The Bureau of Meteorology

Operational Marine Heatwave Prediction: from Weeks to Months to Seasons

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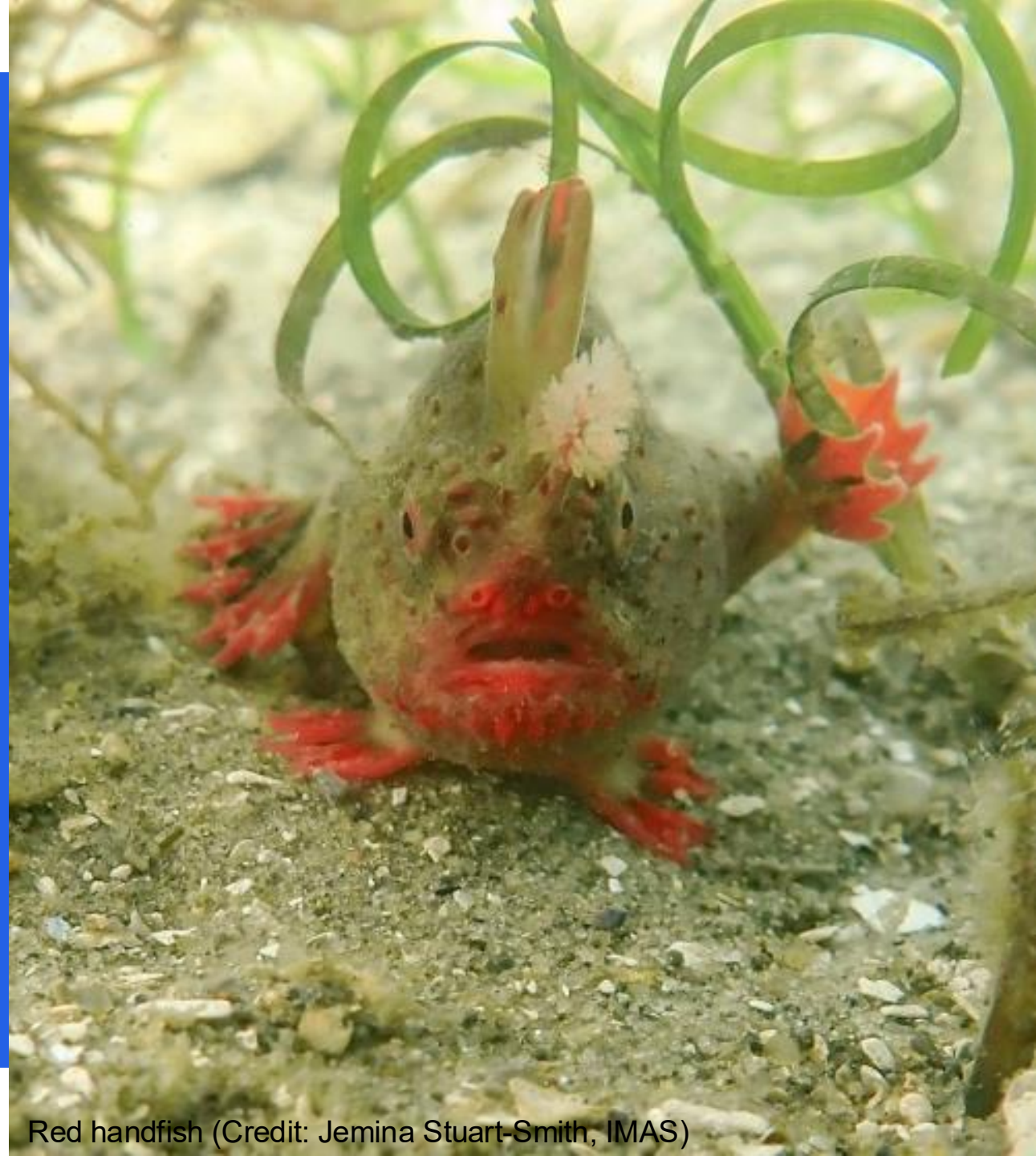


Red handfish (Credit: Jemina Stuart-Smith, IMAS)

SUMMER 2024-2025

IMPACTS FROM MARINE HEATWAVES SUMMER 2024-2025

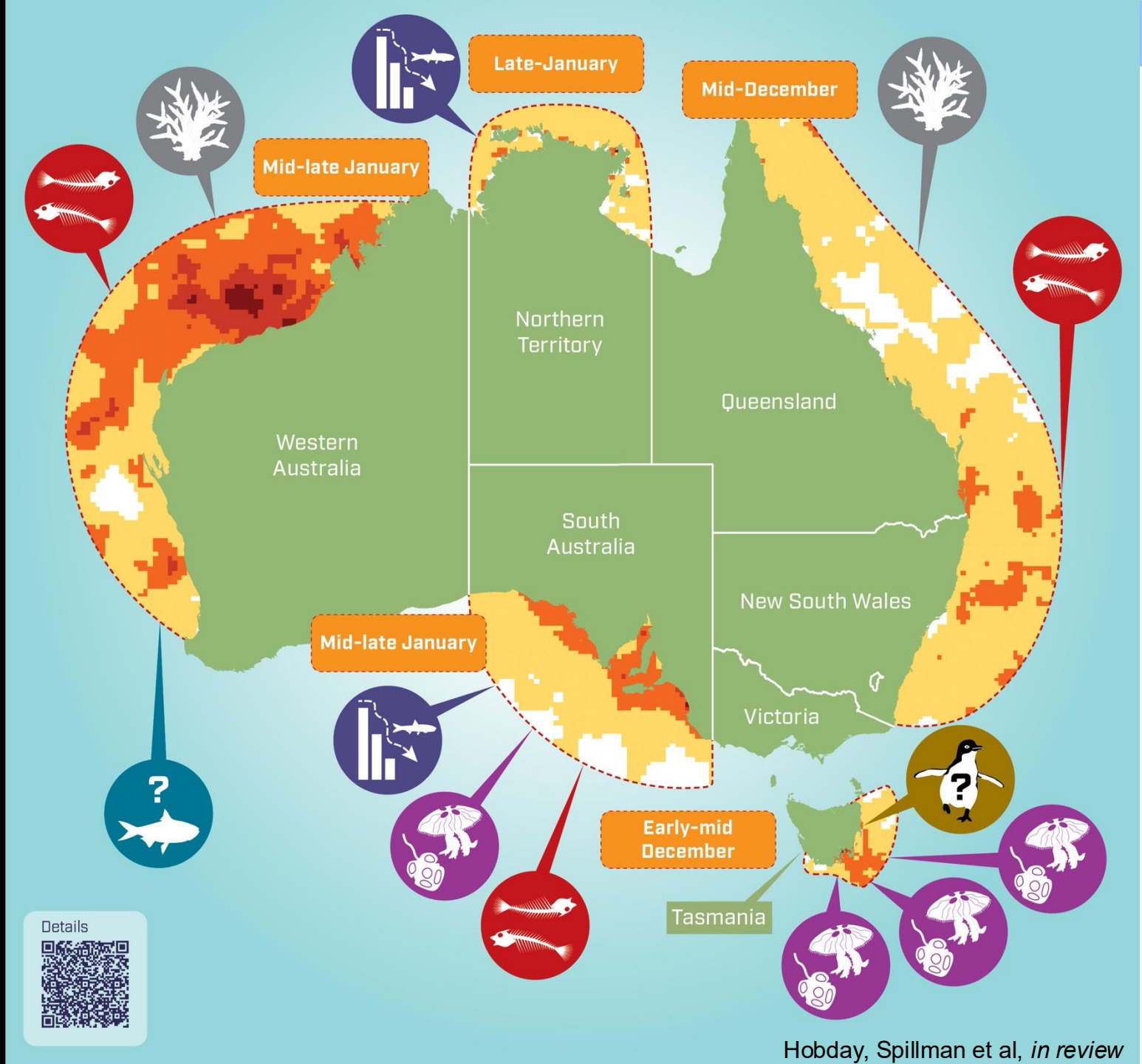
- Fishkill
- Bleaching
- Blooms
- Penguin absence
- Out-of-range species
- Reduced fish catch

CSIRO

Australian Government
Bureau of Meteorology

Supported by

Australian Government
Department of Climate Change, Energy, the Environment and Water
Fisheries Research and Development Corporation



Hobday, Spillman et al, *in review*

Marine heatwave impacts

Climate risks

- Marine heatwaves

Understanding climate risks across time & space scales

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
- Lack of product for processing
- Shellfish toxicity

Economic

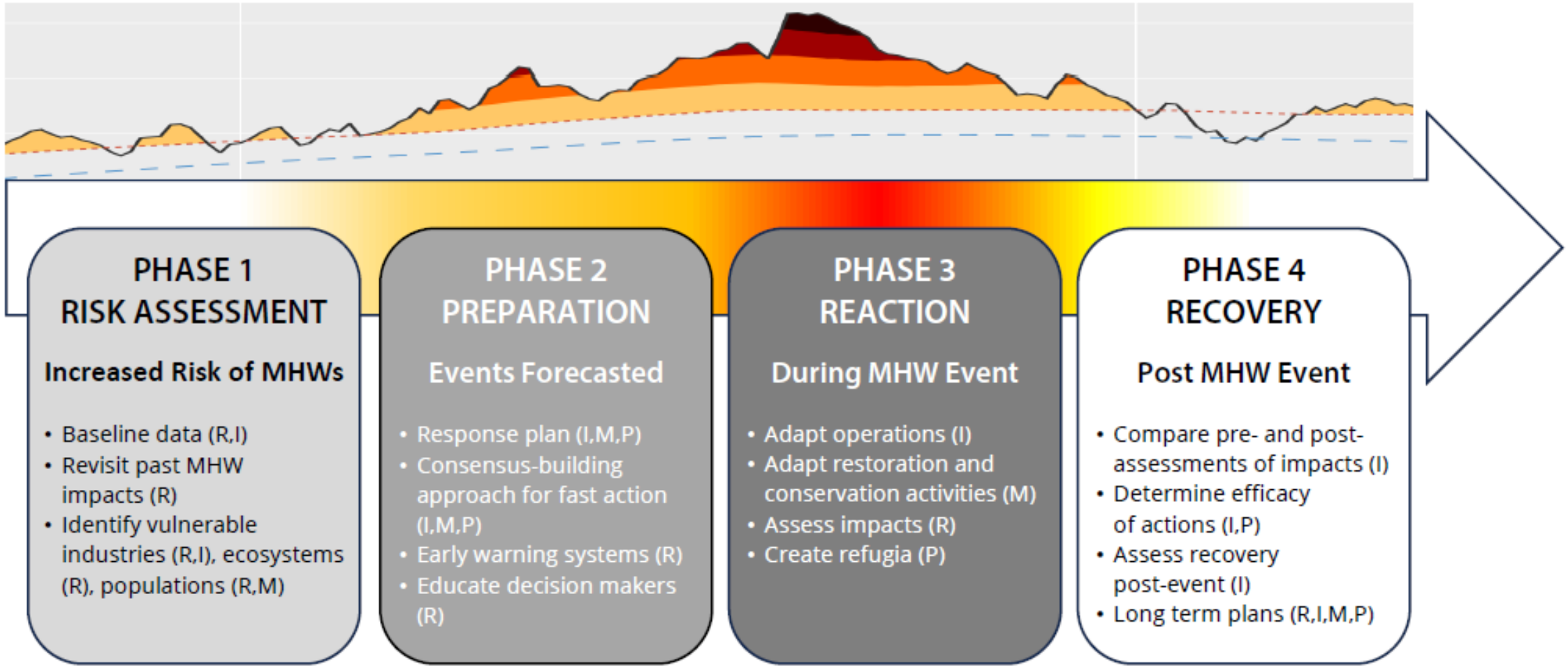
Community & industry impacts

- Decreased resilience
- Increased costs
- Reduced profits
- 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)

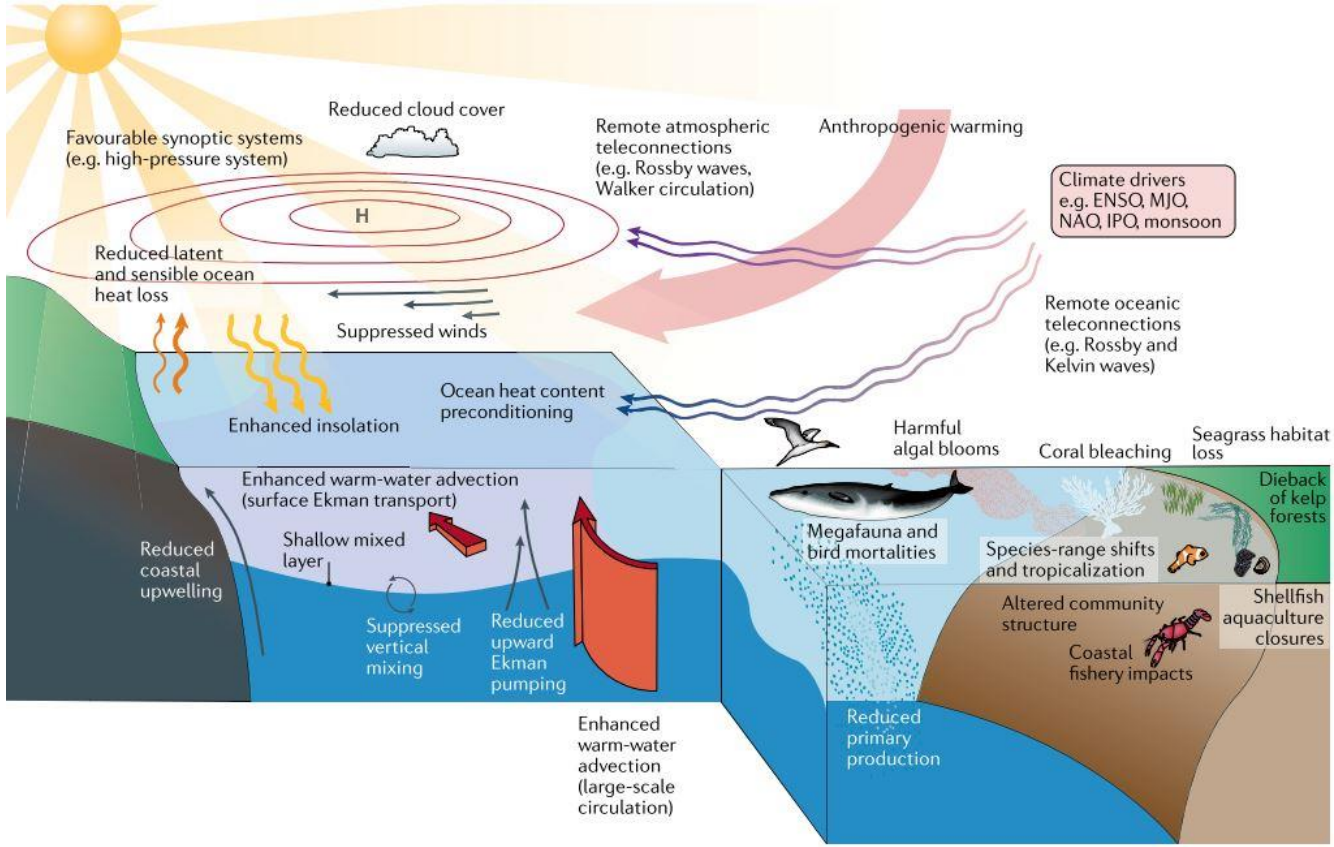
Response phases



Hobday, Spillman et al (2024)

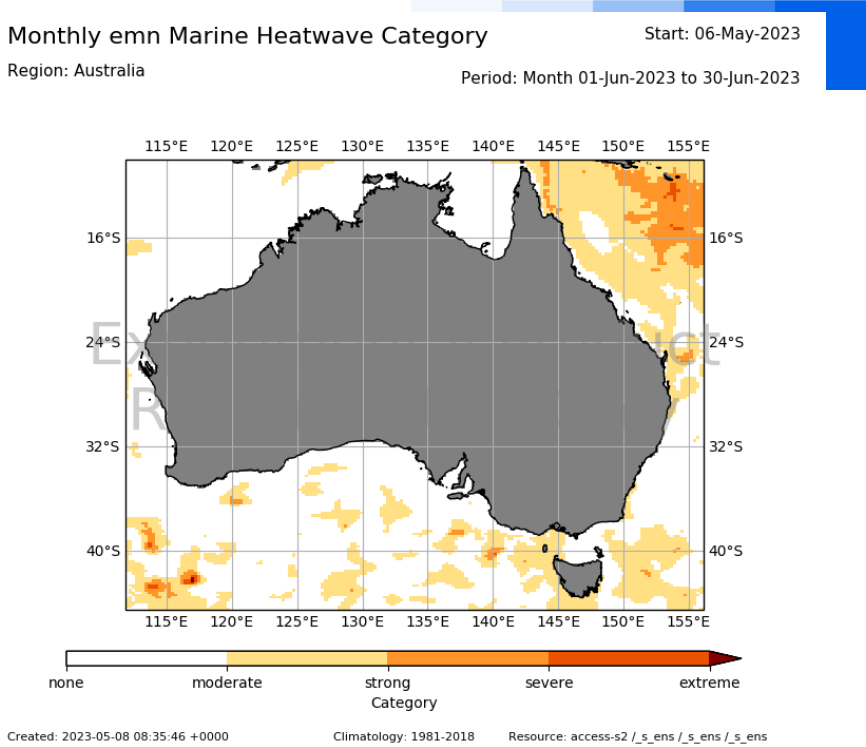
Dynamical forecasting of Marine Heatwaves Project

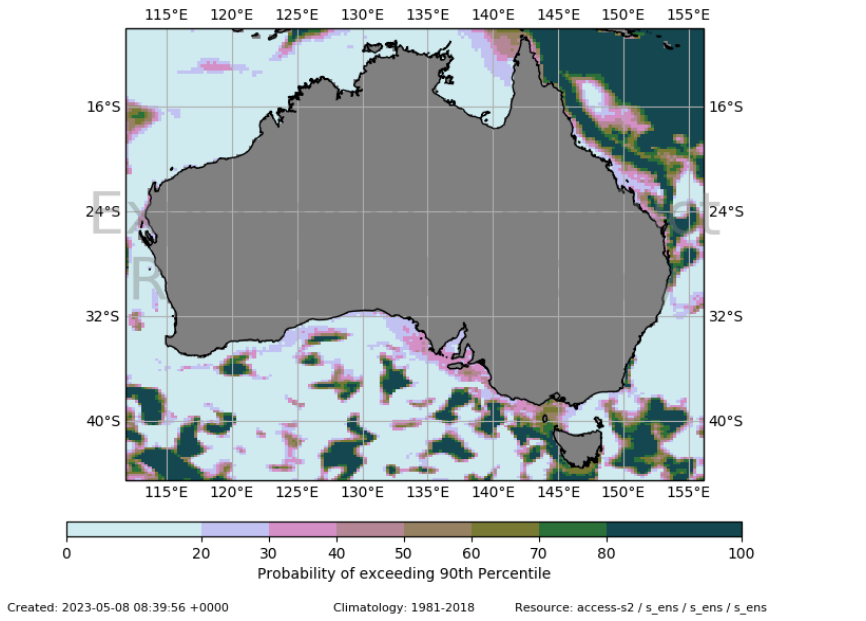
- Collaboration between CSIRO & Bureau
- Aim: to develop a subseasonal to seasonal Marine Heatwave Forecast Product(s)
- Focus on Australia
- Includes verification & stakeholder engagement
- Driven by ACCESS-S forecasts



Marine Heatwave Forecasts

- Marine heatwave category ensemble mean forecast (none/moderate/strong/extreme/)
- Probability of a marine heatwave occurring, i.e. sea surface temperatures (SST) exceeding the 90th percentile.
- Fortnightly and Monthly timescales
- Has been running in trial mode in real time for select users
- Highly complementary to current operational services

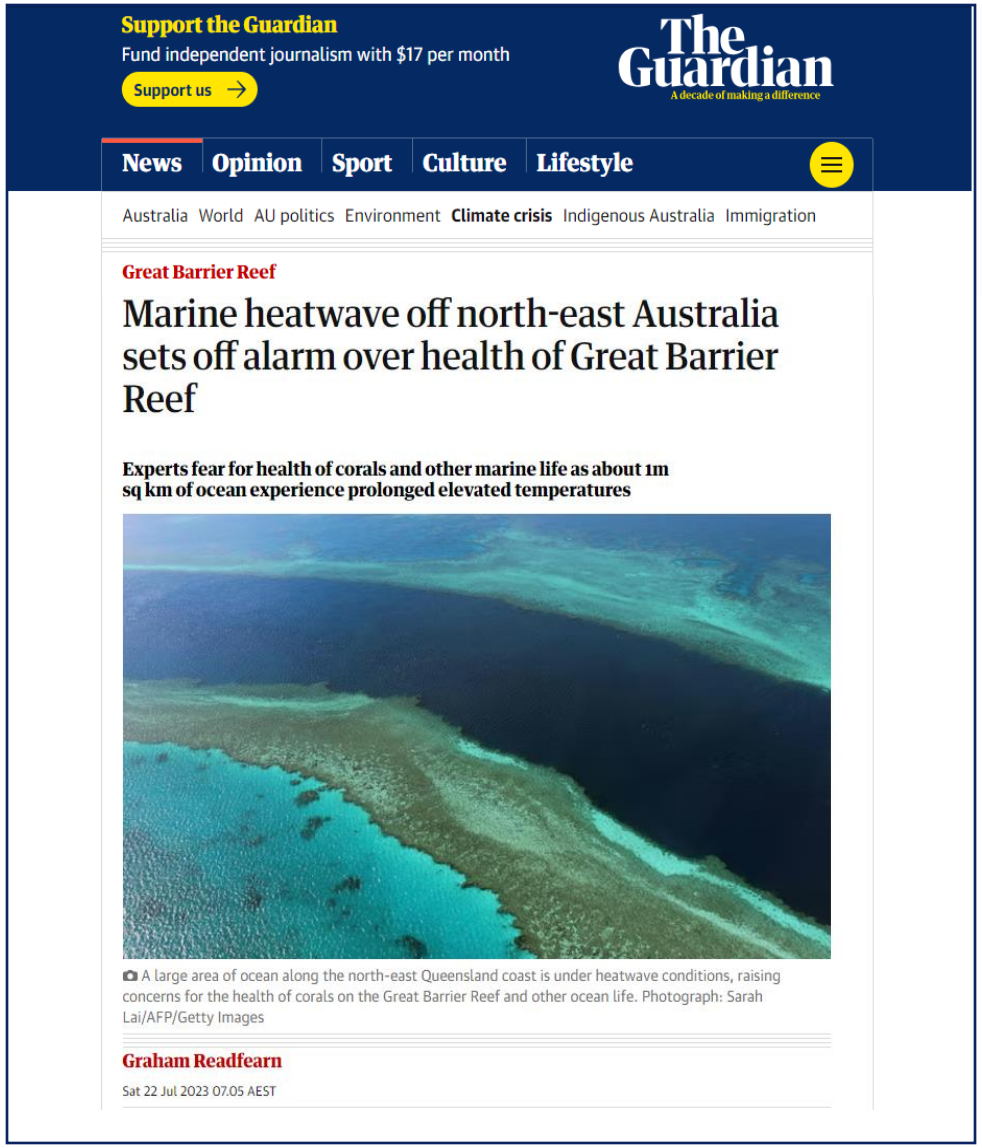




Testing trial MHW products with customers

- National ocean climate briefings to the seafood sector hosted by FRDC for summer
- Current ocean conditions & seasonal outlooks, including trial MHW forecasts
- Build industry awareness, capacity & resilience through research-industry partnership
- Briefings were advertised on social media & in industry newsletters
- Subsequent state briefings by regional experts, drawing on national briefings

https://www.frdc.com.au/climate-change#toc-climate-change-briefings

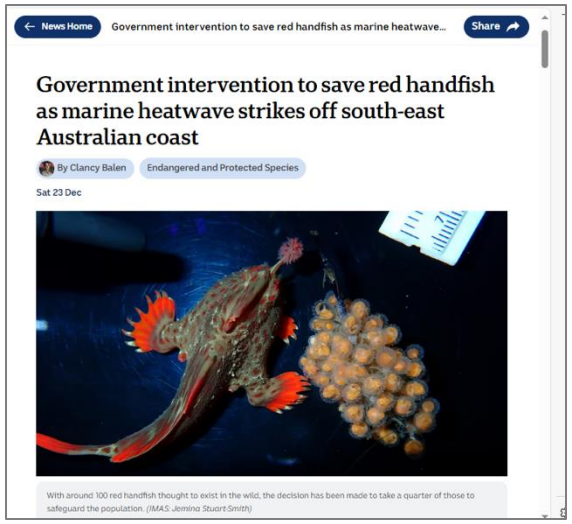


Supporting DCCEEW

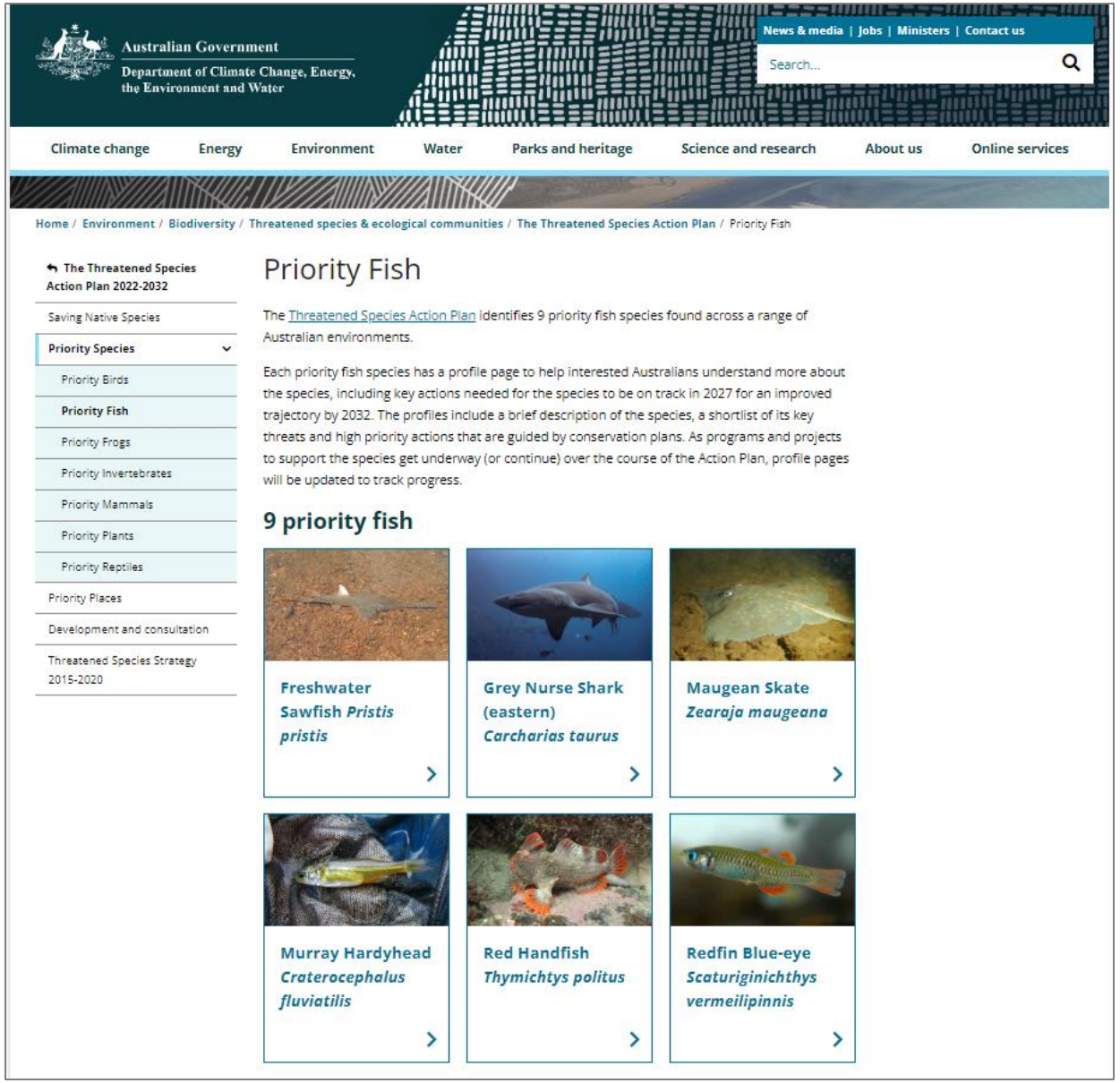
Two high profile conservation efforts:

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

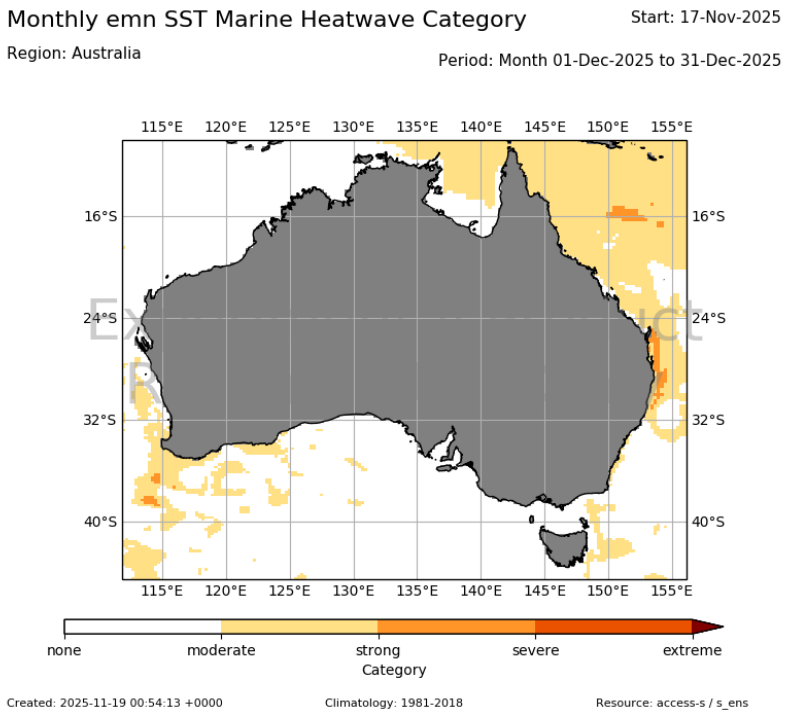
Multi-agency workshop in Dec 2023
Updates over summer to taskforces
Ministerial briefings
Media coverage



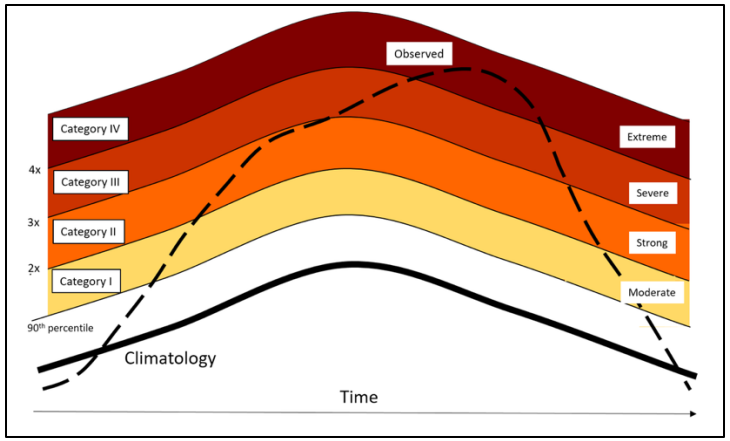
https://www.abc.net.au/news/2023-12-23/intervention-to-save-red-handfish-marine-heatwave/103261502

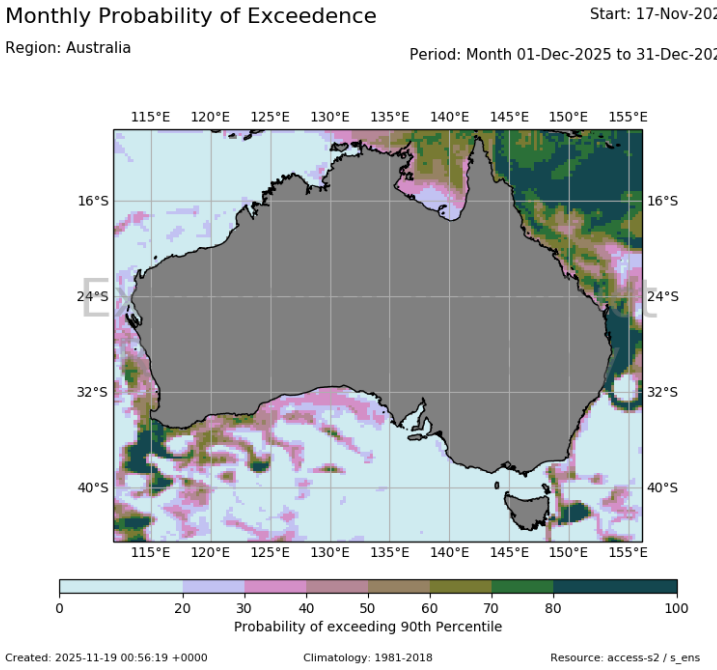


Categorical (intensity) & Probabilistic (likelihood) forecasts

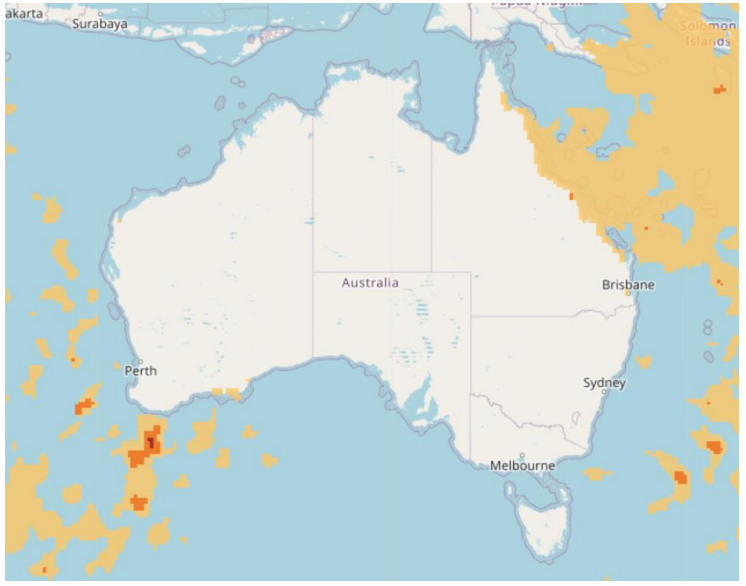


Categorical forecasts based on SST ensemble mean from ACCESS-S



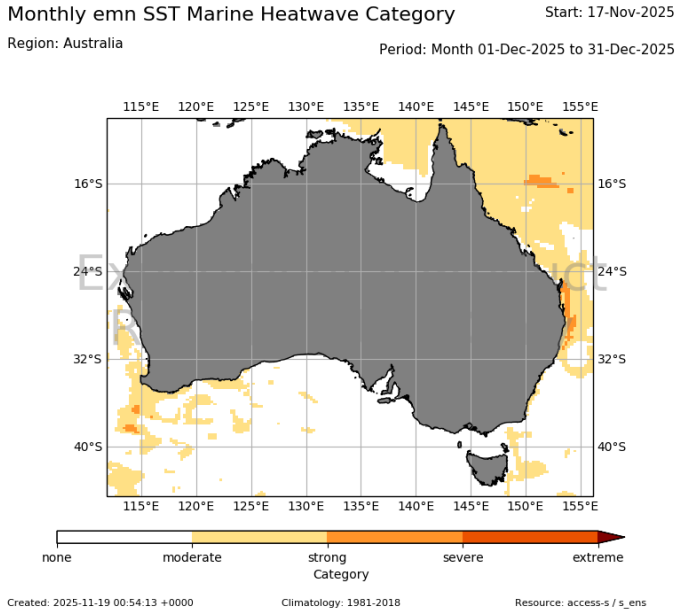


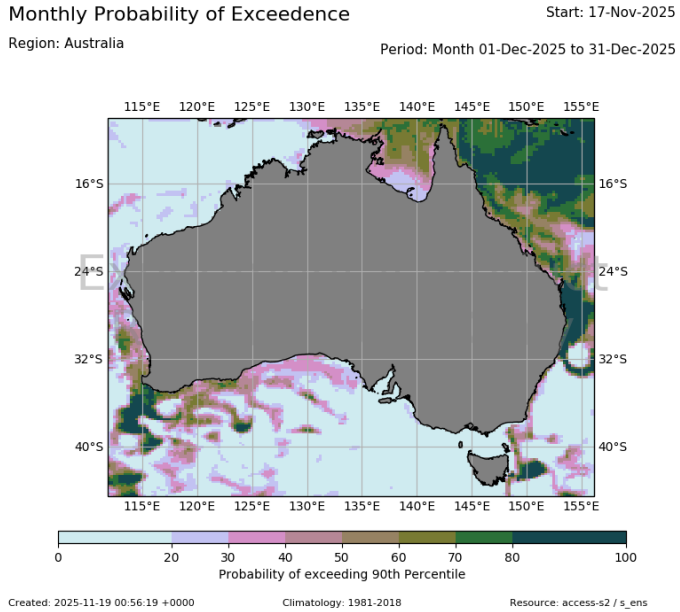
Probabilistic forecasts derived from 99 ensemble members

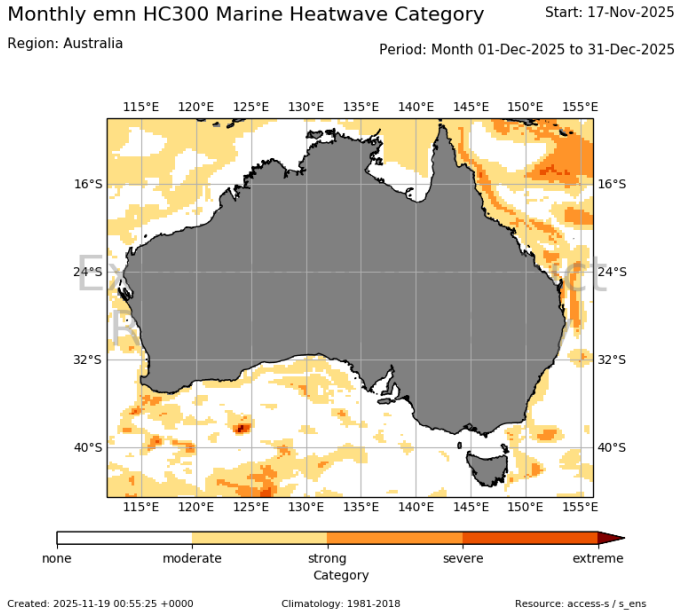


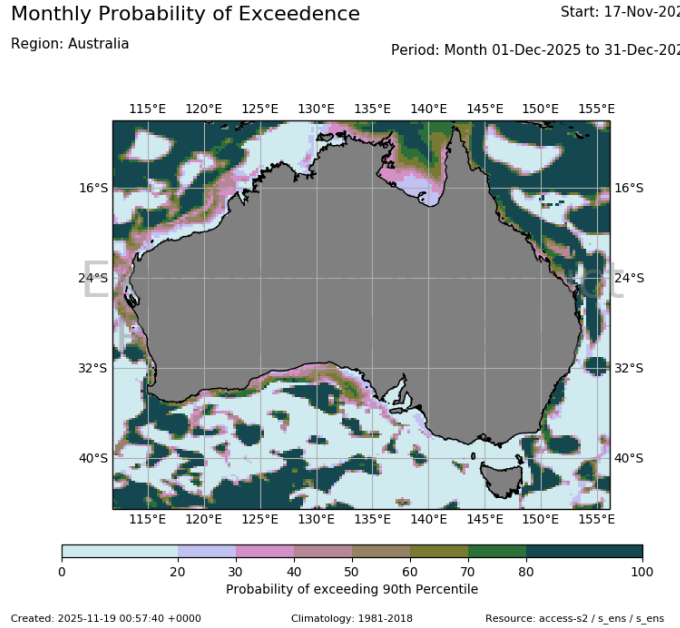
Surface and Subsurface Marine Heatwaves

- Most marine heatwave monitoring and prediction is based on sea surface temperature
- Observations readily available, good global coverage, good model skill
- However most impacted systems reside in the subsurface
- Corals and other photosynthetic species reside in the euphotic zone up to 200 metres
- Species relying on these ecosystems
- Migration of pelagic species
- Drivers: Vertical advection, downwelling, eddies



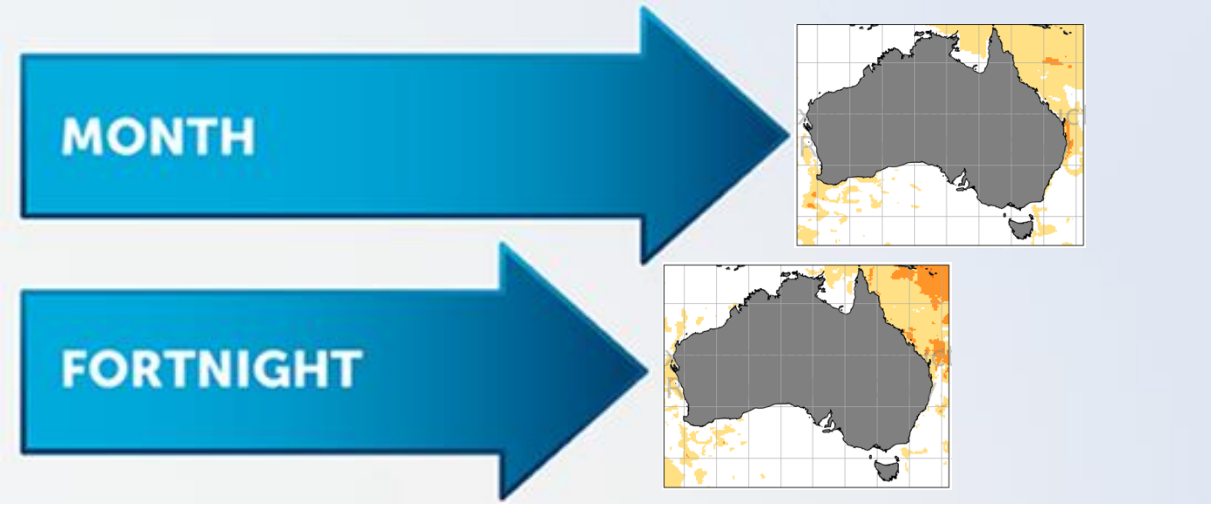


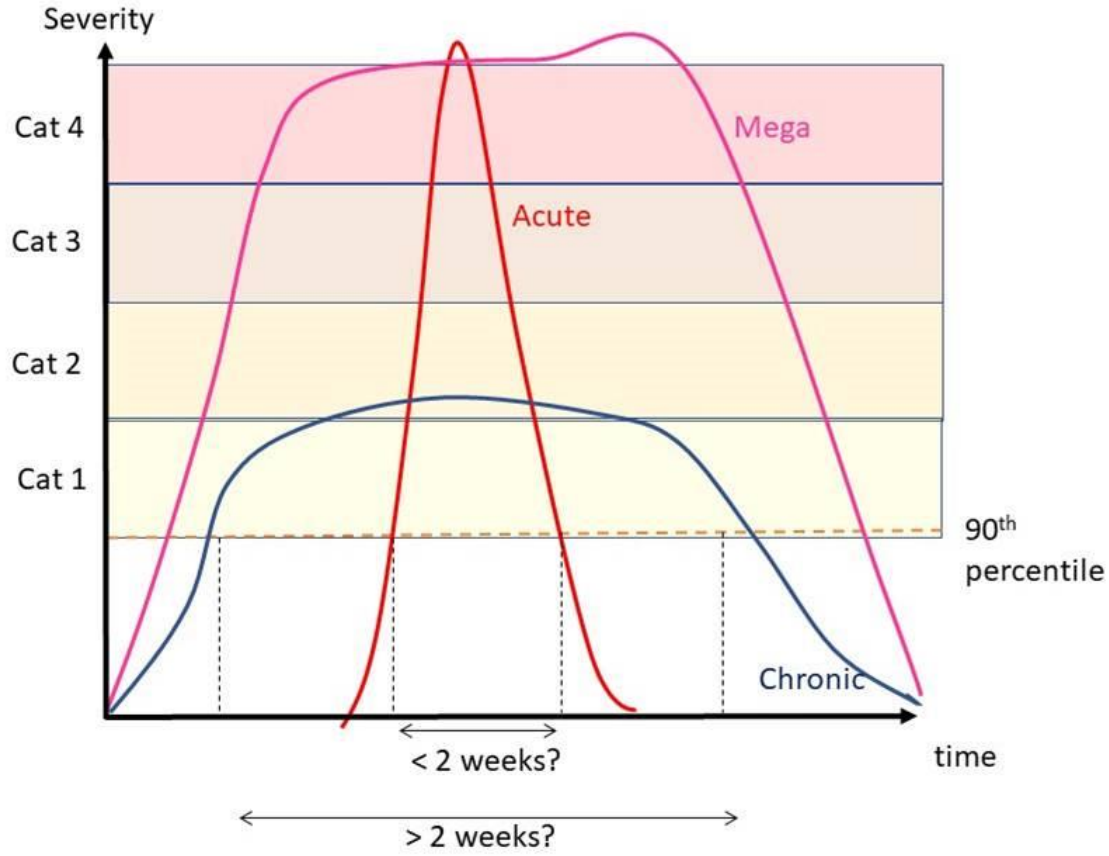




Chronic vs Acute

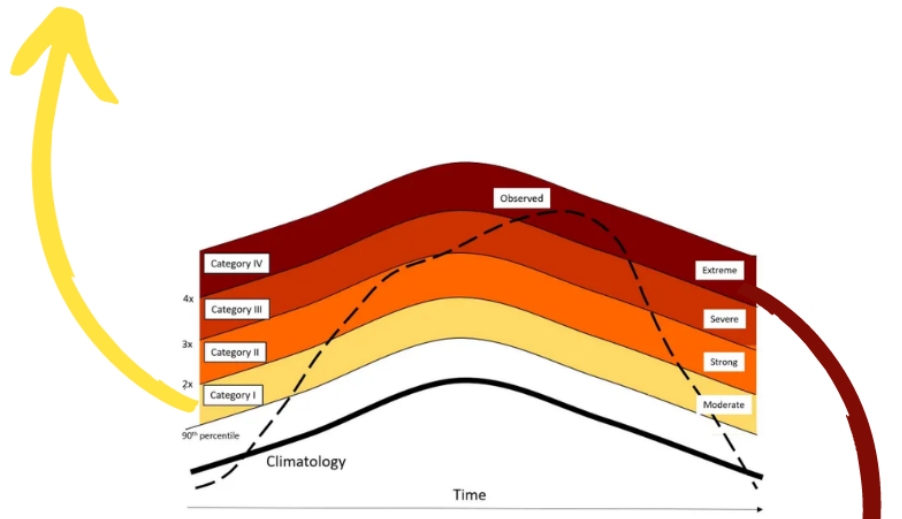
- Duration is important for marine applications and impacts.
- Chronic or acute
- Impacts including coral bleaching, ecosystem degradation, effects on aquaculture and fisheries

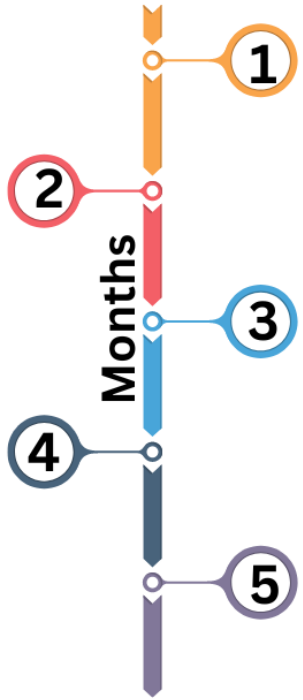


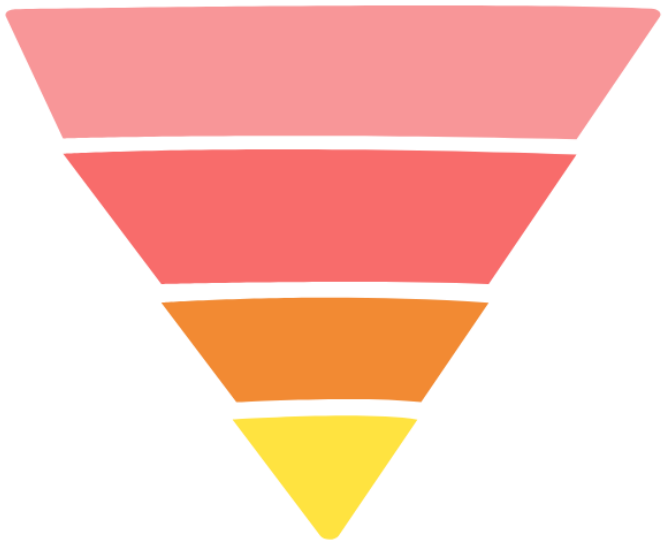


Scales of forecasting difficulty

Easier to Forecast







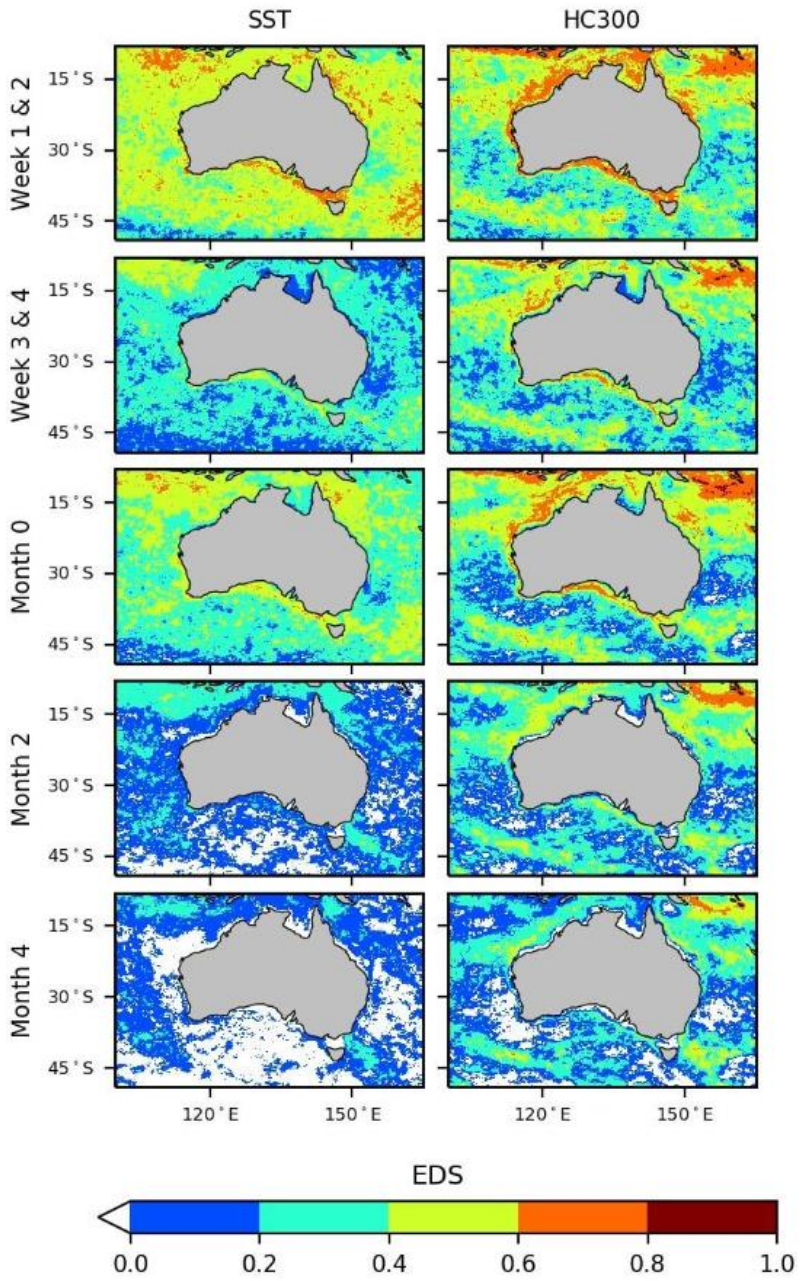
Challenging to Forecast

Skill for SST (and Heat Content)

The Extreme Dependency Score (EDS; Stephenson et al. 2008) was formulated as a method to measure forecasts of extreme binary events that are not skewed by the dominance of correct negatives and are not affected by areas where false alarms might be zero, likely to occur in regions of high skill.

$$EDS_{(x,y,lt)} = \frac{2\log[(a+c)/n]_{(t,x,y,lt)}}{\log[a/n]_{(t,x,y,lt)}}$$

where *a* is number of hits, *c* is number of misses, and *n* is the sample size.



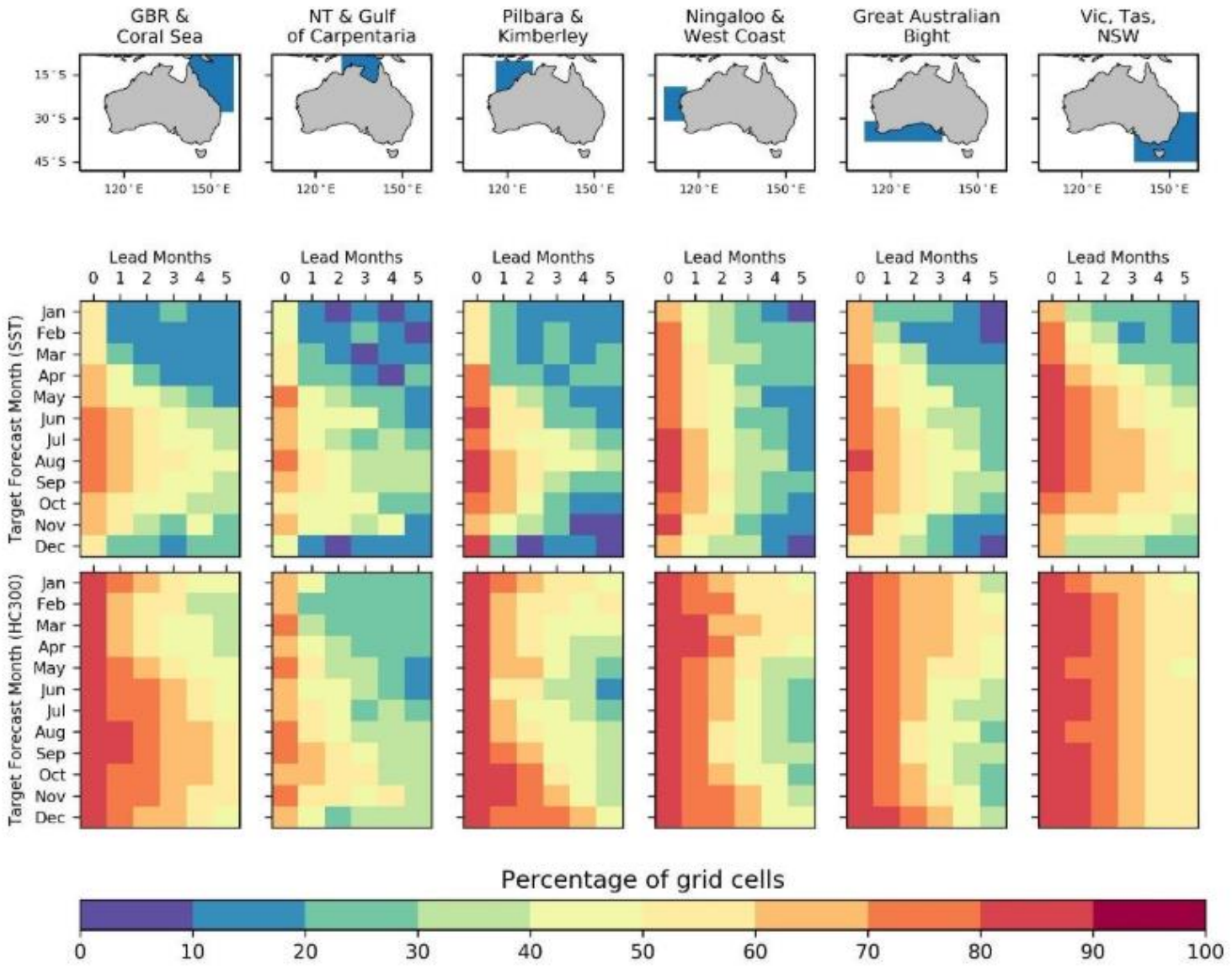
Skill for SST (and Heat Content)

Percentage correct within regions =

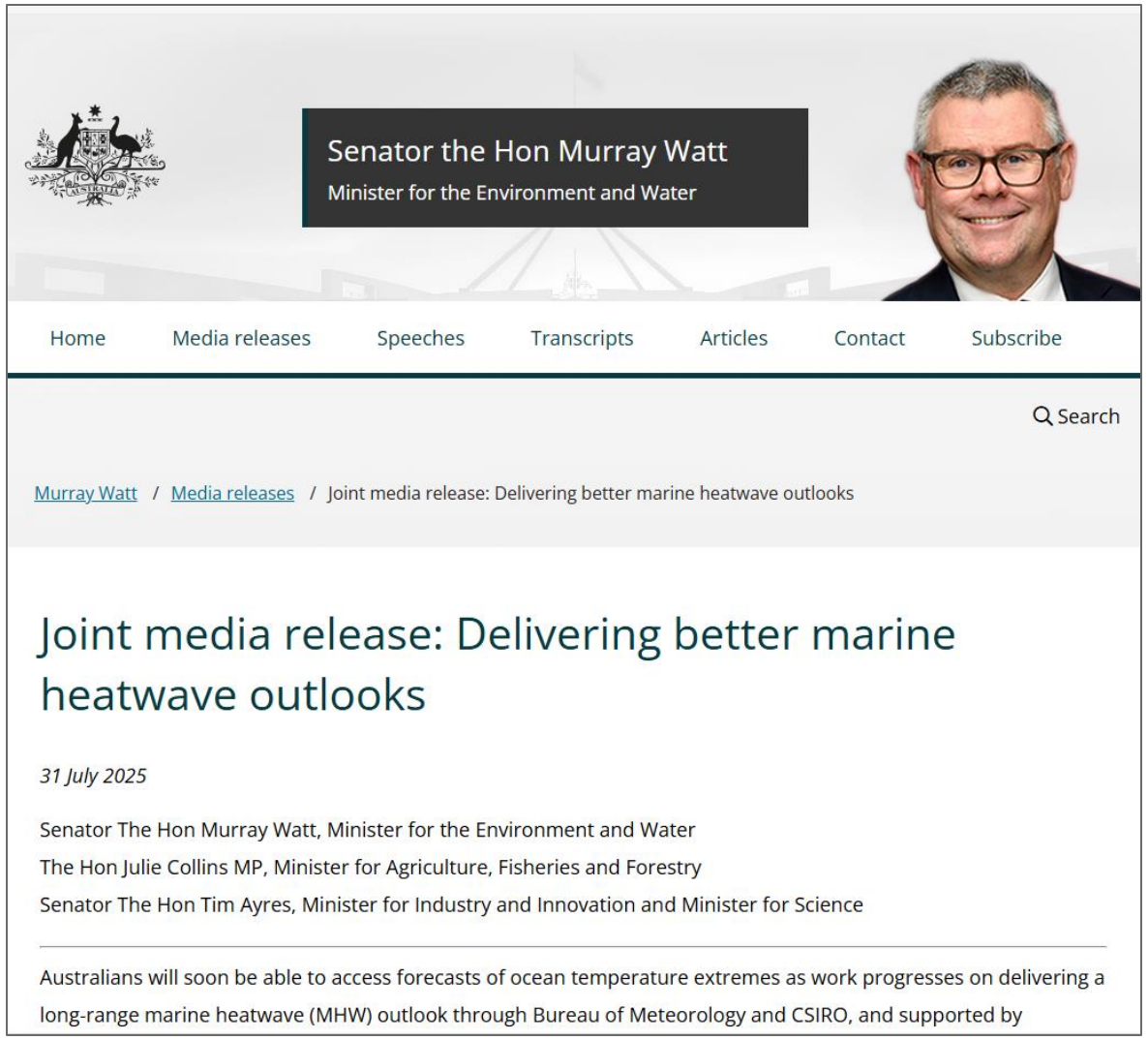
$$\frac{\text{Forecasted MHW (num grid cells)}}{\text{Observed MHW (num grid cells)}}$$

HC based forecasts show improvement over SST, especially in the warmer months.

Gulf of Carpentaria & NT least skillful.



Public marine heatwave forecast



https://minister.dcceew.gov.au/watt/media-releases/joint-media-release-delivering-better-marine-heatwave-outlooks

- Bureau-CSIRO research project operational deliverable
- Marine heatwave likelihood & severity up to 4 months ahead
- Funding from DCCEEW with Katrina Maguire, CSIRO & FRDC to operationalise this summer

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

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

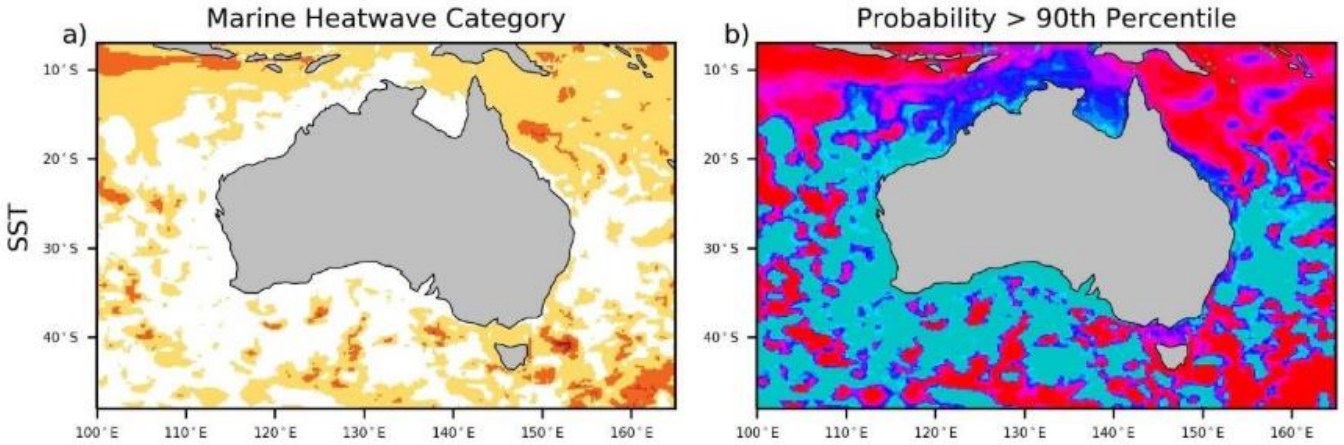
www.bom.gov.au/climate/ocean/long-range-forecasts

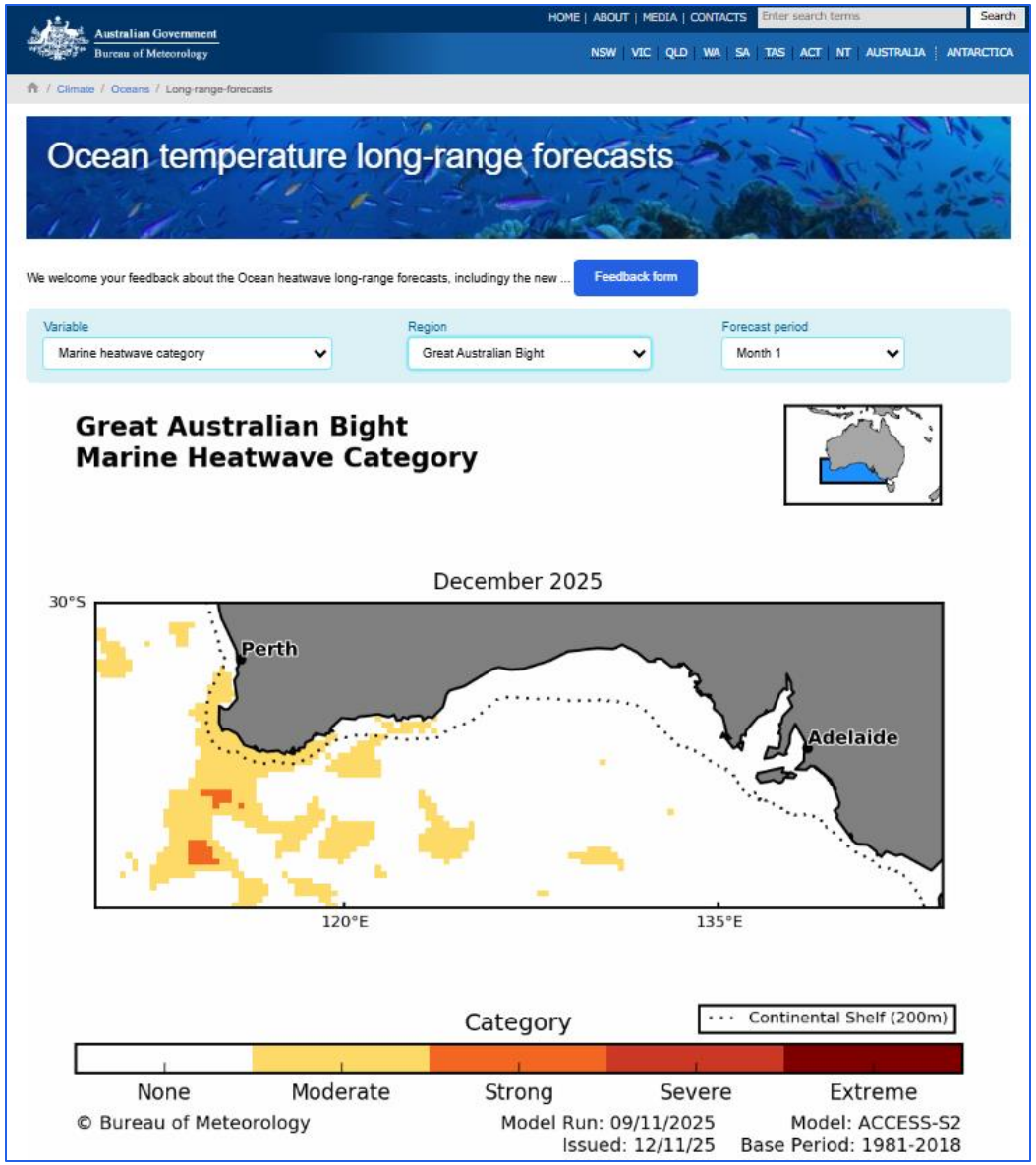
…goes live early December 2025

- Fortnights 1 and 2
- Months 1 to 4
- Delineated regions around Australia

Sits alongside existing service:

- SST and SST Anomaly
- Degree Heating Months
- Hotspot





The Bureau of Meteorology

Thank you

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