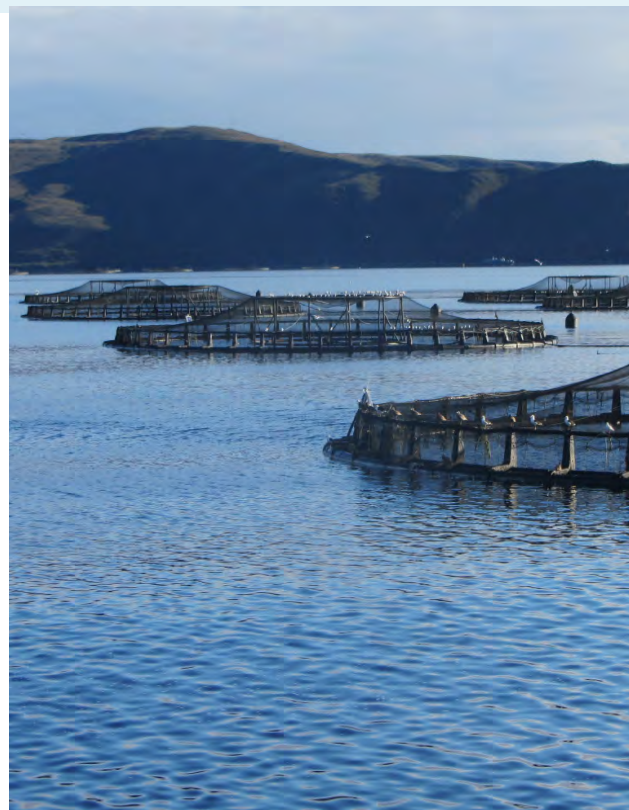




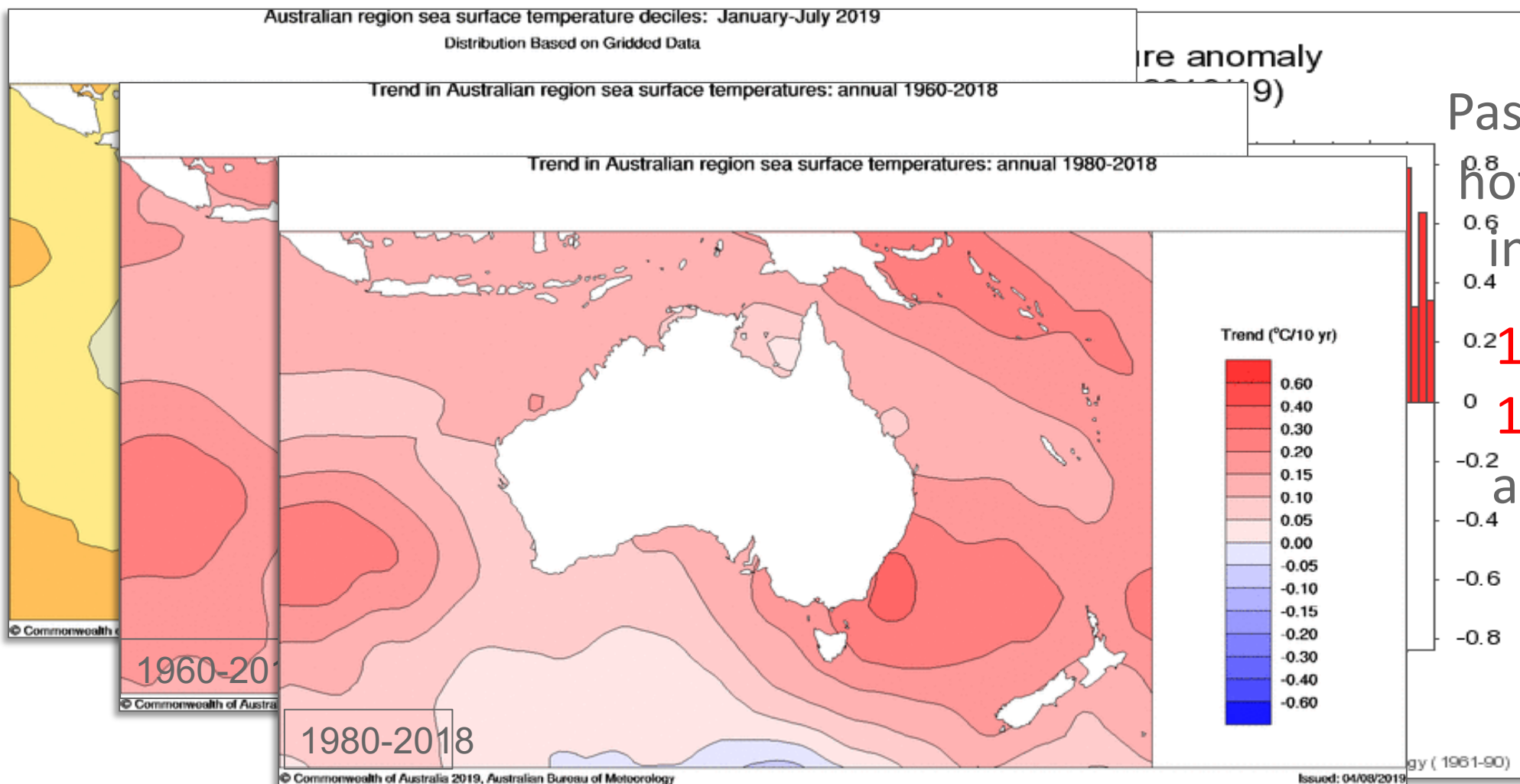
Using seasonal forecasts to manage impacts of extreme ocean temperatures on marine industries

Claire Spillman, Grant Smith, Alistair Hobday, Jason Hartog,
Catherine de Burgh-Day, Paige Eveson





Warming oceans



Past two summers hottest on record in Tasman Sea:

17-18: 1.49 °C

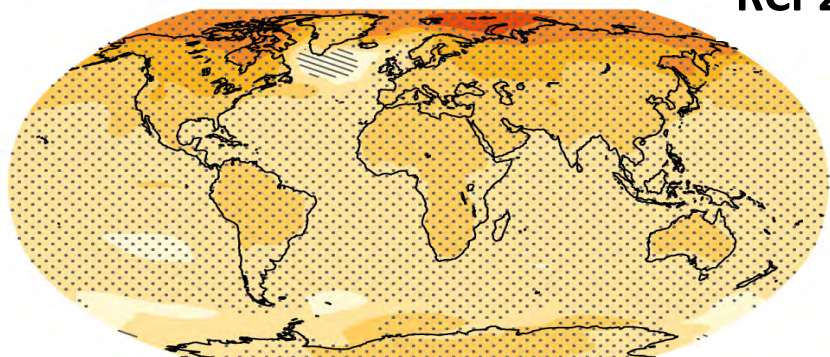
18-19: 1.15 °C

above average

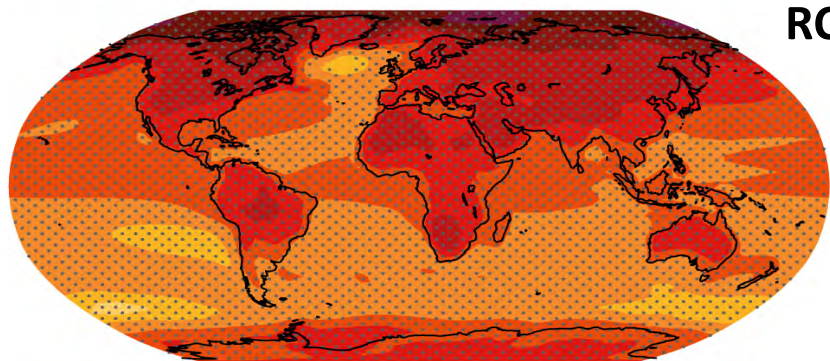


Impacts of rising ocean temperatures

RCP2.6



RCP8.5



Change in average surface temperature (1986–2005 to 2081–2100)

Marine heat events

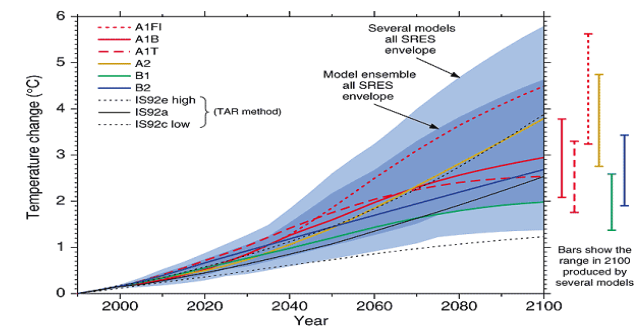
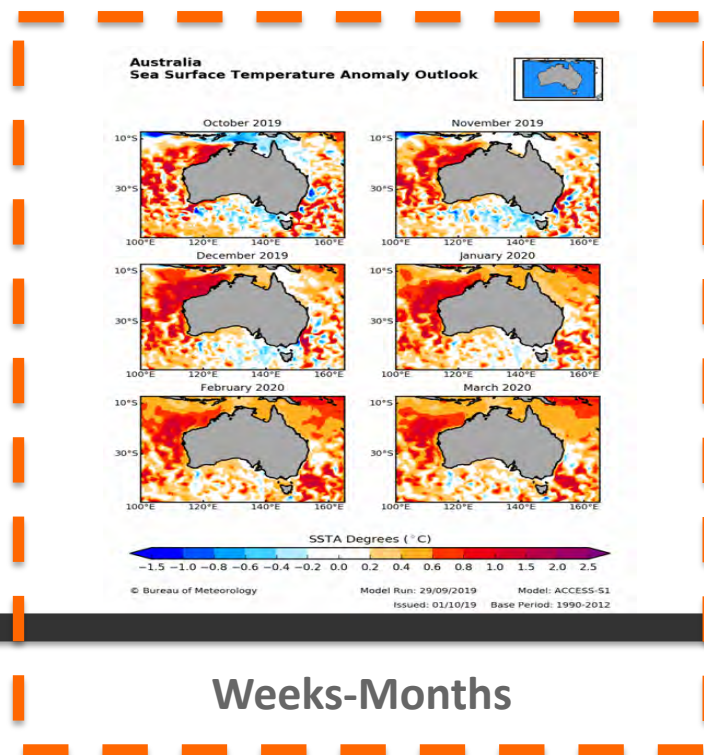
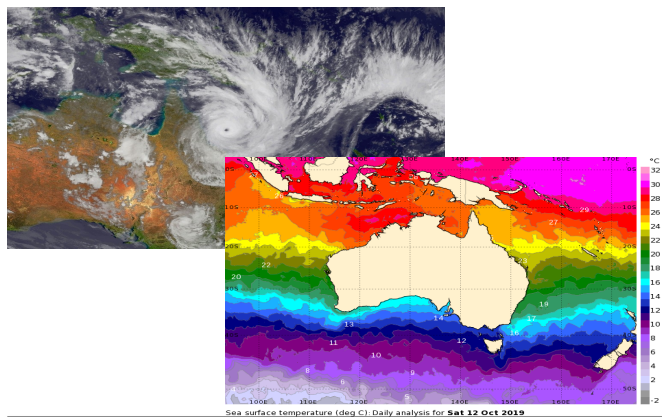


- Mass coral bleaching
- Thermal limits exceeded
- Changes in growth rates
- Increased disease risk
- Changing habitat distributions
- Altered migration & spawning
- Altered food availability



Role for seasonal forecasting?

Advance warning of marine heat events can provide an early window for implementation of management strategies to **minimize impacts** on marine resources and **increase resilience**



Days

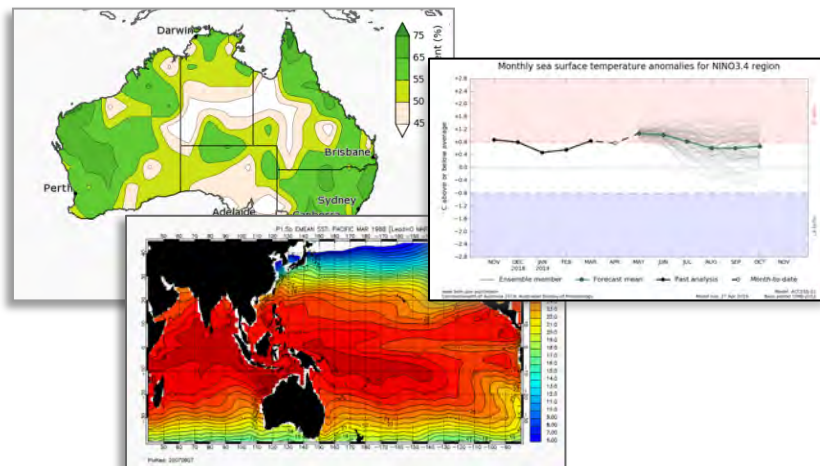
Weeks-Months

Years-Decades

Seasonal timescale



Seasonal forecasting



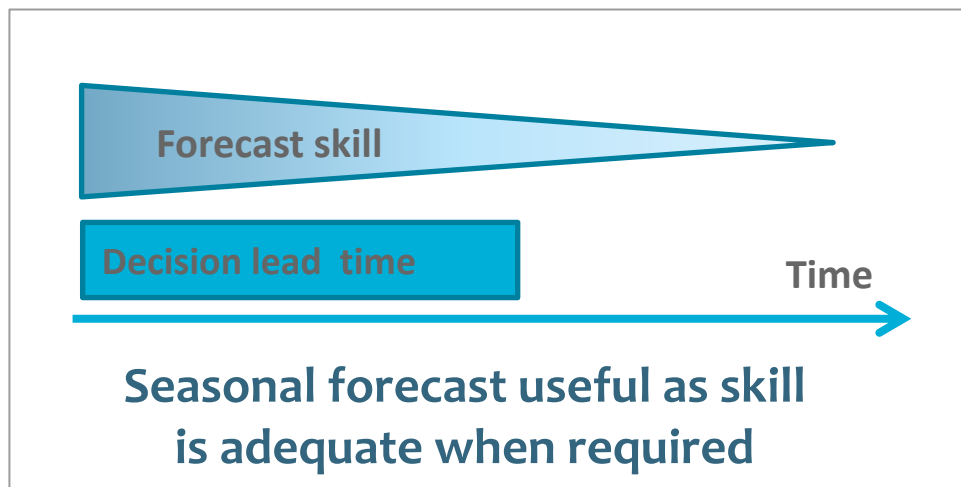
What is seasonal forecasting?

Seasonal forecasts provide information on average environmental conditions for several weeks to months into the future.

Dynamical models can incorporate climate change signals unlike statistical models

When is seasonal forecasting useful?

Usefulness depends on the **timing** of management decision, critical environmental period and **forecast accuracy**.

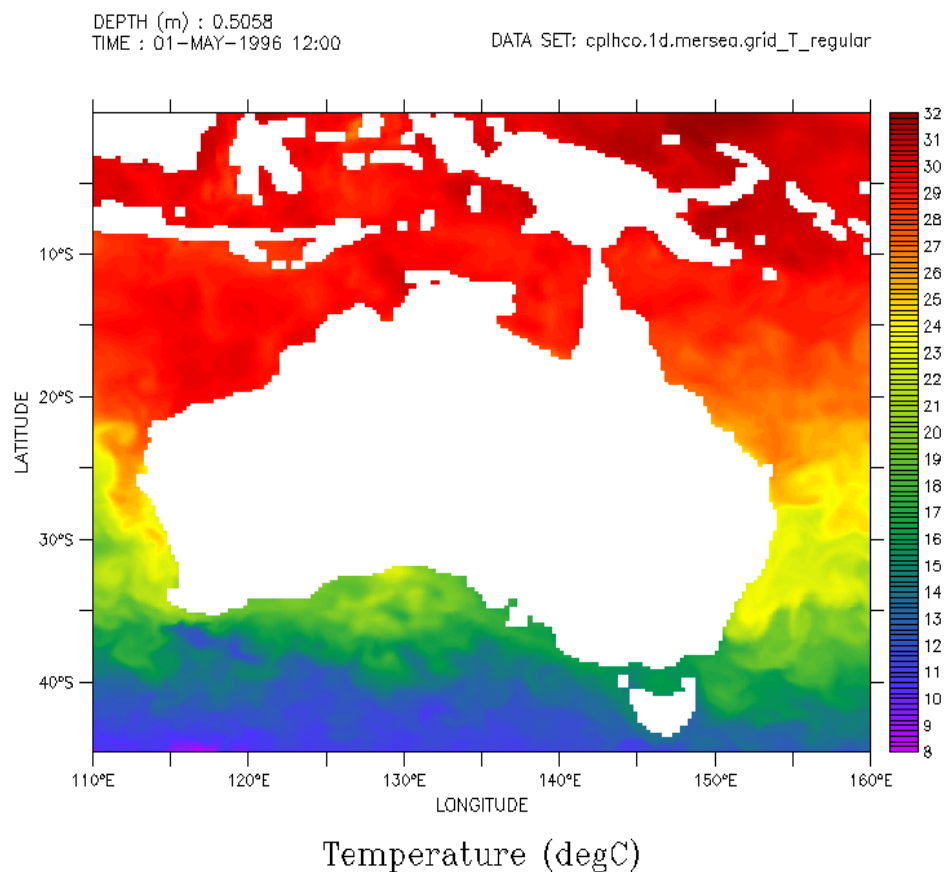




ACCESS-S

Australian Community Climate & Earth System Simulator - Seasonal

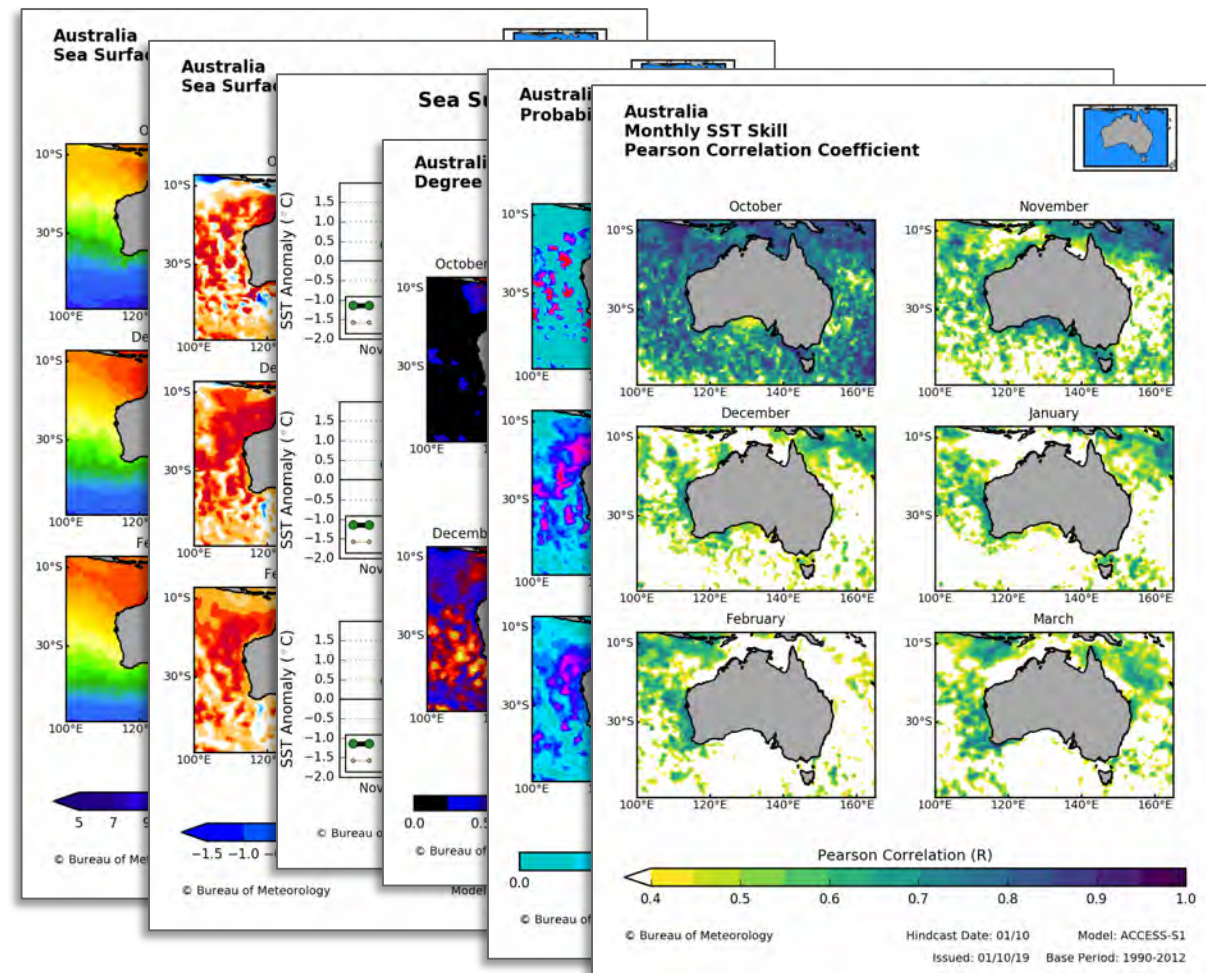
- New Bureau operational dynamical **global** seasonal ensemble prediction system (ACCESS-S1)
- Hindcast dataset 1990-2012
- Forecasts out to 6 months
- Realtime 99 member ensemble forecasts from 2018
- ACCESS-S2 operational in 2020
- **Ocean model (NEMO):**
 - Horizontal: 25 km x 25 km
 - Vertical: 1-200 m layers
- Temperature, salinity, currents, winds, SL, MLD





Operational SST forecast service for Australia

- Replaces and expands legacy operational POAMA SST GBR forecast service
- Operational ACCESS-S1 monthly SST-based forecasts out to 6 months
- Products updated twice weekly in realtime
 - Mean corrected SST
 - SST anomalies (ref 1990-2012)
 - Regional SST reef indices
 - Hotspots & Degree Heating Months
 - Probability of exceedance
 - Forecast skill



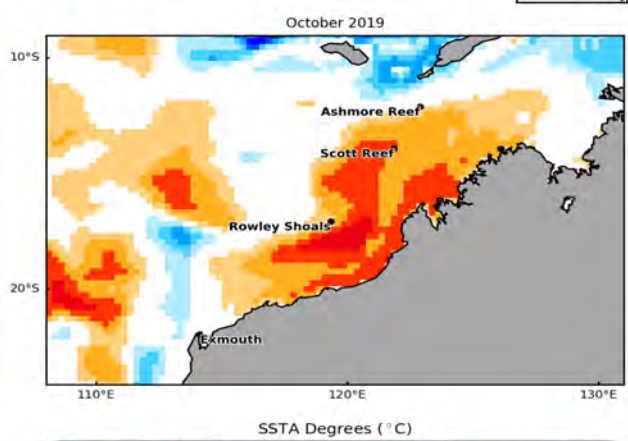


Australian Bureau of Meteorology

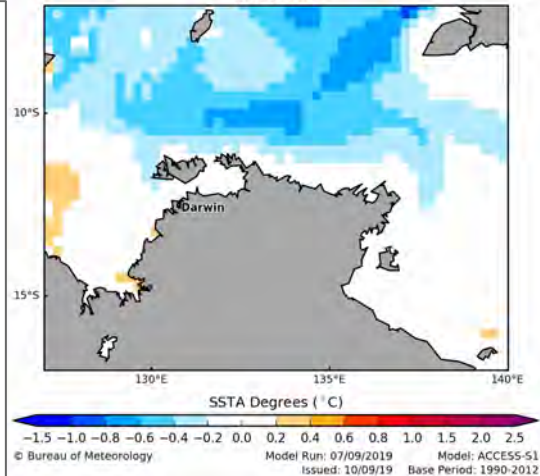
Christmas & Cocos (Keeling) Island Sea Surface Temperature Anomaly Outlook



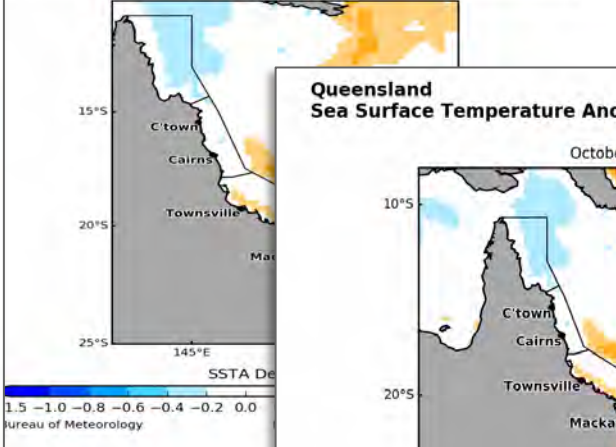
North Western Australia Sea Surface Temperature Anomaly Outlook



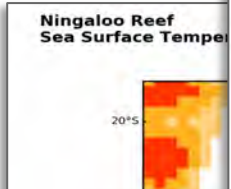
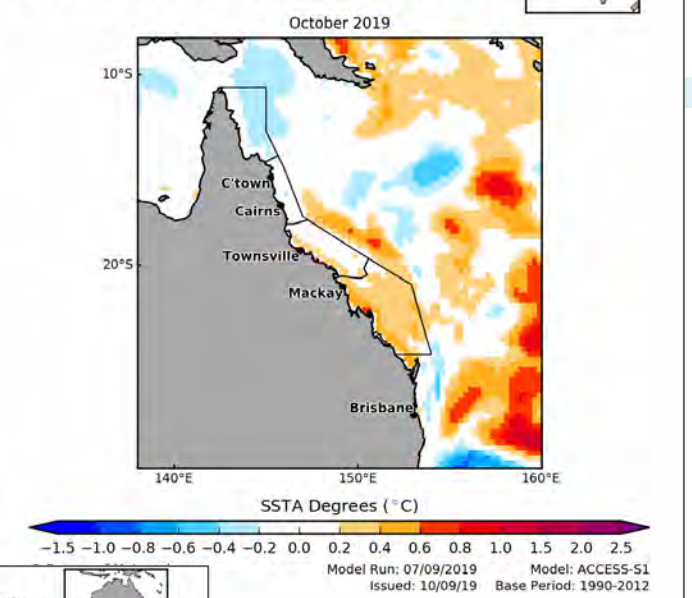
Northern Territory Sea Surface Temperature Anomaly Outlook



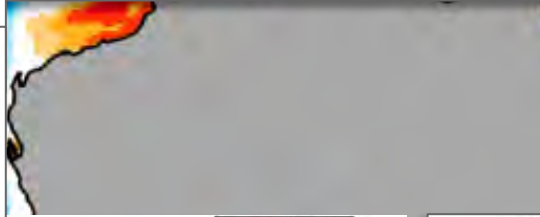
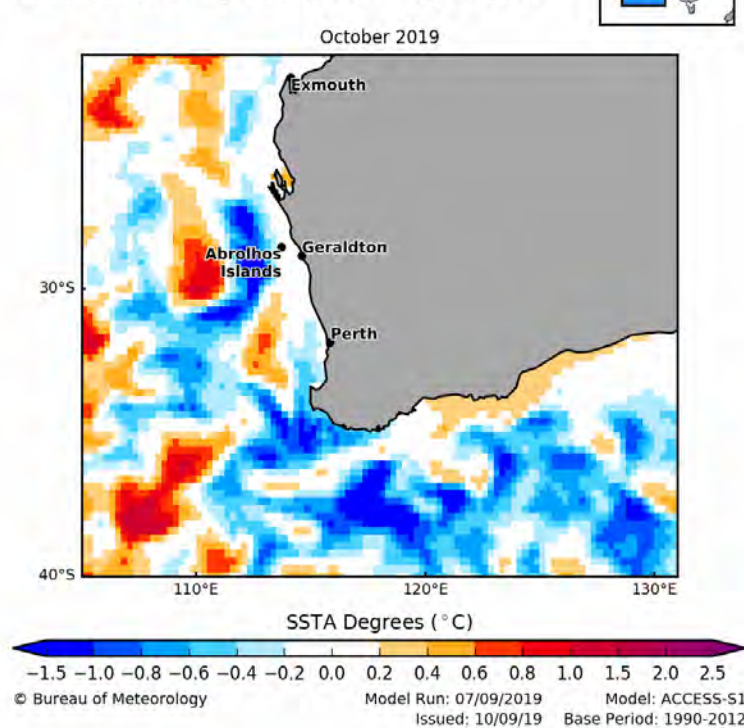
Great Barrier Reef Sea Surface Temperature Anomaly Outlook



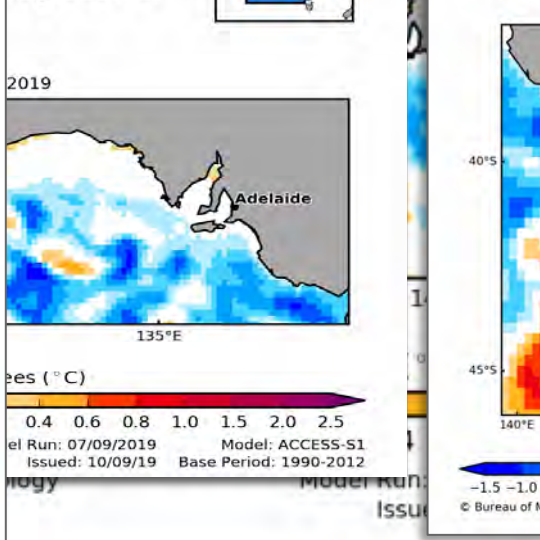
Queensland Sea Surface Temperature Anomaly Outlook



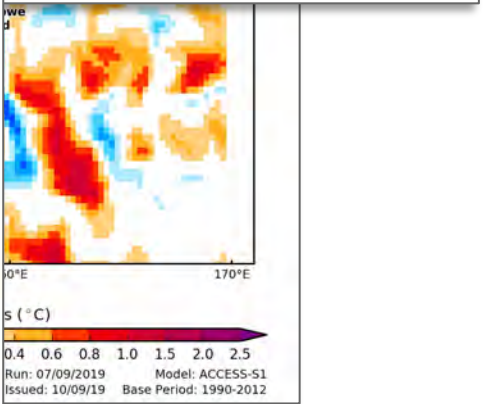
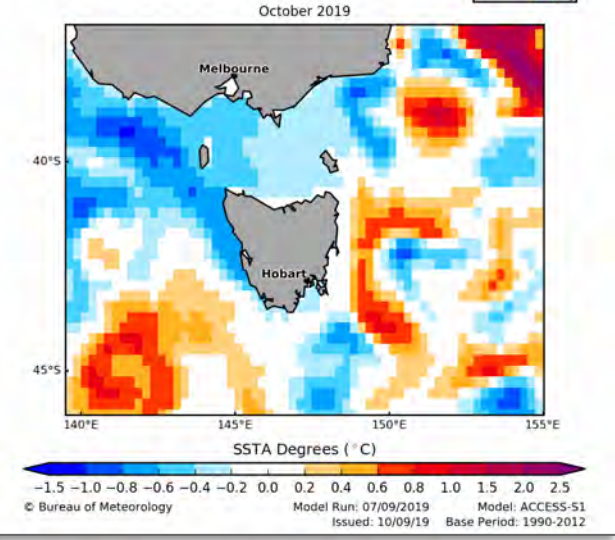
South Western Australia Sea Surface Temperature Anomaly Outlook



New South Wales Sea Surface Temperature Anomaly Outlook



Victoria & Tasmania Sea Surface Temperature Anomaly Outlook



© Bureau of Meteorology Model Run: 07/09/2019 Model: ACCESS-S1 Issued: 10/09/19 Base Period: 1990-2012

© Bureau of Meteorology Model Run: 07/09/2019 Model: ACCESS-S1 Issued: 10/09/19 Base Period: 1990-2012


© Bureau of Meteorology Model Run: 07/09/2019 Model: ACCESS-S1 Issued: 10/09/19 Base Period: 1990-2012

© Bureau of Meteorology Model Run: 07/09/2019 Model: ACCESS-S1 Issued: 10/09/19 Base Period: 1990-2012

Ocean temperature forecasts for industry

Marine Heatwaves 
Various in prep

 **Coral Reefs**
Smith & Spillman 2019
Spillman et al 2012

 **Tuna & Billfish**
Spillman et al in prep

 **Sth Bluefin Tuna**
Hobday et al 2011

 **Sth Bluefin Tuna**
Eveson et al 2015

 **Dolphinfish**
Brodie et al 2017

 **Atlantic Salmon**
Spillman & Hobday 2014

 **Pacific Salmon**
De Burgh-Day 2019



Australian Government
Great Barrier Reef Marine Park Authority

 **NIWA**
Taihoro Nukurangi

 **AUSTRALIAN INSTITUTE OF MARINE SCIENCE**

 **FRDC**

 **TSGA**

 **tassal**

 **CLIOTOP**
Climate Impacts on Oceanic Top Predators

 **Australian Marine Parks**

 **Australian Government**
Australian Fisheries Management Authority

 **Australian Southern Bluefin Tuna Industry Association (ASBTIA)**

 **APFA**



Working with industry



- Strong industry engagement essential
- Clear understanding of industry issues, capabilities & operational requirements
- Forecast support & training
- Industry feedback

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?



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Informing industry decisions

- Where do we survey this summer?
- Should we put our resources into monitoring coral bleaching this summer or other activities?
- Where to put our IMOS gliders to monitor an event?
- Will our fish stocks be further south this year?
- When should we leave port?
- Do we need extra staff to manage operations this summer?
- Should we thin our stocks or increase our seeding?
- Do we need to order more feed?
- Should we harvest early? Could we get two harvests this year?
- Where do we place our fish aggregation devices?





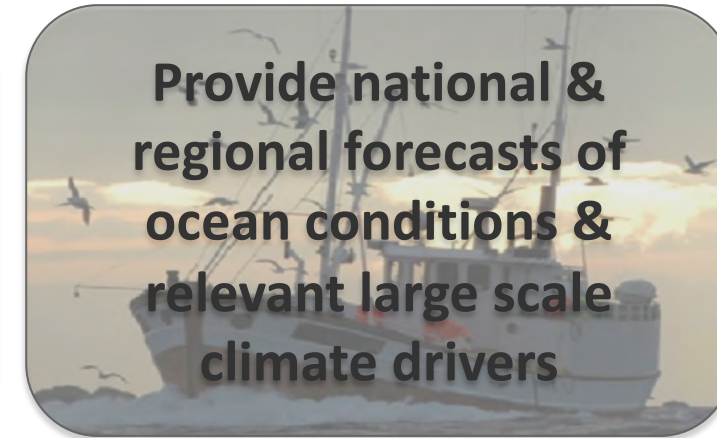
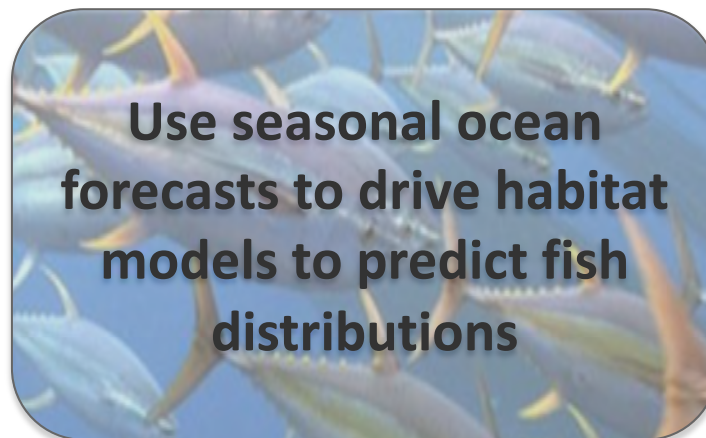
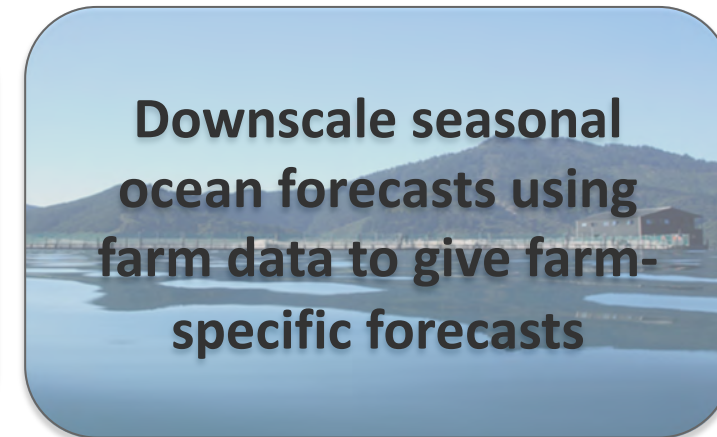
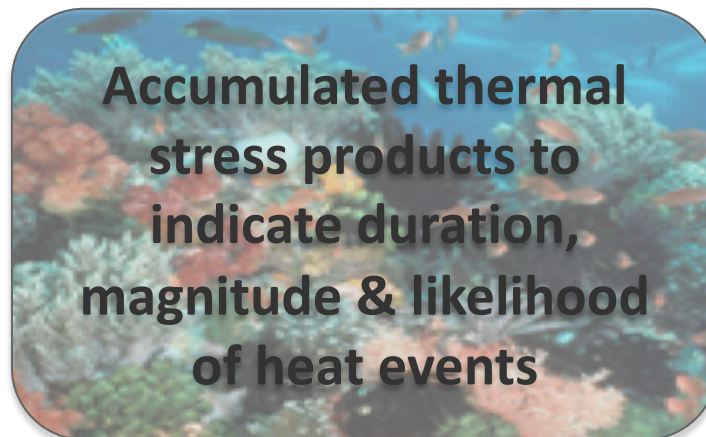
Tailoring forecast information

Typical management issues:

Changing fish distributions
Impacts on growth rates, disease risk and habitat distributions
Mass coral bleaching & mortality

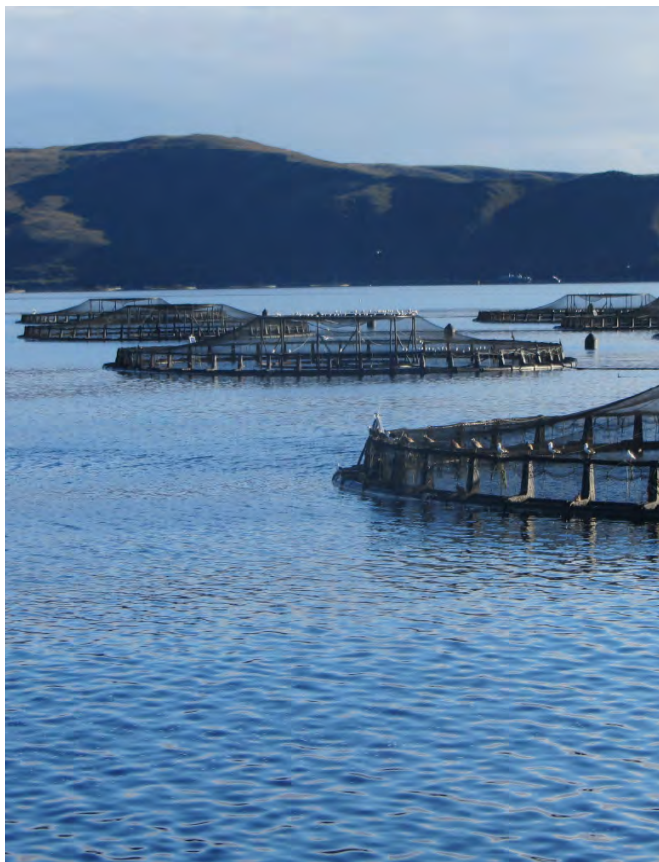
Management tools:

Tailored seasonal forecast products based on ocean temperature up to a season ahead to allow industries and managers to better plan operational activities





Benefits of seasonal forecasting



- Managers use seasonal forecasts to plan operational activities for the upcoming summer
- Provides an early window to implement management strategies to reduce impacts of marine heat events
- Probabilistic forecast information for risk assessments
- Brief government, stakeholders & general public
- Identification of future threats for long term planning
- Use could extend the period of time in which industry can cope in a location as environmental suitability declines due to climate change



Prediction of marine heat events in the future

- Advance warning of potential marine heat events allowing for proactive management and response
- Wide range of potential marine applications
- Gain an understanding of the processes occurring & the influence of large scale climate drivers
- Identification of future threats for long term planning & policy development
- Warming oceans under climate change are likely to increase both the frequency and severity of heat related impacts on marine resources in the future





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Thank you

Seasonal ocean outlooks: <http://www.bom.gov.au/oceanography/oceantemp/sst-outlook-map.shtml>

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