marine & Coastal Ecosystems North-East Atlantic	RESPONSE VARIABLE CATEGORIES	CLIMATE CHANGE								
		Warming / heat waves	Extreme weather events	Atmospheric CO_2 concentration	Ocean acidification	Sea level rise	Salinity (hypo)	Cooling	Rainfall regimes (reduced)	Inundation
 KELP FORESTS	Density/Abundance	9%								
	Distribution	23%					58%			
	Growth	20%					8%			
	Habitat structure	2%	100%							
	Metabolism	16%								
	Photosynthesis/Respiration	17%					17%			
	Reproduction	13%					17%			
	Other									
	Total number of studies	179	1				12			
 MAËRL BEDS	Density/Abundance									
	Distribution	33%			9%					
	Growth	33%			36%					
	Habitat structure									
	Metabolism	33%			27%					
	Photosynthesis/Respiration				27%					
	Reproduction									
	Other									
	Total number of studies	4			13					
 SALT MARSHES	Density/Abundance	3%		7%		7%			6%	
	Distribution									
	Growth	16%		21%		12%				
	Habitat structure	32%		14%		52%			69%	
	Metabolism					5%			19%	
	Photosynthesis/Respiration	41%		29%		15%			6%	
	Reproduction	8%		21%		8%				
	Other		100%	7%		2%				
	Total number of studies	37	1	14		60			16	
 SEAGRASS BEDS *Zostera marina*	Density/Abundance	18%					15%			
	Distribution	3%	100%				8%			
	Growth	15%					15%			
	Habitat structure	9%					15%			
	Metabolism	42%					38%			
	Photosynthesis/Respiration	12%					8%			
	Reproduction									
	Other									
	Total number of studies	33	1				13			

Response Legend: Fully / Mostly Negative; Fully / Mostly Positive; Fully / Mostly Neutral; Fully / Mostly Unclear; Mixed; Not tested

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Biology of Heat Waves

Effect of CC on MCEs

•**Warming and marine heatwaves** consistently have **the strongest negative effects** across almost all ecosystems.

• Mediterranean **coral communities** experience reduced abundance, slower growth, and impaired metabolism during heatwaves.

•**Seagrass meadows** also suffer from declining growth and changes in photosynthesis, reducing their ability to store carbon and provide habitat.

•The North-East Atlantic, **kelp forests** show strong declines in abundance and habitat structure during warming events. Since kelp forests support many marine species, their loss affects the entire ecosystem

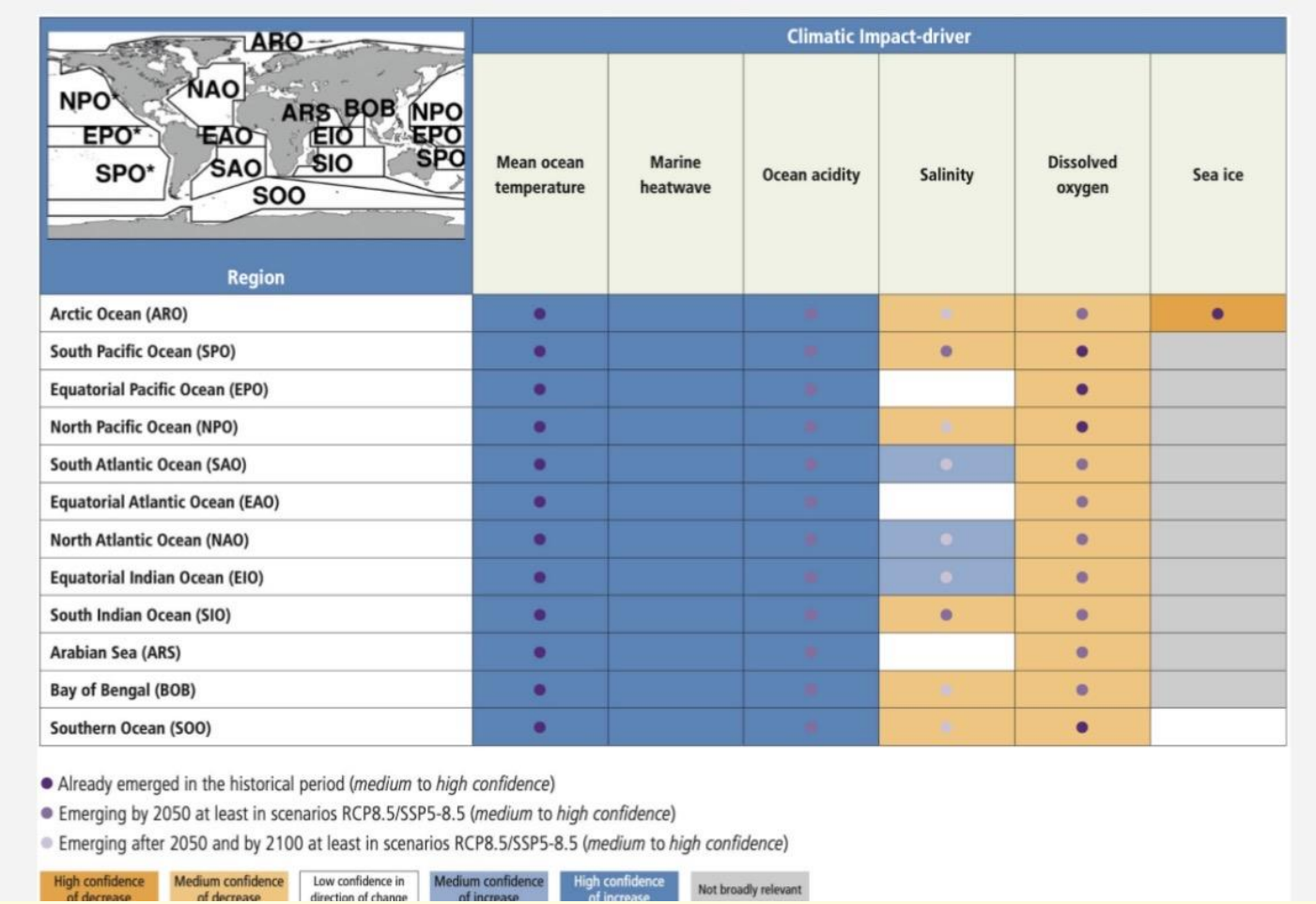
Future Marine Heatwaves

- The "permanent" Heatwave
- The Baseline issue
- The need for forecasting

Future Marine waves by Continental Region

Location	Increase/Decrease	Confidence of change
Africa	Increase	High confidence
Asia	Increase	Medium to high confidence
Australia	Increase	High Confidence
South America	Increase	High confidence
Europe	Increase	Medium to high increase
North America	Increase	High confidence
Pacific and Caribbean Islands	Increase	High confidence

Future Marine Heatwaves by Ocean



- Marine Heatwave Tracker

Exam Questions

- Name place & year of one of the past MHWs.
- Name 3 physical key drivers of MHWs and how they influence them.
- Why is it important to predict future marine heatwaves and what is a key challenge in defining them?
- What are the main impacts of heatwaves on MCEs?

Sources

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