The Bureau of Meteorology

Operational seasonal prediction services to support marine end user decision making

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OFFICIAL

Supporting effective decision making
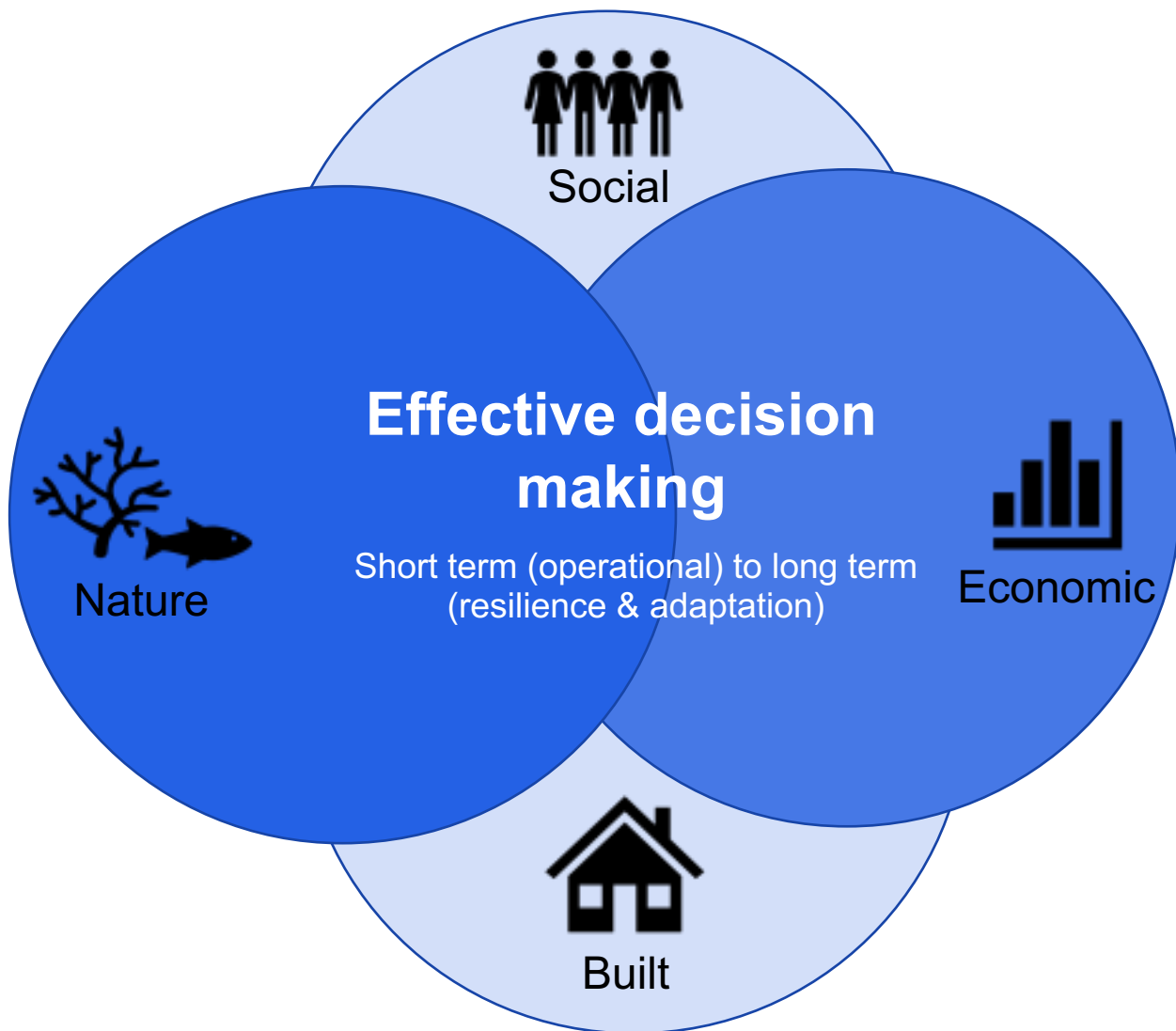
Understand climate risks
- Climate hazards, risks, stressors
- Across time & space scales

Monitor and assess vulnerabilities, risks and potential impacts
- Monitoring, assessment and advice
- Adaptive capacity & response/mitigation levers
- Across social, economic, natural & built sectors
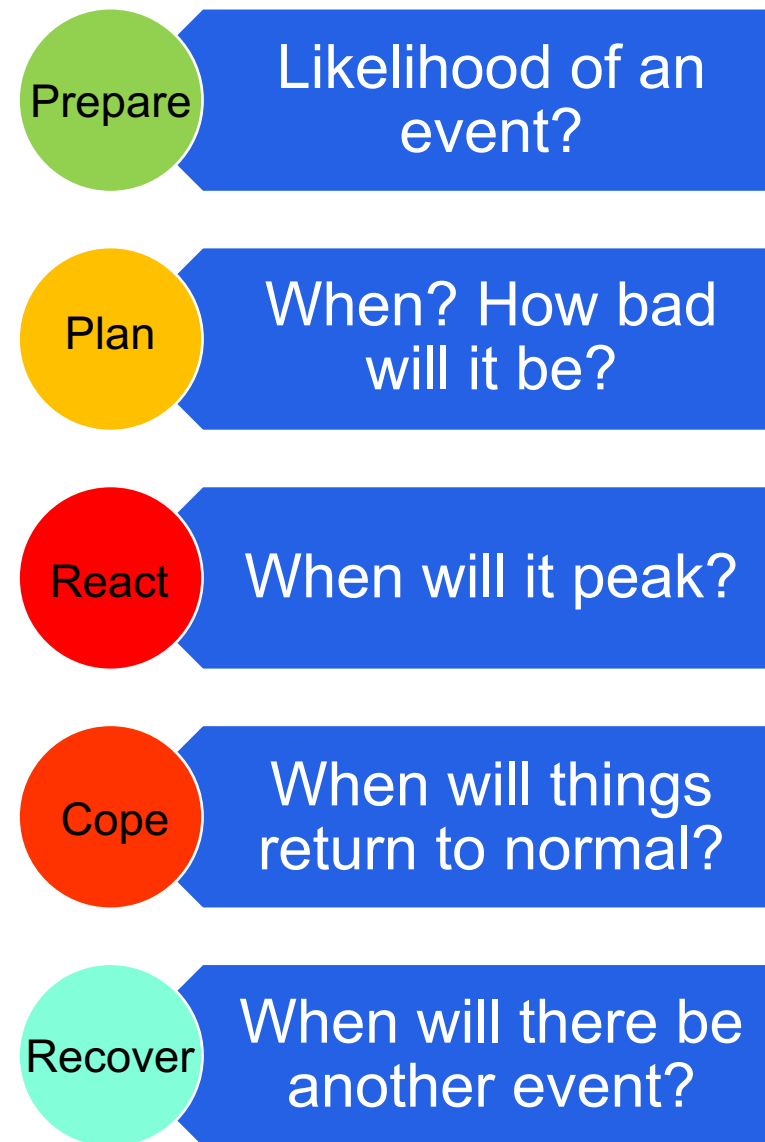
Adapted from Australian Climate Services

Ocean climate risks and impacts

Climate risks

- Increasing ocean temperatures
- Marine heatwaves
- Sea level rise
- Flooding
- Acidification
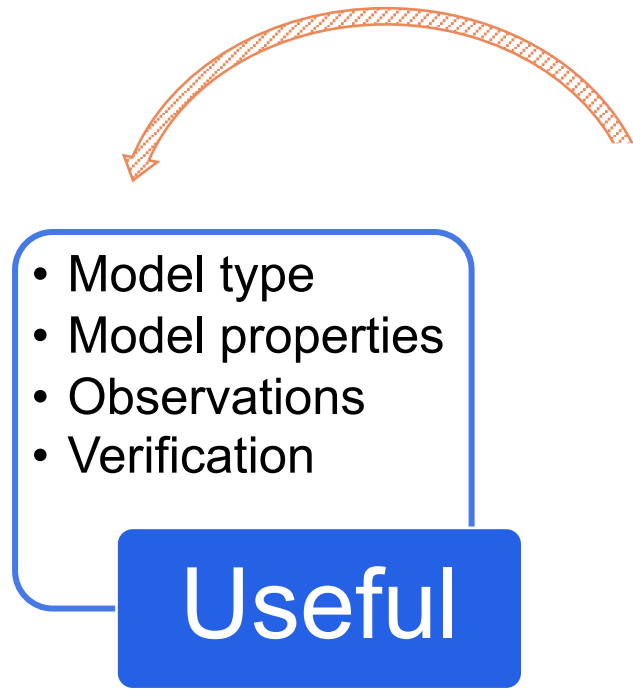
Adapted from Hartog et al (2023)

What is the role for seasonal forecasts?

- Understanding and predicting climate risks across time & space scales
  - Advance warning of events
  - Evolution of events
  - Return to 'normal' conditions

- Supports more effective decision making

- Provides an early window for implementation of strategies to minimise impacts and maximise opportunities

- Responses are influenced by **agility** & **risk appetite** of users

Prepare — Likelihood of an event?

Plan — When? How bad will it be?

React — When will it peak?

Cope — When will things return to normal?

Recover — When will there be another event?

Hobday, Spillman et al (2016); Hartog et al (2023)

Ingredients for a good seasonal forecast

- Model type
- Model properties
- Observations
- Verification

Useful

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

Spillman, Hobday, Feng & Behrens, in prep

What is subseasonal to seasonal forecasting?

Subseasonal to seasonal (S2S) forecasts provide information on average environmental conditions beyond 1 week out to months into the future

Dynamical models can incorporate climate change signals unlike statistical models

Typical grid resolutions ~25-60km (coarser than for weather forecasts and finer than for climate change projections)

Edwards (2011) Wiley Interdisciplinary Reviews: Climate Change
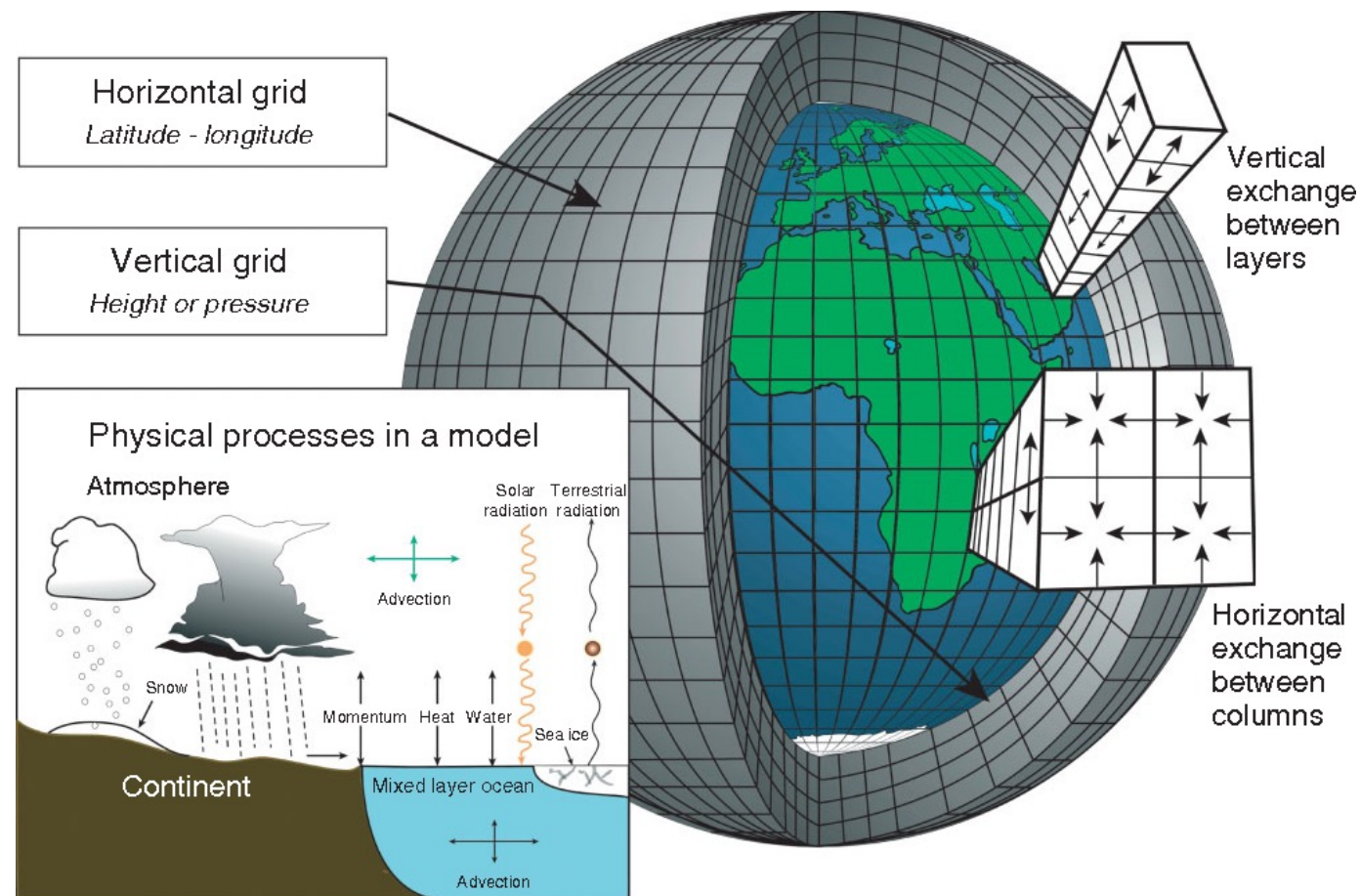
ACCESS-S2

Australian Community Climate & Earth System Simulator – Seasonal v2

- The Bureau's global dynamical coupled ocean-atmosphere ensemble prediction system

- Operational since Oct 2021
- Ocean grid: 25 km x 25 km
                    1-200 m, 75 levels

- 1981-2018 hindcast dataset
- Runs daily out to 6 months
- 99-member realtime ensemble

The Bureau of Meteorology
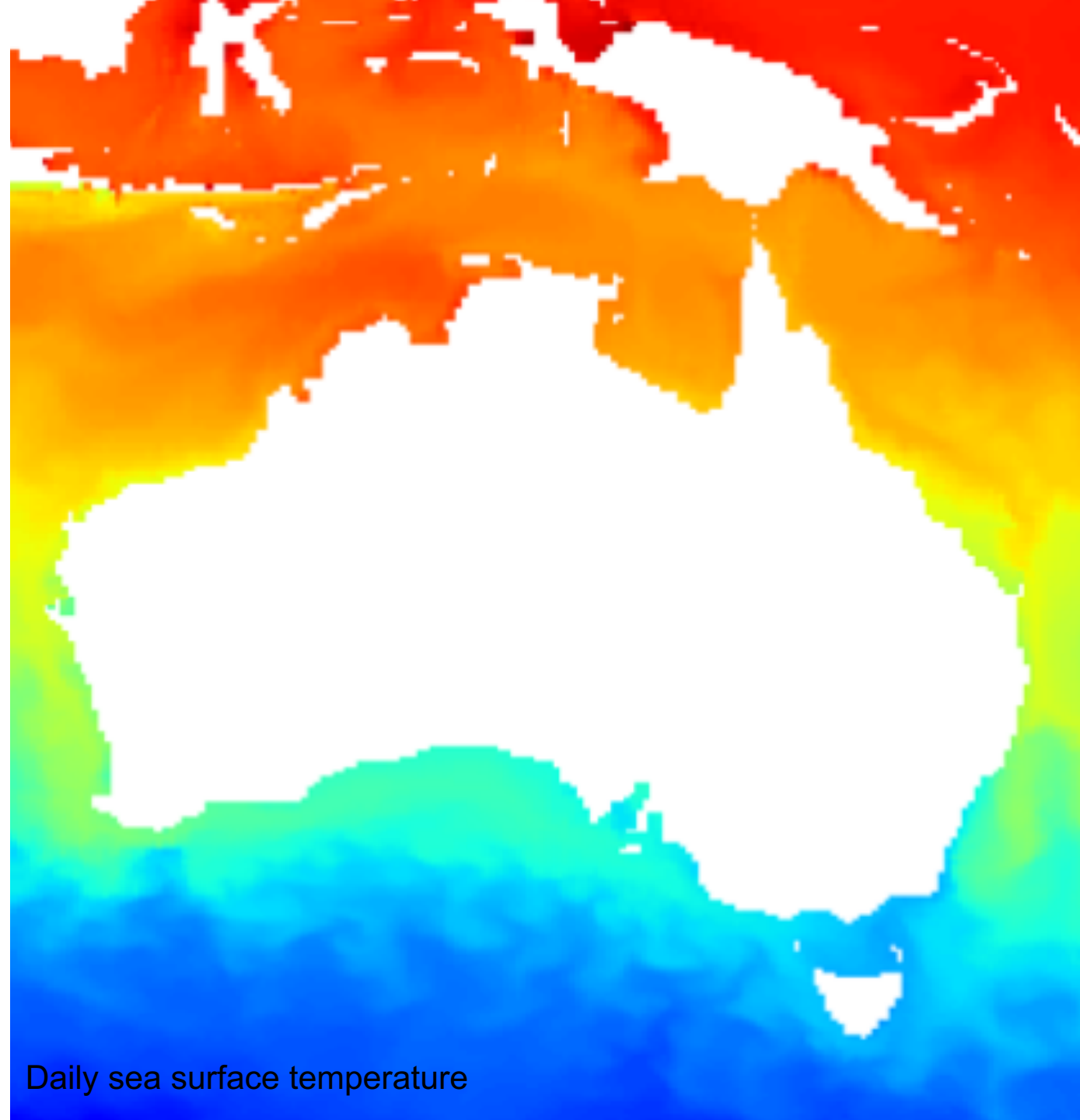
Daily sea surface temperature

When is seasonal forecasting useable?

Depends on the <u>timing</u> of management decision, critical environmental period and forecast accuracy.

Verification is a critical component of seasonal forecasting. Effective communication of forecast accuracy and skill is essential for forecast uptake.

Forecast skill

Decision lead time

Time
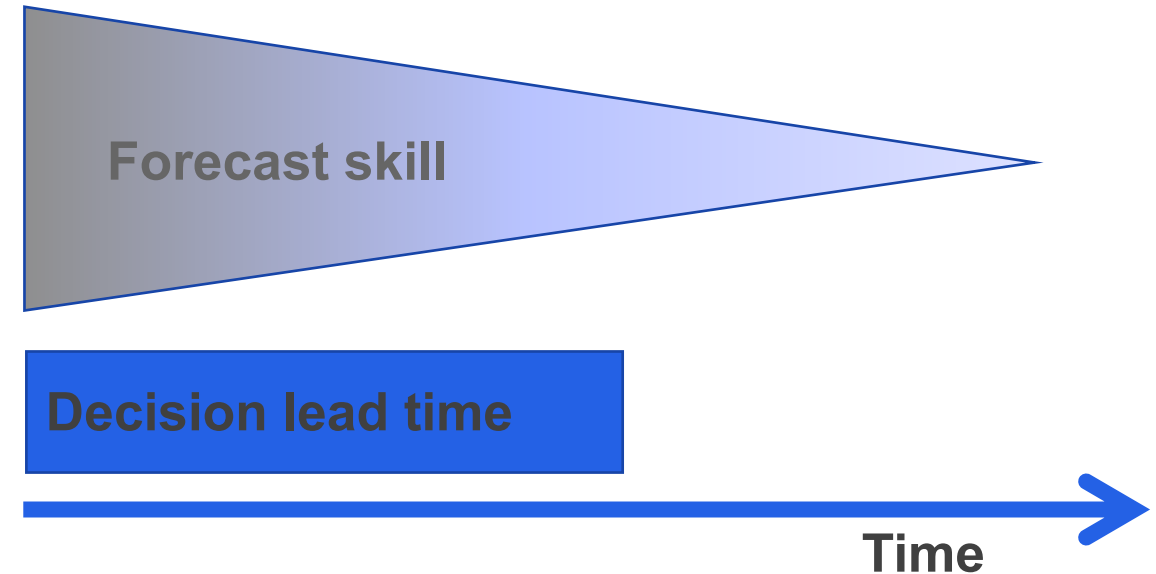
Hobday et al (2016) Fisheries Oceanography

Getting to know the decision makers

What management decisions are made? When and by who?

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

Did having a forecast change any decisions? How?

Benefits of seasonal forecasts

Use of seasonal forecasts to support decision-making can
<u>reduce costs</u> in a poor season and
<u>increase profits</u> in a good season

It could extend time an industry can cope in a location as suitability declines due to climate change

Hobday et al (2016) Fisheries Oceanography
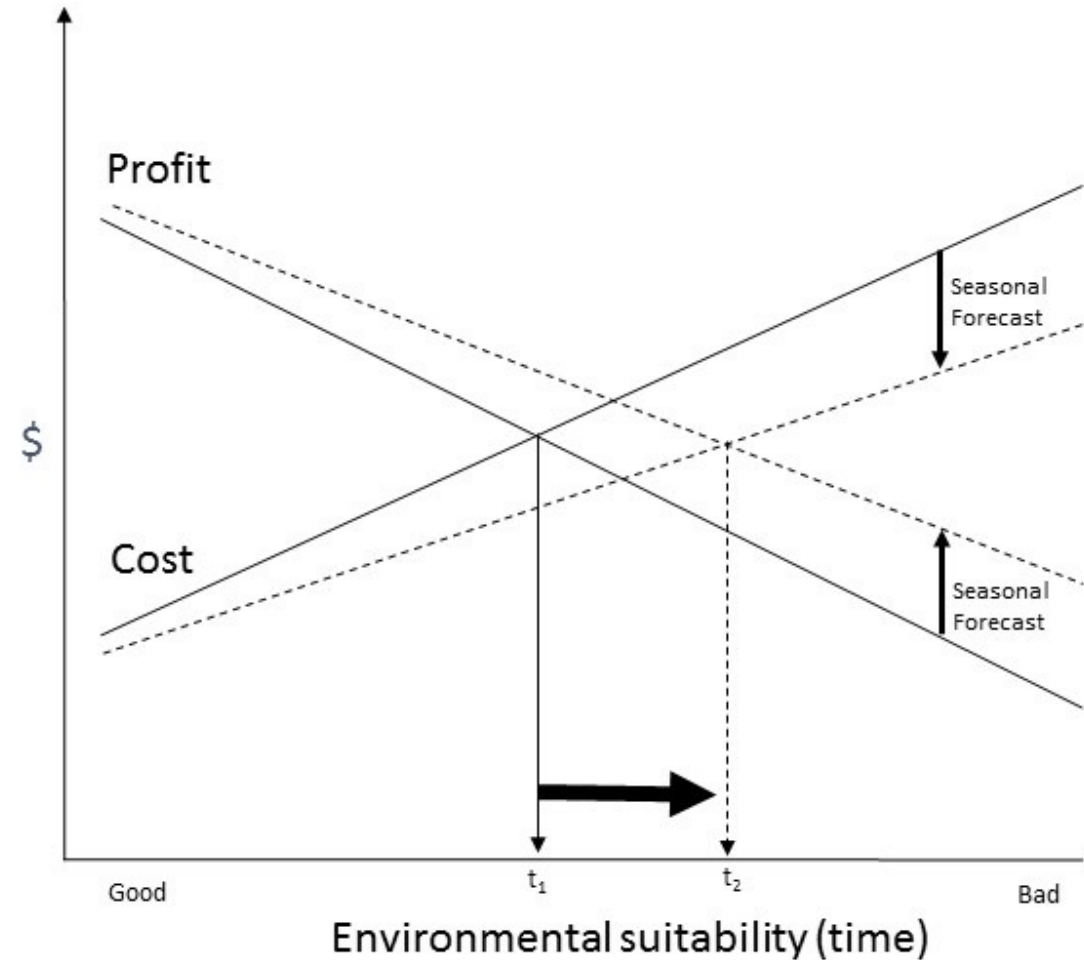
Forecast end users

- Government agencies
- Marine managers
- Fisheries regulators (AFMA)
- Aquaculture
- Commercial fisheries
- FRDC
- IMOS e.g. event-based sampling
- Defence
- Emergency services
- Research agencies & universities

How are seasonal forecasts used?

- Managers use seasonal forecasts to plan operational activities for the upcoming season
- Provides an early window to adapt management plans to mitigate impacts
- Input into downstream models
- Downscale information to station/farm/site scale
- Allow time to relocate resources for monitoring
- Probabilistic forecast information for risk assessments
- Brief government, stakeholders & public

Benefits of an end-to-end and connected approach

Feedback

Courtesy of Debbie Hudson
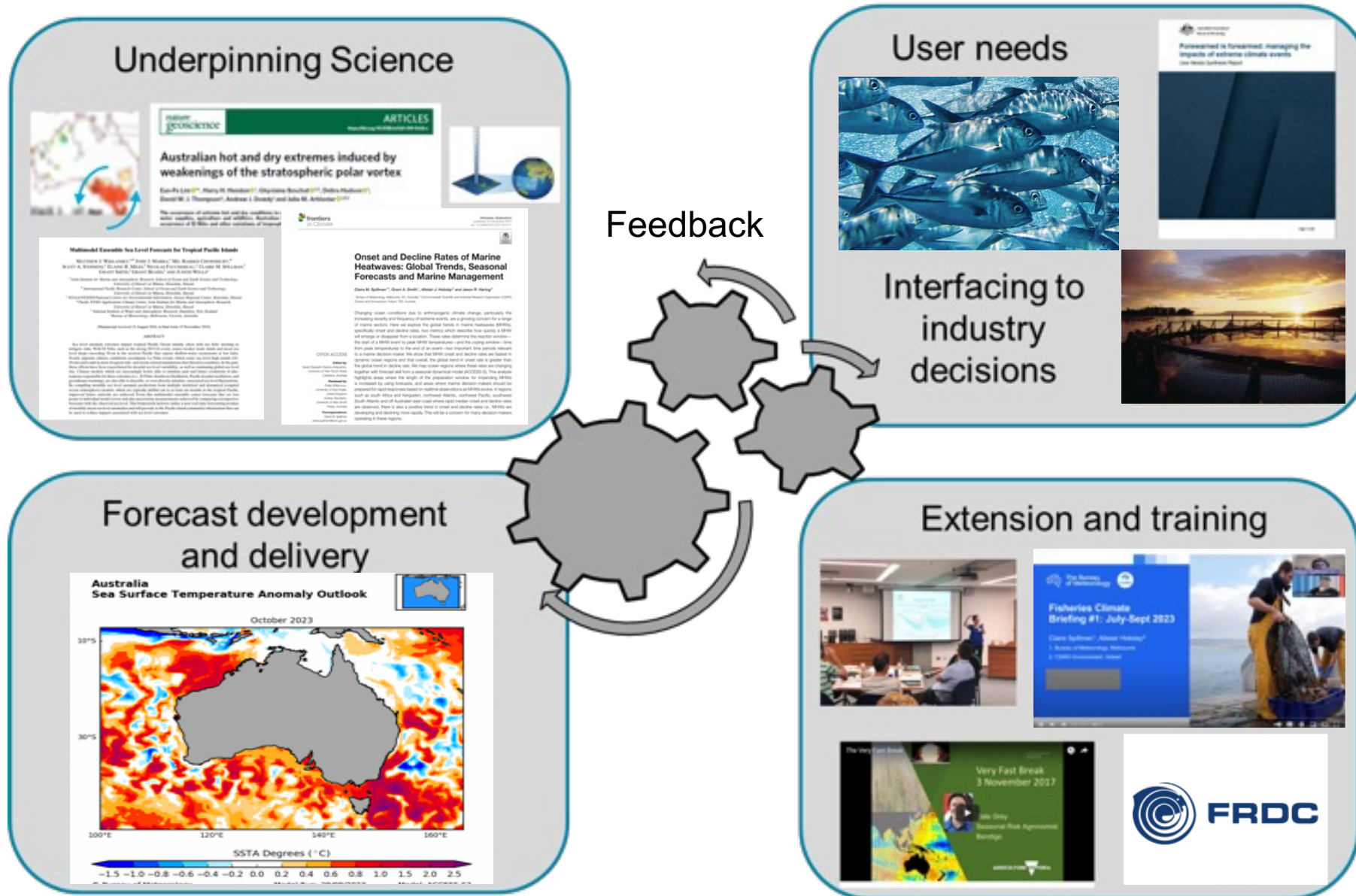
The importance of co-design, engagement & partnerships

No matter how accurate a climate outlook is:

- If it doesn't provide information users need

- If it isn't issued when users are making their critical decisions

- If it is misinterpreted

- If it cannot help make a decision….

The forecast has little real value

The footpath that was built

The footpath the user wants

Canberra 2017
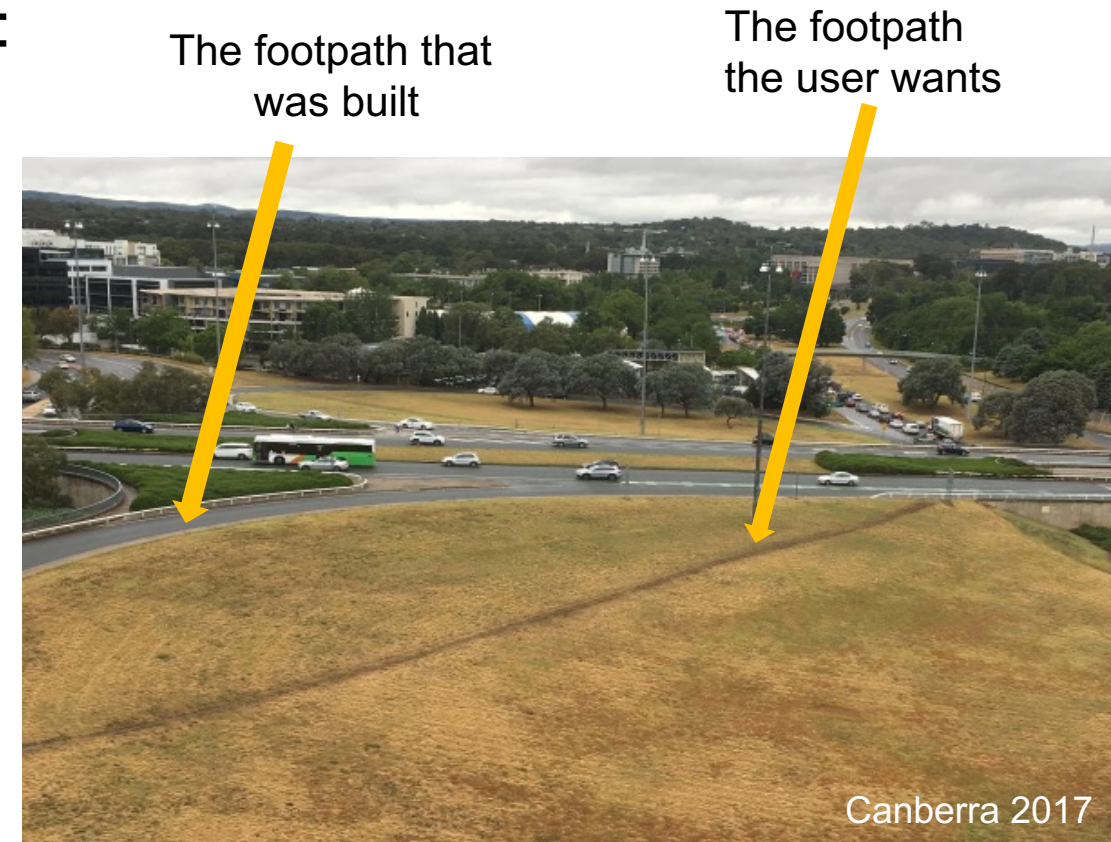
From: Andrew Watkins

Producing an operational seasonal forecast

ACCESS-S

Realtime system
- Operational October 2021
- Runs every day
- Time lagged ensemble
- Multiweek/seasonal systems

Ocean data assimilation

Hindcast system
- Retrospective forecasts
- 1981-2018, 4 starts/month
- Climatologies, percentiles
- Skill assessment

Forecast data

Climatologies Percentiles

Skill information

Post processing pipeline
Ensemblation | Anomalation | Calibration

Research
- Product development
- Trial products
- Testing prior to transition
- Monitoring
- Bug fixes

Operations
- Operational products
- Data feeds

Public webpages

Input to downstream services

Registered data services

Data feeds

Trial product webpage
- Customer feedback

Wedd et al 2022, Griffiths et al 2023

Delivering an operational service

- Operationally supported with service level agreement

- Internal product, data feed or public facing product/service

- Delivery methods
    - Online
    - Datafeeds
    - Reports
    - Briefings

- Future maintenance/upgrades

- Technical & scientific documentation

- Decision support tools

Operational Bureau seasonal ocean services

- **Climate driver outlook**
  - ENSO outlook
  - Indian Ocean Dipole (IOD) outlook
  - Subsurface information

- **Ocean temperature outlooks**
  - Australia & global

- **Marine heatwave forecasts**
  - Trial, transitioning to operations

- **Sealevel outlooks**
  - Pacific focus
  - Service expansion through ACS

Seafood Sector: Ocean Services & Information

Ocean Temperature Outlooks
Realtime sea surface temperature forecasts for Australian waters up to 6 months ahead (25km resolution)
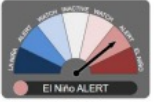- SST, SST anomalies, accumulated thermal stress
- Forecast accuracy
www.bom.gov.au/oceanography/oceantemp/sst-outlook-map.shtml

Climate Driver Outlook
Current conditions and climate outlook:
- ENSO (La Niña/El Niño)
- Indian Ocean Dipole
- Southern Annular Model (SAM)
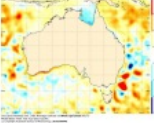- Cloudiness & trade winds
www.bom.gov.au/climate/enso/

OceanMaps
Daily ocean forecasts out to 7 days for Australia
- SST & salinity
- Sealevel, currents
www.bom.gov.au/oceanography/forecasts/

Wind & Wave Forecasts
For the Australian coast
www.bom.gov.au/australia/meteye

Rainfall & Air Temp Outlooks
Seasonal outlooks for up to 3 months ahead
www.bom.gov.au/climate/outlooks/

Tide Predictions
Australia, South Pacific and Antarctica
www.bom.gov.au/australia/tides/

Tropical Cyclone Outlooks
Outlook for Australia for Nov-April
www.bom.gov.au/climate/cyclones/Australia/
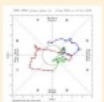
Tropical Climate Update
Past fortnight over northern Australia
www.bom.gov.au/climate/tropical-note/

Madden-Julian Oscillation (MJO)
- Current phase
- Observed cloudiness
- Outgoing longwave radiation
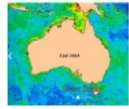www.bom.gov.au/climate/mjo/

Sea Temperature Analysis
Latest global daily satellite SST
www.bom.gov.au/marine/sst.shtml

IMOS Ocean Current
Observed SST, ocean colour, waves, sealevel for Australia
https://oceancurrent.aodn.org.au/

Realtime Marine Heatwave Tracker
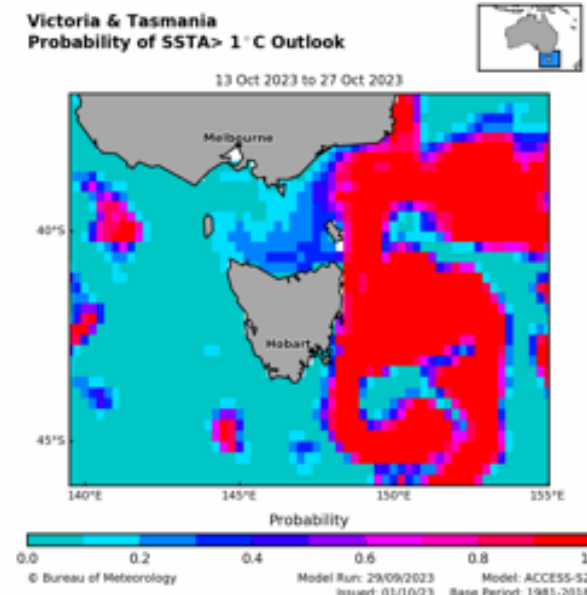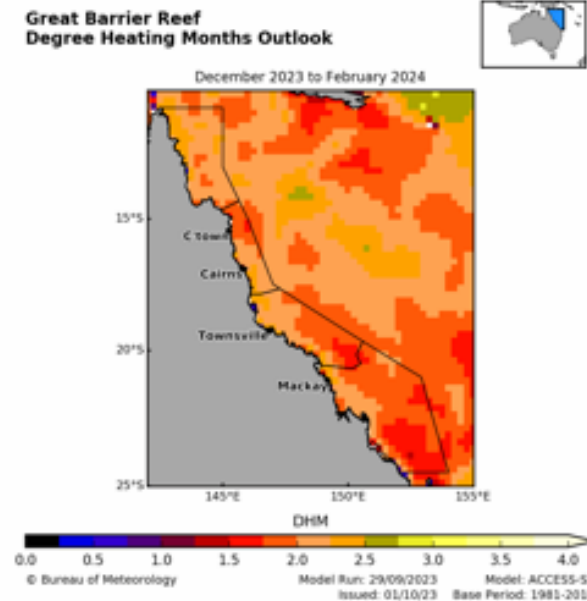www.marineheatwaves.org/tracker.html

Historical SST & Trends
www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries

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

Ocean temperature outlooks

- Seasonal ocean temperature outlook first developed for GBR in 2009
- First operational coral bleaching risk forecasts in the world
- SST, thermal stress and probabilistic products out 6 months into the future
- Skill information

- Expanded to all Australian waters with ACCESS-S in 2018

http://www.bom.gov.au/oceanography/oceantemp/sst-outlook-map.shtml
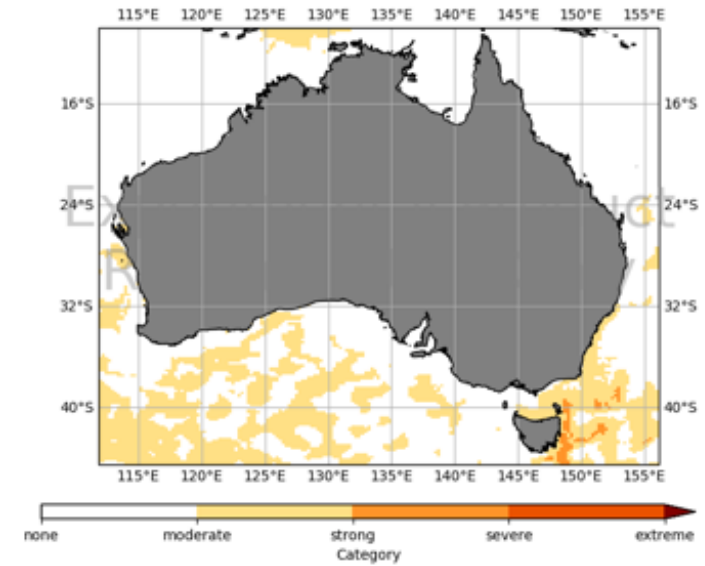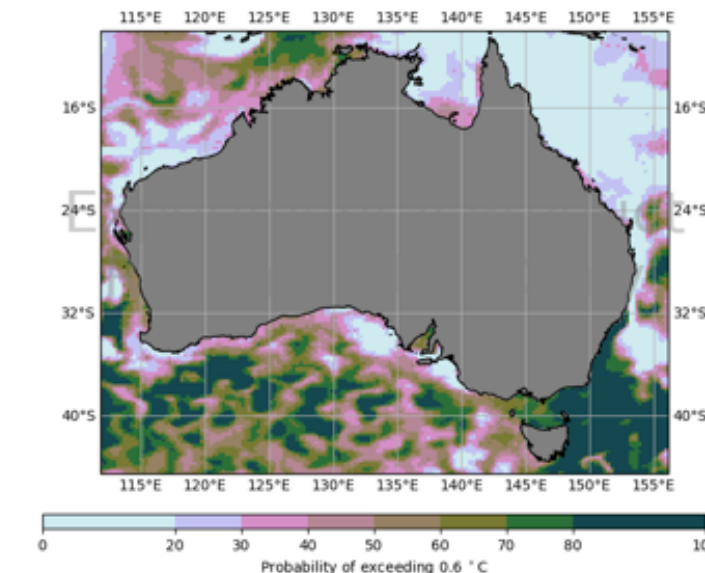

Smith & Spillman 2019; Spillman & Smith 2021
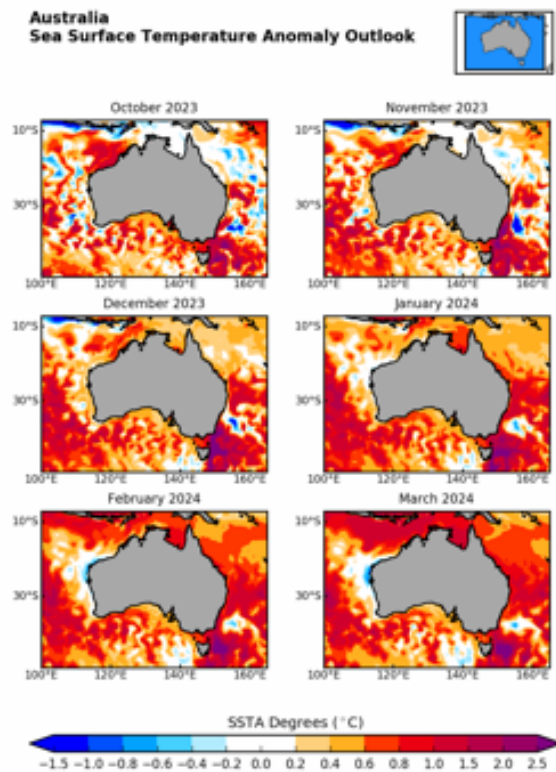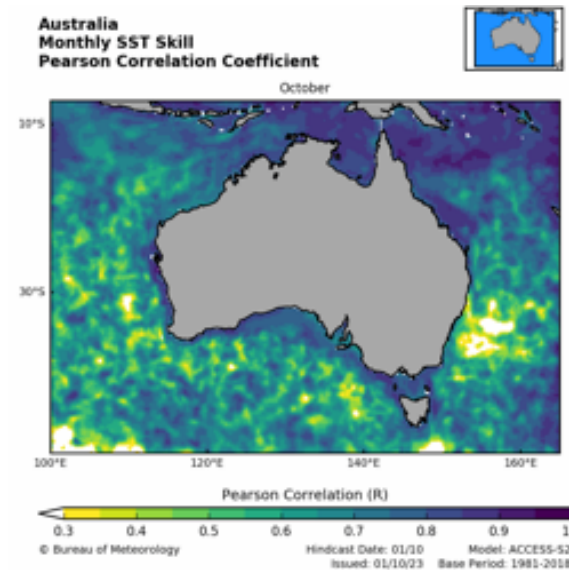
Marine heatwave outlooks

- Bureau-CSIRO research project
- Prototype seasonal MHW forecast products running in trial mode
- Used in national and targeted briefings
- FRDC have confirmed funding to operationalise these products
- Planned public release mid 2024 as part of the seasonal ocean outlook product suite

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

Monthly emn SST Marine Heatwave Category
Region: Australia
Start: 18-Nov-2023
Period: Month 01-Dec-2023 to 31-Dec-2023

Created: 2023-11-20 10:23:29 +0000   Climatology: 1981-2018   Resource: access-s / s_ens

Monthly Sea Surface Temperature Anomaly (°C)
Region: Australia
Start: 18-Nov-2023
Period: Month 01-Dec-2023 to 31-Dec-2023

Probability of exceeding 0.6 °C

Created: 2023-11-20 10:21:50 +0000

Smith & Spillman (in review), Smith et al (in prep)

Seasonal sealevel forecasts

- Operational seasonal SSH forecasts via the COSPPac Pacific Portal
- Used with tide predictions for Pacific Islands to assess risk of flooding

- Trial multi-model SSH forecasts at Pacific tide gauges from UHSLC
- Work in Australian Climate Service (ACS) to develop a coastal flooding hazards service

http://access-s.clide.cloud/

https://uhslc.soest.hawaii.edu/sea-level-forecasts/

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High-tide flooding (HTF) early warning system

Tide Prediction **+** Sea Level Rise **+** *ACCESS-S Seasonal Anomalies (planned)* **Predicted (deterministic)**

+

Statistical (climatological distributions) High-frequency residual **=** Daily probability of HTF (1-12 month lead)

Based on NOAA system (Dusek et al. 2022)

HTF **Predicted** **Observed**

HTF threshold

5% warning threshold

Example: Townsville Tide Gauge, 2009-2010

Exploring inclusion of seasonal predictions, ENSO-residual impact, calibration options

From Ryan Holmes

Brier skill score (Const. ref.)

Higher = better

Performance best where tides are largest, worst where events are residual-driven
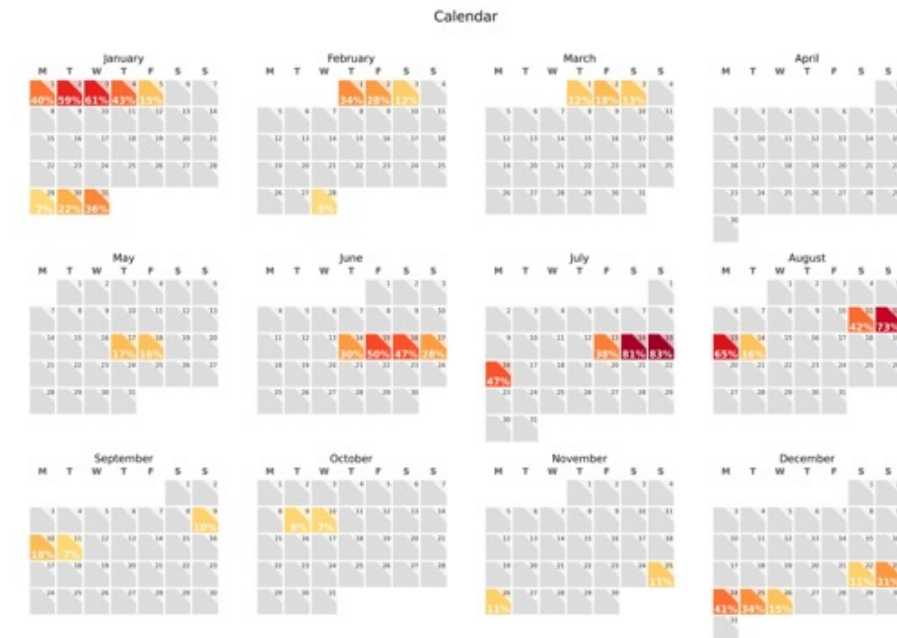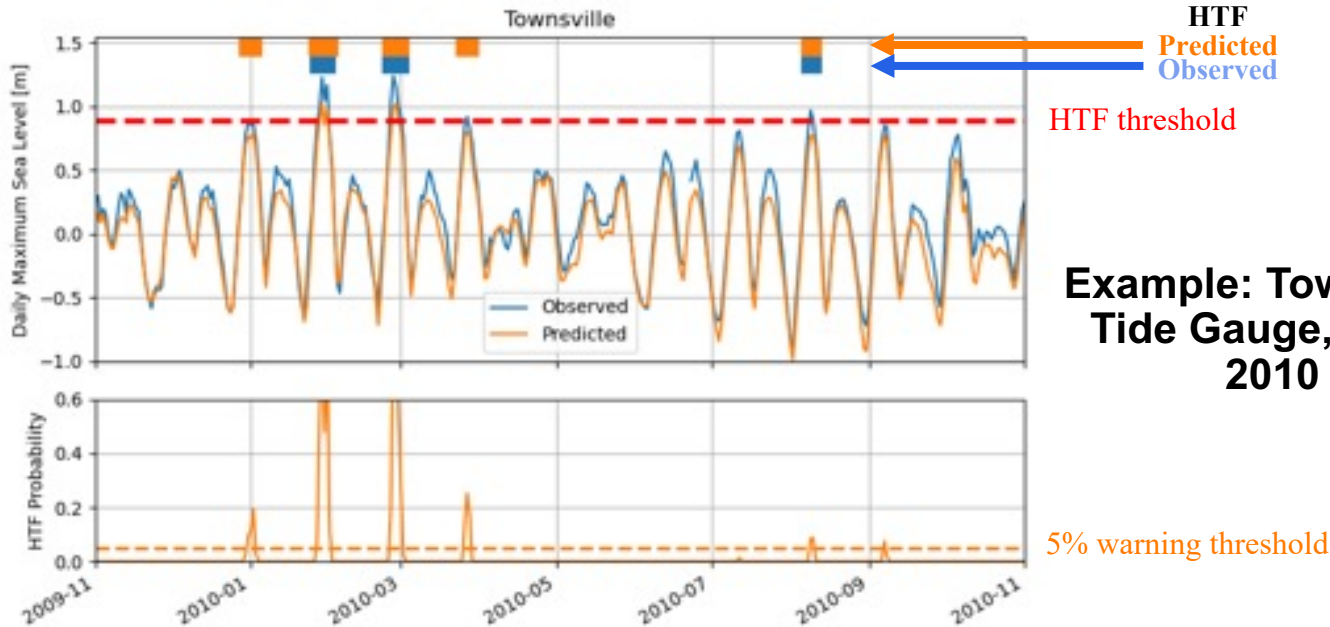
Calendar

Possible product: High Tide Flooding Calendar

Decision support

- Where do we monitor this season?
- 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?

Ability to use forecast information depends on agility

Management responses are influenced by **agility** & **risk appetite** of industries and sectors

Example:

Aquaculture likely to have greater agility, and hence more options, than wild fisheries

Hartog et al (2023)

Take home points

- For effective decision support:
  - the model needs to be <u>useful</u>
  - forecasts need to be <u>useable</u>
  - the forecast information <u>used</u>
- Co-design with users is critical!

- Seasonal forecasting allows for **proactive management** and response, increasing the **resilience** of marine industries, resources and coastal communities in the future.

Thank you

National fisheries briefings:
Briefing 1 - 23 June: https://www.youtube.com/watch?v=EhqalioYD4c
Briefing 2 - 25 August: https://www.youtube.com/watch?v=-Fp9g35KbNw