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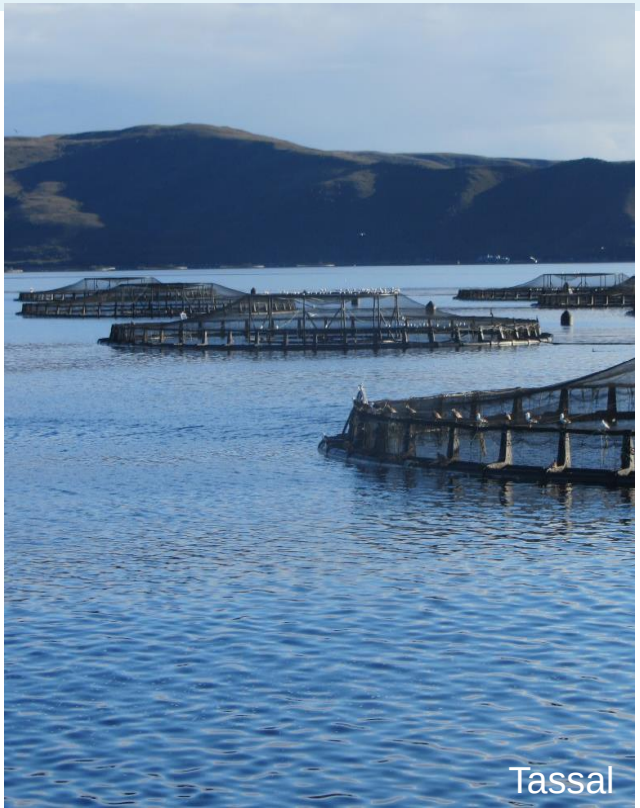
Spatial management of fisheries in a changing ocean – using operational oceanography

Claire Spillman, Alistair Hobday
Jason Hartog, Paige Eveson, Stephanie Brodie



Tassal

Boat sales

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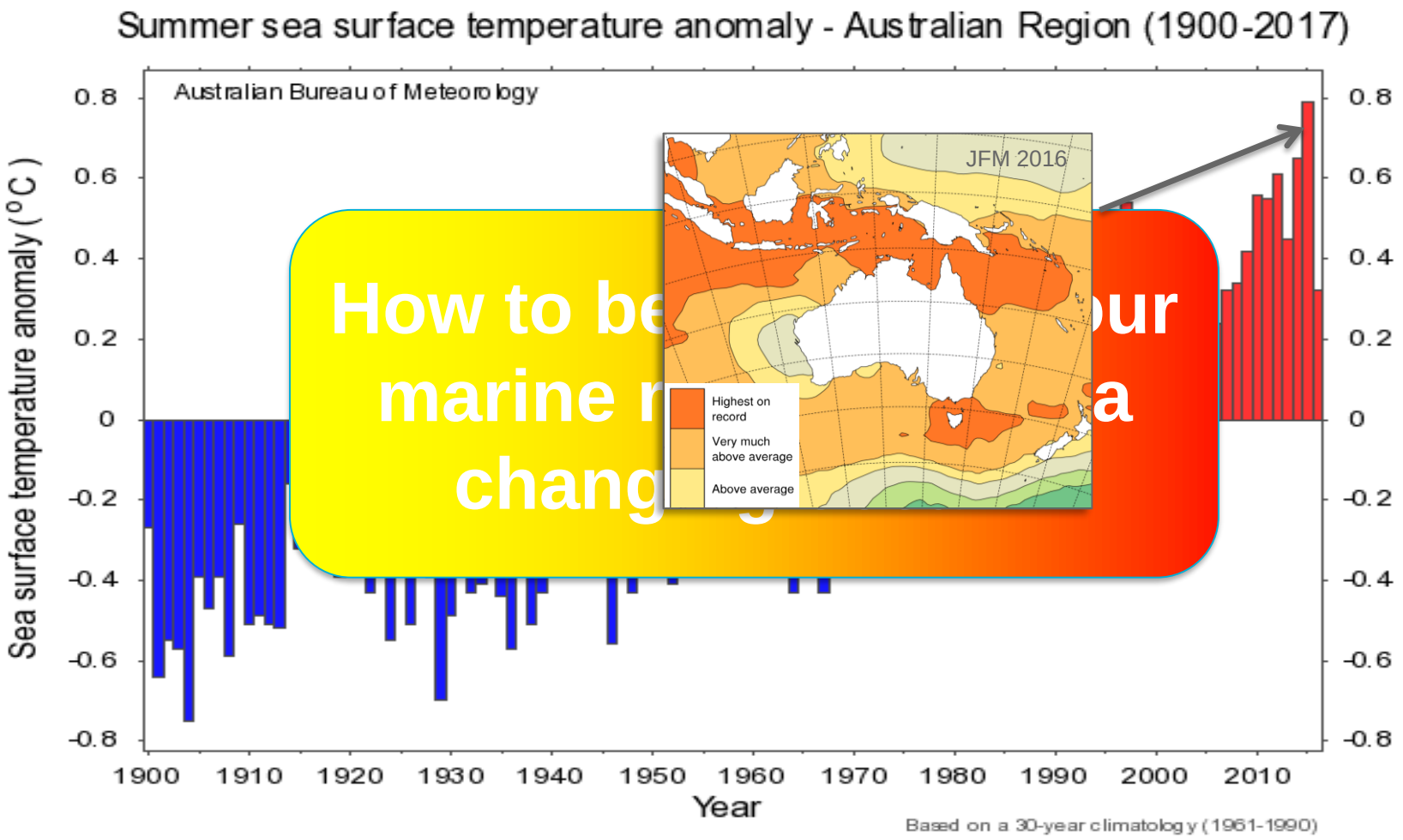
Warming oceans



ERSSTv4 SST dataset : climatology 1961-1990

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WA's scallop industry recovering from five-year collapse

By Sarah Taillier

Posted 1 Jul 2016, 5:43pm

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Anglers have helped detect a shift in the habitat of black marlin

December 2, 2015 2.27pm AEDT

The Great Ba surveys revea

Tom Arup, Environment Edi

Published: April 20, 2016 -

Reef on the brink

The Great Barrier R

Australia's natural wonder is in morta killed almost a quarter of its coral this for the rest. Using exclusive photogra investigates how the reef has been de

by Michael Slezak

ABC NEWS LOCATION: Sydney, NSW Change

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Special coverage China Power: Communist cash, Australian politics and the battle for influence

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Hot weather reducing salmon production, Tasmanian aquaculture company says

By Rosemary Bolger

Posted 26 Feb 2016, 3:46pm

A Tasmanian salmon producer is blaming hot weather for reduced dissolved oxygen levels that are slowing the growth of its fish on the state's west coast.

In its half-yearly report, Huon Aquaculture said a hot summer was putting Macquarie Harbour under additional stress, with oxygen levels in the water falling.

"Huon has responded by reducing feed and installing oxygenating systems to limit the impact of the degrading environment on its fish," the statement

Marine life spawns sooner as our oceans warm

Tasmania marine heatwave hits seafood industry and puts some species at risk

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Seafood hit by climate change, Australian study finds

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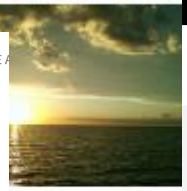
Andrew Darby



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Evidence of climate change: Australian fish feeling the heat

AUSTRALIA

Indian Ocean heatwave risk to fish

Daniel Mercer

This summer's sea tem hottest on record for Au

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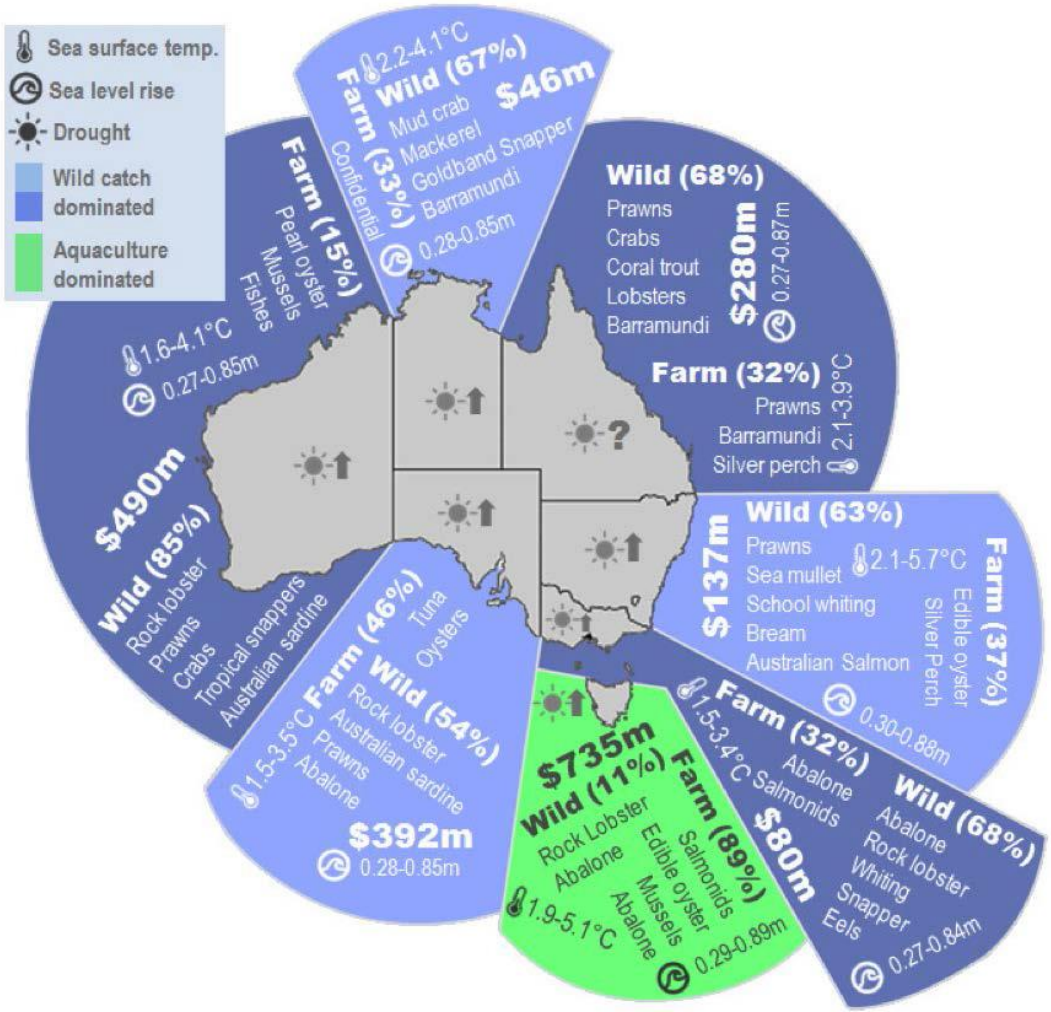
Climate change impacts on fisheries & aquaculture



- Changing habitat distributions
- Changes in growth rates
- Altered migration timing and routes
- Altered food availability
- Changes in spawning
- Reduced number and quality of offspring
- Altered swimming performance
- Disease risk

Hobday et al 2008, Frusher et al 2014, Savage & Hobsbawn 2015, Pearson & Connolly 2017

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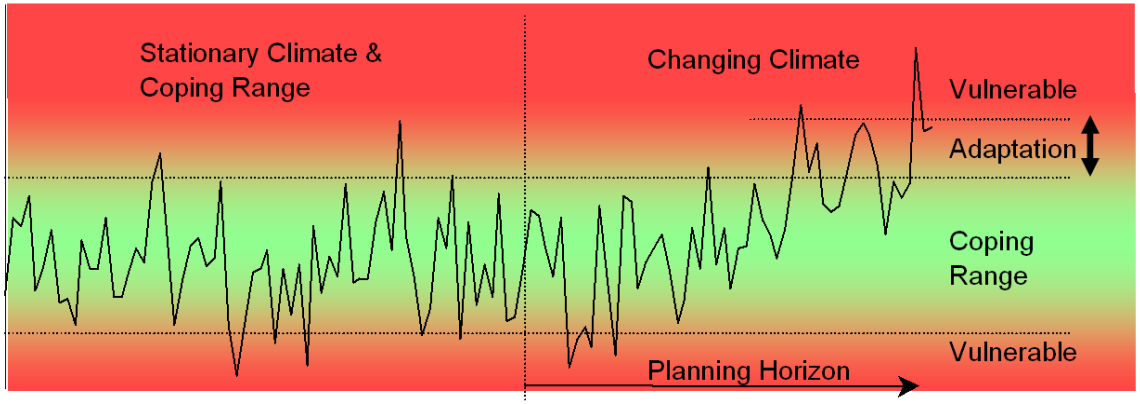
Climate variability vs climate change

In marine management & industries, coping with climate variability is often "business as usual"…

Coping with climate variability is **responsive** adaptation
Cost effective? Efficient? Opportunity?

Climate change is a new factor
Can it be managed as for climate variability?



Anticipating climate variability & change is **proactive** adaptation

Jones & Mearns 2005

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Management decision timescales

Weather timescales: 1-7 days

Minimal warning time

Reactive management

Seasonal timescales: 2 weeks-9 months

Early window for implementation of strategies to minimise impacts and maximise opportunities

Climate forecasting: 10 – 100s years

Long term planning

Seasonal timescale most useful for proactive management. Business performance and industry resilience could be improved with predictions about future conditions.

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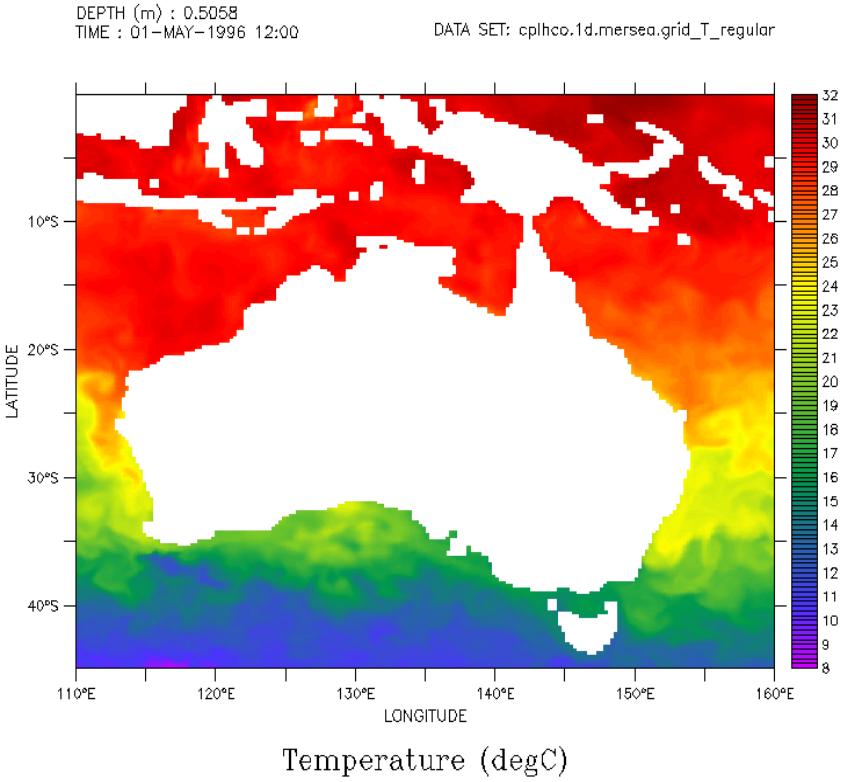
ACCESS-S

Australian **C**ommunity **C**limate & **E**arth **S**ystem **S**imulator - **S**easonal



- ACCESS-S1 replaces POAMA as Bureau operational system in 2017
- UKMO collaboration
- Dynamical global coupled ocean-atmosphere model
- Ocean grid 25km x 25km
- Assimilates satellite & *in situ* SST, *in situ* T&S profiles, altimetry & satellite sea ice
- ACCESS-S2 operational 2019

Animation: Xiaobing Zhou. Ocean model: NEMO/NEMOVAR (Waters et al 2015)

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Seasonal forecast product development

Essential ingredients:

- Strong industry engagement
- Clear understanding of user issues, skills & requirements
- Skilful model forecasts
- Appropriate forecast delivery
- Ocean & fish observations

Critical information:

- What management decisions are made and when?
- Spatial & temporal scales?
- Variable of interest?
- Minimum skill level required?
- Level of operational support?

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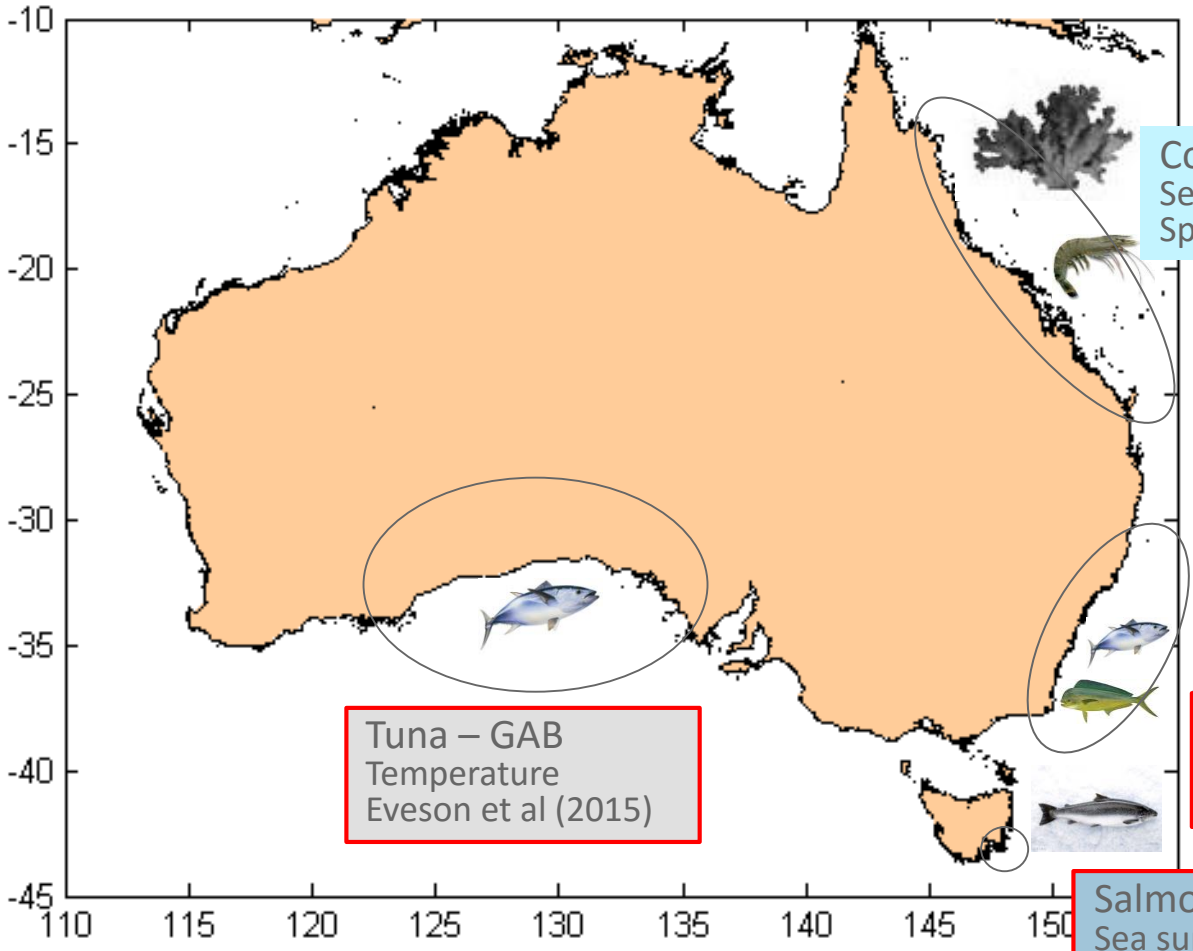
Marine seasonal forecasting applications



Sea level – West Pacific
Sea level
Miles et al (2014)

Coral – Great Barrier Reef
Sea surface temperature
Spillman et al (2009,2011,2012)

Prawns - Queensland
Rainfall & air temperature
Spillman et al (2015)

Tuna – Eastern Australia
Temperature at depth
Hobday et al (2011)

Rec fishing – East Australia
Sea surface temperature
Brodie et al (2017)

Tuna – GAB
Temperature
Eveson et al (2015)

Salmon –Tasmania
Sea surface temperature
Spillman & Hobday (2014)

Hobday et al 2016, Tommasi et al 2017. Images: Leal et al 2014, NSW DPI

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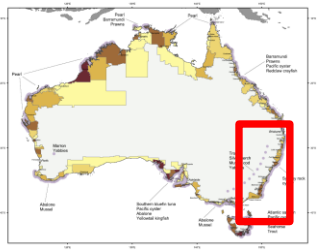
1. Southern bluefin tuna

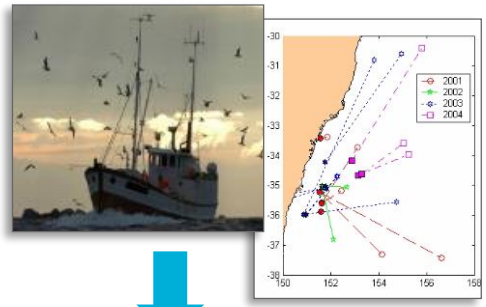


Eastern Australia

- AFMA
- Reduce non-quota capture
- Inform spatial zoning to regulate fisher access
- 2 weeks to 6 months ahead
- Winter ocean temp 0-200m (May-Nov)

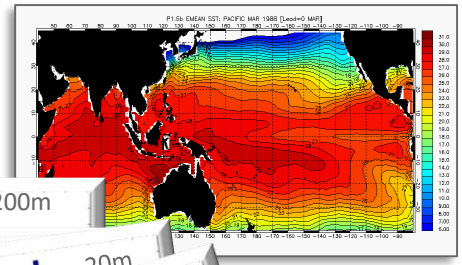
Hobday et al (2011)

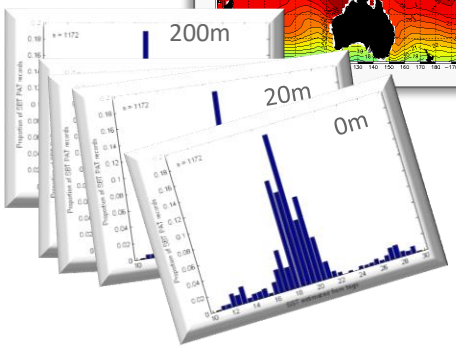
SBT habitat forecast products



Catch data
Tuna tags

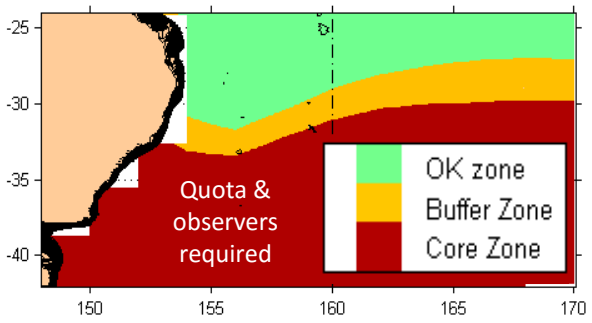
POAMA forecast



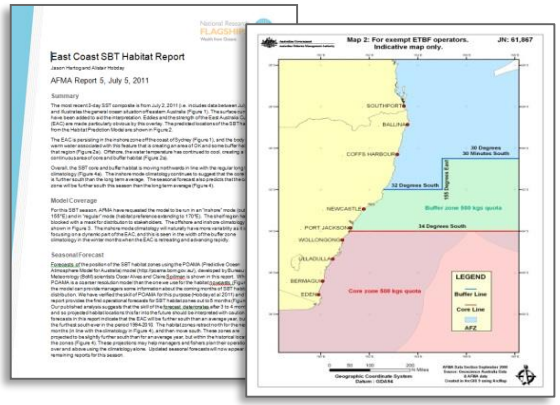


Observed temperature preference by depth

Probability maps by lead



Management decision



Seasonal habitat distribution forecasts assist AFMA to set management zones

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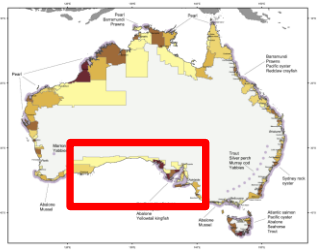
1. Southern bluefin tuna

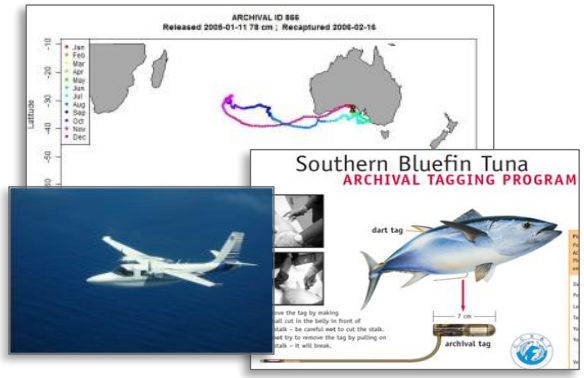


Great Australian Bight

- Peak industry body and fishers
- Changing SBT distributions
- Improve industry efficiency
- 1-2 months ahead
- Summer SST (Dec-Mar)

Eveson et al (2015)

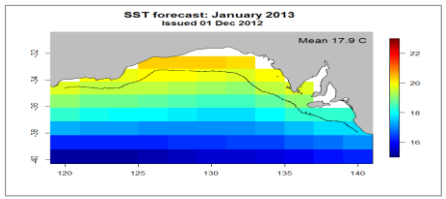
SBT habitat distribution forecasts

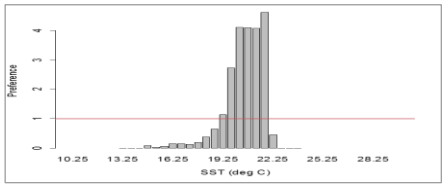


SBT data for habitat model

+

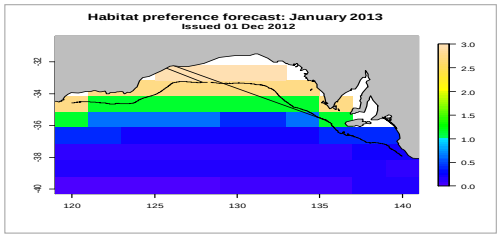
POAMA ocean forecasts





Habitat distribution model

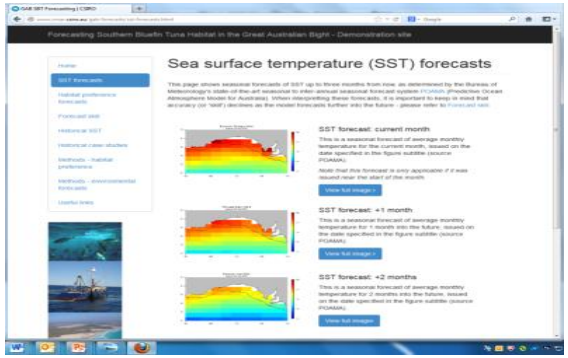
Habitat distribution forecasts



Skilful up 2 months ahead

Meetings & education
Industry feedback

Forecasts online



Habitat distribution forecasts allow fishers to better plan their port departures and operational activities

http://www.cmar.csiro.au/gab-forecasts/index.html

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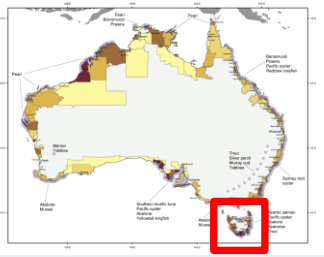
2. Salmon aquaculture

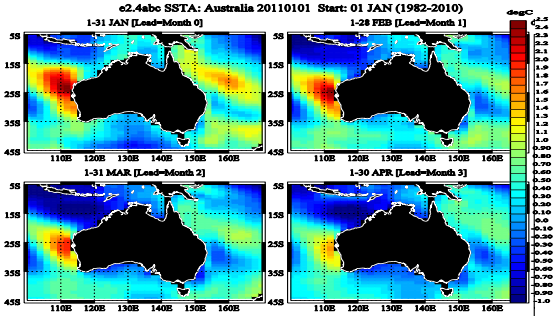


Tasmanian Salmon
Salmon Growers Association
Salmon grown towards upper thermal limit
Reduce vulnerability to temp extremes
1 month to a season ahead
Summer SST

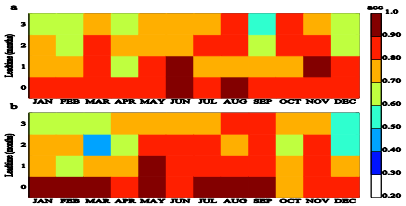
Spillman & Hobday 2014

Tailored salmon farm forecast products

Farm temp data & monthly climatologies

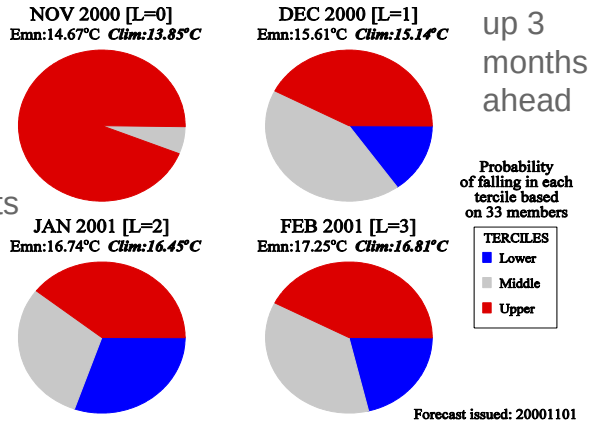


Regional ocean forecasts



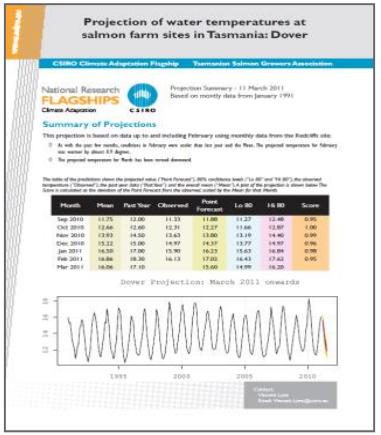
Forecast accuracy information

Farm specific forecasts



Skilful up 3 months ahead

Monthly forecast reports



Meetings & education Industry feedback

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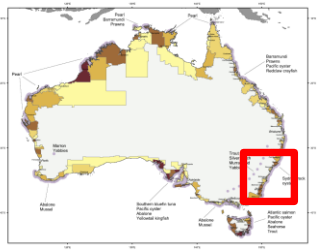
3. Recreational fishing

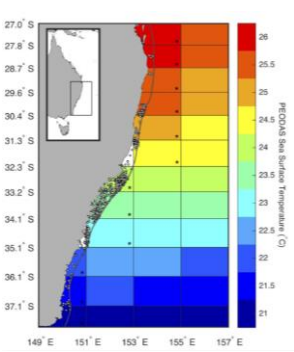


East Coast Dolphinfish
NSW DPI Fisheries Enhancement Team
Enhanced recreational fisheries
Assist planning and retrieval of Fisheries Aggregation Device (FAD) arrays
1 month to a season ahead
Summer ocean temp (Oct-May)

Brodie et al (2017)

Dolphinfish distribution trial forecast products

- Geographic spatial forecasts of dolphinfish habitat (fish km^{-2})
- Latitudinal summary identifying the location of fish density peaks



POAMA SST forecasts

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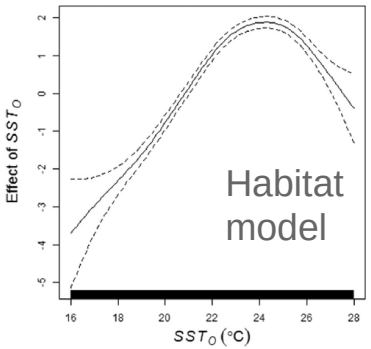
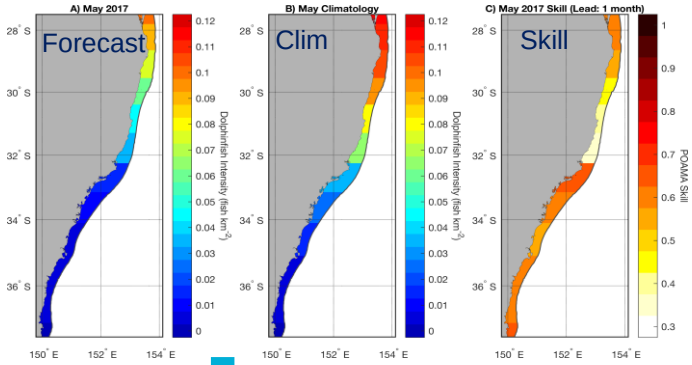
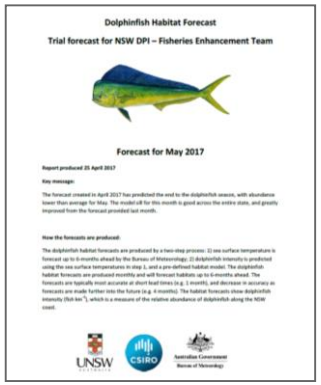




Monthly forecast reports



Assisted FAD program to identify dolphinfish distribution, & adjust the positions & density of FAD arrays

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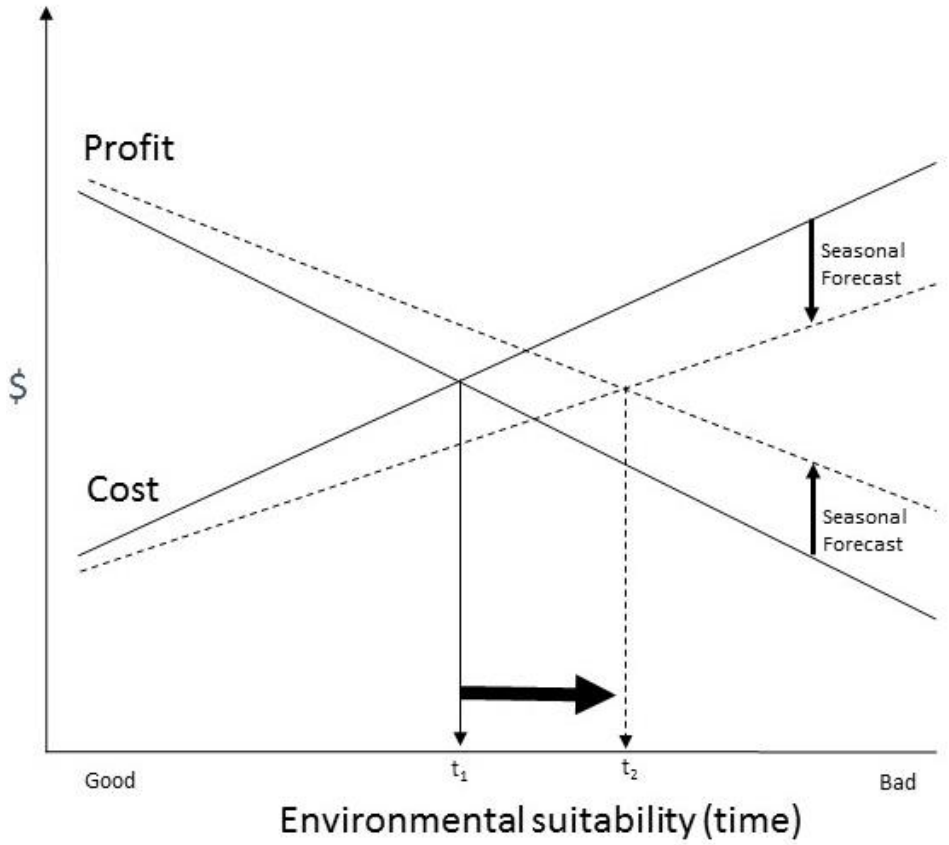
Using seasonal forecasts to reduce vulnerability



Using seasonal forecasting, businesses should be able to **reduce costs** and **increase profits** (relative to no forecast), such that they can **remain profitable** under less suitable environmental conditions **for longer** (until t_2).

Beyond this point, conditions are such that relocation (or another adaptation option) is necessary.

Hobday et al. in review

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The future will be different..

- Climate change is leading to a future where past experience is of reduced value
- Past patterns will not be repeated: novel combinations of physics, chemistry, and biology
- Dynamical seasonal forecast products valuable tools for proactive marine management
- Improves efficiency and enhances resilience of industry to climate variability and change

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Thank you

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- **POAMA:** http://poama.bom.gov.au

- Hobday et al (in review) Frontiers in Marine Science
- Tommasi et al (2017) Progress Oceanography
- Widlansky et al (2017) J. Applied Met Climatology
- Brodie et al (2017) Deep Sea Research II
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