

**FOO 2021**  
**Climate, Marine Heatwaves, and Temperature**

Marine industries, climate extremes and  
adaptation, and ocean data and modelling  
needs across time scales

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temperatures relative to 1850-1900 mean

Before Paris, mankind had emitted about 2500 Gigatonnes of Greenhouse Gases. In the six years since then, it added more than 300 Gt, about 50 Gt each year.

**WE  
ARE  
HERE**

**+ 1.2°C  
< 700 Gt left**

**Pre-Paris  
3.6 – 4.2°C**

114 years of current emissions

Since Paris, projected cumulated emissions by the end of this century declined by 2100 Gt

**Current Policies  
2.7-3.1°C**

75 years of current emissions

Fulfilling current Pledges would reduce them another 1300 Gt

**Pledged Policies  
2.1-2.5°C**

50 years of current emissions

But a reduction of 3200 Gt would be necessary for a good chance to stay below 1.5°C by 2100

**Below 1.5° Pathway**

13 years of current emissions and negative emissions after 2070

1900  
3200 Gt left  
for 1.5° path

Stockholm  
Conference  
2500 Gt left

Rio  
Conference  
2000 Gt left

Paris  
Accord  
1000 Gt left

2100

# Five priority areas for the critical decade

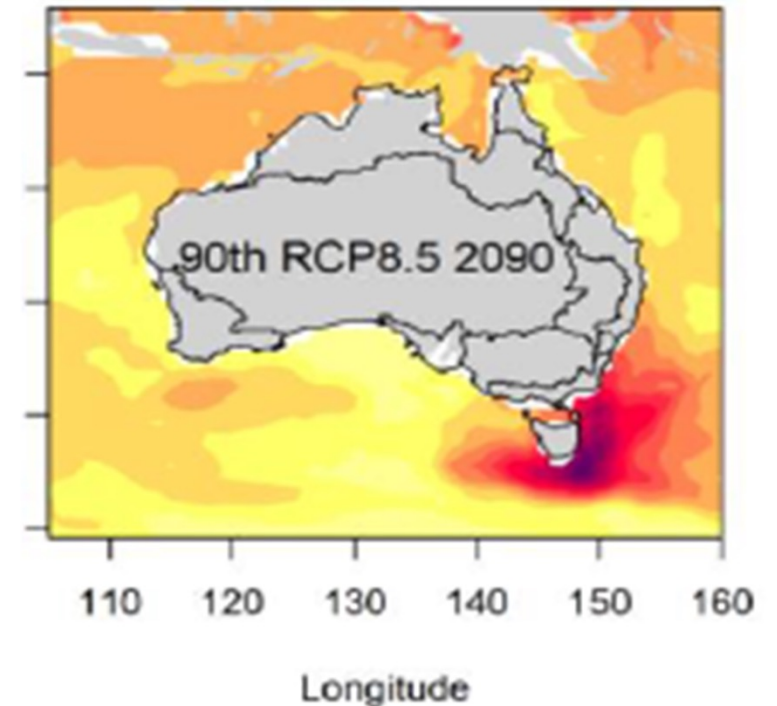
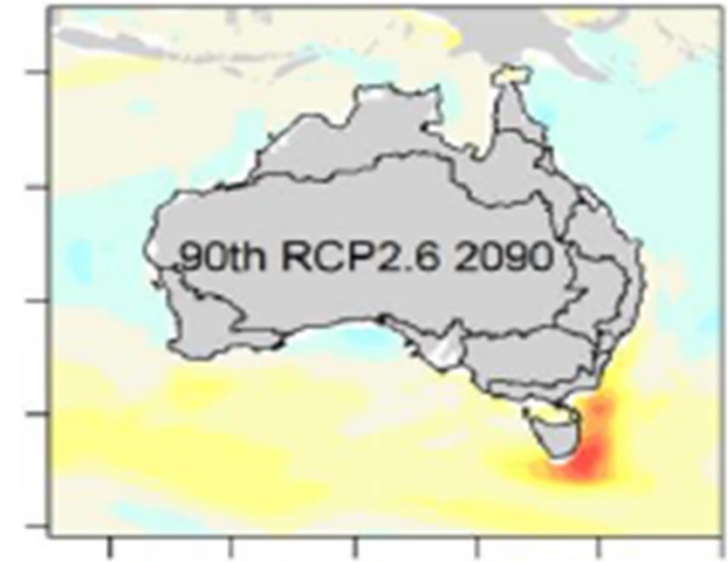
- Past experience less useful
  - Novel combinations of physics, chemistry, and biology
- Need to make decisions that are generally ok even if the details change, based on the best information available at the time
- Learn as fast as we can!



1. Incorporate climate change into assessment and management
2. Help industry and management manage environmental risk (short-term & long-term) – adaptation options and **forecasts**
3. Test adaptation options - models
4. Use new technologies to improve data collection efficiency (and reduce costs, esp. for data limited fisheries)
5. Provide information faster!

# Seafood futures

- Environmental challenges
  - Climate change (e.g. warming)
  - Extreme events (e.g. marine heatwaves)
  - Range changes (e.g. new species)
  - Disease (e.g. new pathogens)
- Socio-economic challenges
  - Recreational and commercial
  - Markets – domestic and international
  - Community - Values and Certification
  - Competition from other industries
    - Renewables, oil and gas





# What do fisheries\* need to know about the future?

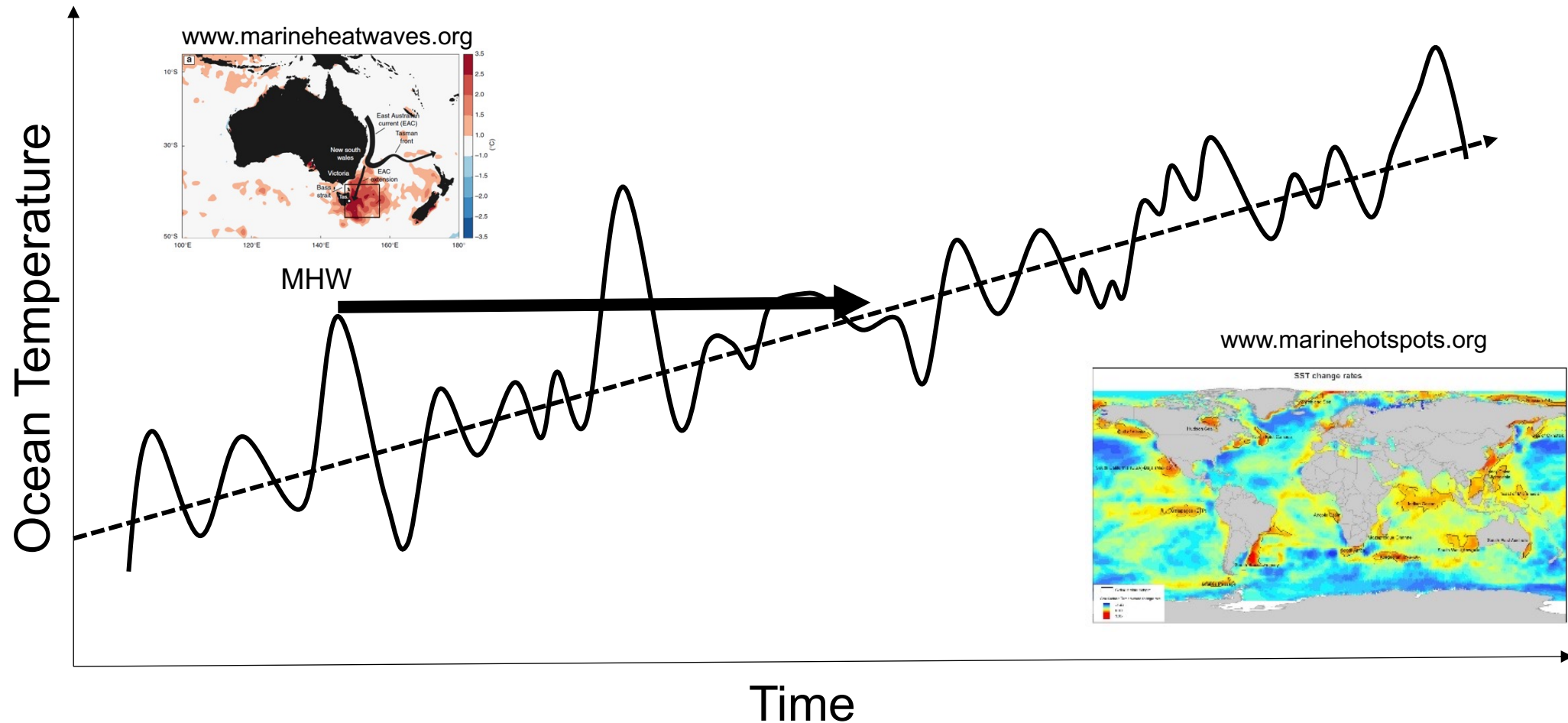
\*fishers and managers and policy makers

1. How many fish?
2. Where are the fish?
3. When will they migrate?
4. What are the prey/predators doing?
5. Plus other stuff



# Physical change: Trend and variability (extremes)

Extreme events – a window to the future

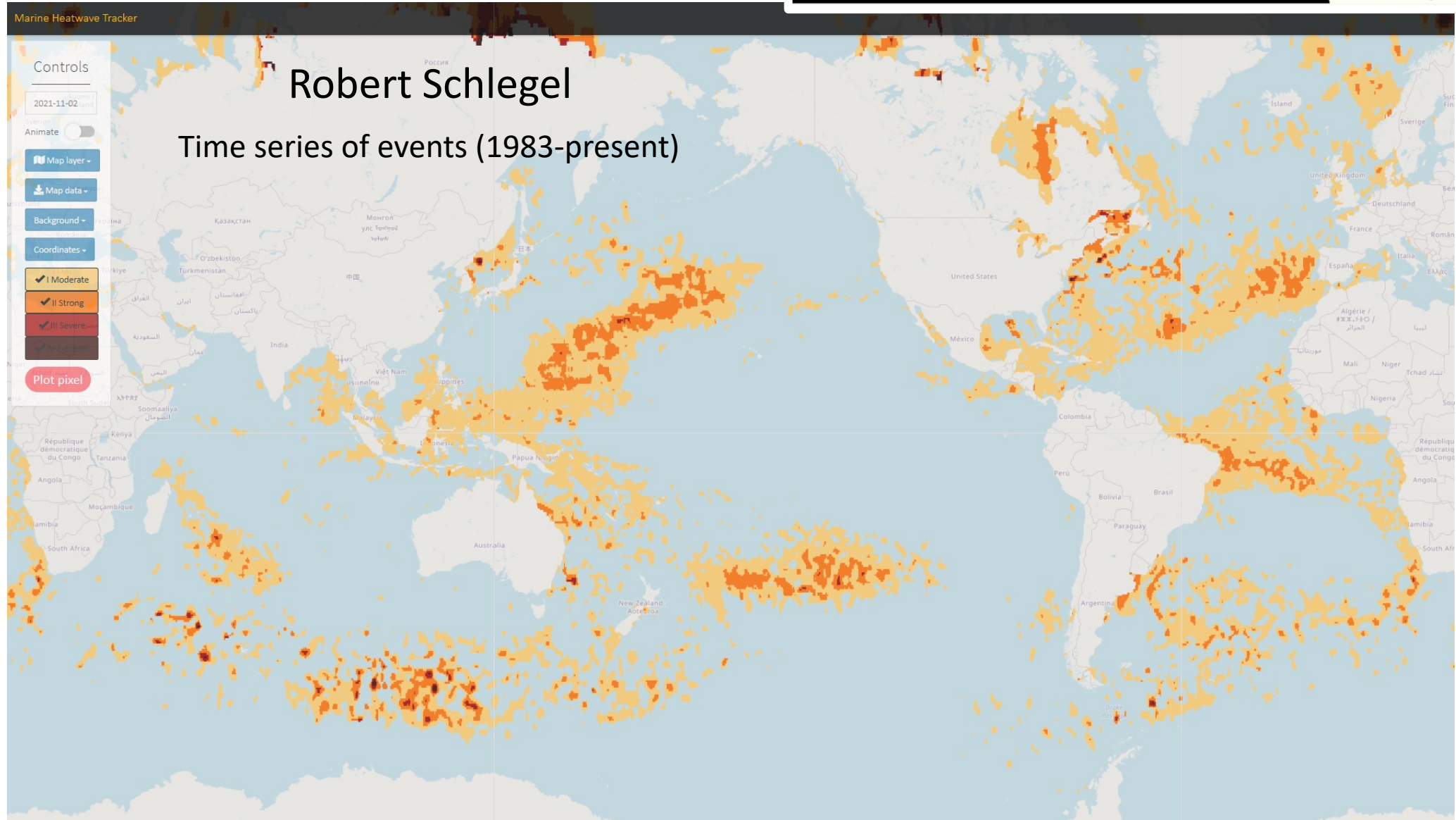
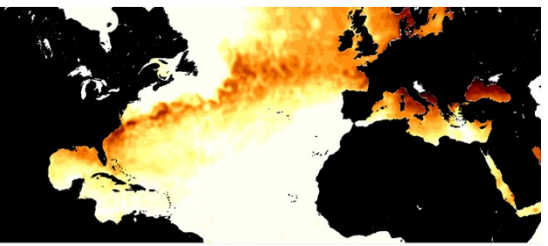


# MHW tracker

([www.marineheatwaves.org/tracker](http://www.marineheatwaves.org/tracker))

## MARINE HEATWAVES

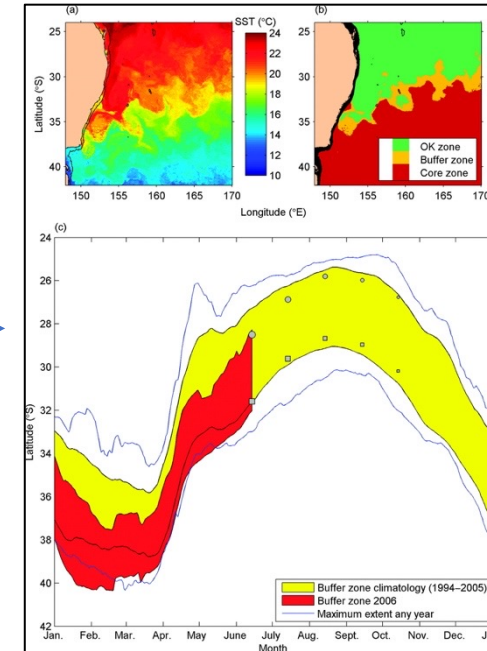
International Working Group





# Forecasting the future

- Nowcasts
  - Short-term (up to 1 year)
  - Decadal (next 1-20 years)
  - Long-term (to 2100)
- 
- Dynamical models (ACCESS)
  - Statistical models (Machine)
- 
- Physics
  - Biology (distribution, abundance)



CSIRO.AU

Marine Resources and Industries Research Portfolio Links

Fisheries – Domestic Fisheries – International

Marine Pollution Biodiversity Management & Conservation

Marine Monitoring & Surveillance

Integrated Ocean Stewardship Climate Impacts & Adaptation

Home / Climate Impacts & Adaptation / Marine Heatwaves / Forecasting Marine Heatwaves

## Forecasting Marine Heatwaves

**The Project: Marine heatwaves in the Indo-Pacific region, their predictability and social-economic impacts**

Our project team is working to improve the skill (accuracy) and leadtime (out to six months) for forecasts of extreme temperature events around Australia, using advanced machine learning statistical methods. This project will run from 2020-2022.

How we make these forecasts: We use machine learning to detect features in the distribution of sea surface temperature and upper ocean heat content which are most predictive of future marine heatwave events. We have built on approaches developed by Ham et al (2019). The machine learning model has been trained on CMIP5 and CMIP6 climate model runs and validated on the GODAS (Global Ocean Data Assimilation System) data set. After conditioning with a training dataset, the machine learning model is then used as a simulator to predict marine heatwave events in the focal region a few months ahead, depending on the regional skill of the forecast system. We are testing the system in two regions of Australia, known to be global warming hotspots (Hobday and Pech 2014), (1) off Western Australia, and (2) Tasman Sea in South-east Australia.

**THESE FORECASTS ARE EXPERIMENTAL PRODUCTS ONLY AND INTENDED FOR RESEARCH PURPOSES**

Forecast region – Western Australia

Our first forecast was created in December 2020, and was based on historical data up to

Marine Heatwaves

Forecasting Marine Heatwaves

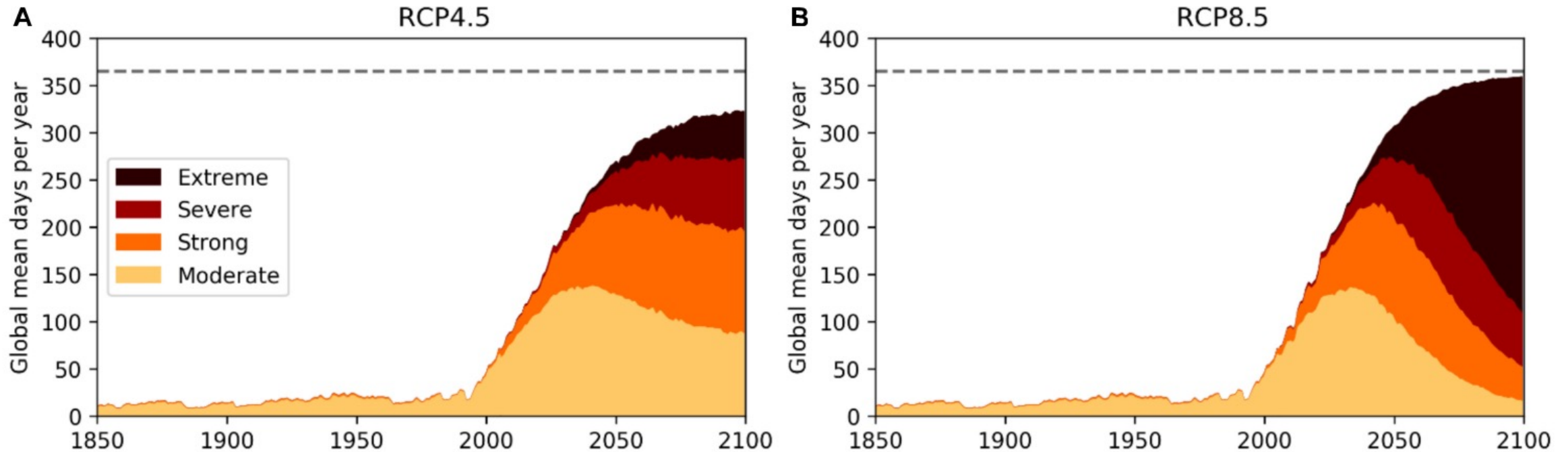
[Dynamical forecasting of marine heatwaves](#)

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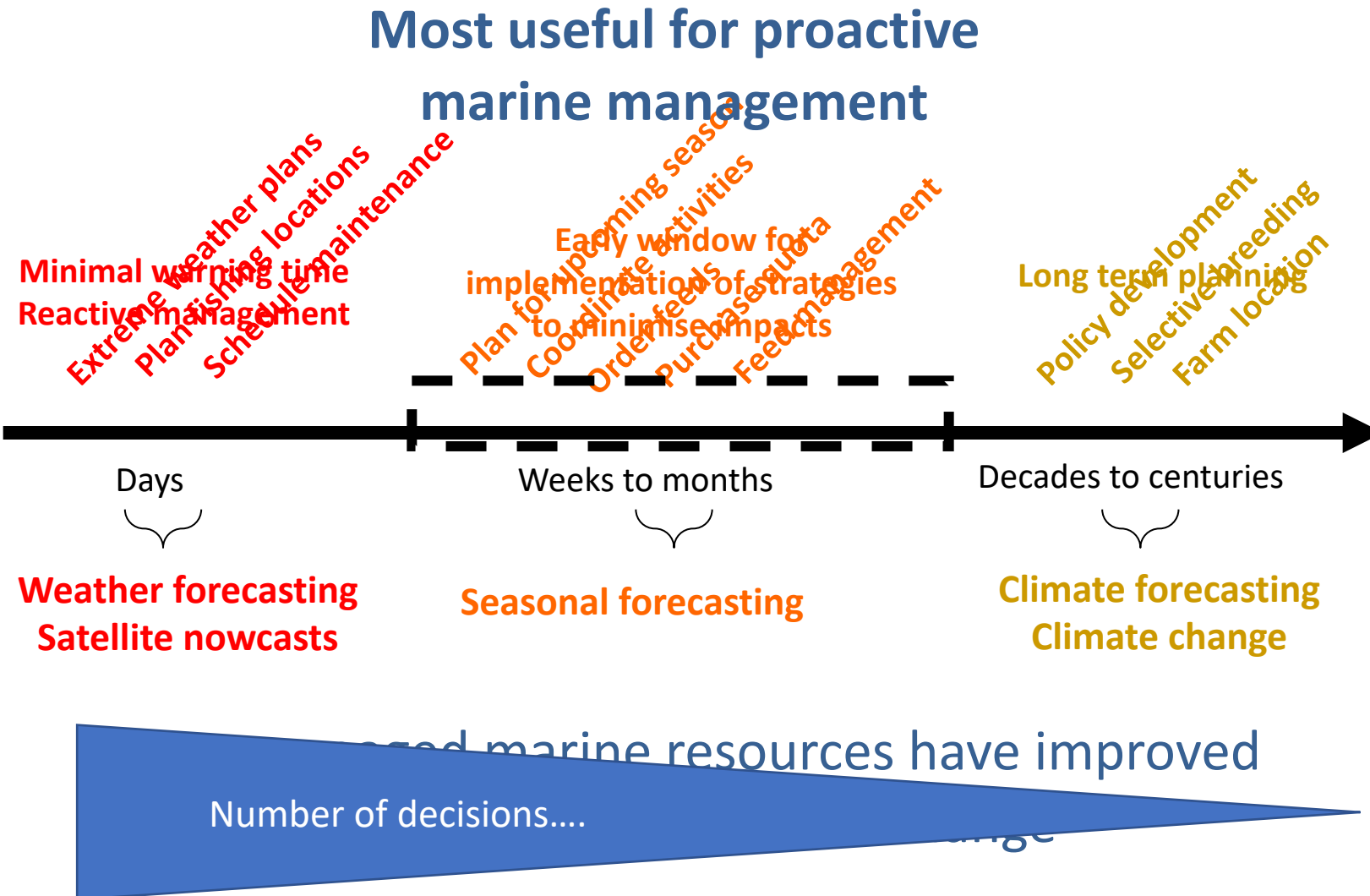
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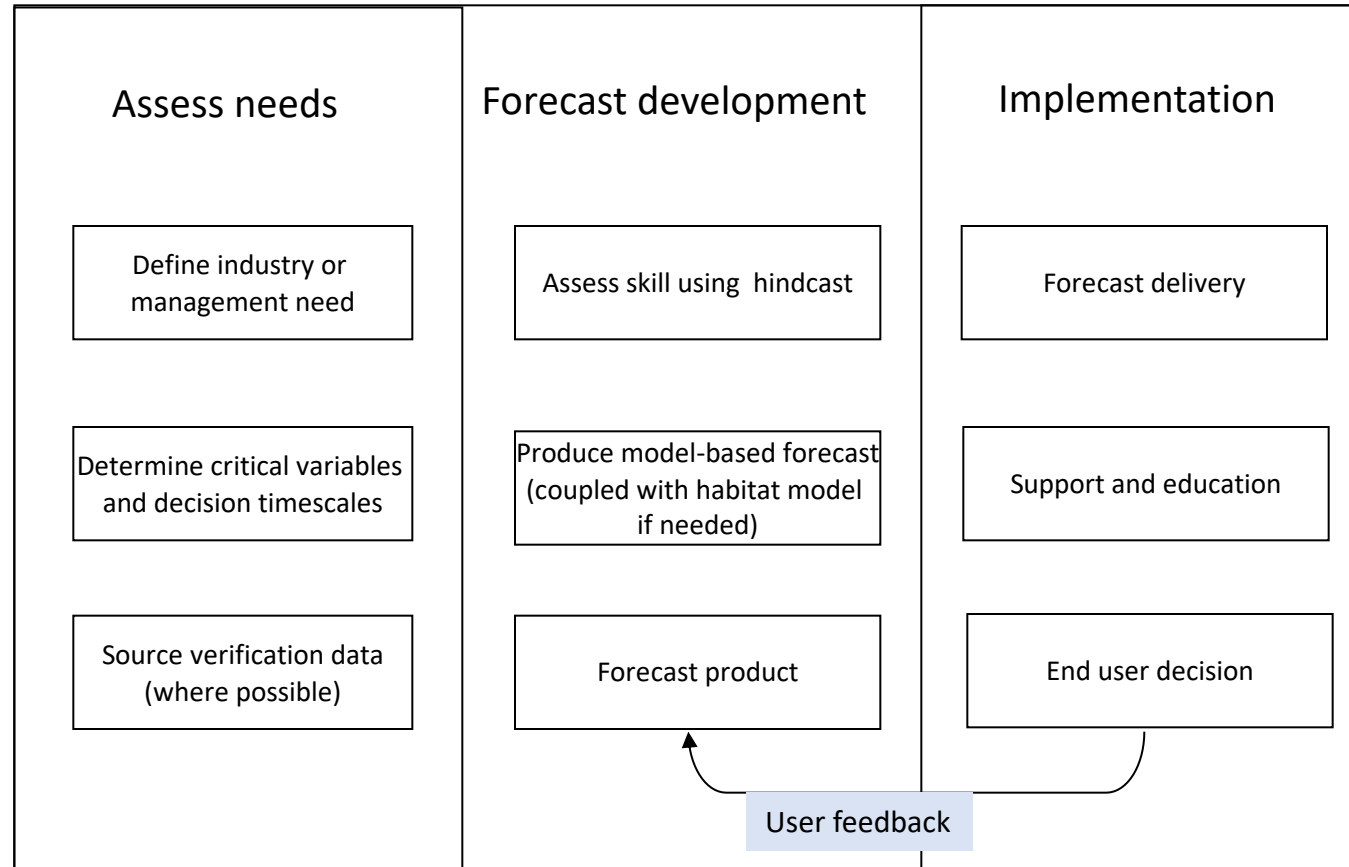
# Long-term Projections – MHWs to 2100



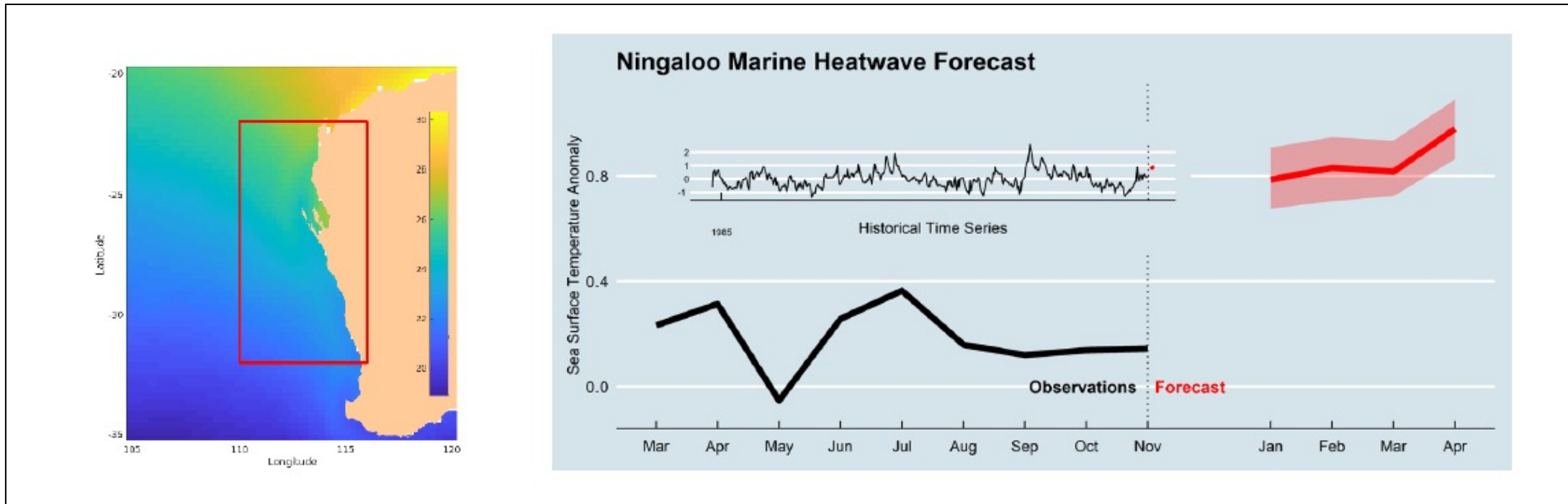
# Forecasts and decision timescales for fisheries & aquaculture



# Developing a forecast – partnerships needed



# Seasonal Forecasts - Predicting WA 2021 MHW



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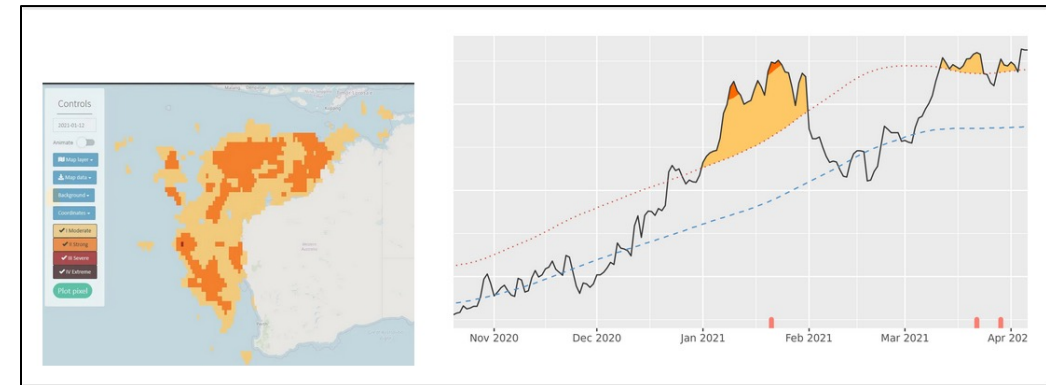
● This article is more than 9 months old

## WA coastline facing marine heatwave in early 2021, CSIRO predicts

Exclusive: Ocean temperatures to peak at about 1°C above average in April, according to forecast, threatening marine life and coral

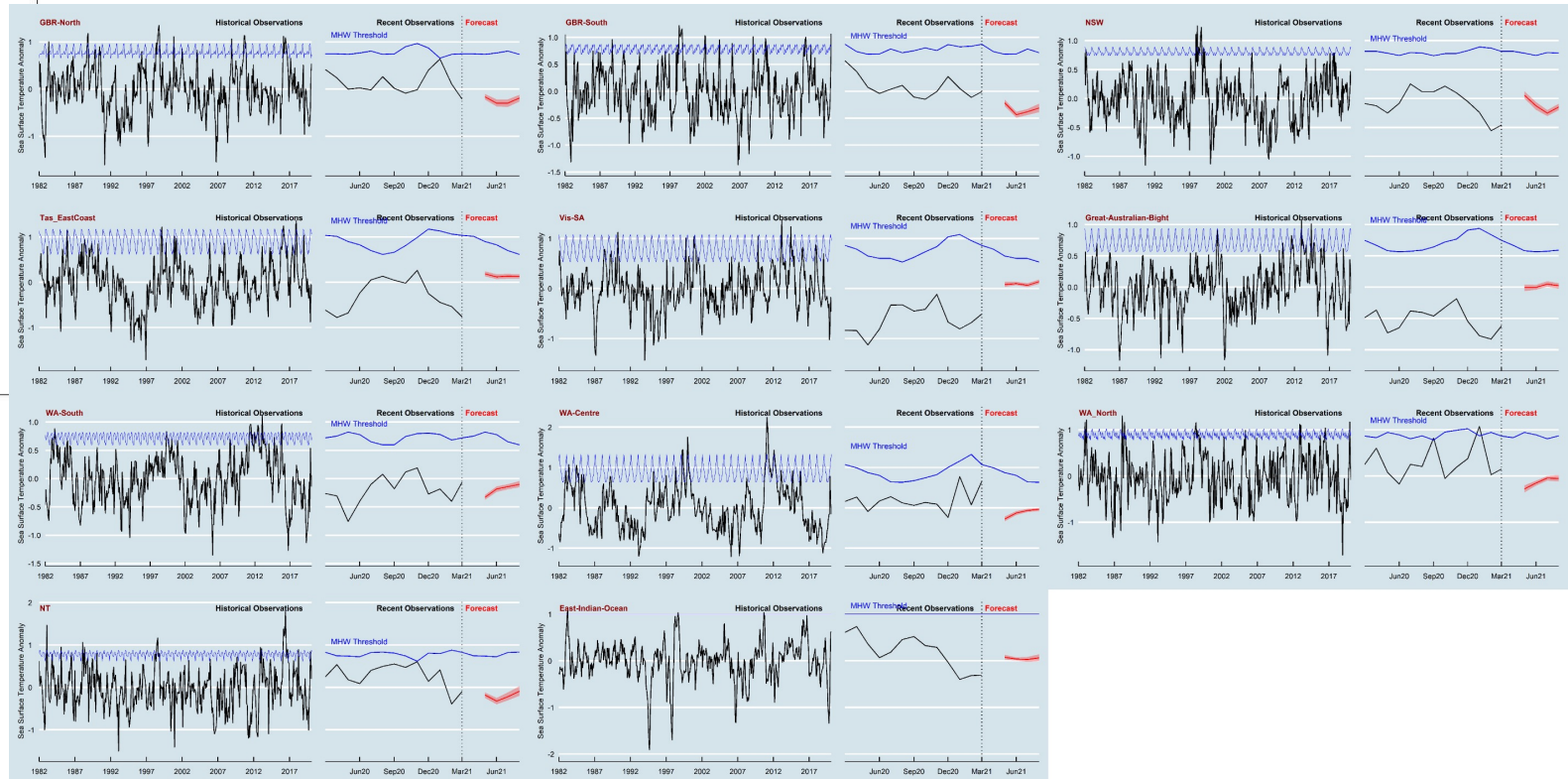
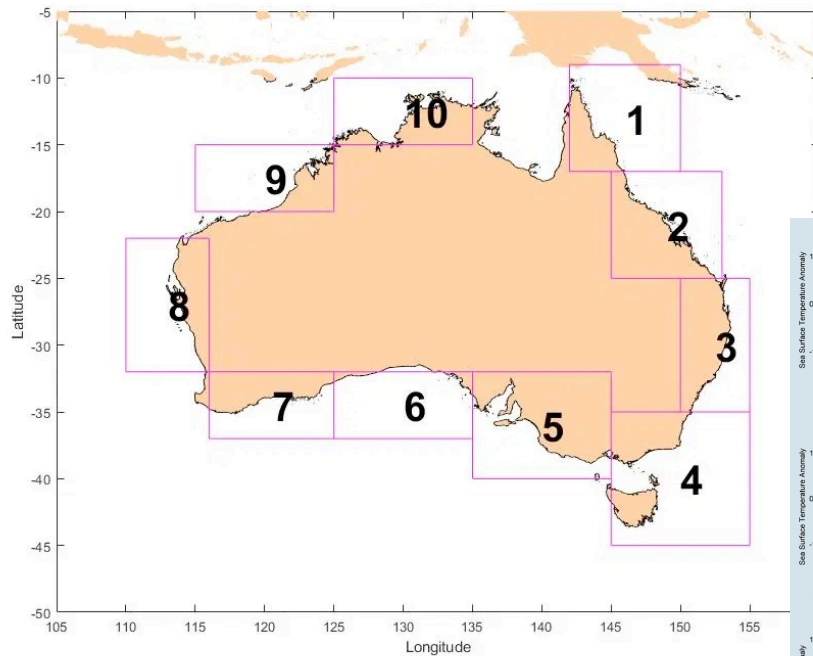
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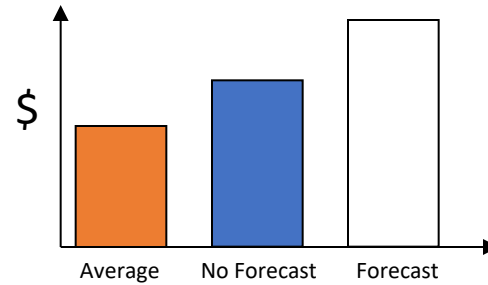


# Australian Regions – MHW seasonal forecasts

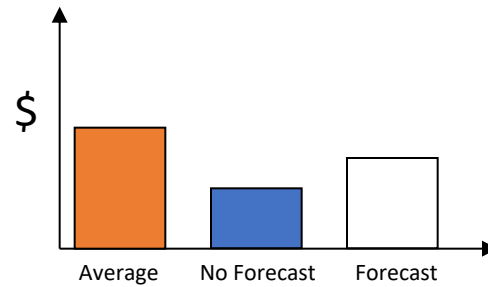


# Benefit of forecast – make money

- With forecast information - in a “good” year do better

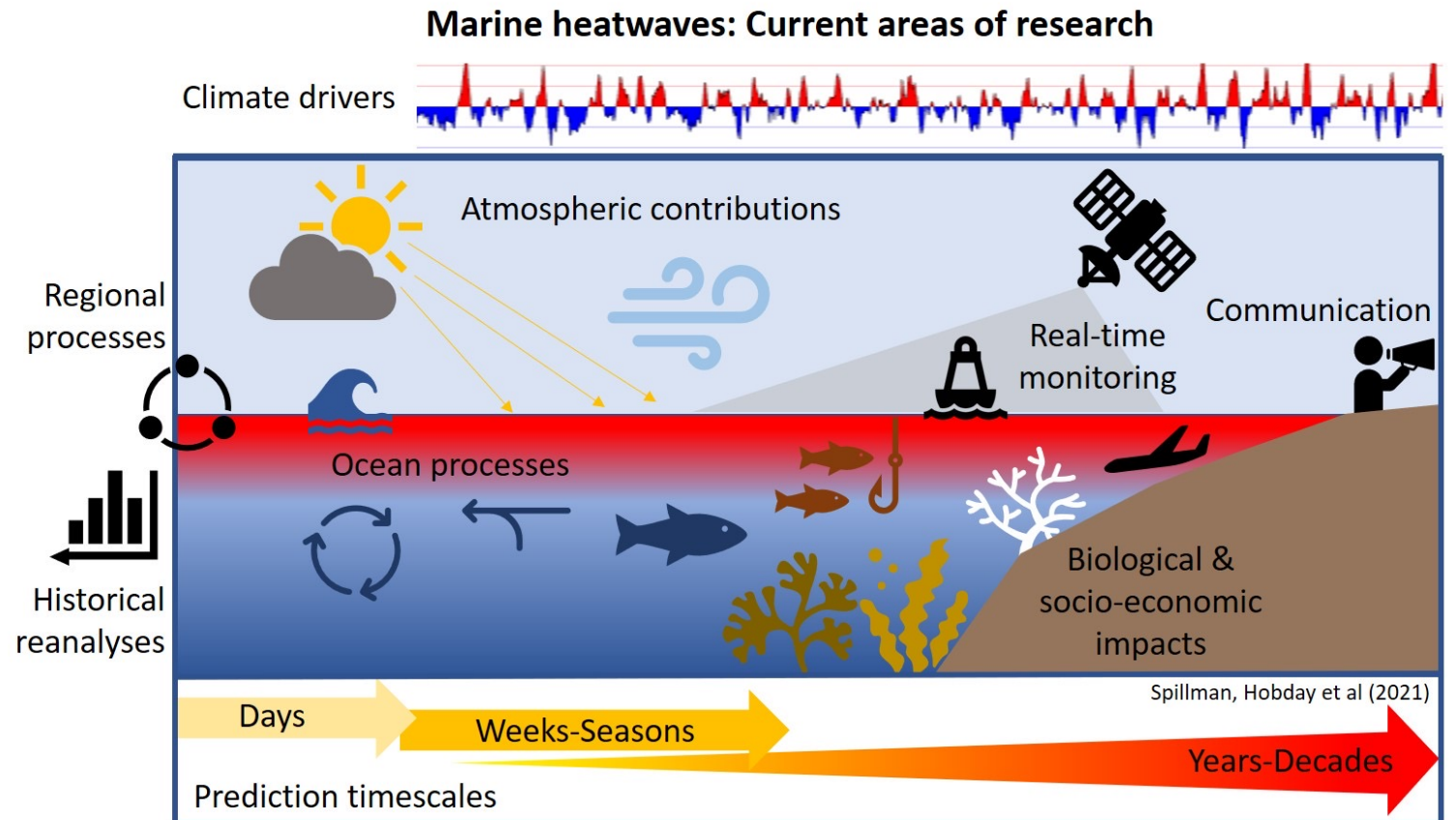


- With forecast information - in a “bad” year lose less



# The future – forecasting extreme events...

- What would you do with a marine heatwave forecast?
- Inform?
  - Who and why?
- Monitor?
  - What and where?
- Intervene?
  - How and when?







# MHW definition (commonly used)

**Anomalously warm:** a MHW must lie above a high percentile, calculated from a baseline climatology

- 90<sup>th</sup> percentile; vary with climatology throughout year
- Common baseline among studies/data if possible (e.g. 1990-2010)

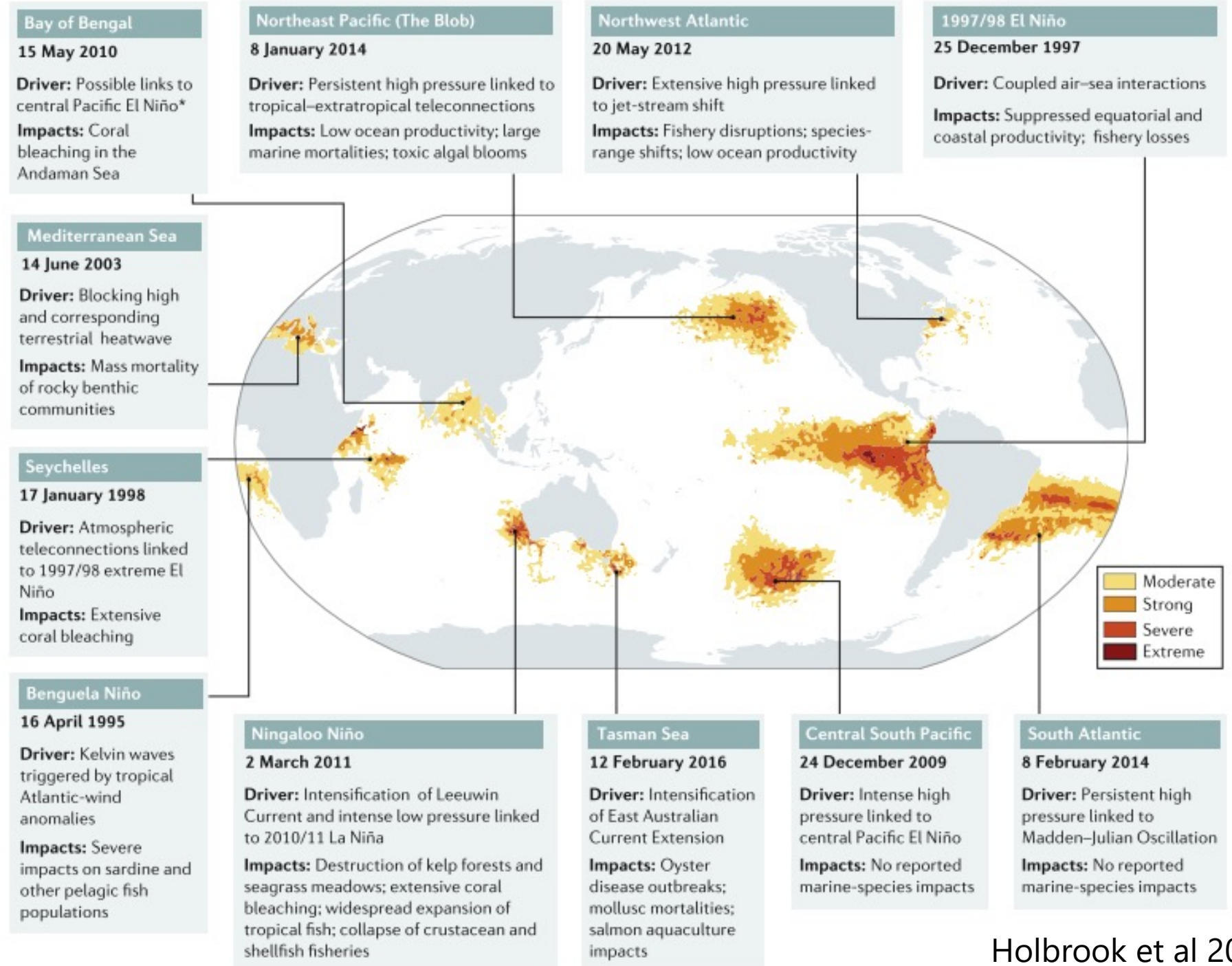
**Prolonged:** MHW persists under above conditions for at least 5 days (thoroughly tested)

**Discrete:** clear start and end dates.

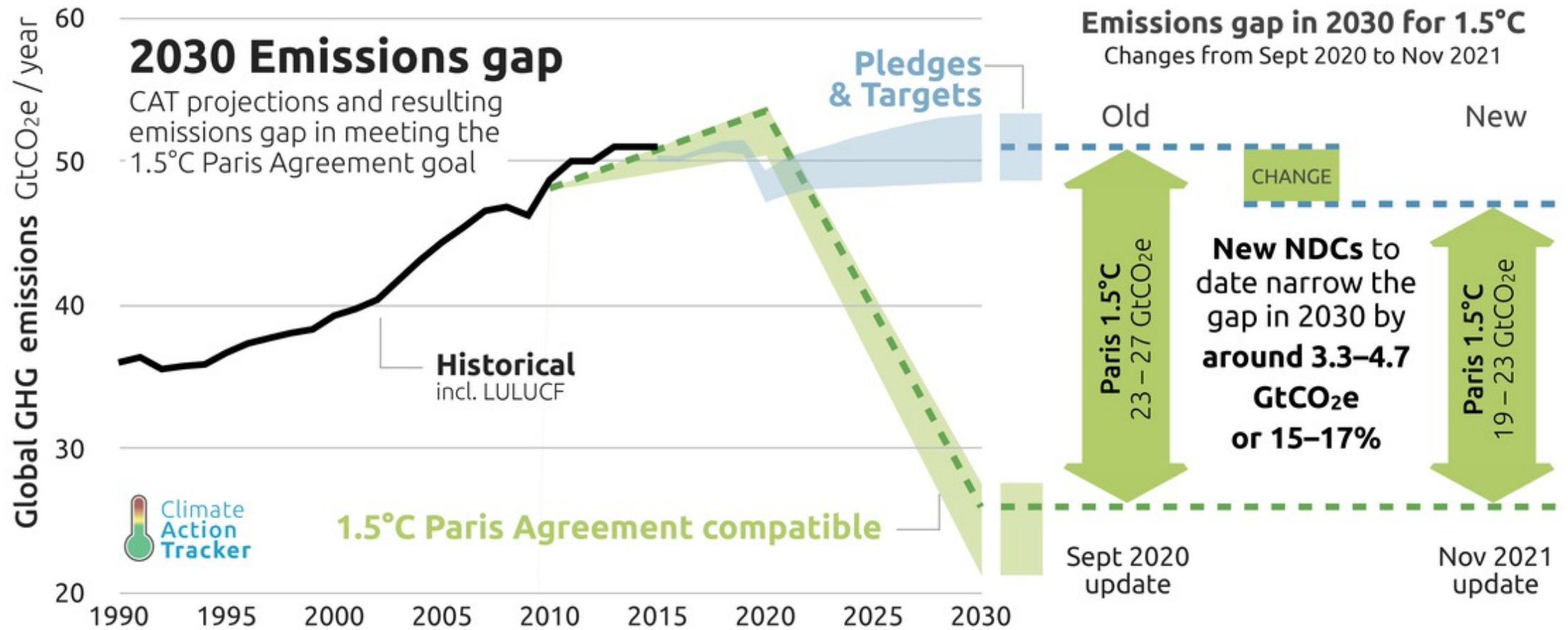
- Events punctuated by 2 or less days considered 1 event



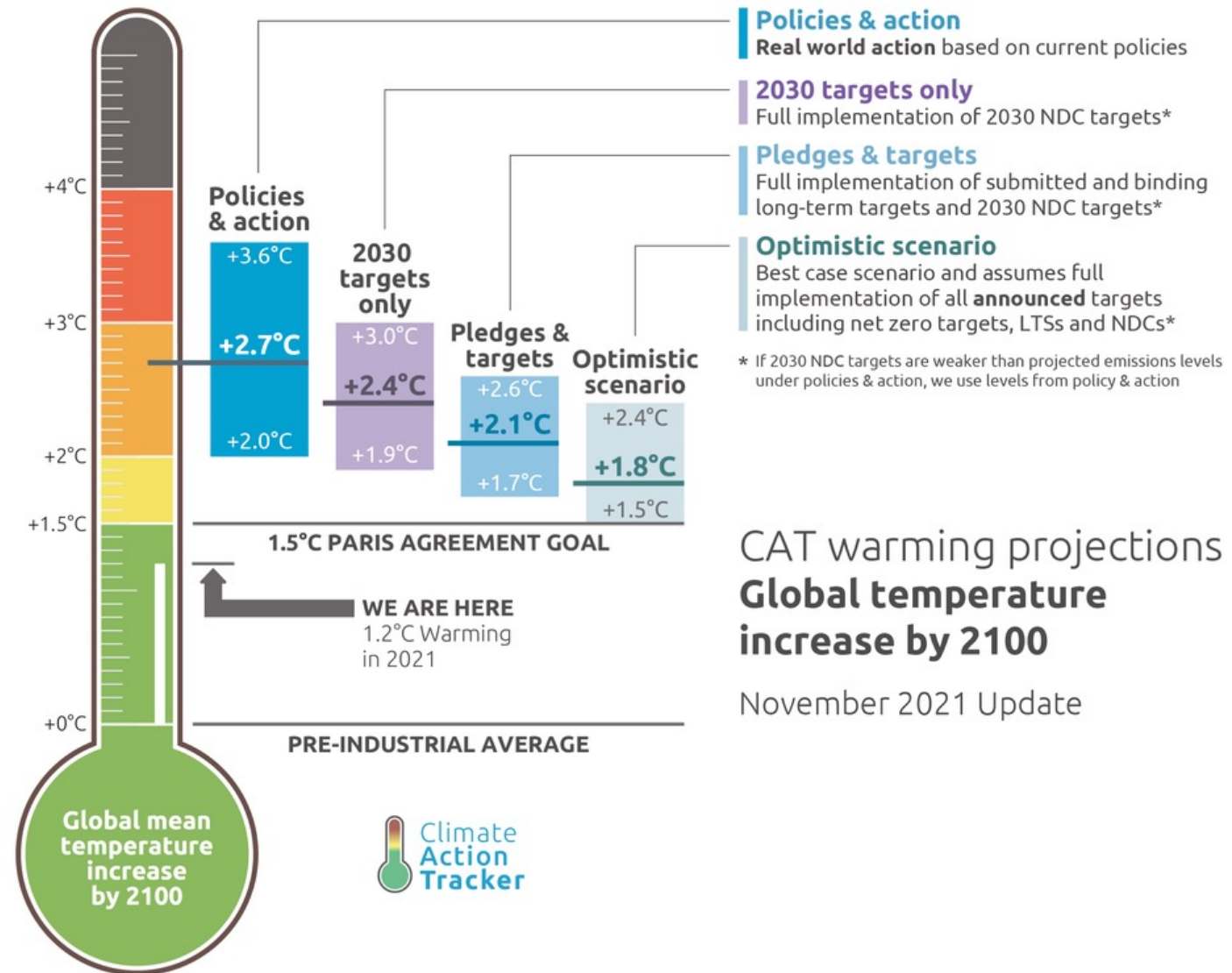
# MHWs – dramatic effects



# After COP26 in Glasgow



# After COP26





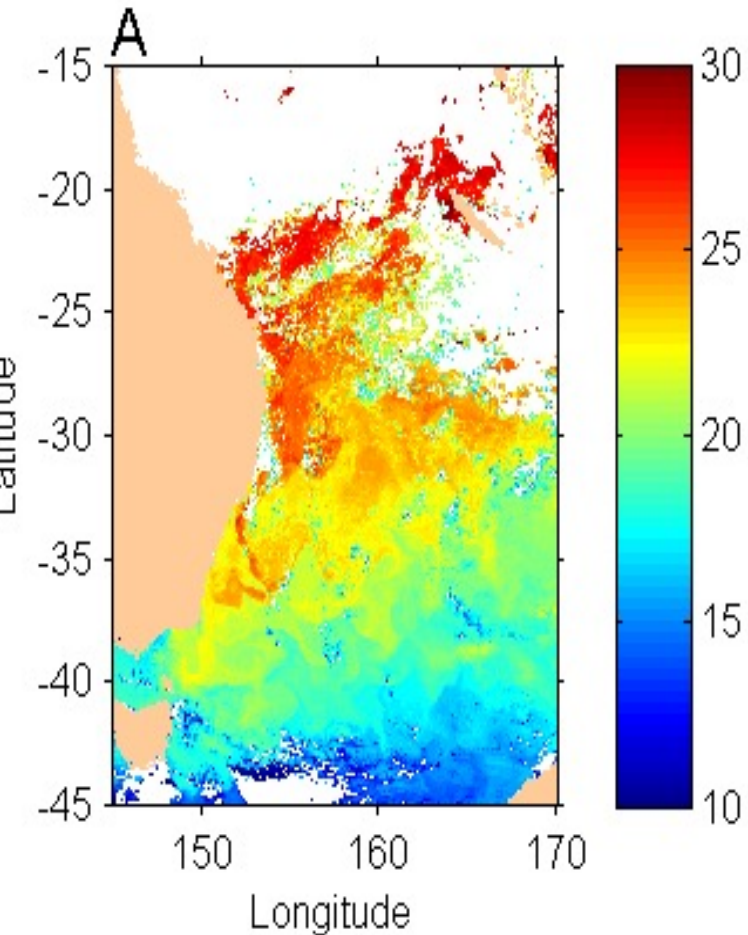
# Variables used to describe fish distribution (habitat)

	Variables	Climatology	Observed	Modelled/derived
Surface	Temperature		x	
	Ocean color (chl)		x	X
	Salinity	X		X
	Fronts		x	
	EKE		x	
Water column	T@D (e.g. 200m)		X	X
	Mixed layer depth	X		X
	Bottom temp	X	x	X
	Nutrients		BGC-ARGO	X
	Oxygen	X	BGC-ARGO	X
	Chlorophyll	X	BGC-ARGO	X
Climate drivers	ENSO, IOD, SAM etc		X	X

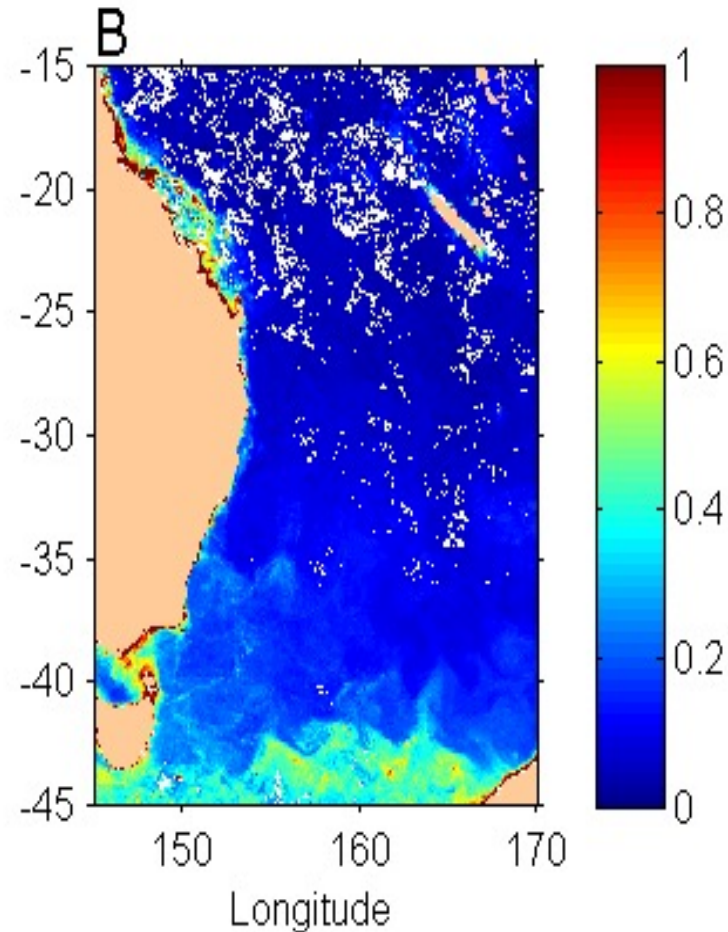
IMPORTANT: Gridded fields used most often for habitat modelling

# Variables used to create distribution maps

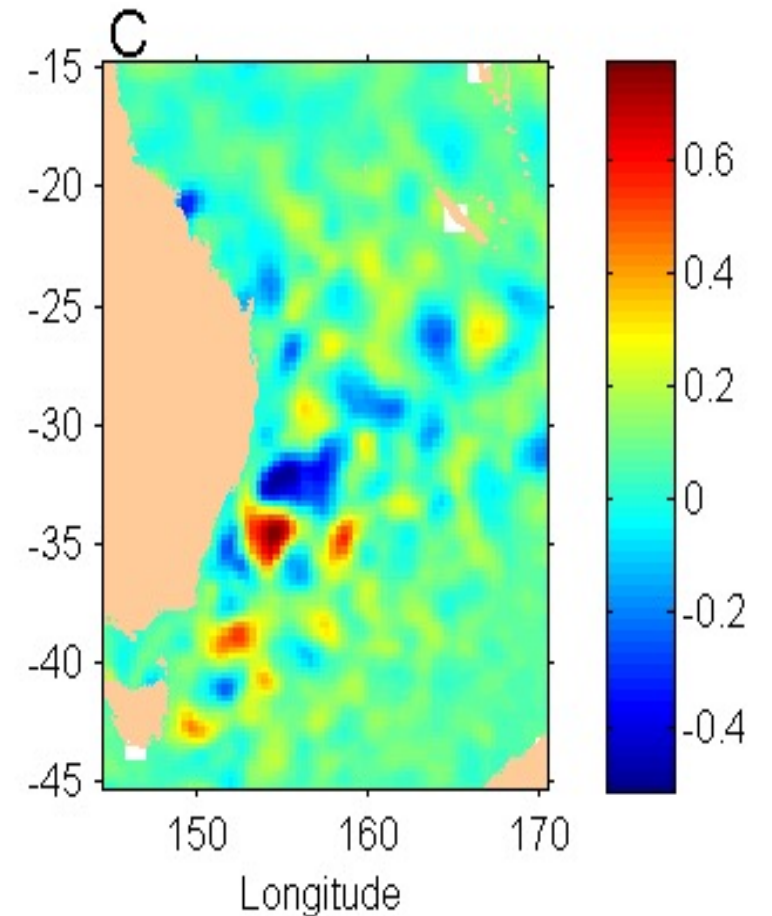
**Primary - Temperature**



**Secondary - Chlorophyll-a**



**Derived - Eddies (SSH-a)**



Hobday and Hartog (2014)