Seasonal and decadal forecast development for a multi-species pelagic longline fishery

Jason Hartog, Alistair Hobday, Paige Eveson, Claire Spillman
Joined by
Kylie Scales, Toby Patterson, Xuebin Zhang, Richard Matear, Don Bromhead, Simon Nicol, John Hampton, John Annala, Robert Campbell, Sean Tracey

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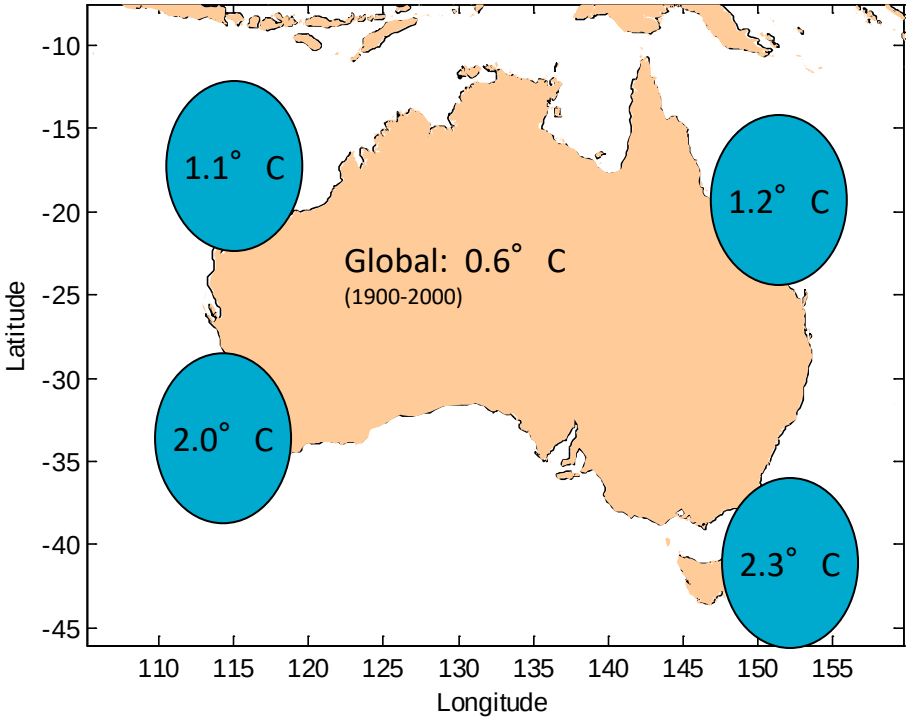
Observed ocean warming around Australia



Pearce, A. and M. Feng (2007)

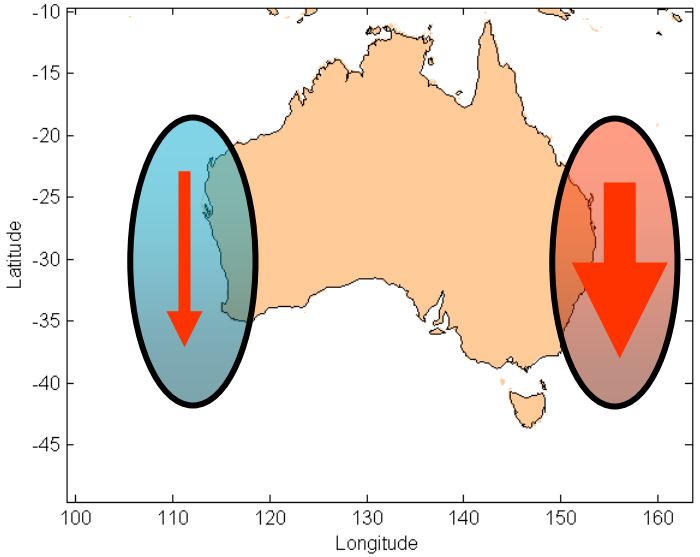
Ridgway, K. R. (2007)

Holbrook, N. J., and N. L. Bindoff (1997)

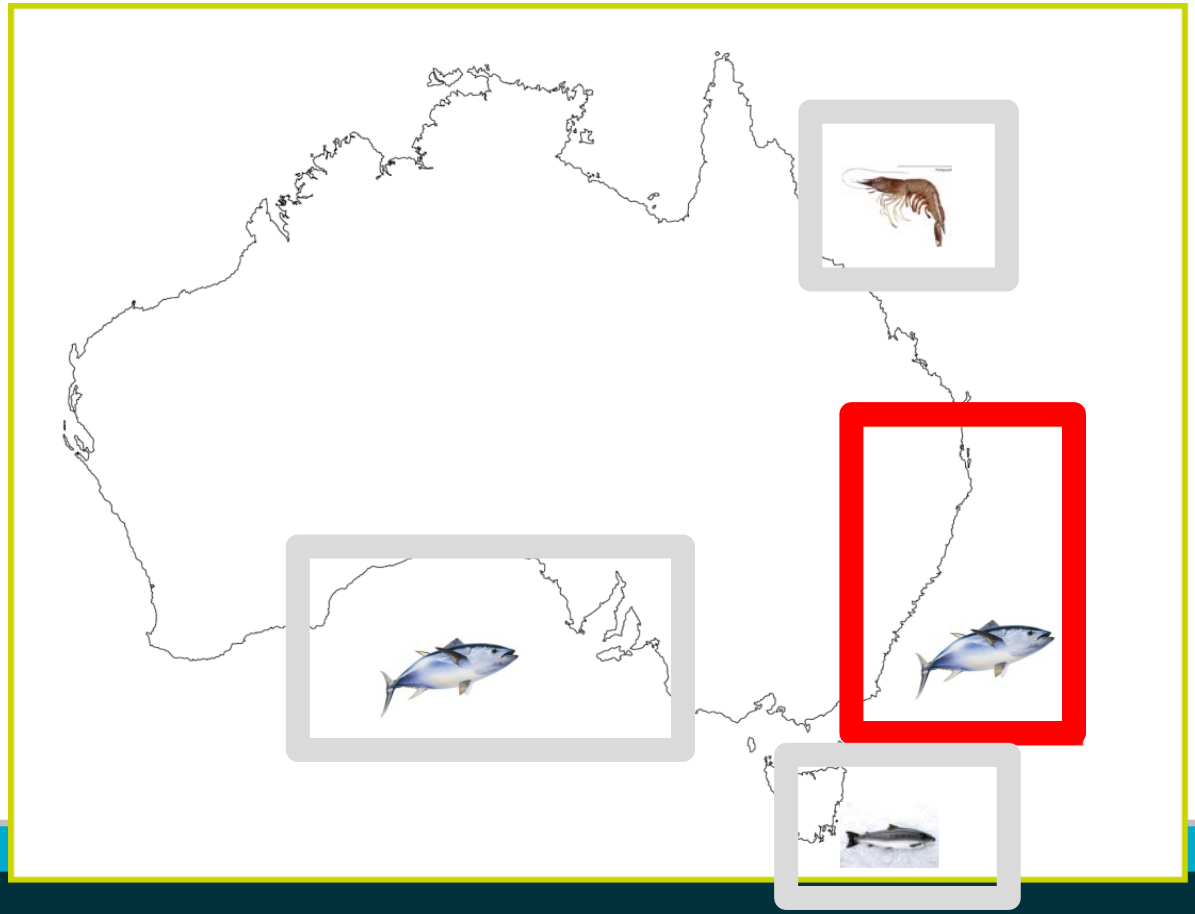
Bindoff, N. L., and J. A. Church (1992)

Projected changes (e.g. distribution)

11 species in Australian longline fisheries



Adult southern bluefin tuna

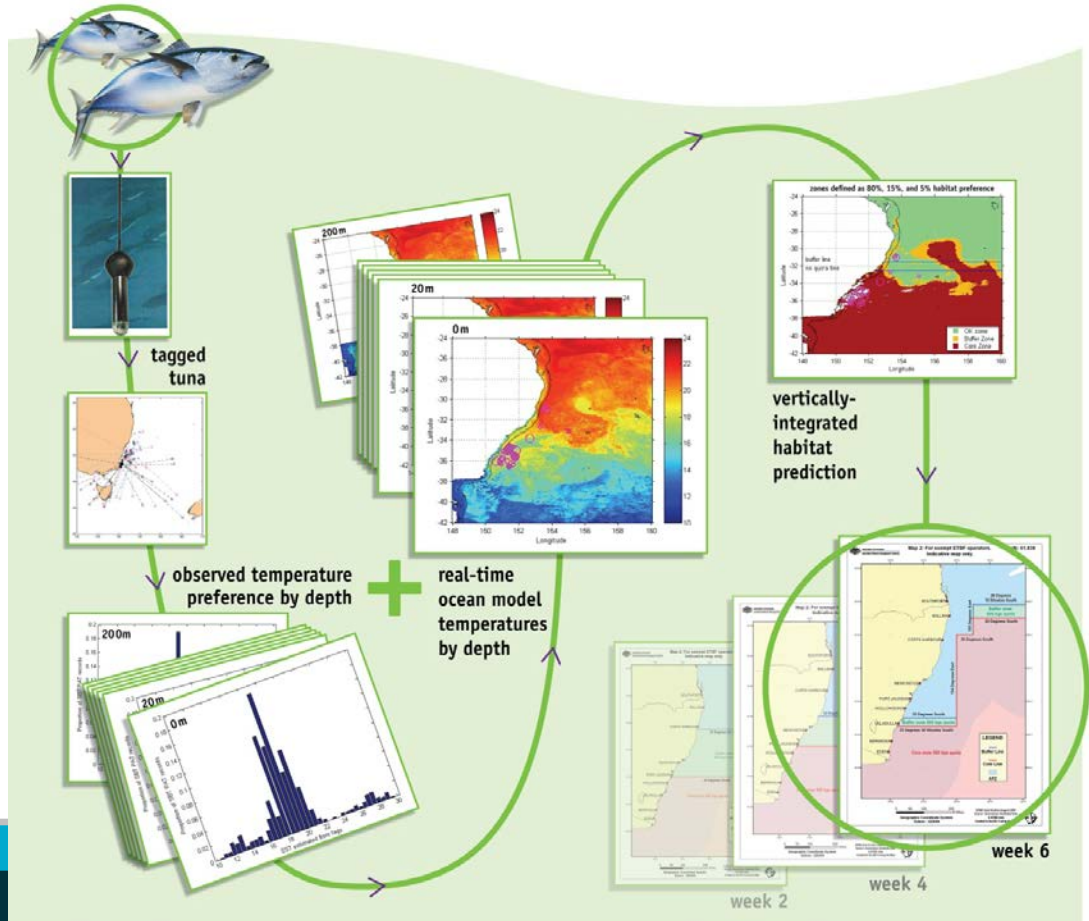


Near real time habitat “prediction” (2003-2014)

- Reduce bycatch of adult SBT
- Three zones based on the expected distribution of SBT
- Report sent to fisheries management agency on a fortnightly basis

Action

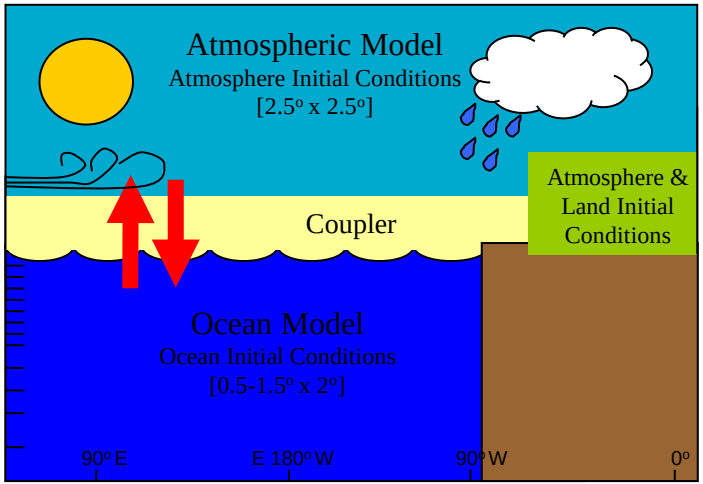
- Agency regulates spatial access of long line vessels to the fishery based on quota holdings.
- Observers required in the core zone.



Seasonal Forecasting

Predictive **O**cean **A**tmosphere **M**odel for **A**ustralia

Global dynamical coupled ensemble ocean-atmosphere and data assimilation seasonal prediction system



- Forecasts out to 9 months
- Weekly to seasonal multi-model predictions
- Ocean and atmosphere products available
- 33 member ensemble
- Probabilistic forecasts
- Run operationally x2 weekly

http://poama.bom.gov.au

Spillman & Alves 2009, Spillman 2011, Hudson et al 2013

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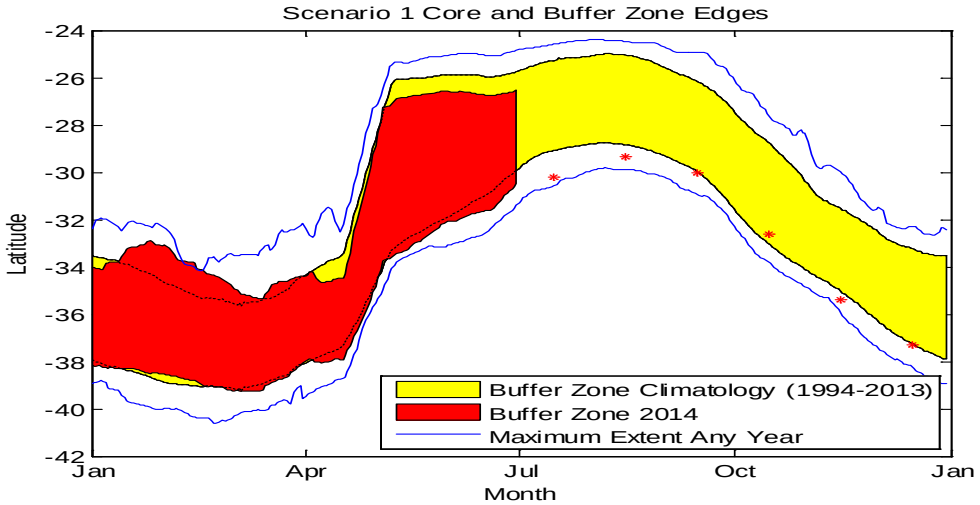
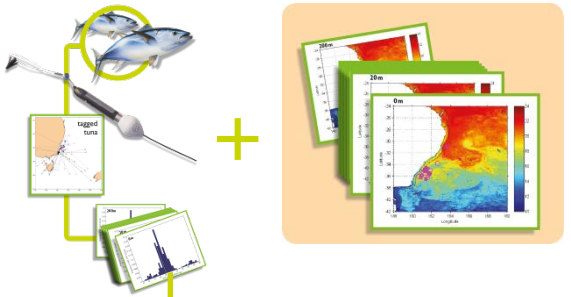
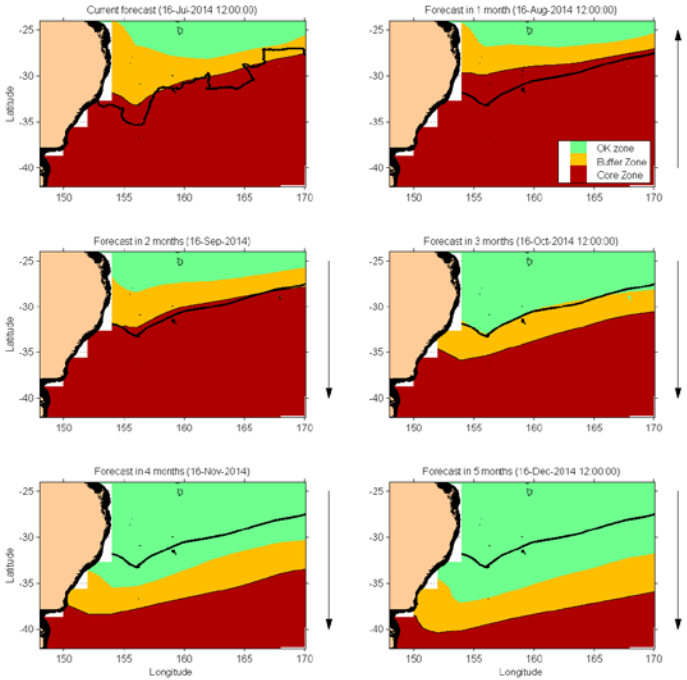
Seasonal Habitat Prediction

- Seasonal forecasts from a coupled ocean-atmosphere model (POAMA) have been added to our habitat model, allowing predictions of SBT habitat out to 5 months.

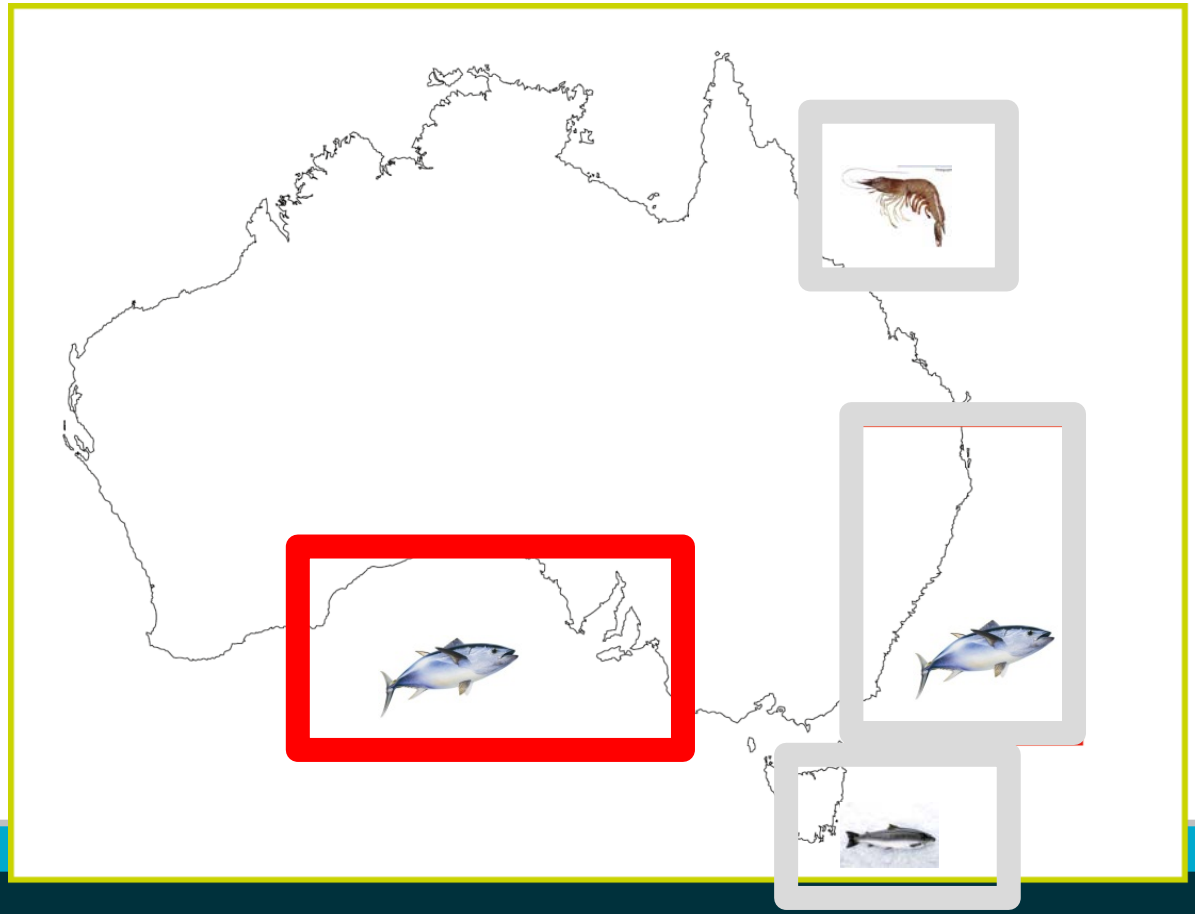
- This seasonal forecasting offers both managers and fishers the potential to plan







Juvenile southern bluefin tuna

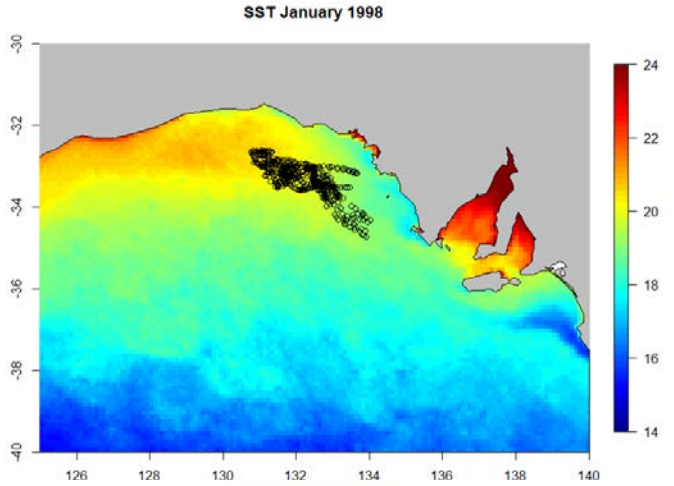


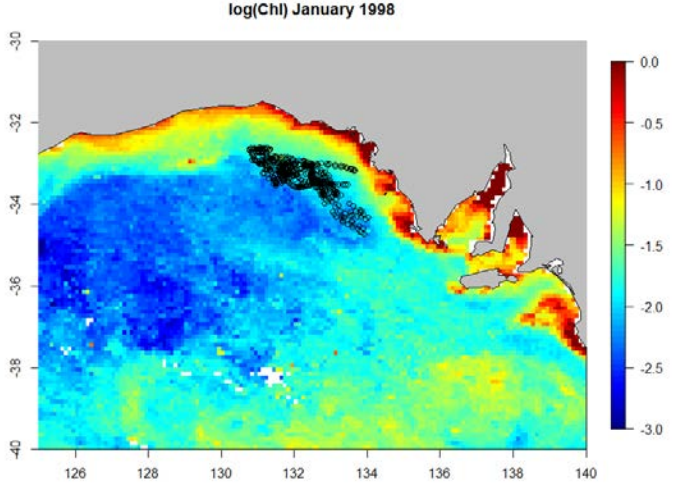
Habitat Preference

- Compared environmental data *(SST, chlorophyll a, mixed layer depth, bathymetry, wind, frontal density, sea surface height)* for:
  1. entire GAB vs.
  2. locations where fish were found within the GAB (from archival tag)

  during Jan, Feb, Mar of 1998-2009
- Those with greatest influence: SST, chl *a* *(combined with SST)*

Eveson et al 2015





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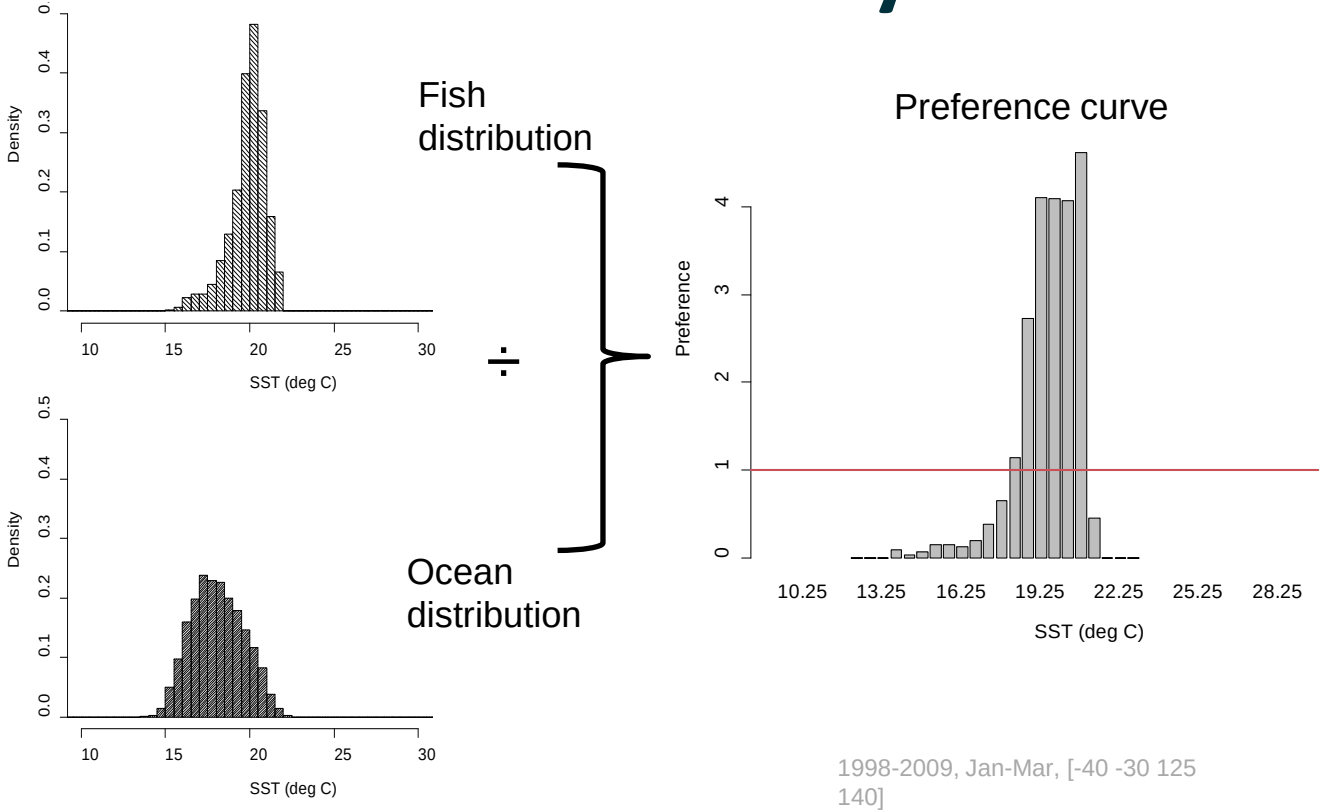
Habitat Preference: SST only

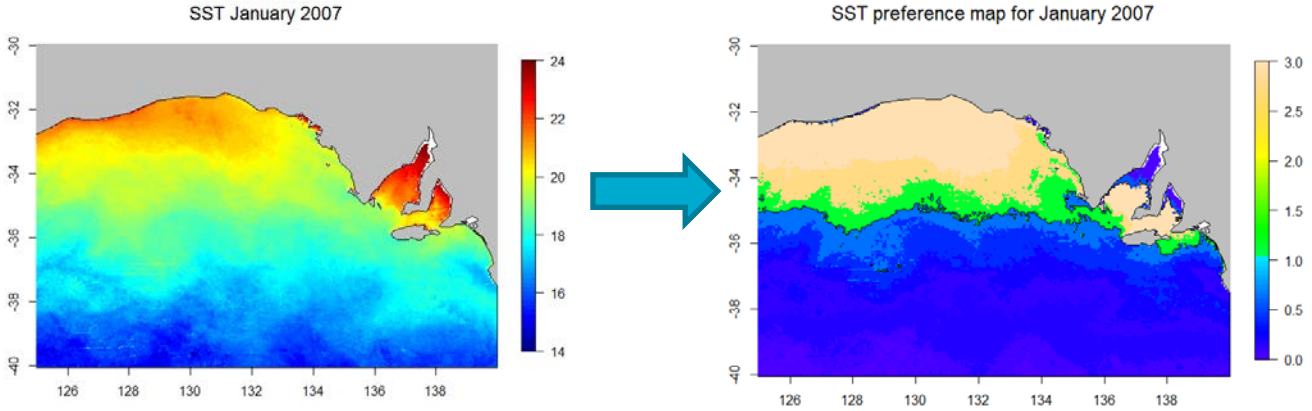


1998-2009, Jan-Mar, [-40 -30 125 140]

Preferred Habitat maps

- Produce map showing regions of preferred habitat for any given time period (e.g. Jan 2007)
  - *Get environmental conditions for that time period*
  - *Look up preference value corresponding to environmental conditions at each location*

SST only



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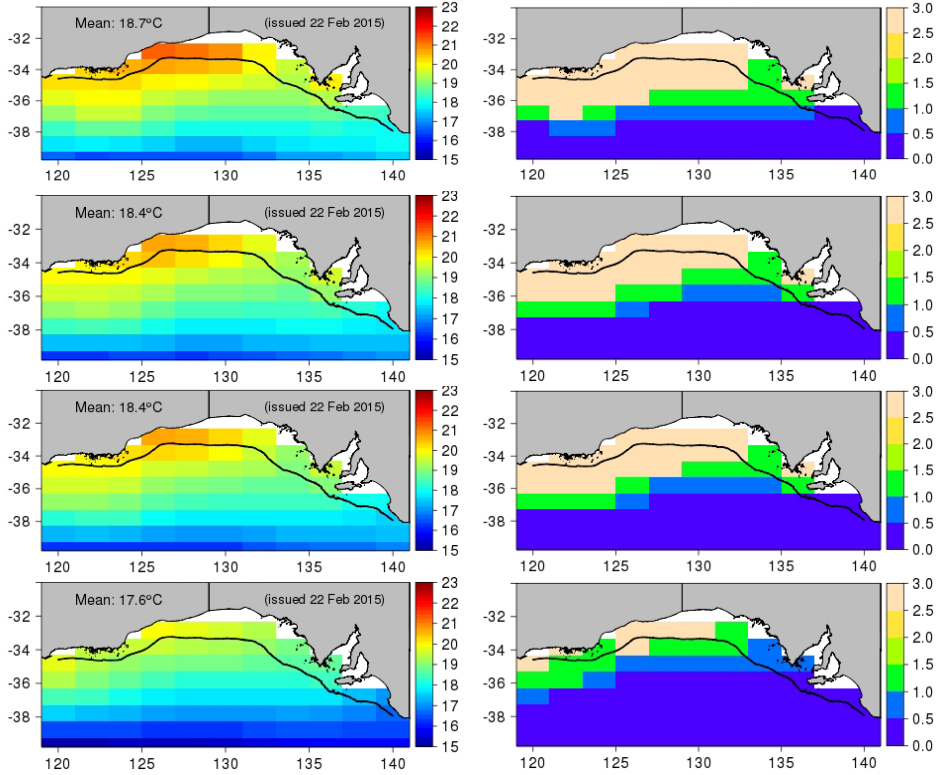
Forecasts issued 22 Feb 2015 (seasonal)

Fortnight 1:
22 Feb – 7 Mar

Fortnight 2:
8 Mar – 21 Mar

Month 1:
March

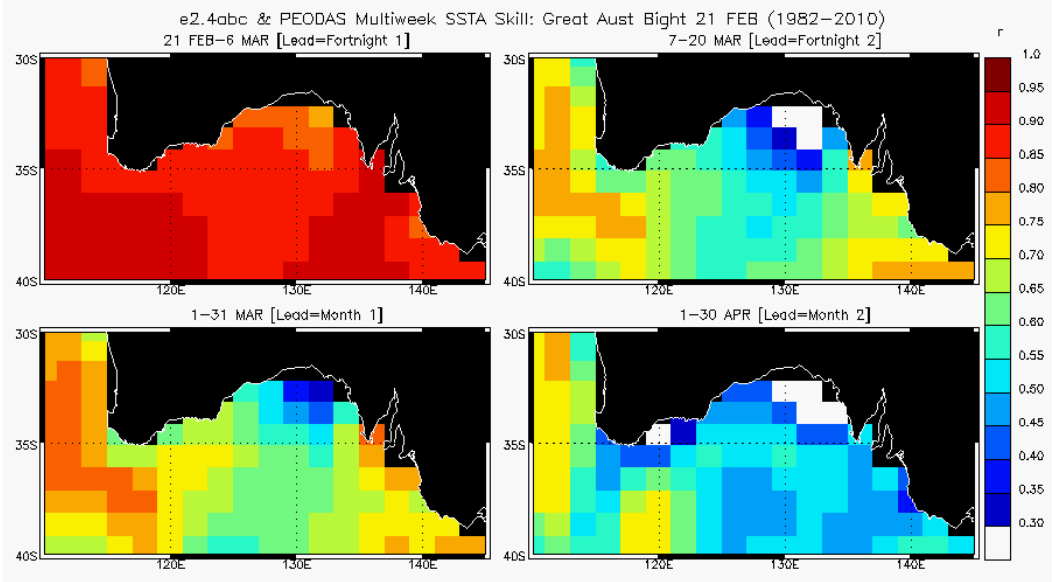
Month 2: April



Eveson et al 2015

Forecast Delivery

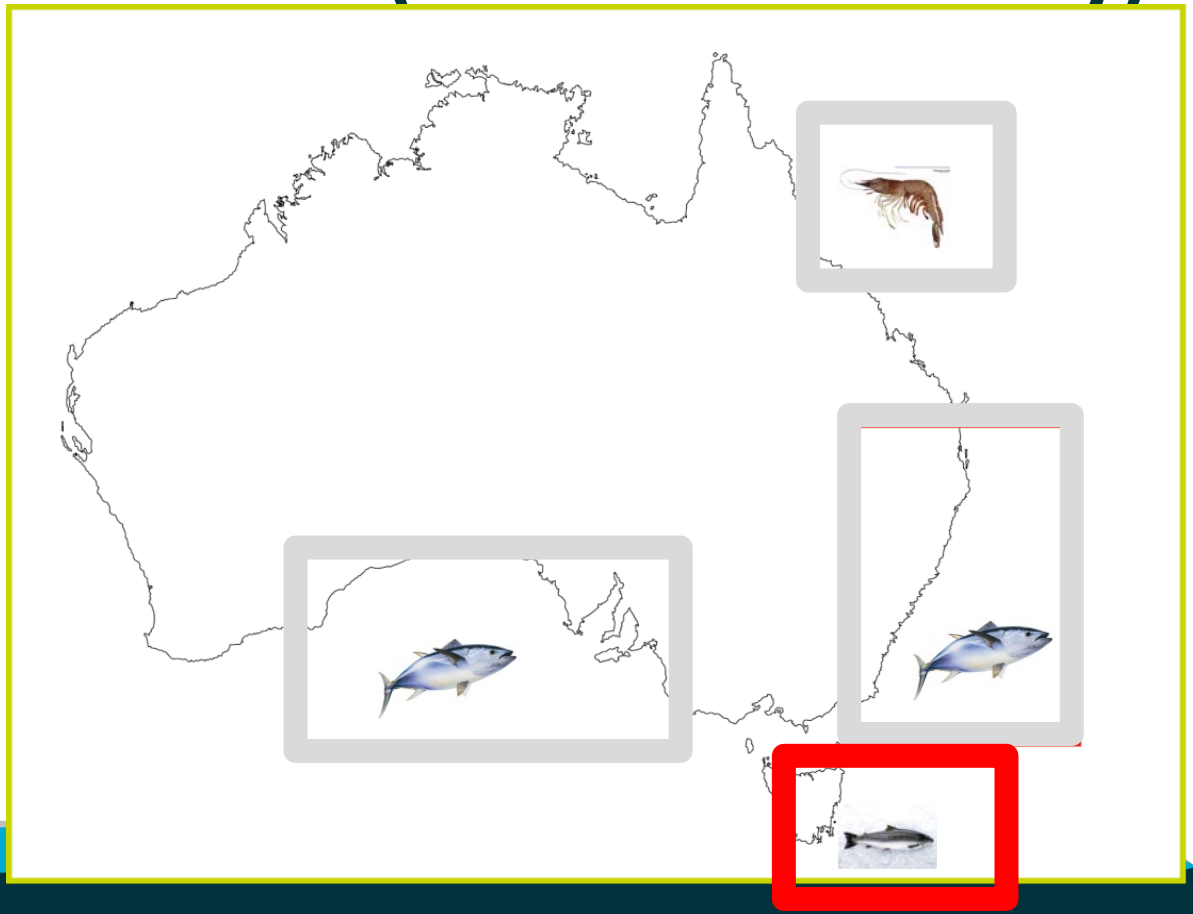
- Usefulness of forecasts depends on forecast skill
- For GAB in Jan-Mar, SST forecasts generally useful up to 2 months in future
- Delivery via website
- Industry rep on project
- 10 companies (year 1)
  - 8 used it for decisions
  - 6 made an alternate decision



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

Salmon Aquaculture (environment only)

- 2011 – 2013
- Marine Heatwave
- 2016 - present



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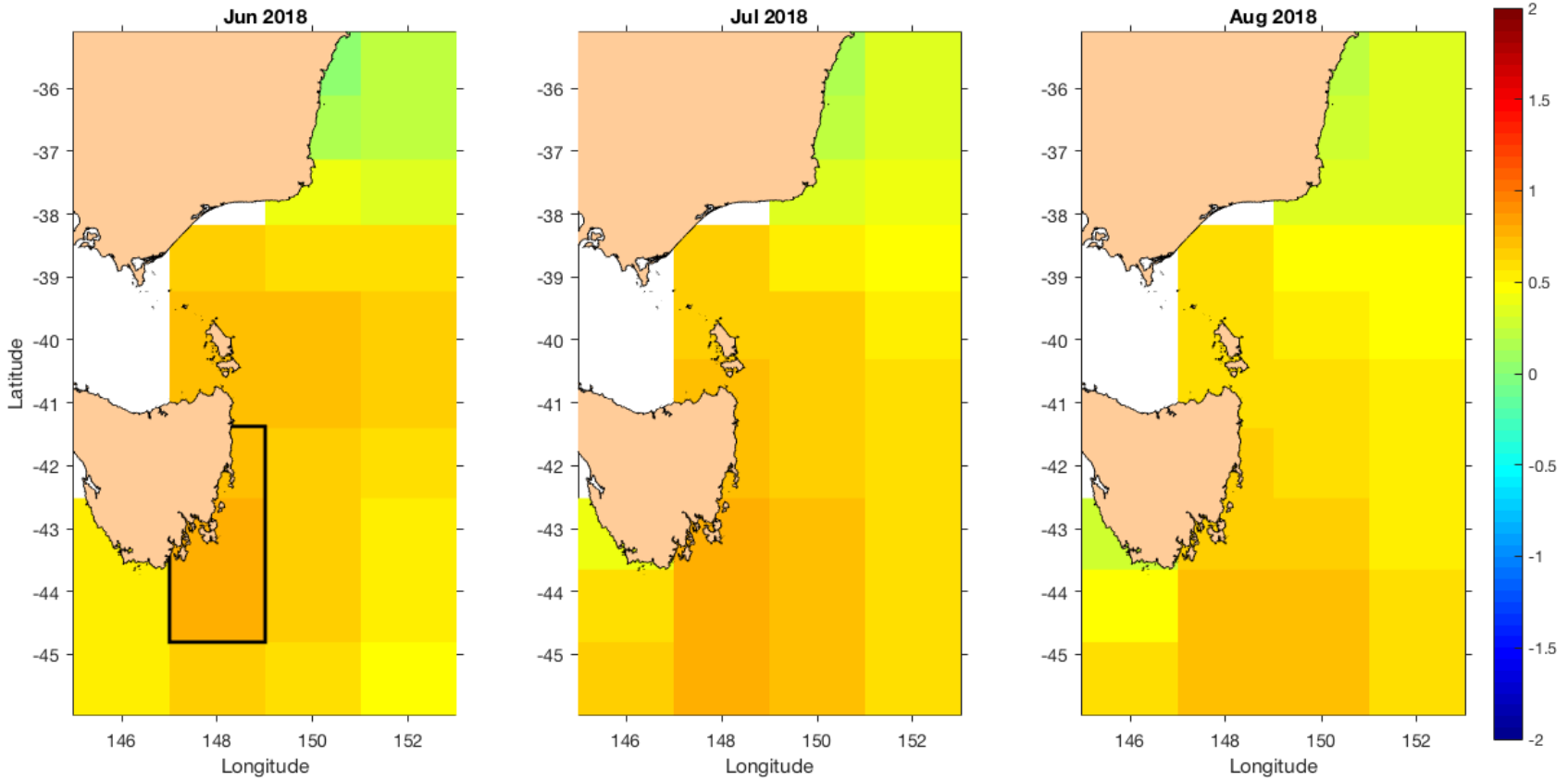
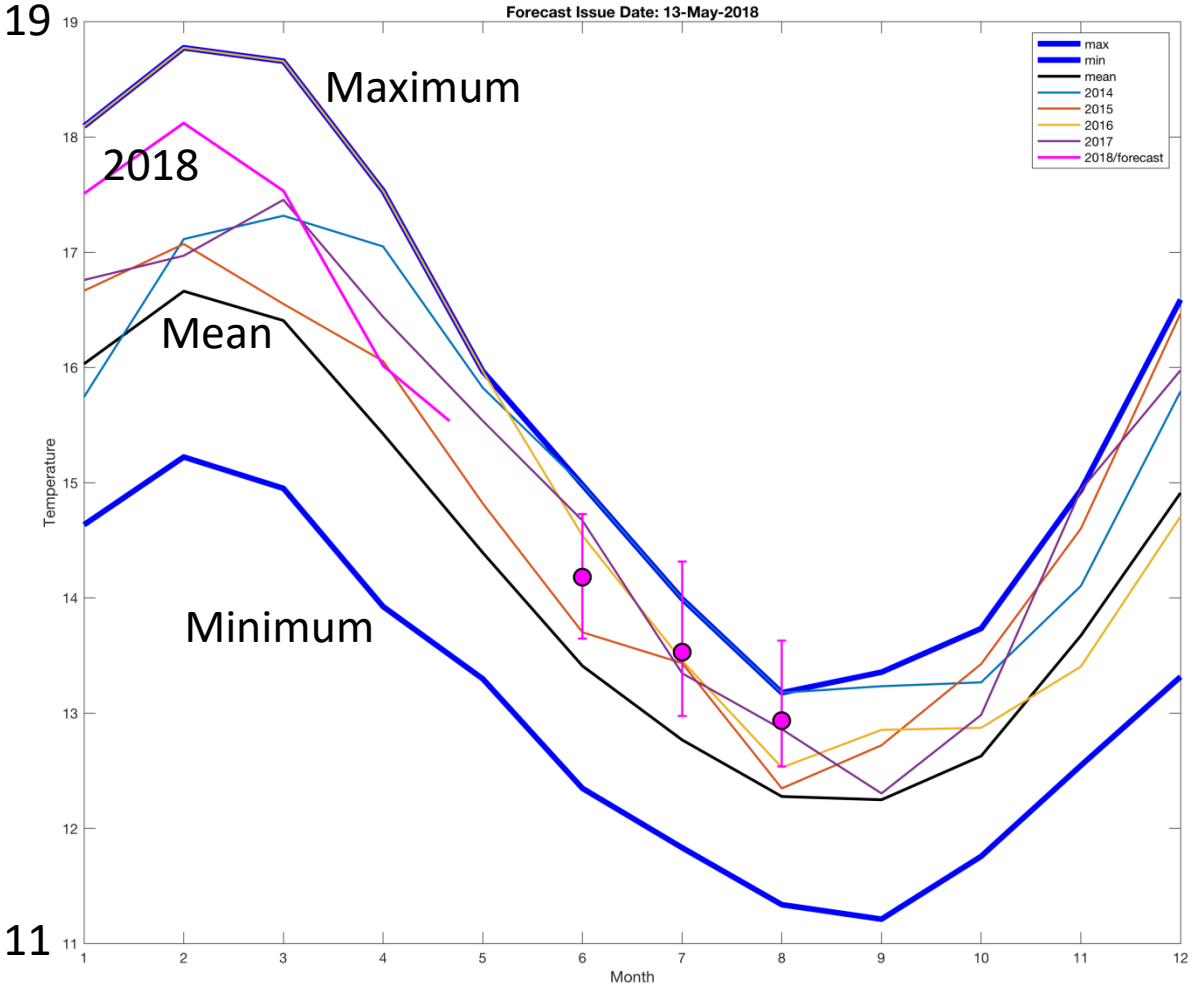
Forecast SST Anomaly





Forecast Issue:
13 May 2018

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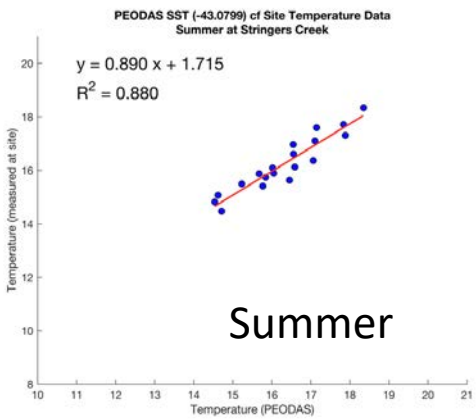
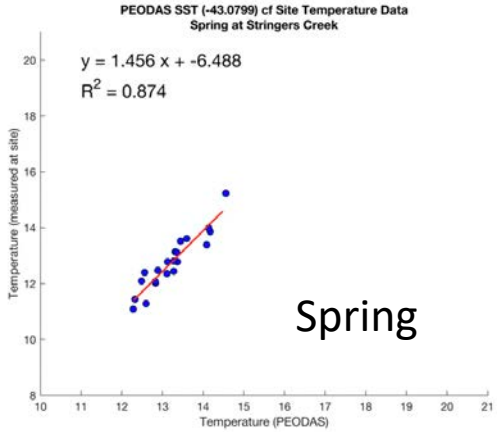
Site specific forecasts (statistically downscaled)

	Stringers Creek	Redcliffs	Creeses Mistake	Sheppards
June	12.4	12.4	11.2	11.3
July	12.0	12.0	10.9	10.9
August	11.5	11.6	10.6	10.5



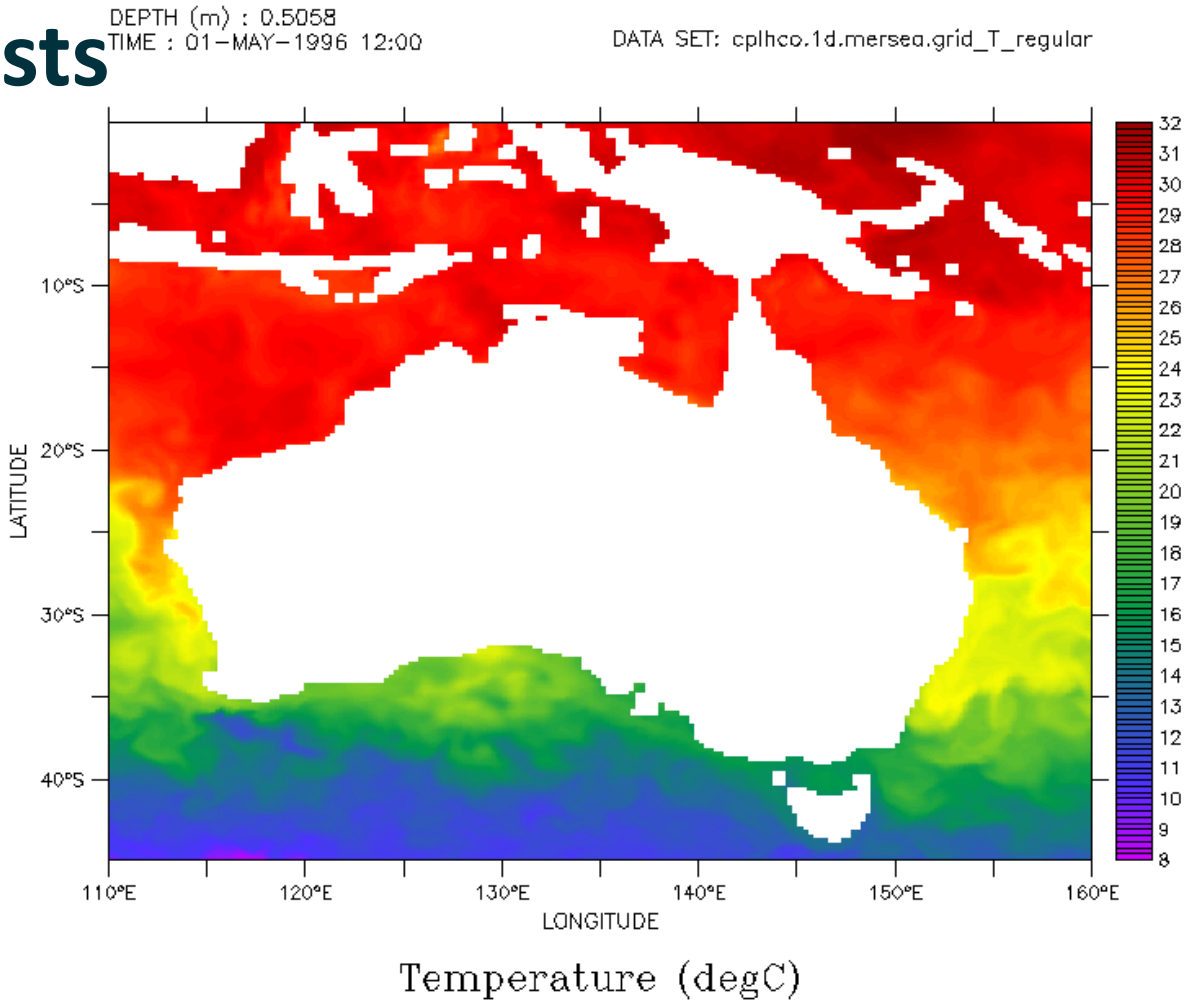
Summer



Spring

Seasonal Forecasts

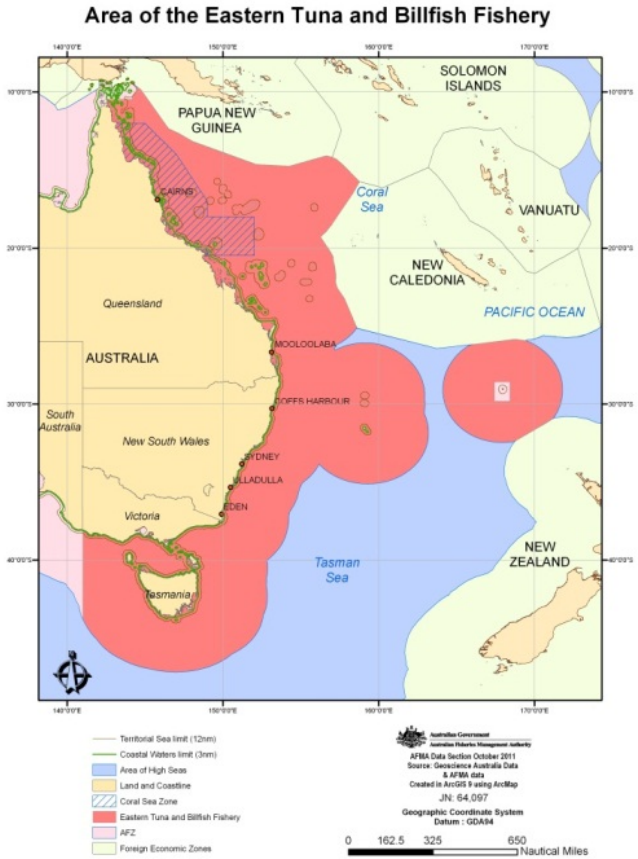
- ACCESS-S1 will replace POAMA as Bureau operational system
- UKMO collaboration
- Dynamical global coupled ocean-atmosphere model
- Ocean grid 25km x 25km
- Assimilates satellite & *in situ* SST, *in situ* T&S profiles, altimetry & satellite sea ice



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

Longline Fishery

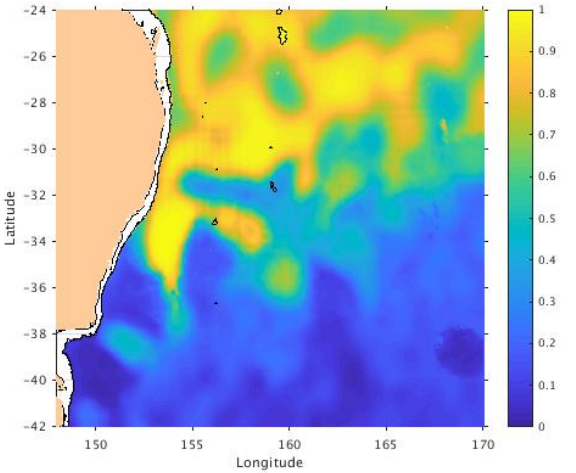
- 5 main target species
  - Tunas - Bigeye, Albacore, Yellowfin
  - Broadbill Swordfish
  - Striped Marlin
- Part of the broader Western Central Pacific Fishery Commission (WCPFC)
- Catch limits set within that framework.

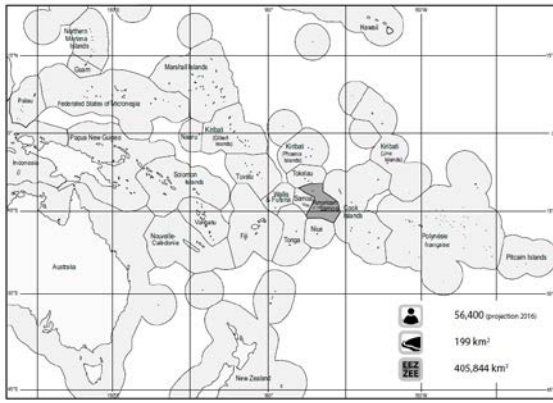


http://www.afma.gov.au/fisheries/eastern-tuna-and-billfish-fishery-page/

Wider Pacific Project

- Apply similar habitat models
- Develop improved habitat models that utilise the new forecasting tools and more variables that can be forecast
  - 5 species (catch data from member countries)
  - Electronic tagging data
- seasonal forecasting (ACCESS-S)
- decadal forecasting (CSIRO Downscaling)





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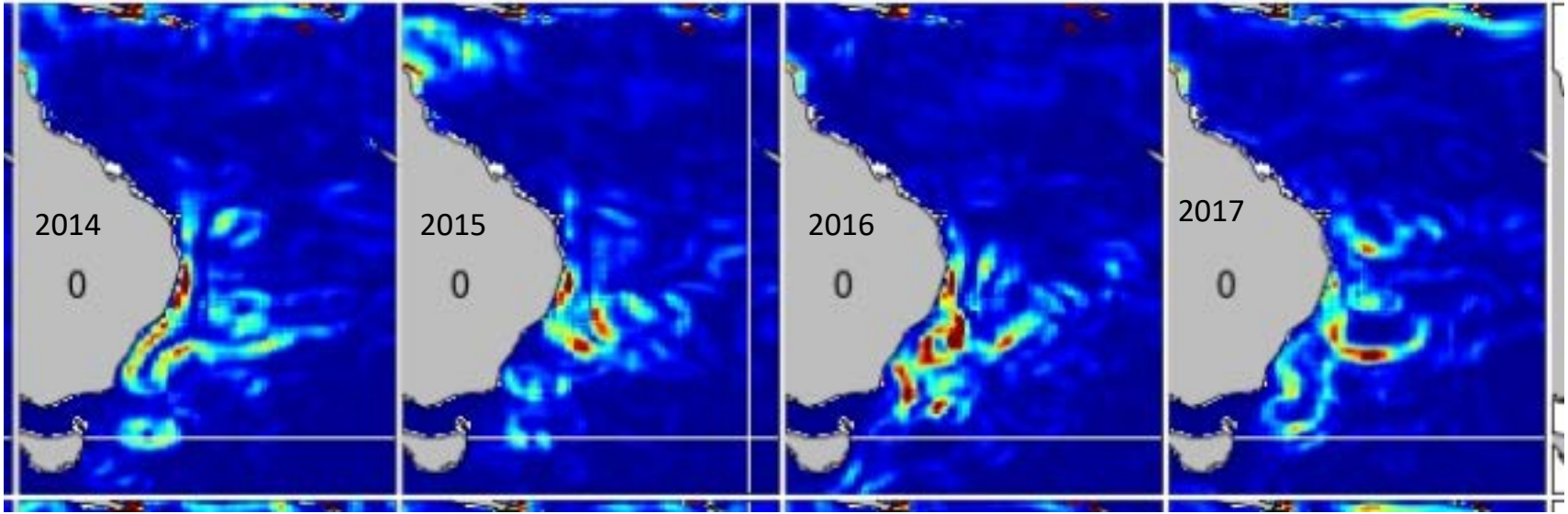
EKE

April



EAC inshore. Strong north-south connection

- Similar patterns?

Little structure

- Dispersed fish?

Lots of structure

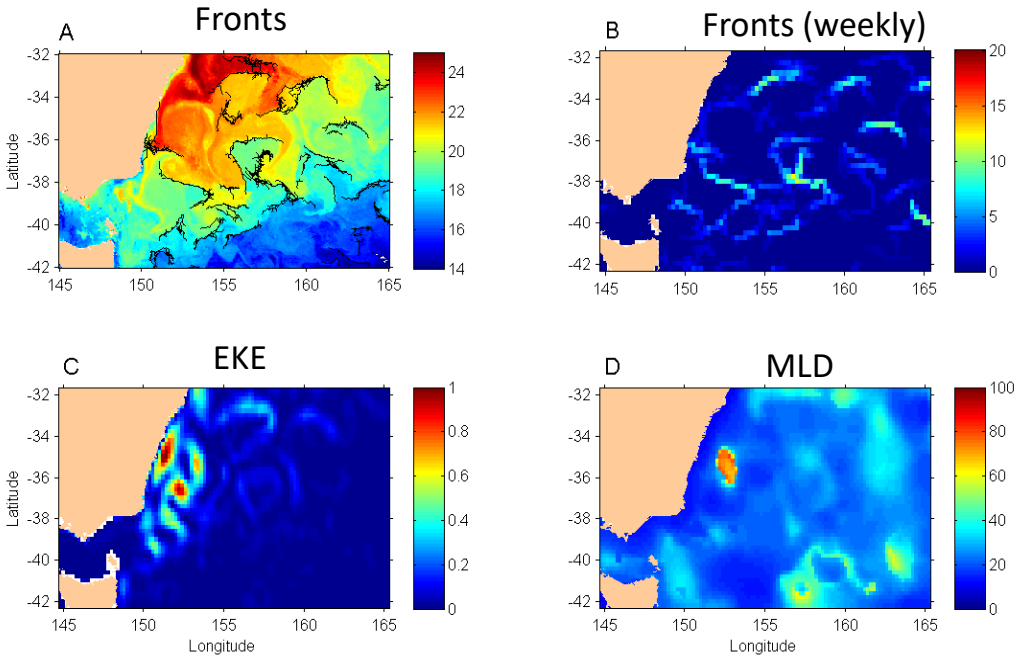
- Spatial clusters

EAC offshore

- Offshore?

Regional and sub-regional conditions

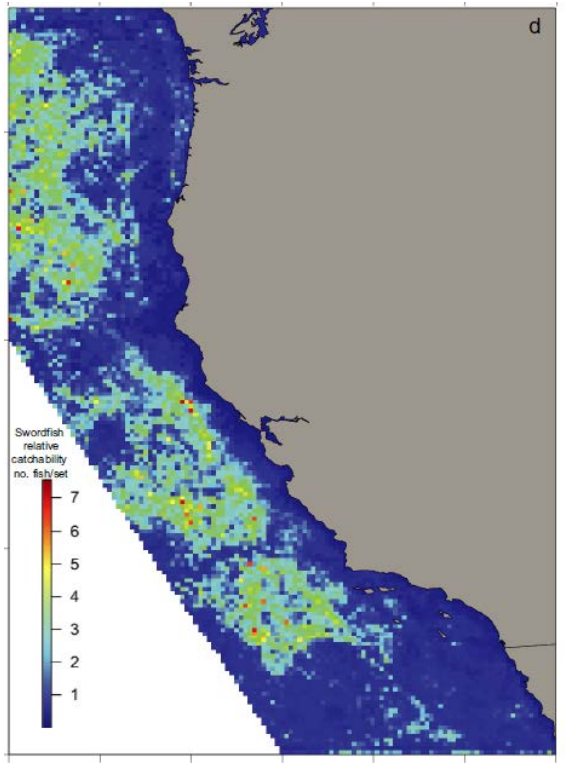
- Environmental factors
  - Presence of fish in a region
    - Sea surface temperature
    - Chlorophyll
    - Sea surface height
      - eddies and currents
    - Fronts
    - Mixed layer depth (MLD)
    - Eddy Kinetic Energy (EKE)
    - Eddy tracking – age and type
  - Catchability of fish
    - Moon phase
    - Turbidity



Development of habitat models

Scales et al. (2017)

- Nowcasts
- By species
  - By size where possible
- Seasonal/monthly
- Phase 1 – environment
  - Temperature, Primary productivity, Derived quantities
  - Test models developed/conditioned in different locations
- Phase 2 – environment and history



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Decadal forecasts (multi year)

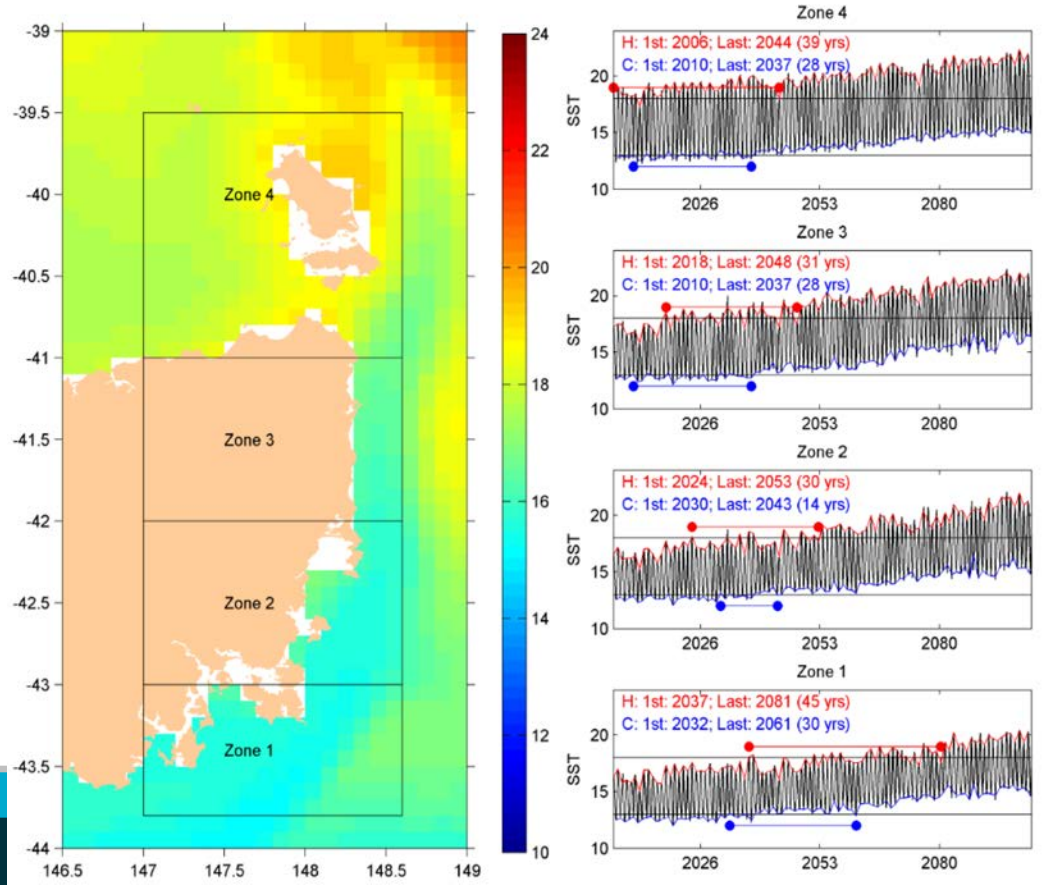
- *Decadal forecasts* provide information on anticipated environmental conditions (e.g. ocean temperatures, biogeochemistry) at lead times of 1-3 years.
  - *These methods are much less developed compared to seasonal forecasts, and developing an underlying decadal ocean forecast model is an area of active research in CSIRO.*
  - *Project team goal is to develop novel decadal species forecasts.*

- *Engagement: What would industry or management do with information about likely conditions 2 years ahead of now?*

Multi - Decadal forecasts (10 -100 yrs)

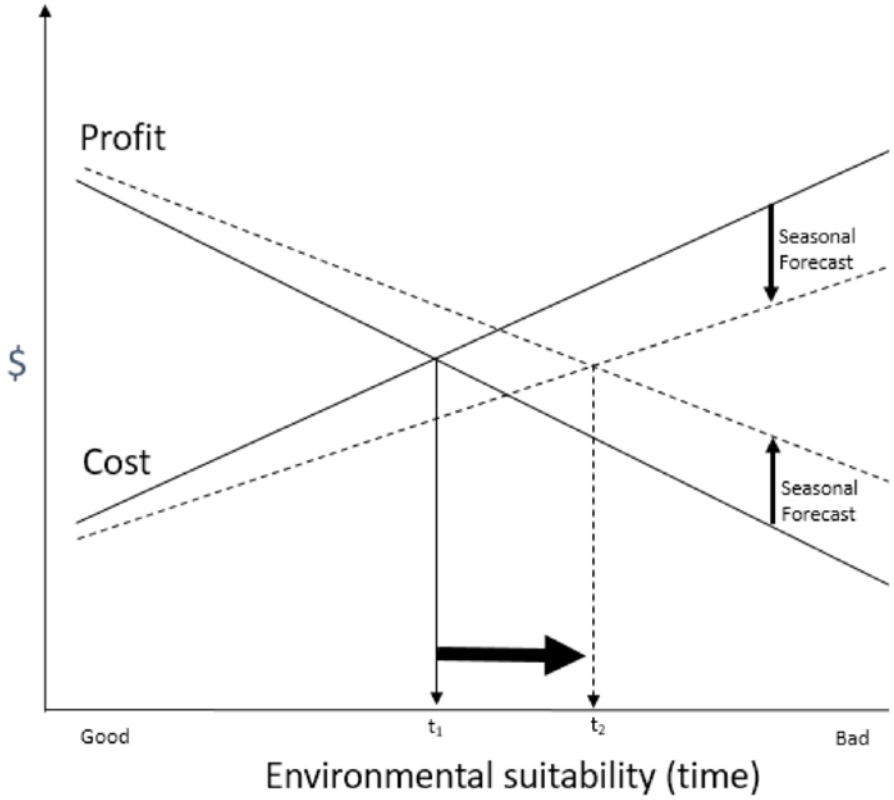
- CSIRO Downscaling
  - 0.1 degrees
  - CMIP5
  - Sea level, temperature and currents

Zhang et al. (2016)
Hobday et al. (2018)



Seasonal forecasts and climate change

Hobday et al. (2018)



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Summary

- Habitat models delivered for fisheries with direct application (managers and fishers)
  - Extended with seasonal forecasts for fisheries and aquaculture applications
- Improve utility with better resolved seasonal forecasts and use of decadal forecasts for 1 – 3 years.
  - Make use of the ability of models to forecast properties other than physics.
- Develop and test habitat models for use in different geographical domains.
- Take advantage of multiple efforts in other parts of the world.