The Bureau of Meteorology

Operational seasonal prediction services to support marine end user decision making

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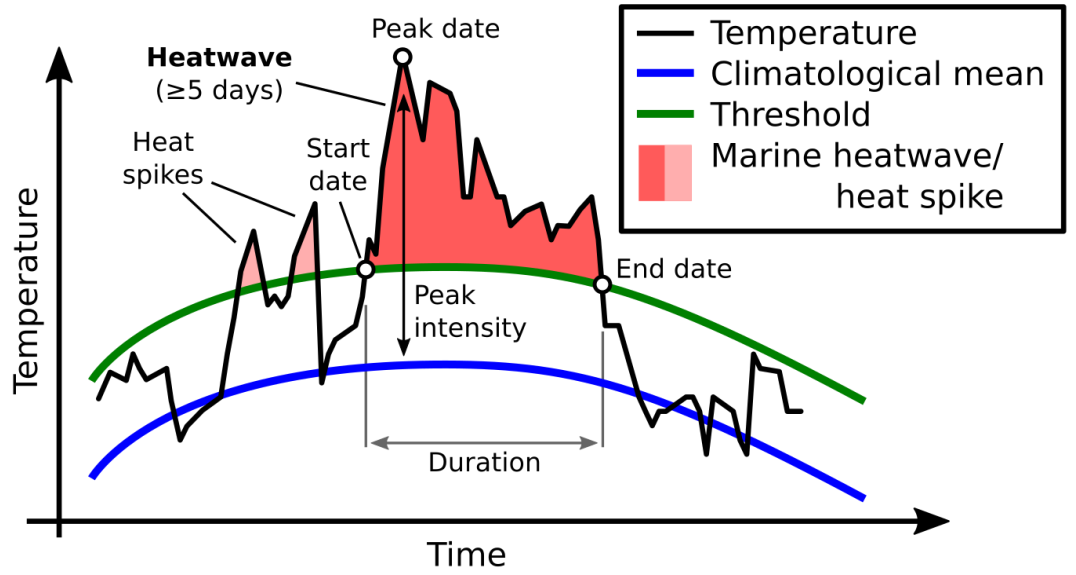
Photo: WA DPIRD

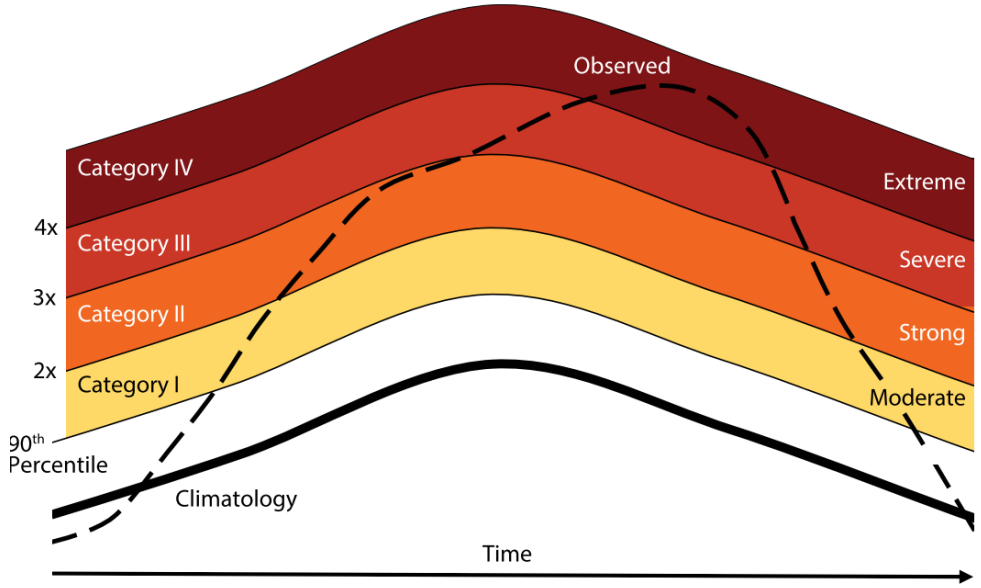
What is a marine heatwave?

- Period of persistent extremely warm ocean temperatures

- Marine heatwaves (MHW) typically defined as 5 or more consecutive days where SST > 90th percentile
- MHW can occur **year round** as referenced to seasonal climatology

- Impacts will depend on timing, severity, duration and location





Hobday et al 2016, Hobday et al 2018

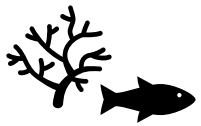
Marine heatwaves…so what?

Climate hazard

- Marine heatwaves

System impacts

- Thermal stress
- Fish kills
- Harmful algal blooms
- Coral bleaching
- Abundance changes
- Increased disease
- Biodiversity loss



Nature

Operational impacts

- Fishery closures
- Changing fishery yields
- Poor fish quality
- Longer at sea
- Tourism site closures
- Beach closures
- Shellfish toxicity



Economic

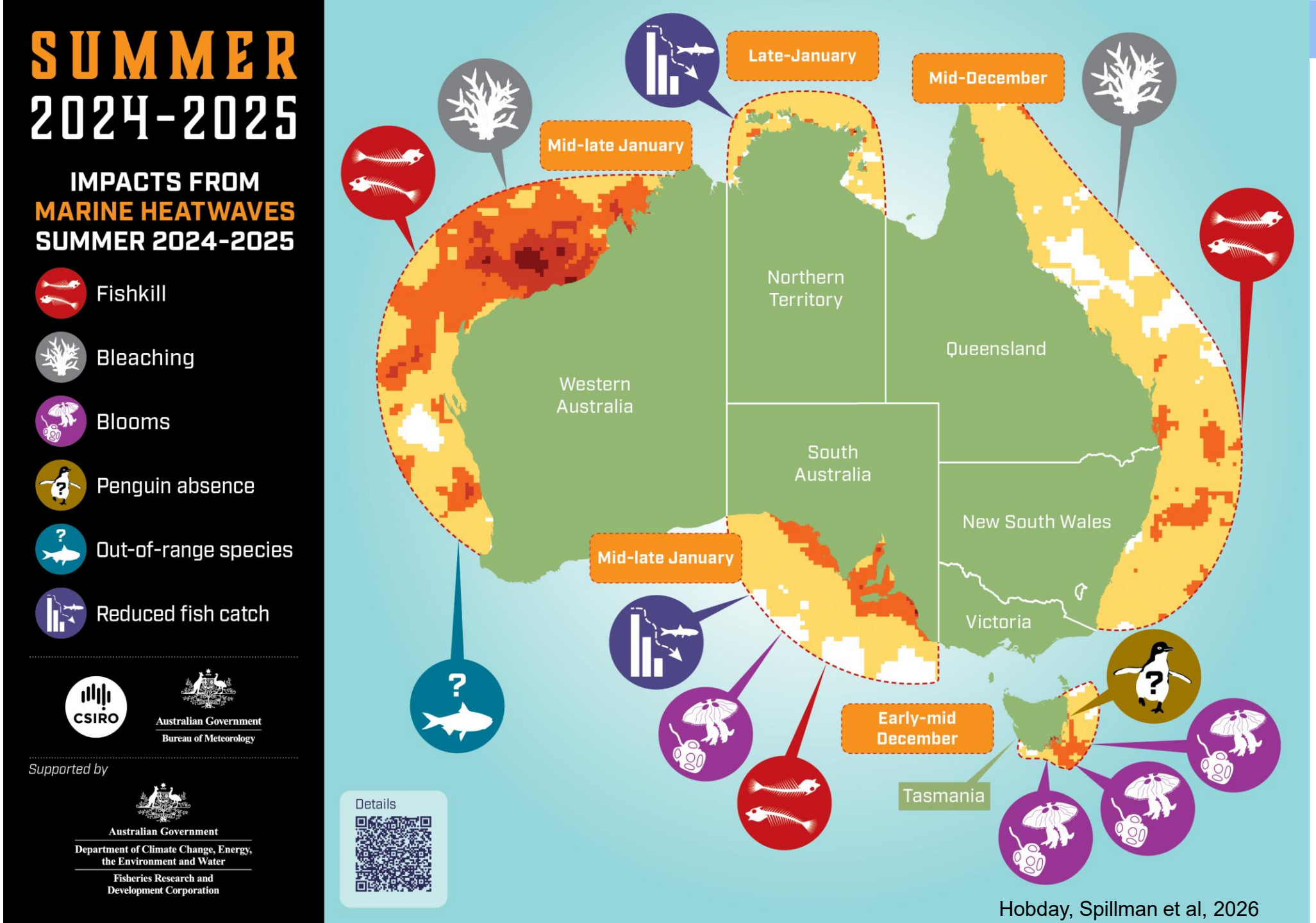
Community & industry impacts

- Decreased resilience
- Increased costs
- Food insecurity
- Illegal fishing
- Fewer jobs
- Damage sites of cultural significance
- Loss of iconic species
- Human health impacts



Social

Adapted from Hartog et al (2023)



Hobday, Spillman et al, 2026

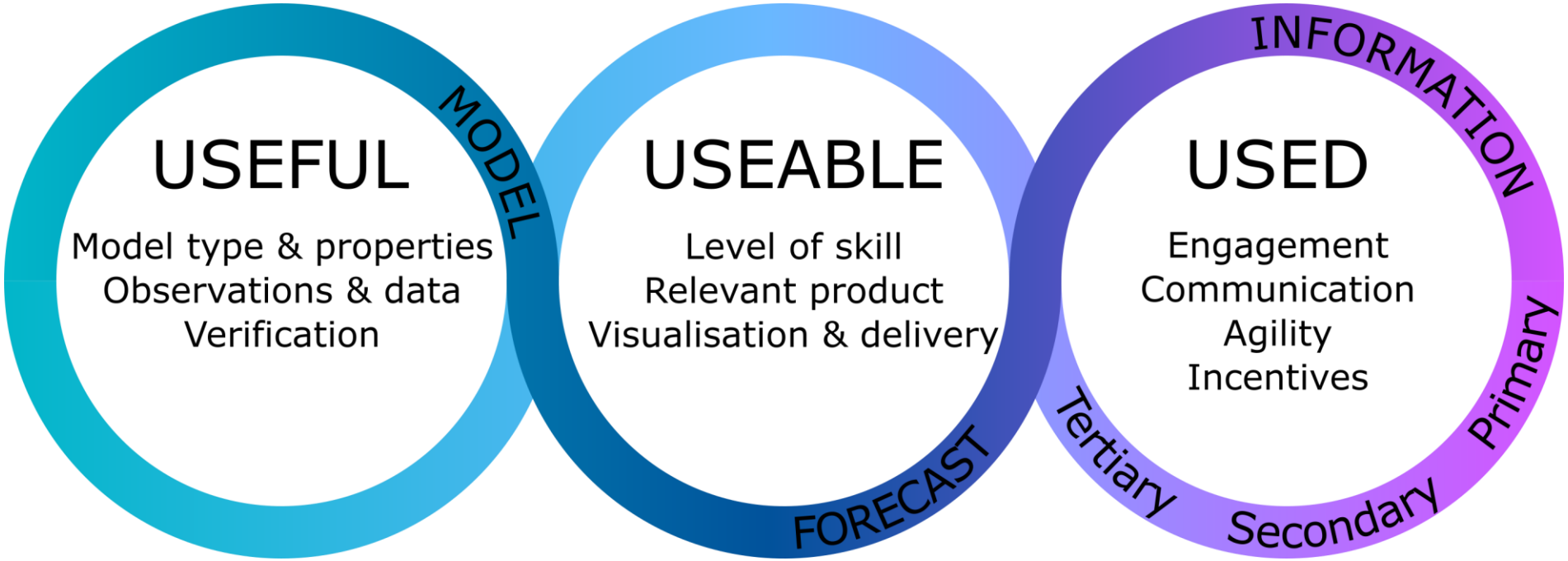
How can marine users respond?

- Seasonal forecasts can provide advance warning of ocean extremes, informing management plans & responses
- **Proactive** vs **reactive**
- Management responses are influenced by **agility** & **risk appetite** of marine sectors



Hobday, Spillman et al (2016)

Ingredients for a good seasonal forecast



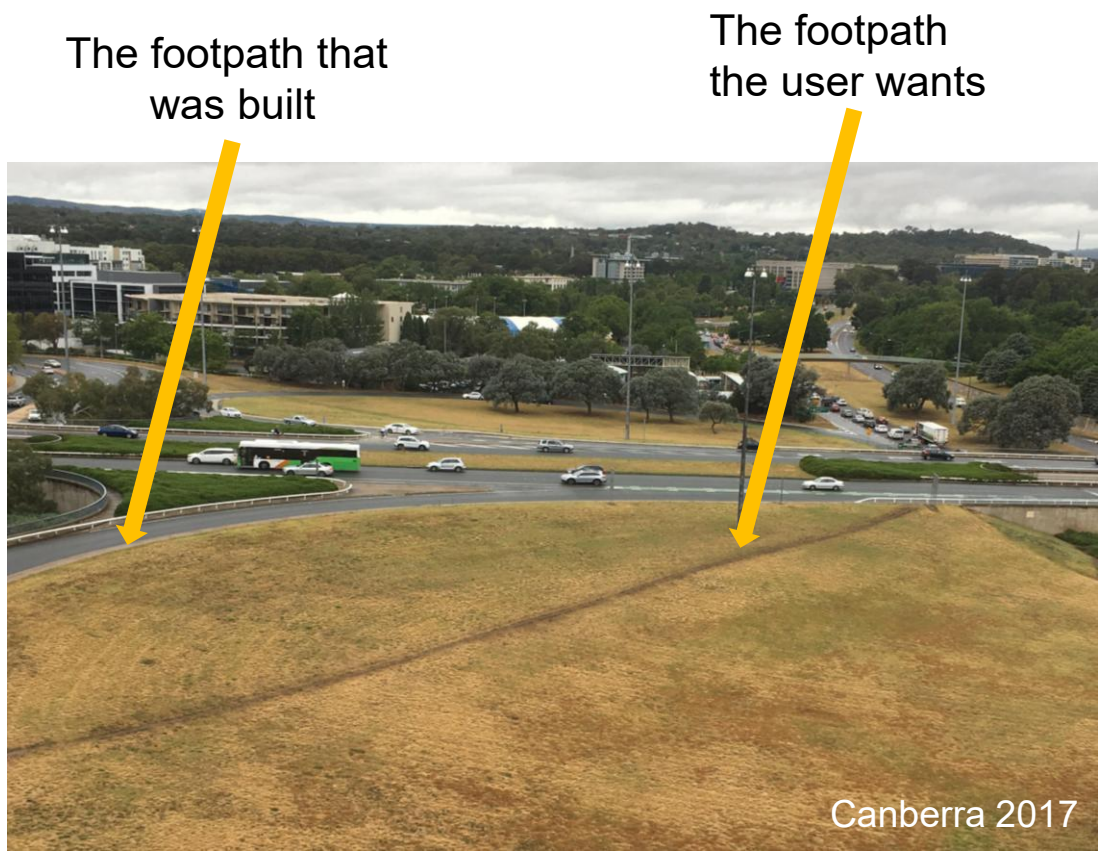
The **model** system must be <u>useful</u>

The **forecasts** must be <u>useable</u>

The **forecast information** must be <u>used</u>

Spillman, Hobday, Feng, Behrens et al (2024)

Stakeholder engagement



From: Andrew Watkins

Effective stakeholder engagement is critical to understand user needs

Q. What decisions are made? When and by who?

Q. Which recent events have impacted you? How?

Q. What do you need in a forecast? How and when do you need it?

Q. Which environmental thresholds initiate action?

Management decisions

- Where to monitor this season?
- Do we need to relocate vulnerable species?
- Will our fish stocks be further south this year?
- When best to leave port?
- Do we need extra staff to manage operations?
- Should we increase or decrease our stocks?
- Do we need to harvest early?
- Will there be food security concerns?





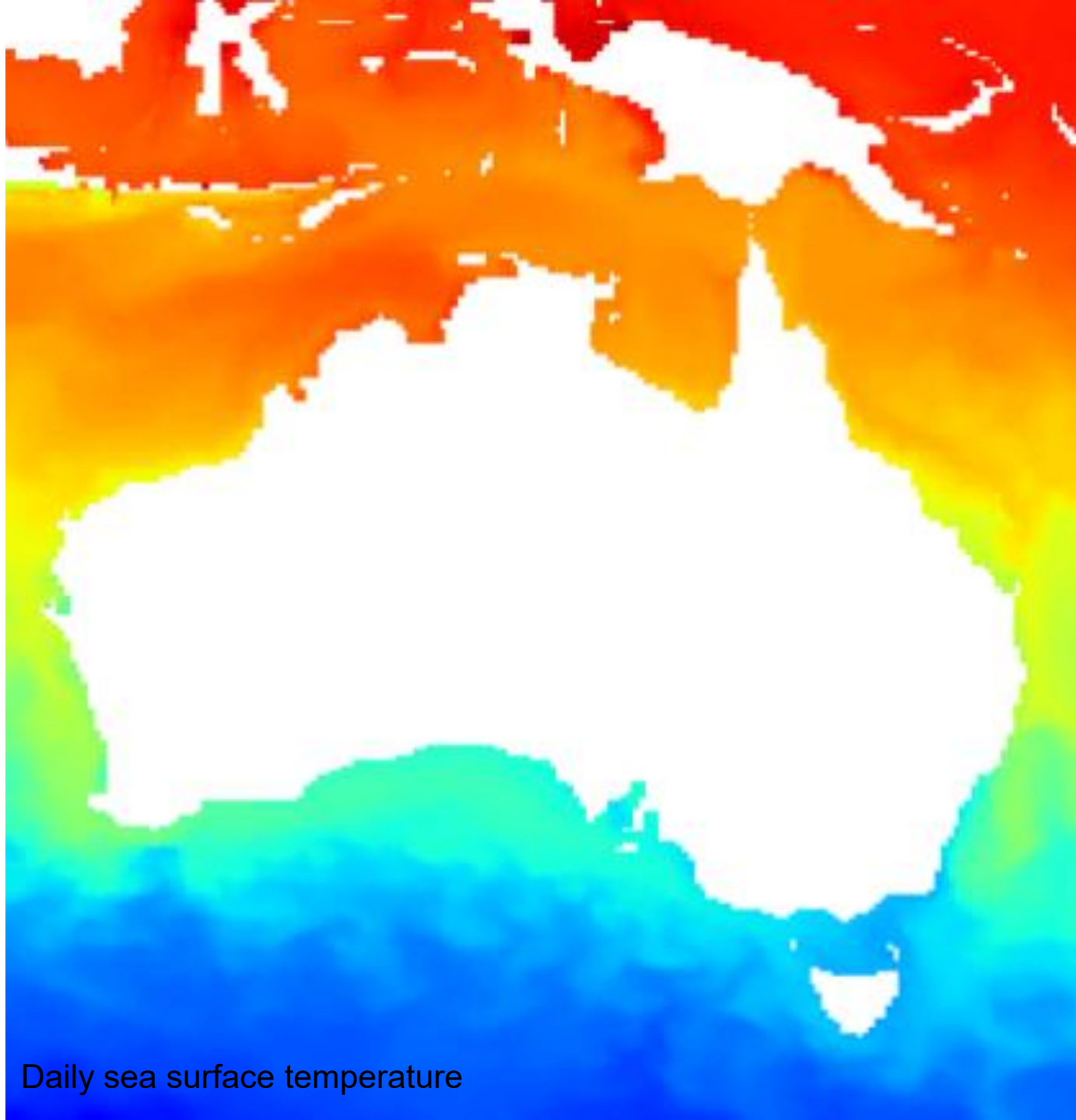




Seasonal ocean forecasts

ACCESS-S2: Australian **C**ommunity **C**limate & **E**arth **S**ystem **S**imulator – **S**easonal v**2**

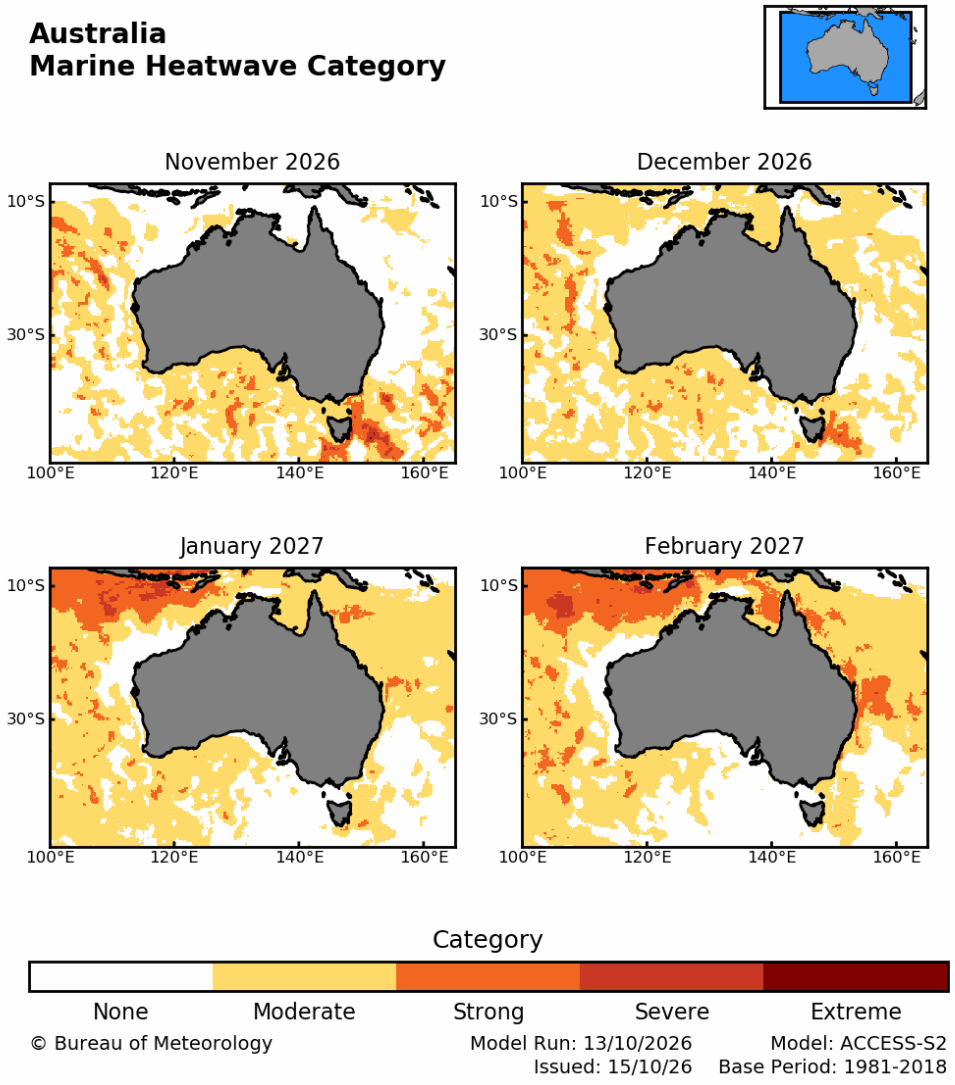
- Global dynamical coupled ocean-atmosphere ensemble prediction system
- 1981-2020 hindcast dataset
- 99-member ensemble
- Runs daily out to 6 months
- Ocean model 25km resolution



Daily sea surface temperature

Hudson et al (2017), Wedd et al (2022)

Operational marine heatwave forecasts



- Exceedance of 90th percentile threshold calculated for that fortnight or month

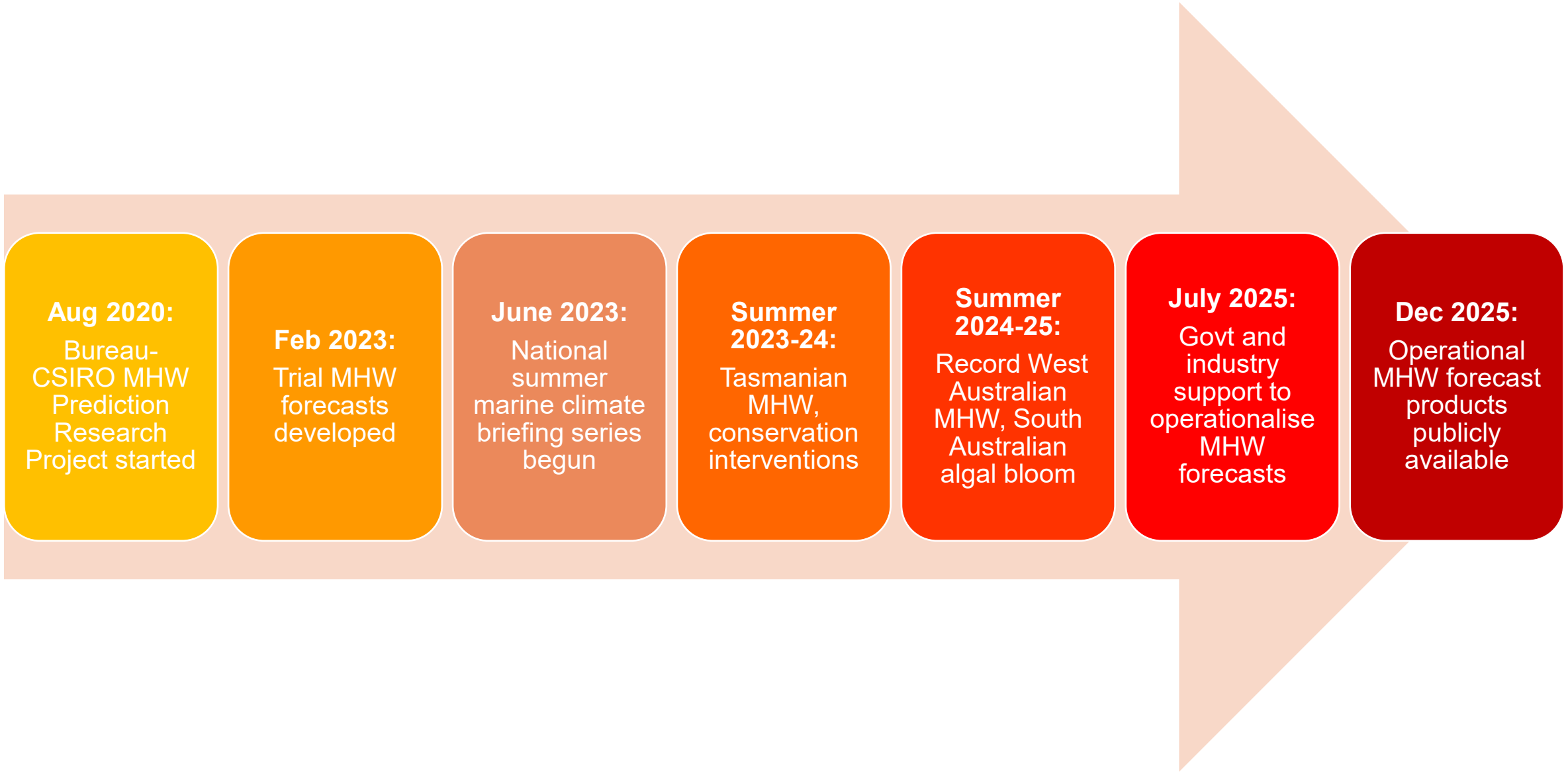
- **MHW Category** & **MHW Probability**
- Provides information about MHW severity, likelihood, duration & location

- Forecasts up to five months ahead
- **Skill** varies with season, region & lead

https://www.bom.gov.au/climate/ocean/long-range-forecasts/

Smith and Spillman (2024), Smith et al (in review)

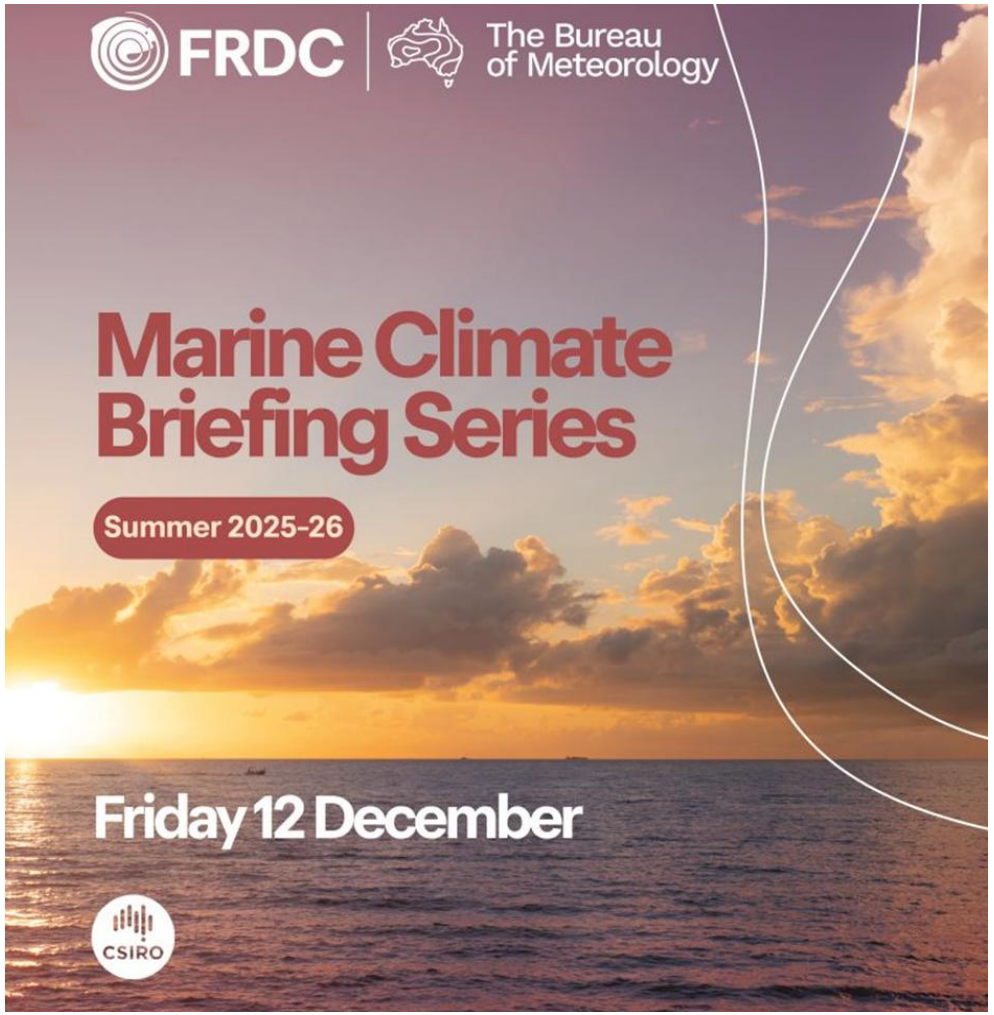
Long-range marine heatwave forecast development



Smith & Spillman (2021), Hartog et al (2023), Smith et al (in review)

National marine climate briefings

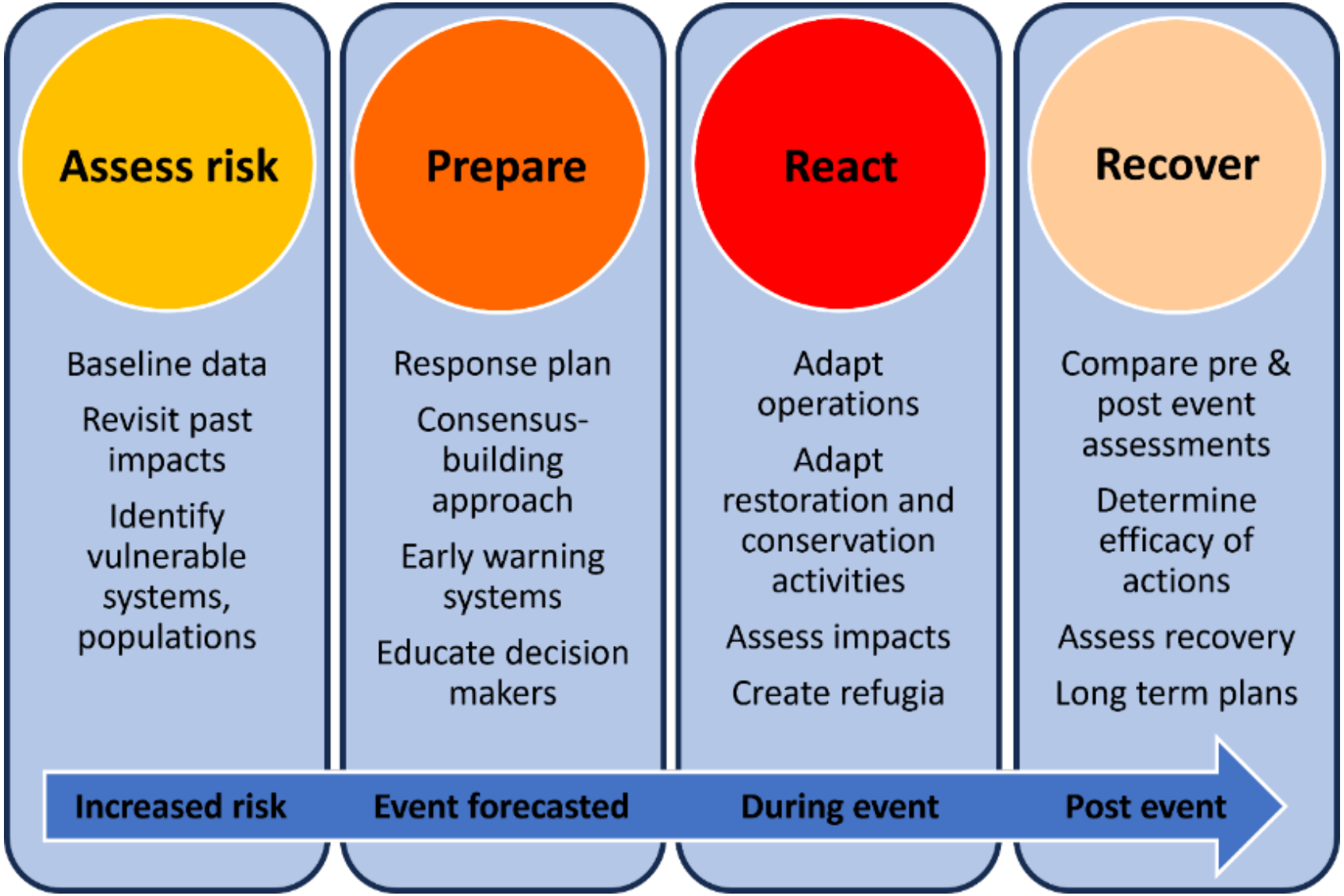
- National marine climate briefings hosted by national fisheries body over summer since June 2023
- Wide range of participants from industry, government and management
- Build industry awareness, capacity & resilience through partnerships
- Subsequent state briefings by regional experts, drawing on national briefings



https://www.frdc.com.au/climate-change

Hobday, Spillman et al (2025)

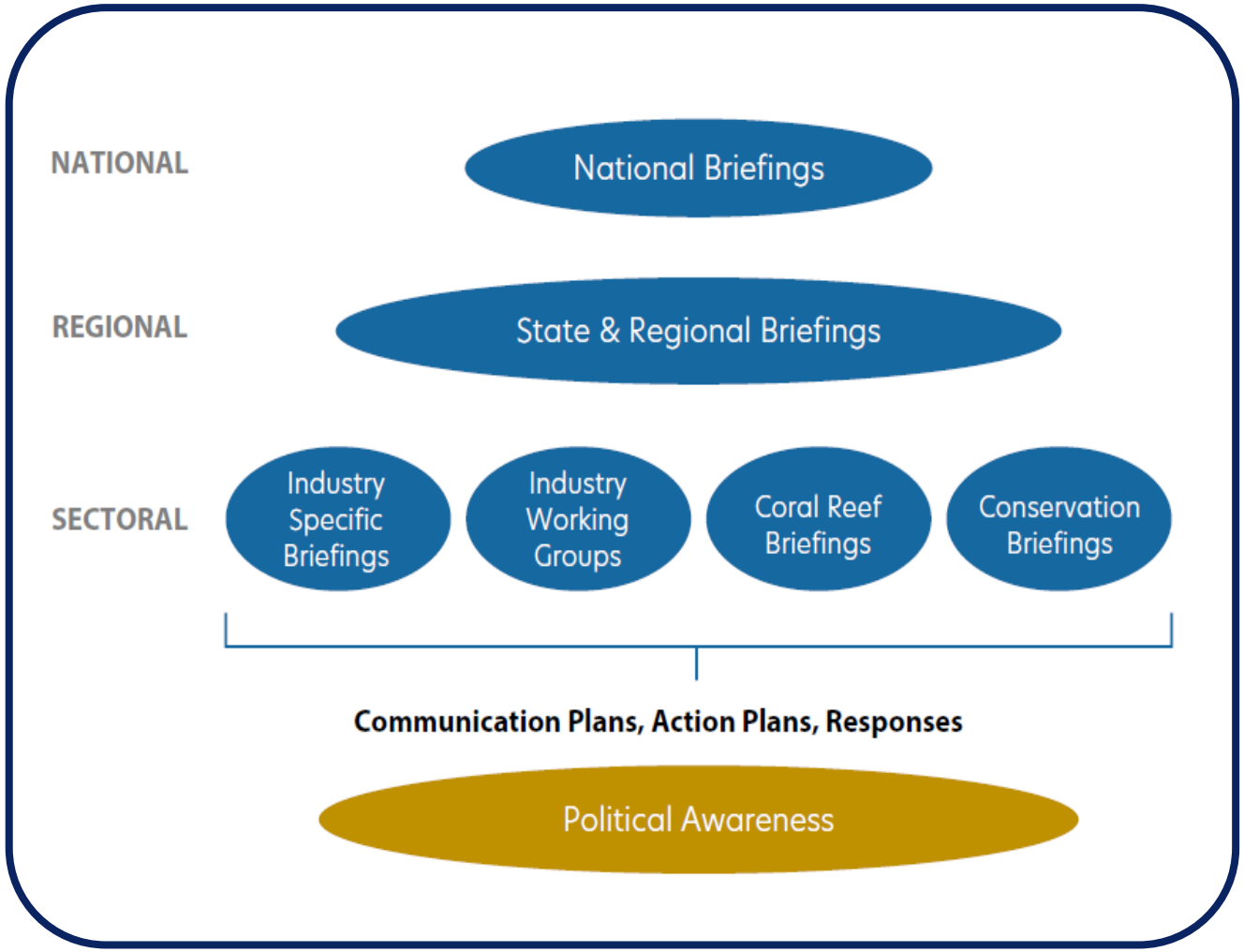
Marine heatwave phases & responses



Hobday et al (2024)

Forecast uptake

1. Marine heatwave response plans
2. Industry response plans
3. Scientific surveys
4. Preparedness workshops
5. Inclusion in national strategies
6. Conservation interventions

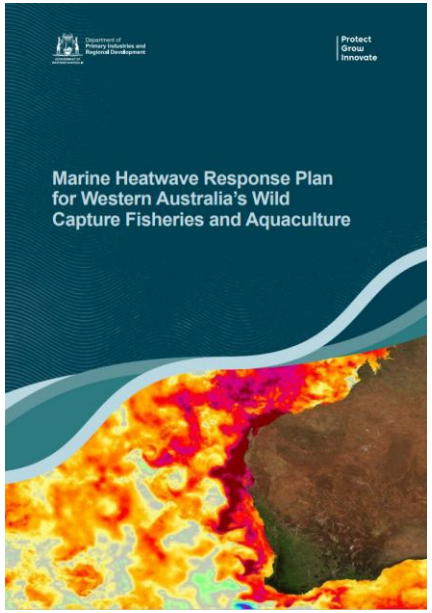


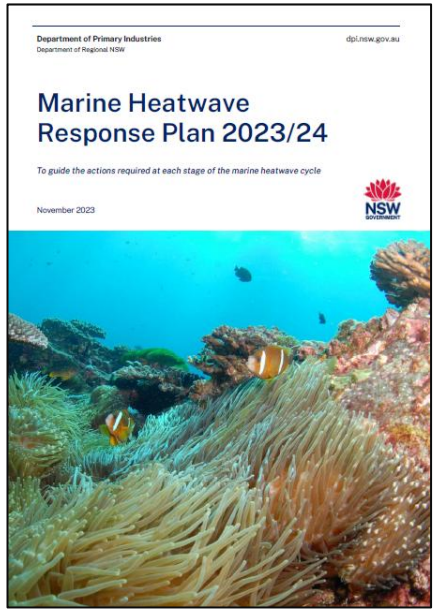
Hobday et al (2024)

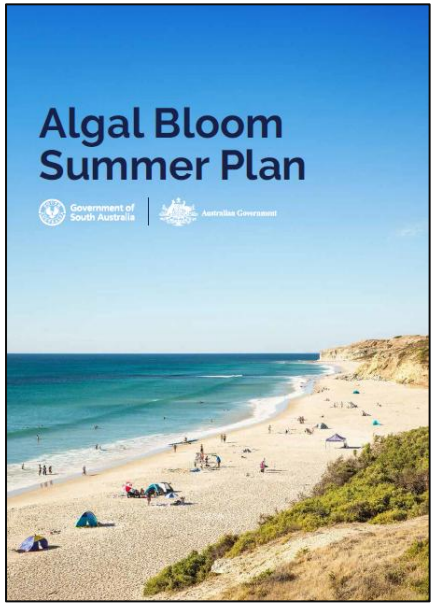
1. Marine heatwave response plans

MHW Response Plan

- Early warning systems
- Risk assessment
- Communication
- Emergency response
- Management response
- Evaluation & future planning







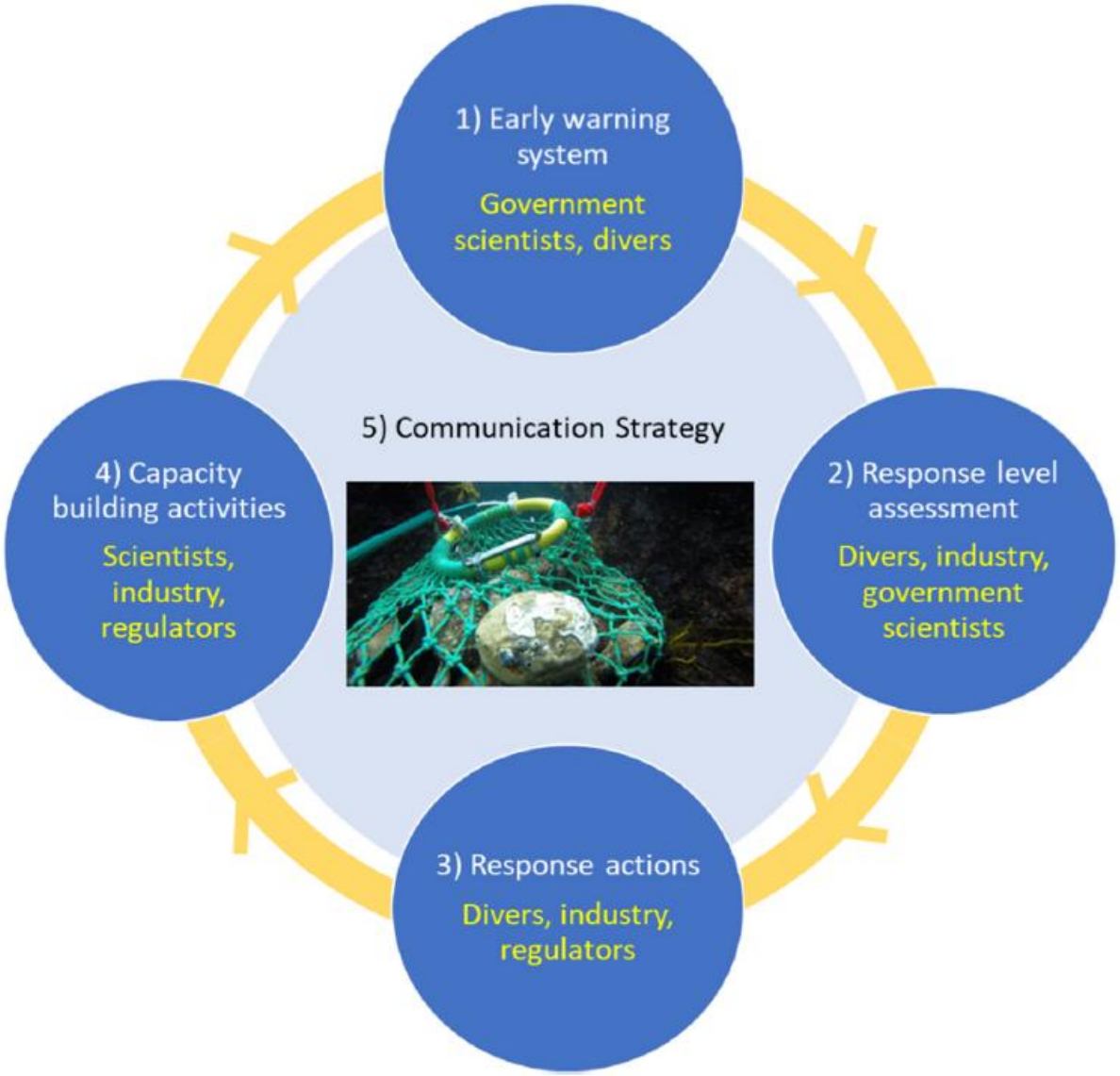


Hobday et al 2024; 2026; Coleman & Champion 2025; WA DPIRD; TAS NRE

2. Industry response plans

New South Wales: Abalone





Coleman et al 2025

3. Event-based sampling

- **IMOS Event-based sampling glider program** to monitor emerging MHWs over the Australian continental shelf
- Improve understanding of the dynamics, evolution and impacts of MHWs on marine ecosystems
- Data can be used for underpinning science, model verification, case studies

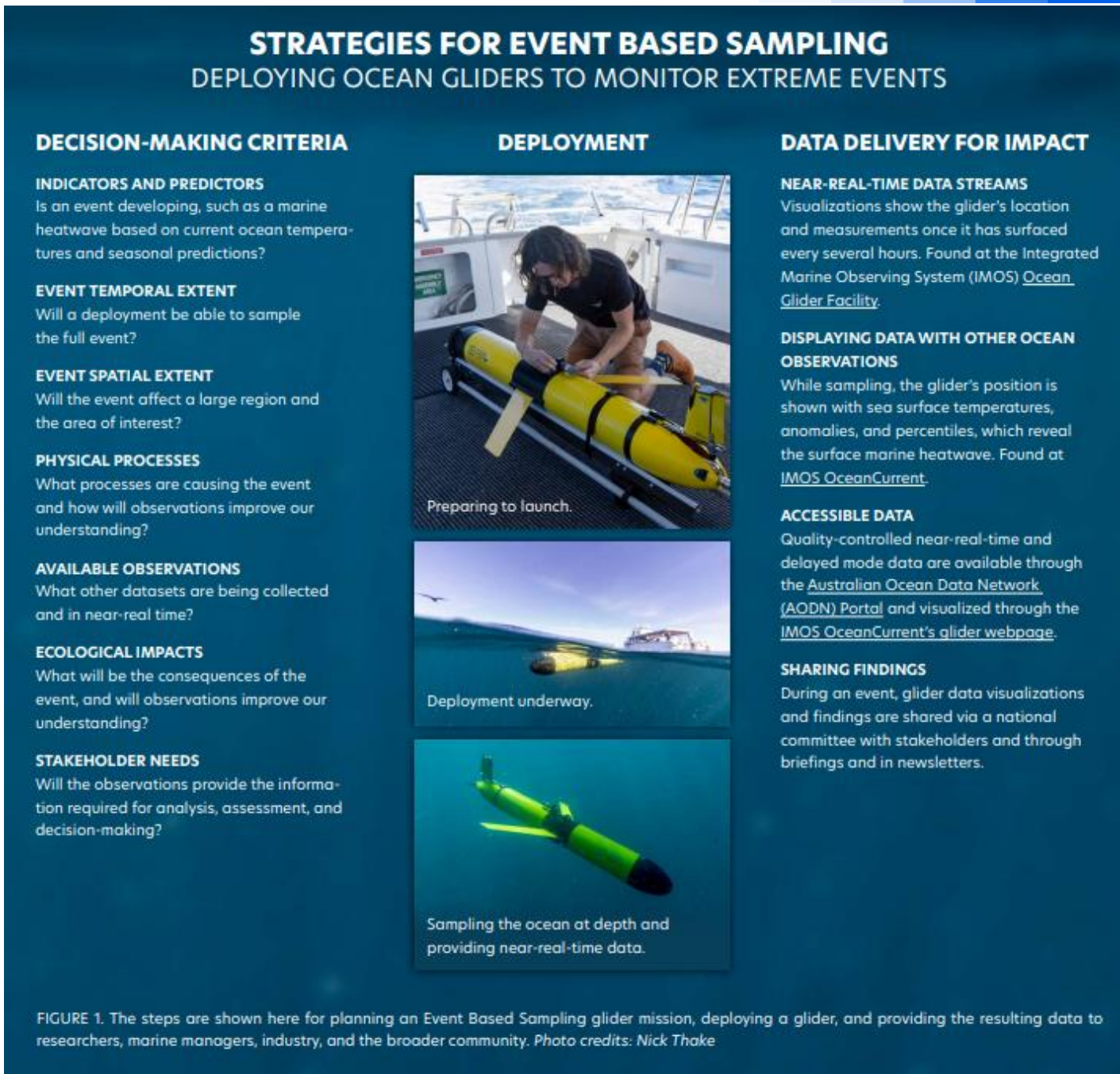
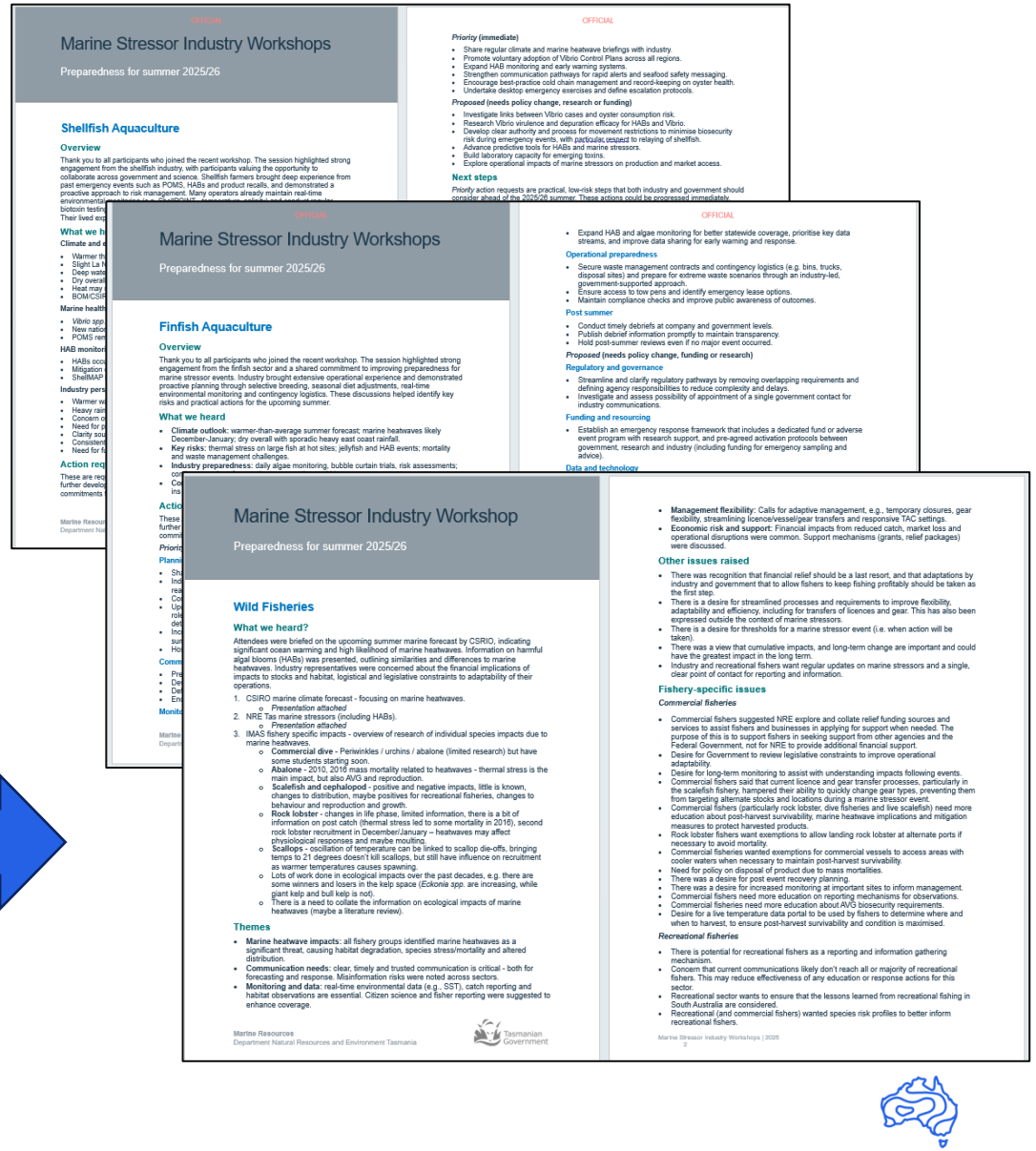


FIGURE 1. The steps are shown here for planning an Event Based Sampling glider mission, deploying a glider, and providing the resulting data to researchers, marine managers, industry, and the broader community. *Photo credits: Nick Thake*

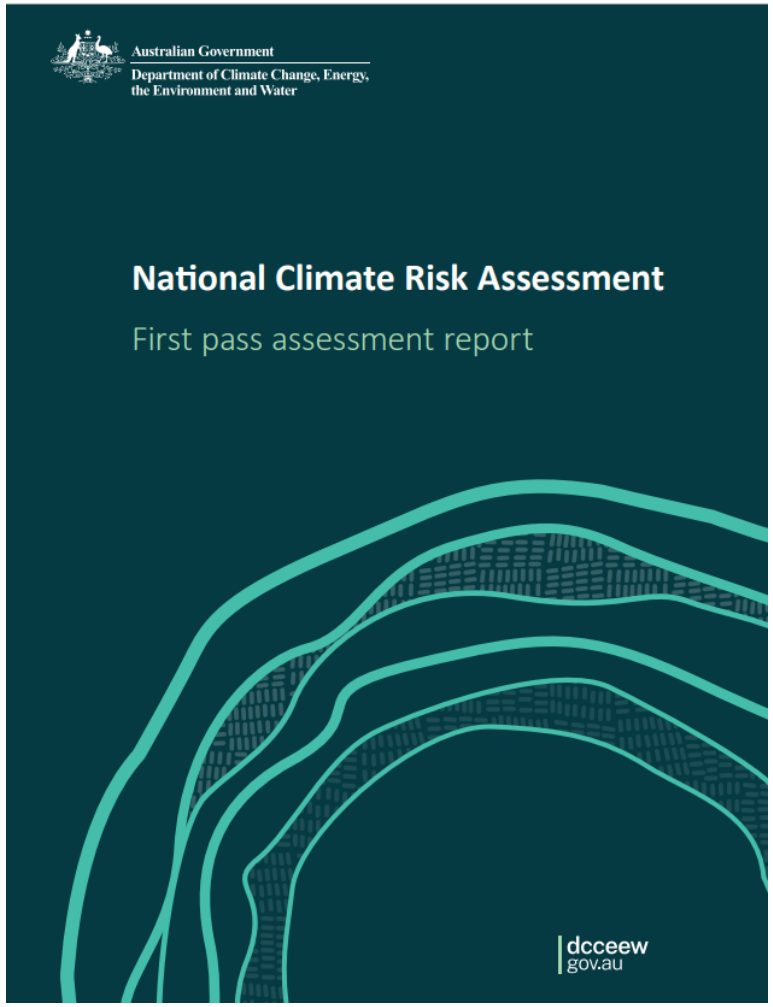
Benthuysen et al (2024)

4. Preparedness workshops

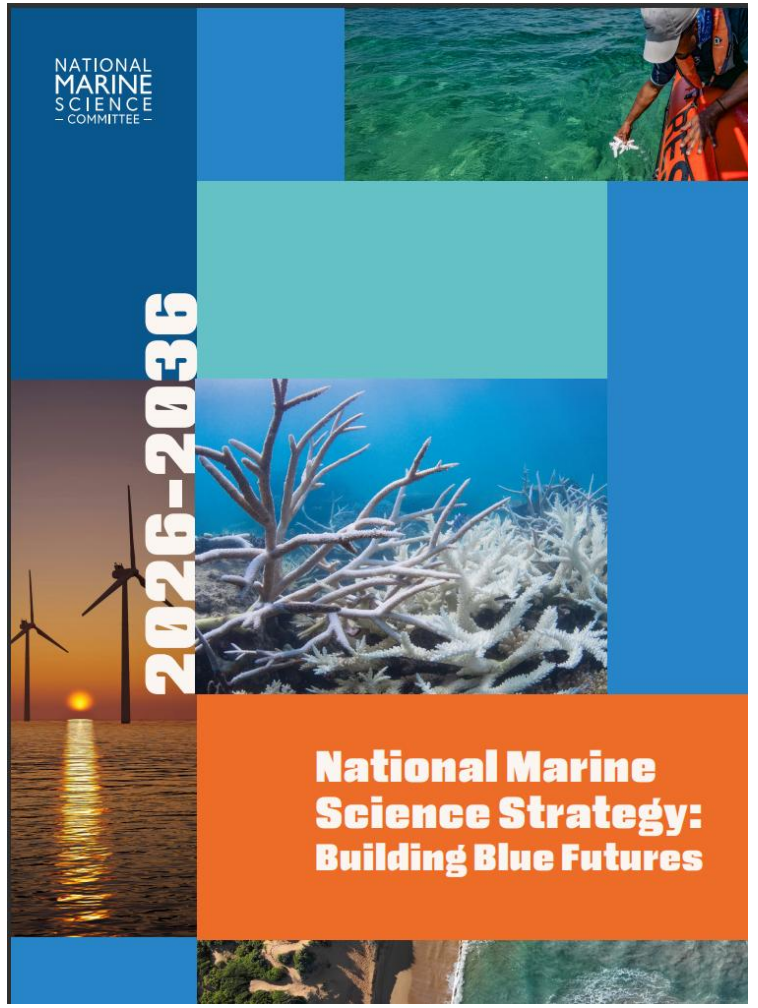




5. Inclusion in national initiatives and strategies







6. Supporting conservation

Two high profile conservation efforts supported by MHW forecasts:

- National Recovery Team for Maugean Skate
- National Recovery Plan for Three Handfish Species

Multi-agency workshops, ministerial briefings, media coverage





Photos: Rick Stuart-Smith, Aquaculture Environment

But.. a lack of agility can still limit forecast uptake



The ability of different marine sectors to use climate forecast information depends on their **agility**

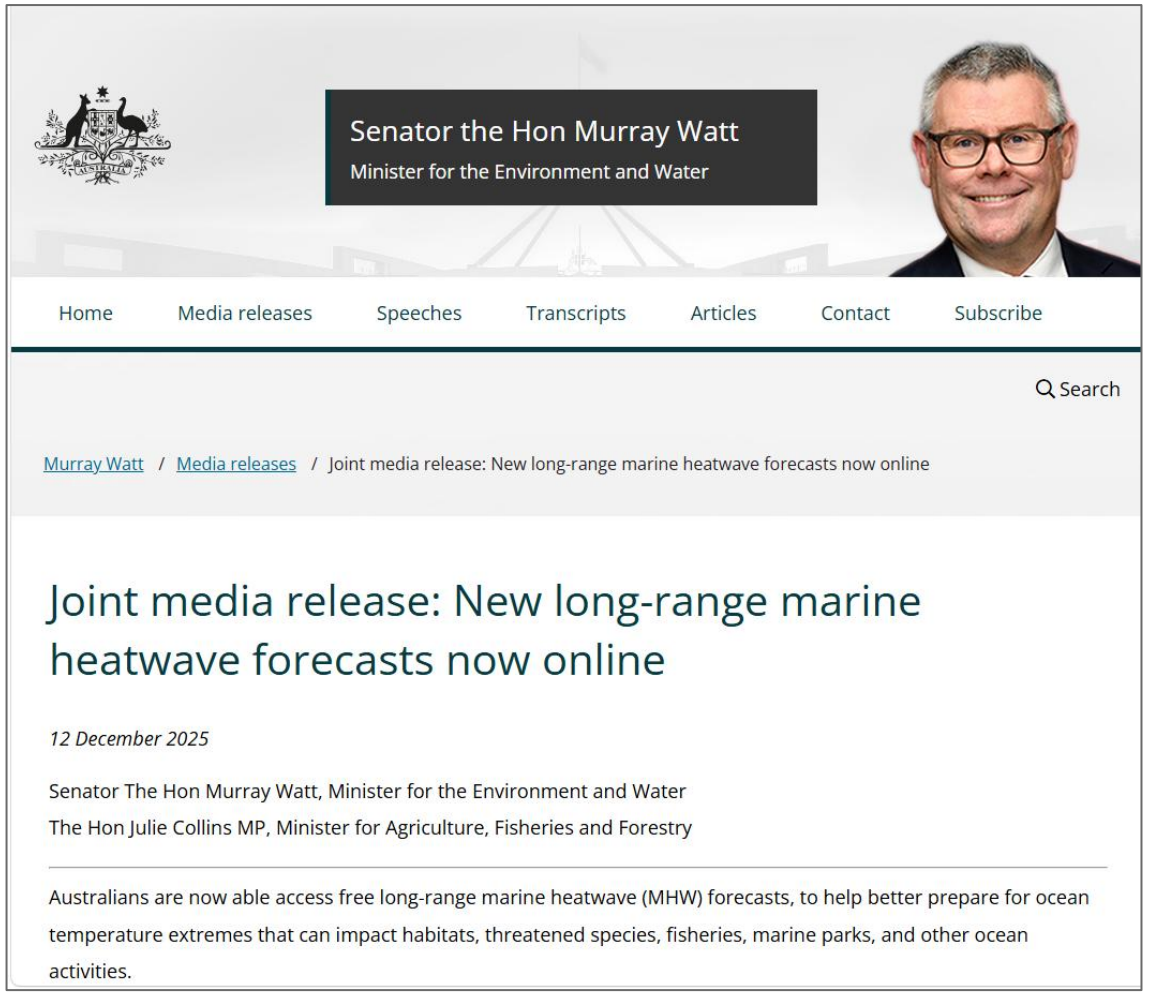
Hartog et al (2023)

Reflections

Five years of effort:

- Operational MHW SST-based forecasts for Australia delivered
- Extension to Western Pacific
- Strong stakeholder & community engagement is critical
- Growing range of uses & applications
- Improved preparedness

Future opportunities?



https://minister.dcceew.gov.au/watt/media-releases/joint-media-release-new-long-range-marine-heatwave-forecasts-now-online

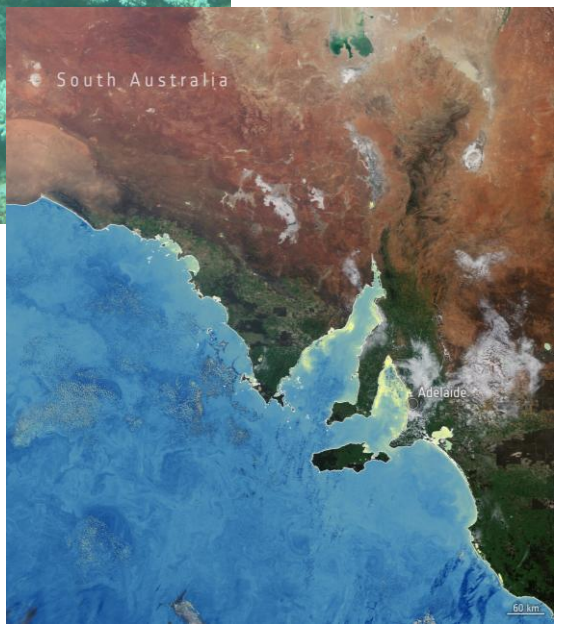
Hobday et al (2026)

Ecosystem management

Opportunities

- High resolution coastal MHW forecasts
- Subsurface MHW forecasts + other variables
- Ecoforecasts
- Forecast delivery and uptake





Challenges

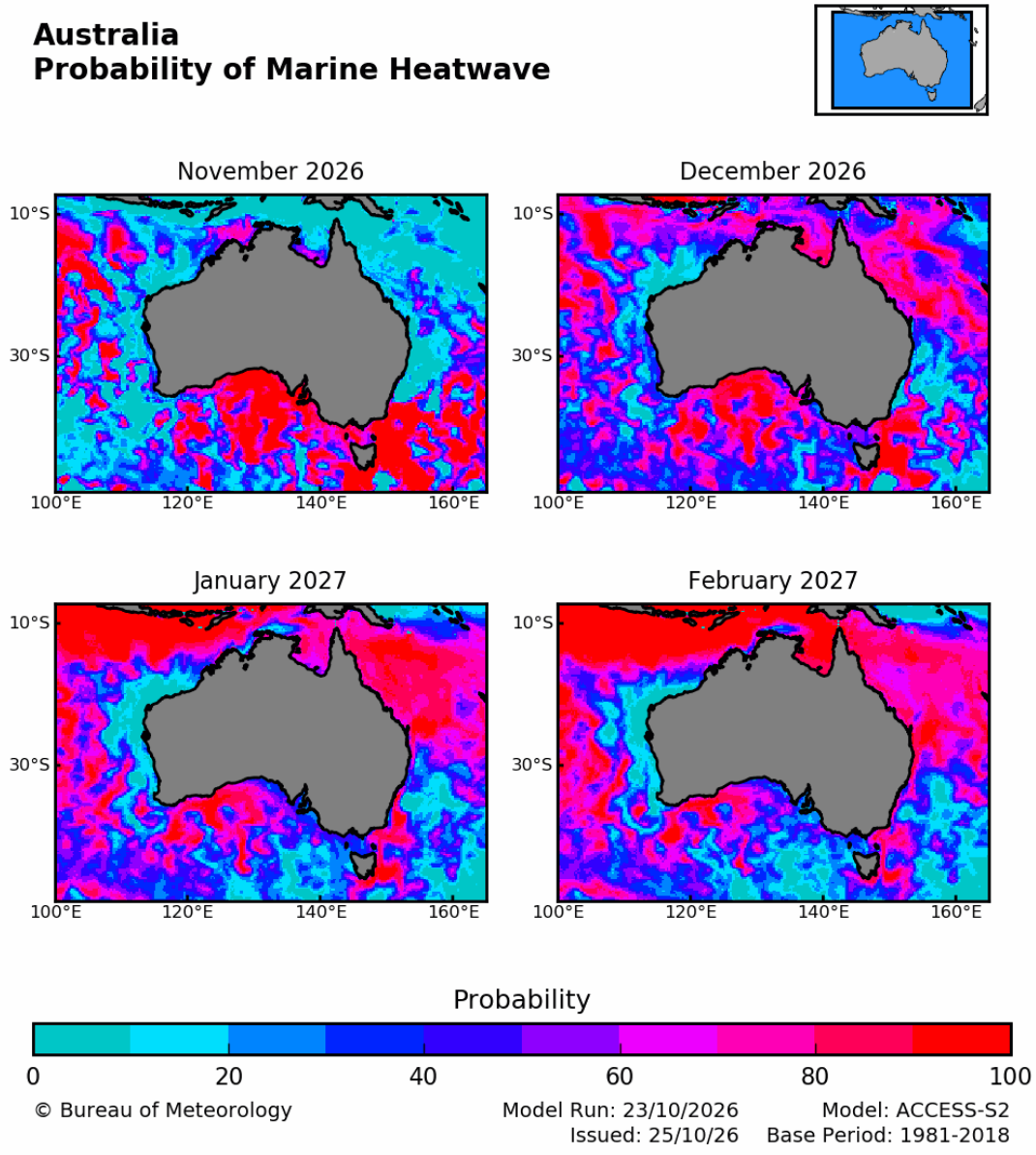
- Downscaling, high-quality coastal data
- Limited skill, complexity, compound events
- Poorly understood relationships, limited obs
- Integration into existing frameworks, stakeholder engagement

Hobday and Spillman (2026)

Looking to the future

- National initiatives
- Ocean literacy
- Multidisciplinary research
- Sustained observations
- New forecast tools
- Emerging applications
- Continued stakeholder engagement

A strong El Niño is underway..
what is in store for this summer?



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CSIRO

Thank you

Marine Heatwave Research Project:
https://research.csiro.au/cor/research-domains/climate-impacts-adaptation/marine-heatwaves/dynamical-forecasting-of-marine-heatwaves/