

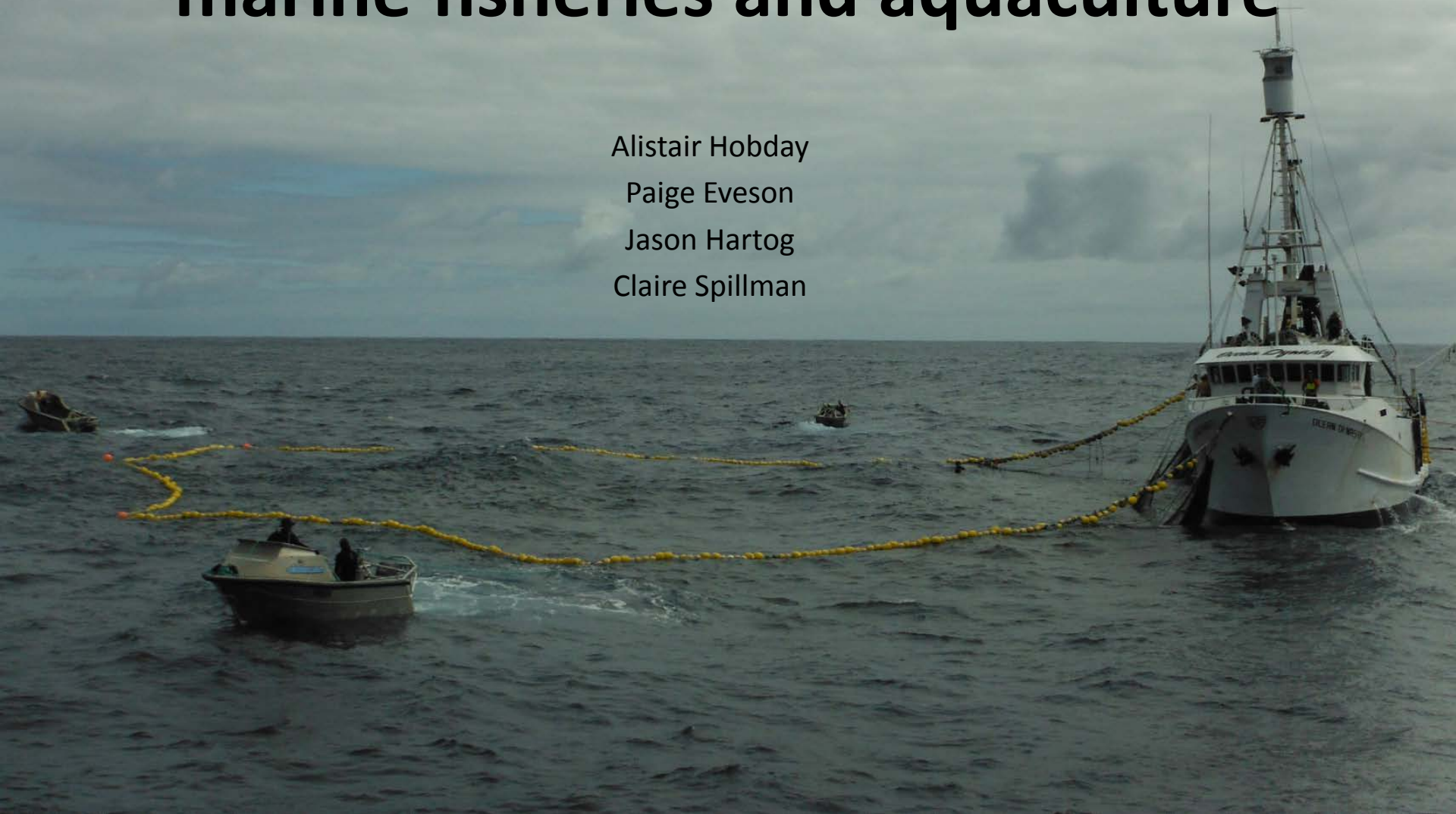
Seasonal forecasting as a stepping stone to climate adaptation in marine fisheries and aquaculture

Alistair Hobday

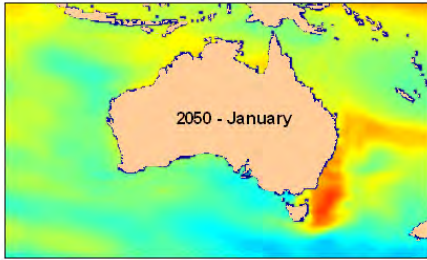
Paige Eveson

Jason Hartog

Claire Spillman

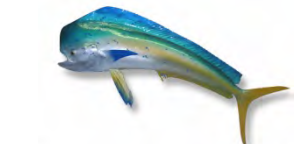
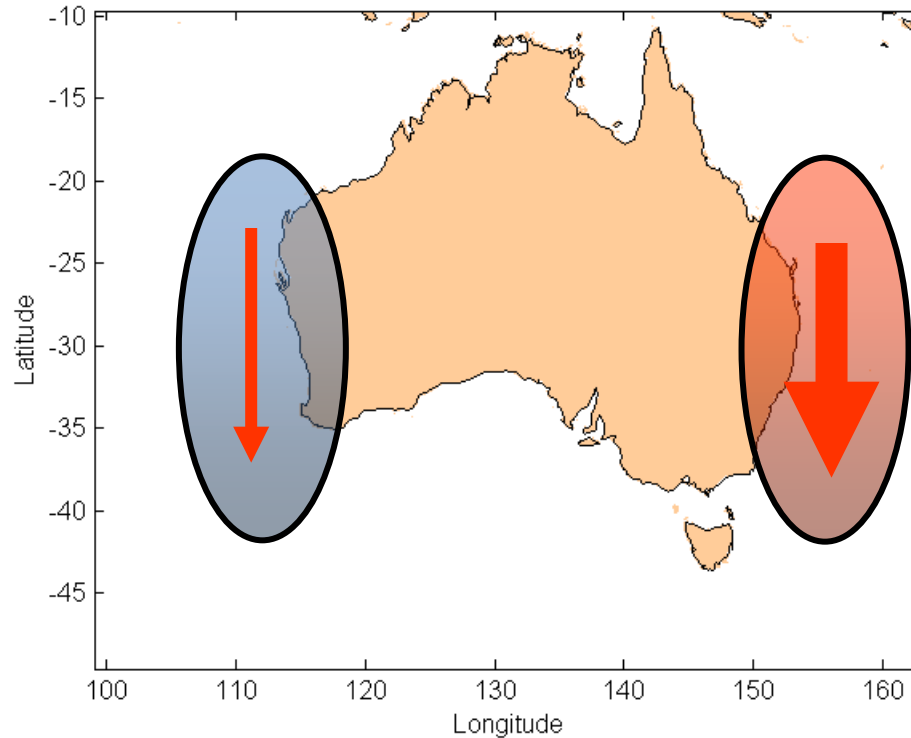


Projected changes (e.g. distribution)



Hobday and Lough 2011

11 species in Australian longline fisheries



YELLOWTAIL TUNA *Thunnus albacares*



Hobday 2010

The future will be different...

- Past experience less useful
 - novel combinations of physics, chemistry, and biology
- Need to make decisions that are generally ok even if the details change, based on the best information available at the time
- Risk management approach

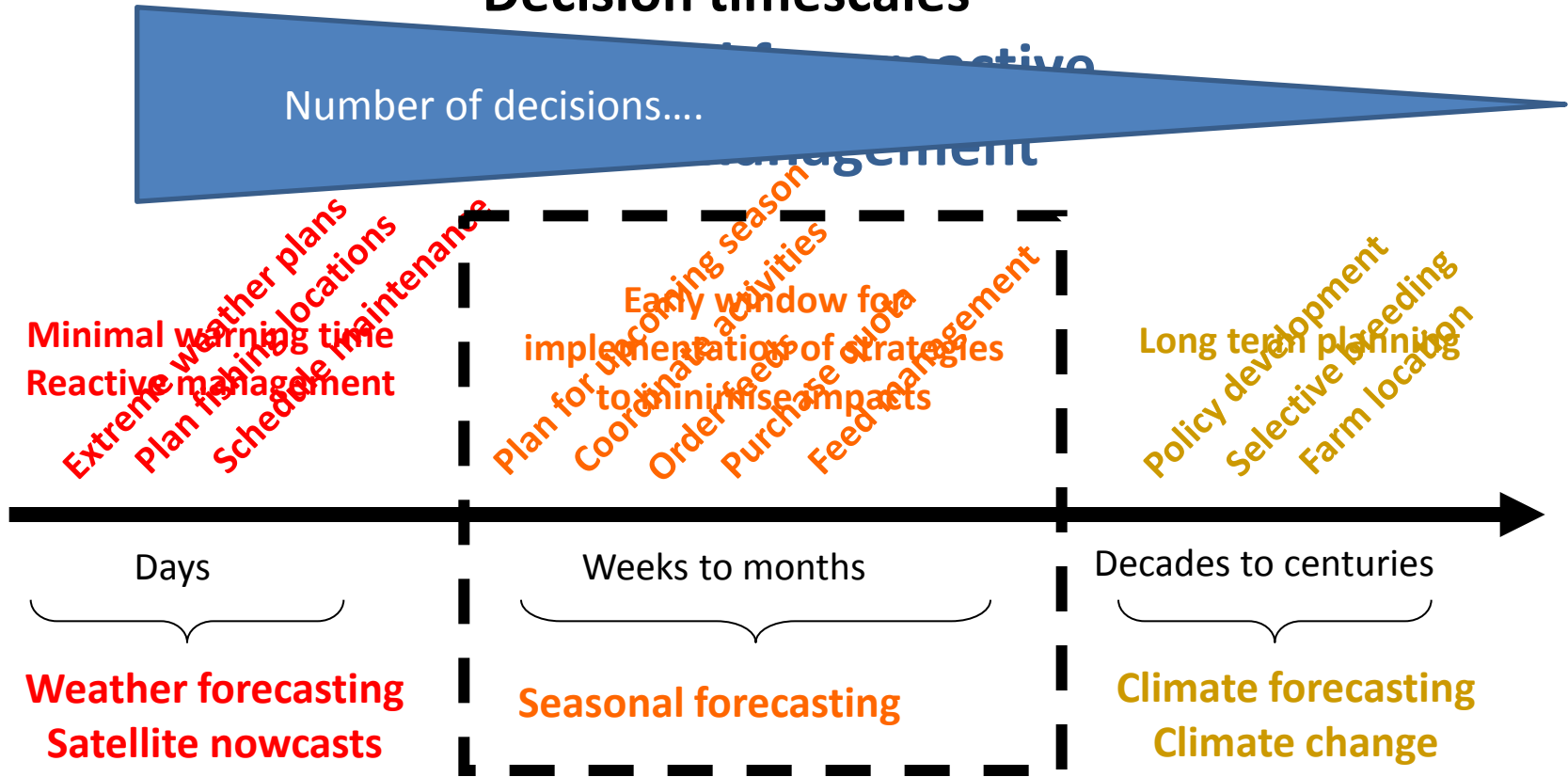


Reactive or Proactive adaptation

- In fisheries and aquaculture, coping with climate variability is “business as usual” to many...
 - Responding to climate variability is reactive adaptation
- Climate change is a new factor for businesses
 - Can it just be managed as for climate variability?
- Proactive adaptation is anticipating change
 - Business performance could be improved with information about the future

Recognize relevant time scales

Decision timescales

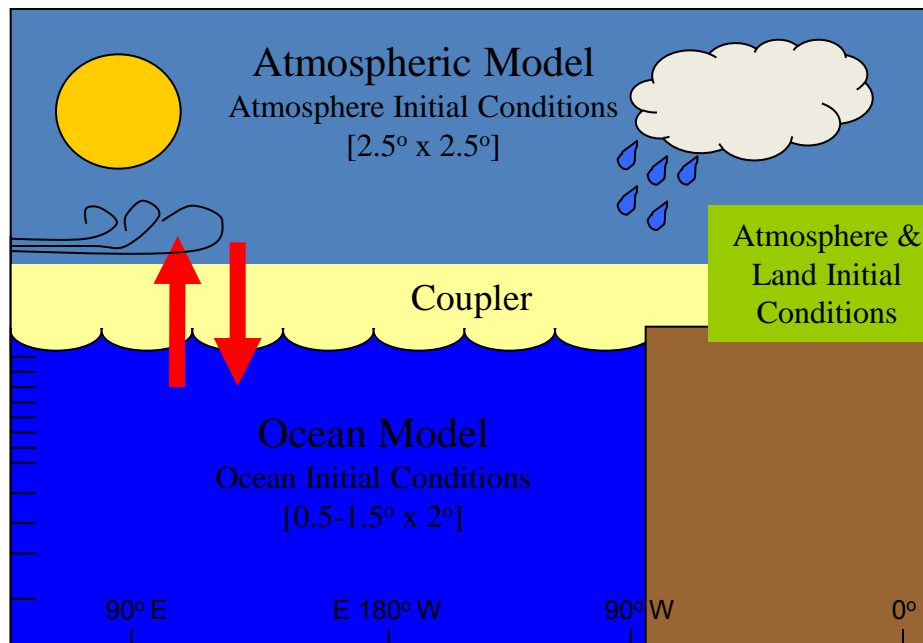


Better managed marine resources have improved resilience under climate change

Seasonal forecasting

Predictive Ocean Atmosphere Model for Australia

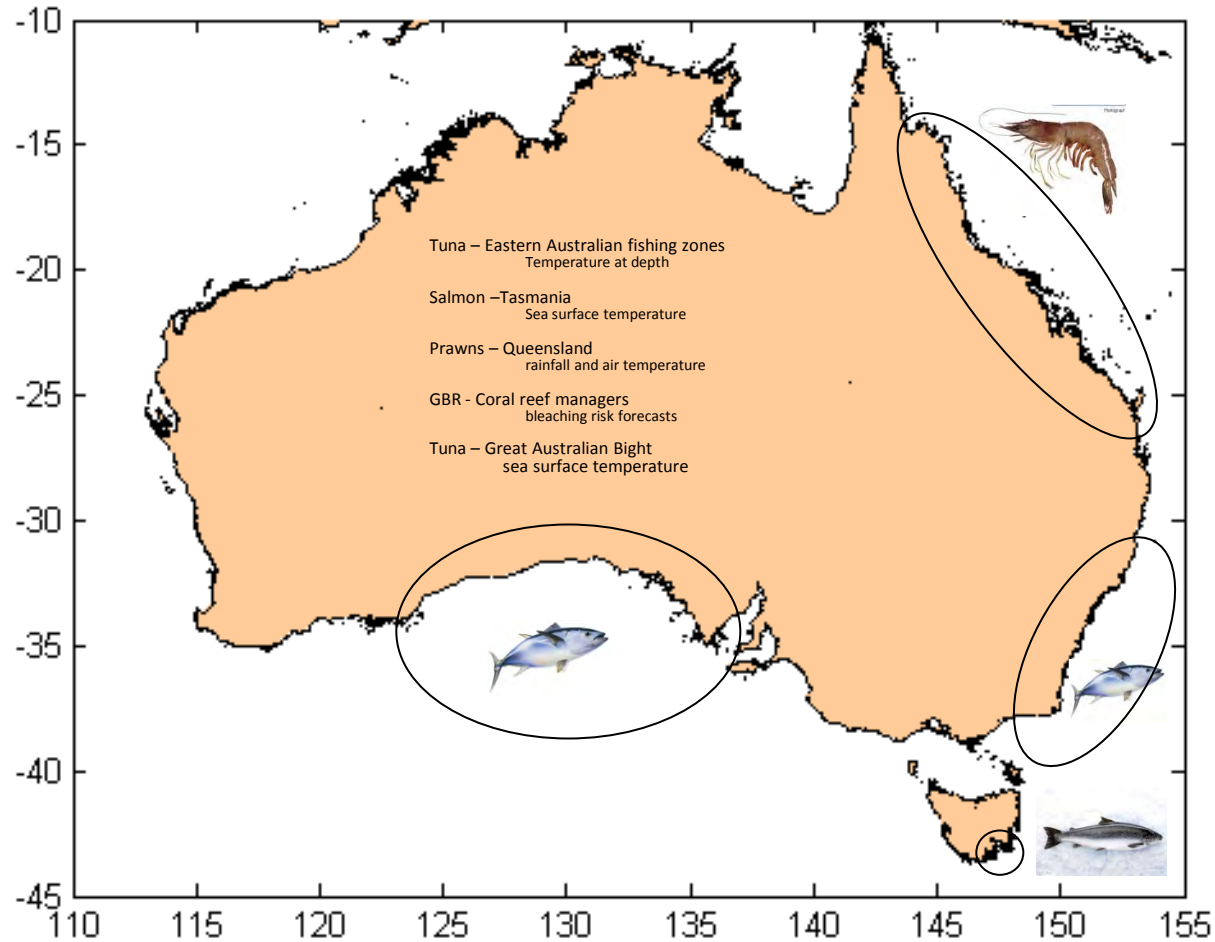
Global dynamical coupled ensemble ocean-atmosphere and data assimilation seasonal prediction system



- 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>

Who is using our seasonal forecasts?



Southern bluefin tuna - Purse-seine



Fisher issue:

Changing SBT distributions

Fisher need:

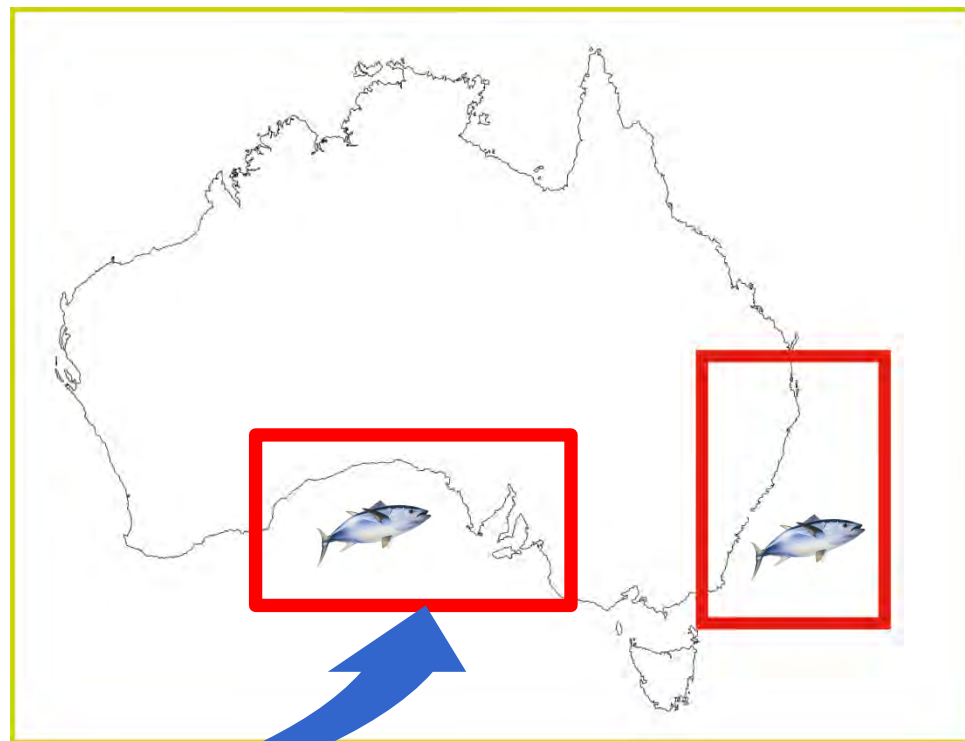
Improve efficiency of industry

Fisher solution:

Invest in research and fisher education

Fisher support:

Seasonal forecasts to improve operational planning of fishers



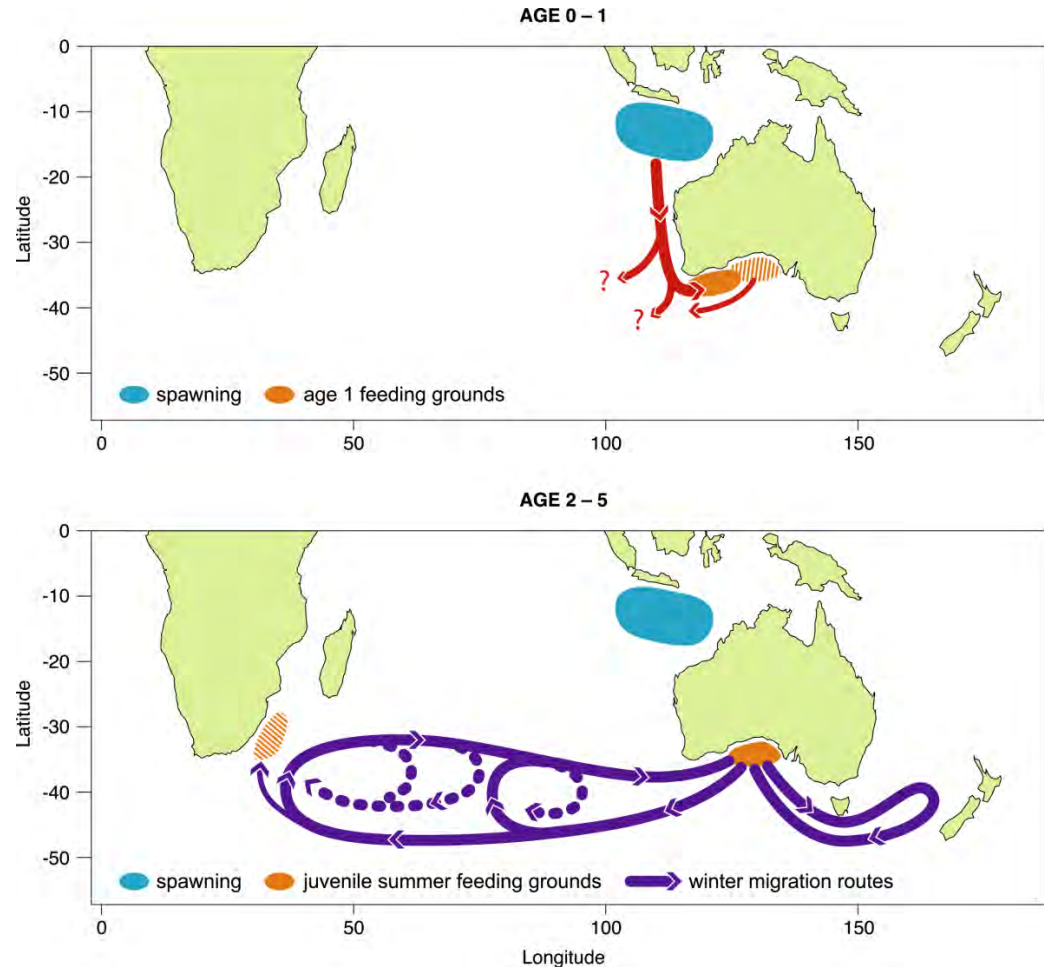
Quota limited fishery



Juvenile southern bluefin tuna



- Juveniles (age ~2-5) make annual cyclic migrations
- Spend winters across southern ocean
- Spend summers in GAB (Dec-Apr)
- Purse-seine fishery worth ~\$60 million annually occurs in GAB in summer

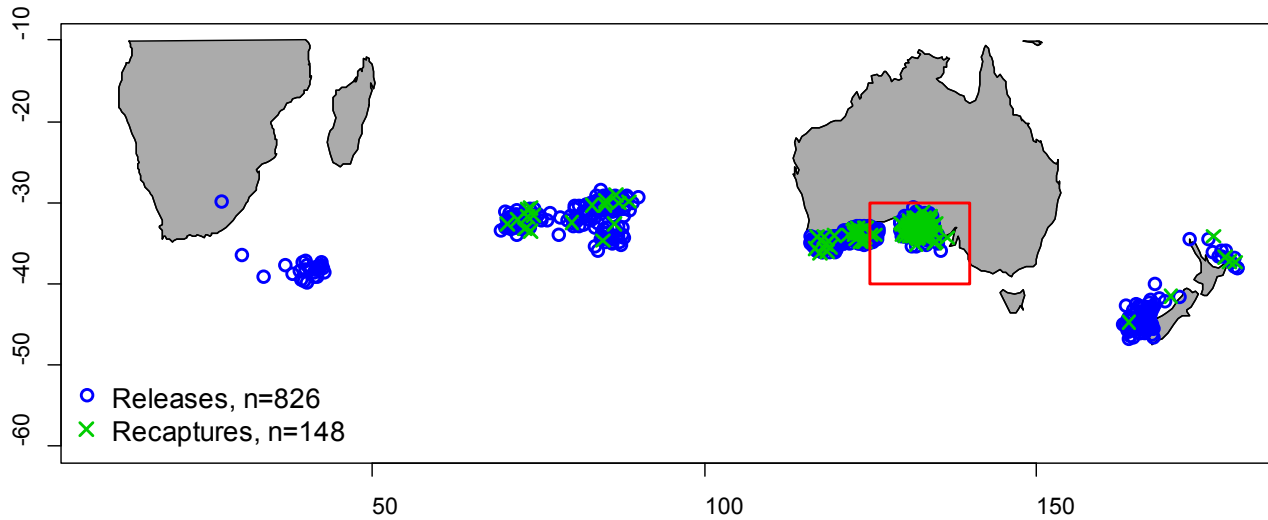




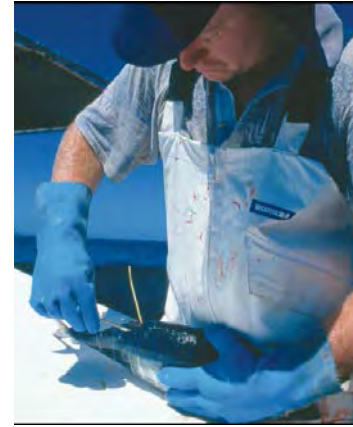




1. Tuna environmental data



- Archival tags released in 1998-2008
 - Released at ages 1-4 (n=826)
 - Recaptured at ages 2-6 (n=148)
- 42% of releases and 78% of recaptures occurred in the GAB (red box)
- Provide daily environmental data



A\$250 REWARD* * A\$250 for returned archival tags
* Tablet, cap or mug for each dart tag

Southern Bluefin Tuna
ARCHIVAL TAGGING PROGRAM

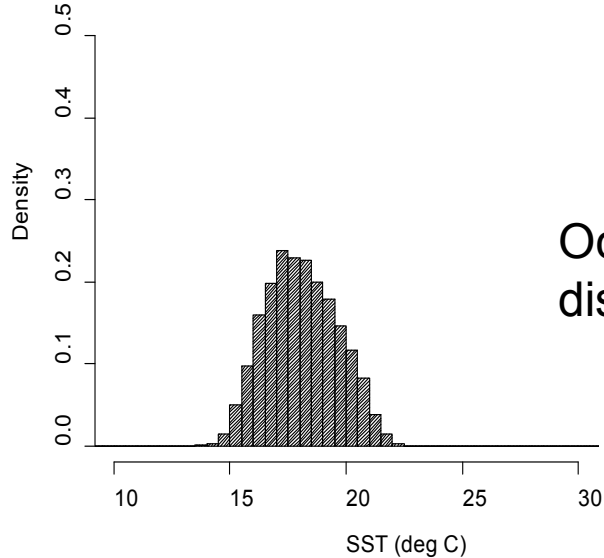
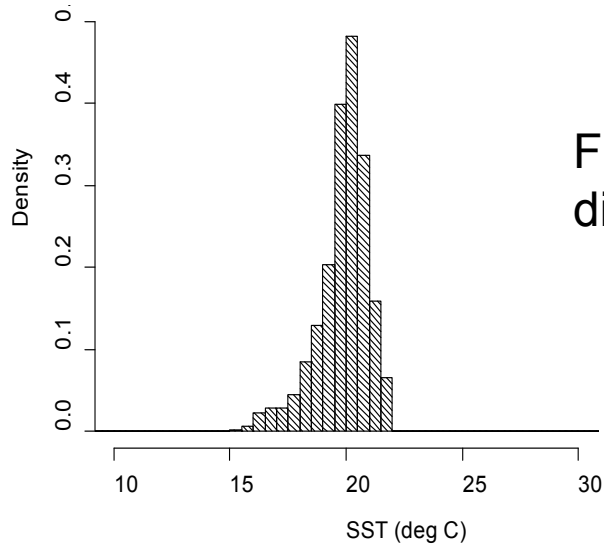
or a digital camera of the same value

Please return tag with the International Ocean Bottom Tag (IOBT) PS for St. David West, 402 York, Australia. Phone: +61 8 8362 4300 Fax: +61 8 8362 4007 email: oap@dmr.gov.au

Take photos
Pleasee approve (optional)
Length (mm)
Tag number
This name
Your photo address
Email name

Remove the tag by making a small cut in the belly in front of the stake - be careful not to cut the stake. Do not try to remove the tag by pulling on the stake - it will break.

2. Build Habitat Model - SST preference

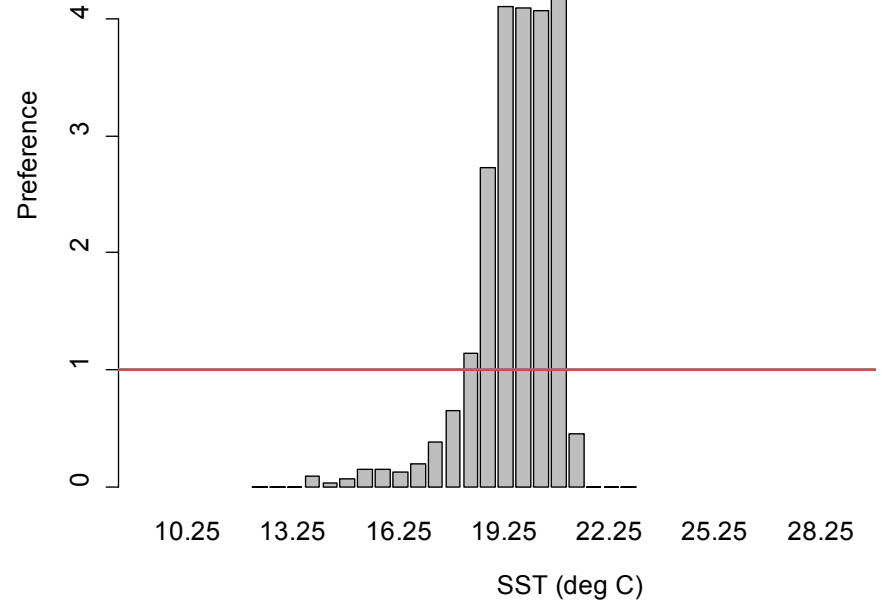


Fish distribution

Ocean distribution

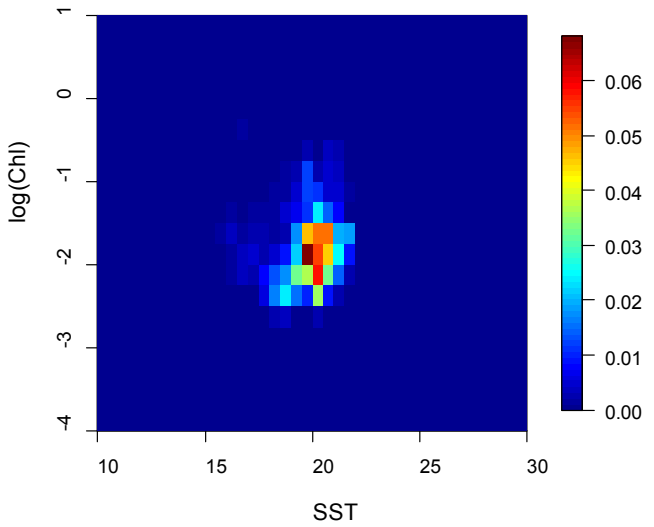


Preference curve

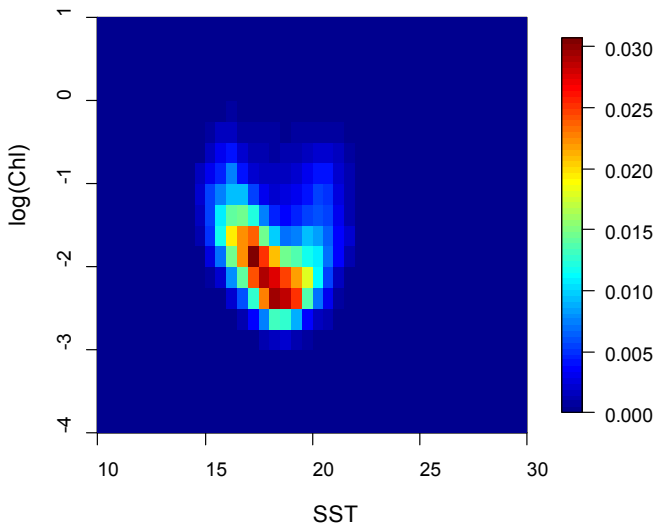


1998-2009, Jan-Mar, [-40 -30 125 140]

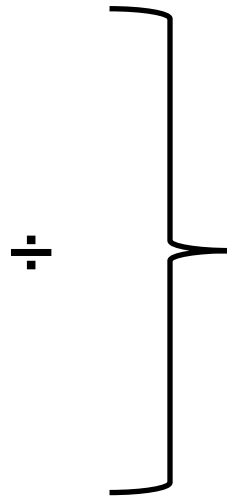
2. Build Habitat Model - SST & chlorophyll



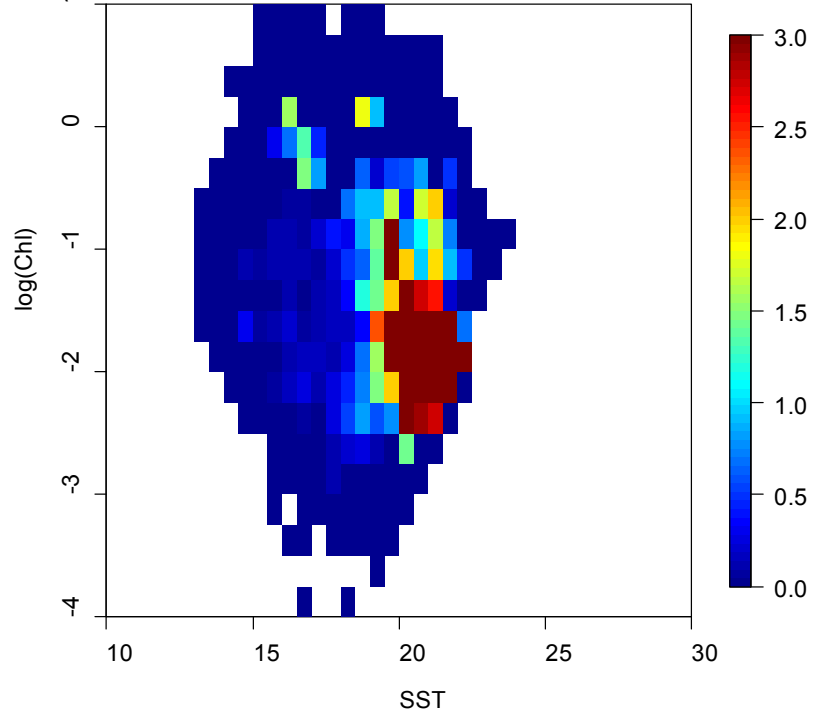
Fish distribution



Ocean distribution



Preference surface

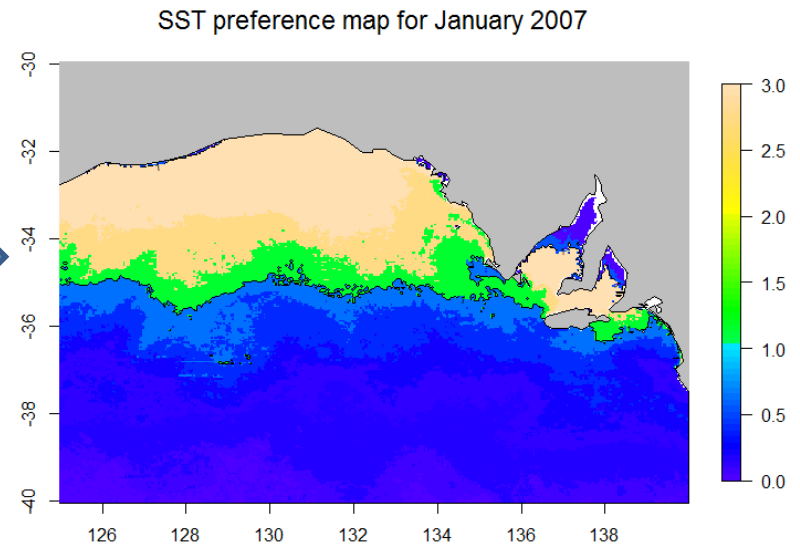
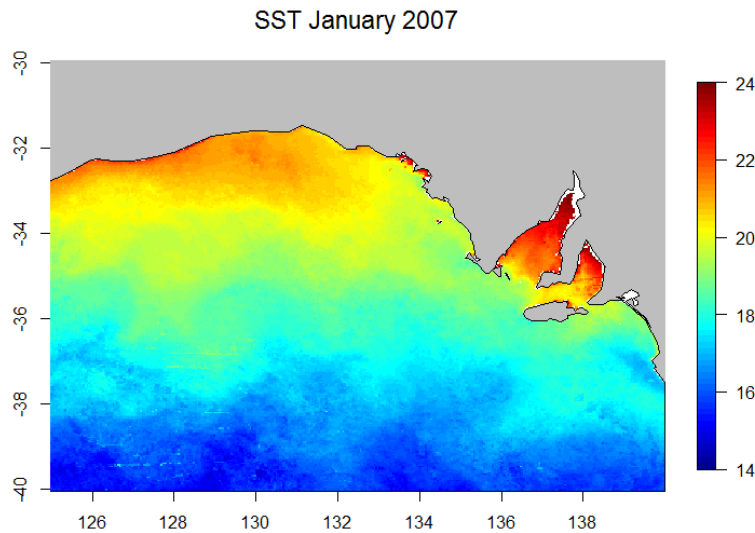


1998-2009, Jan-Mar, [-40 -30 125 140]

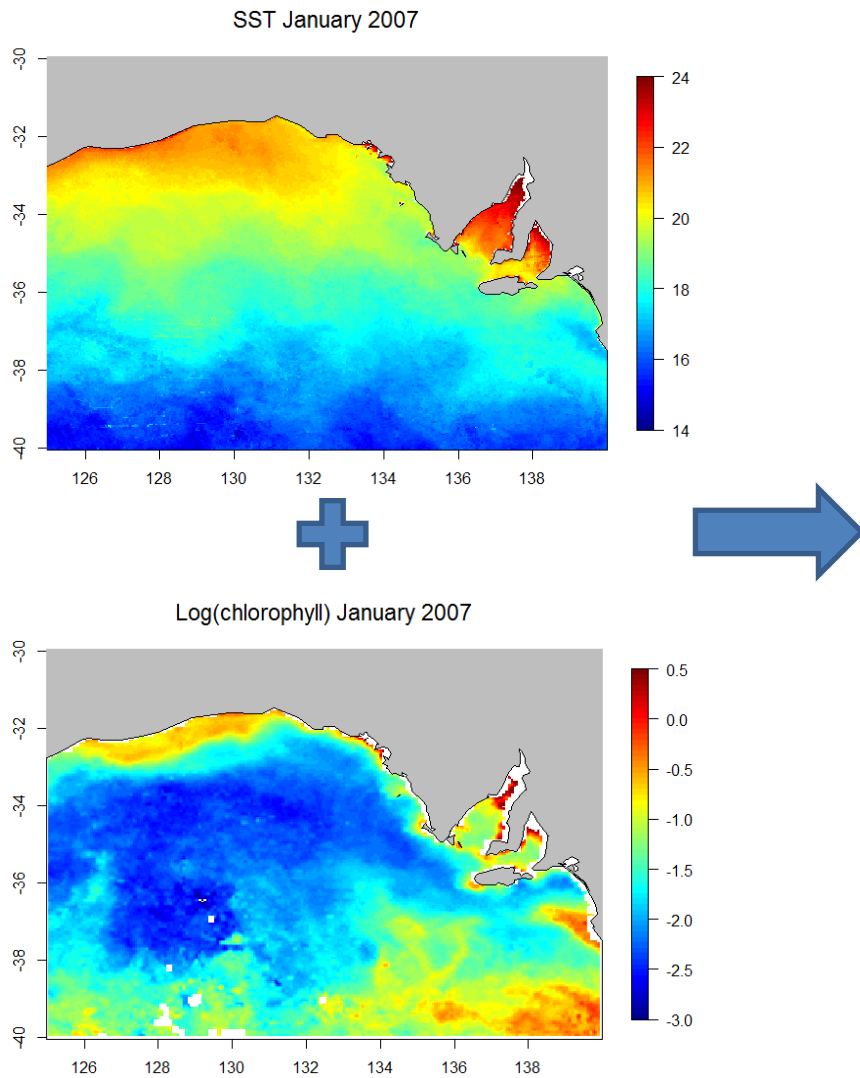
3. Preferred habitat maps - historical

- Get environmental conditions for time period (e.g. Jan 2007)
- Look up preference value corresponding to environmental conditions at each location in region

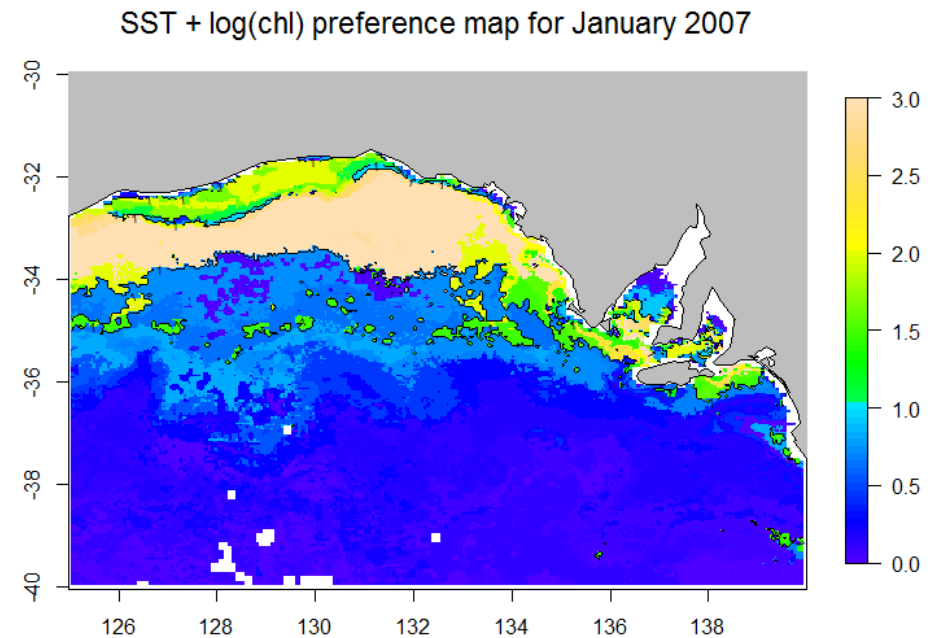
SST only



3. Preferred habitat maps - historical



SST + chlorophyll a

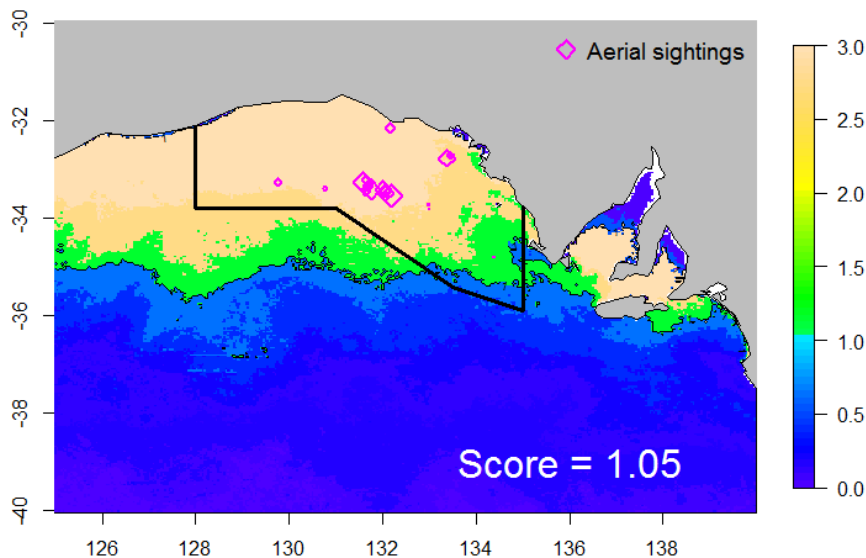


4. Validate habitat preferences

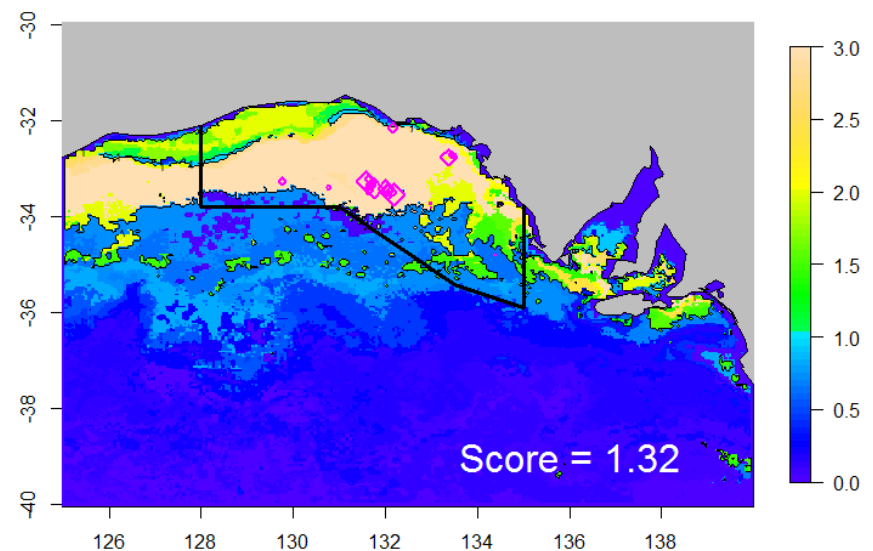


- Aerial survey for SBT conducted annually from Jan-Mar
- Use location of sightings to evaluate habitat preferences
 - $Score = \frac{Prop'n\ sightings\ within\ preferred\ habitat}{Prop'n\ survey\ area\ containing\ preferred\ habitat}$
- $Score > 1$ means preferences are informative (= 1 if fish randomly distributed)

SST preference map for January 2007



SST + log(chl) preference map for January 2007



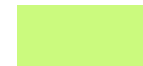
4. Validate habitat preferences

- Consider all years and months of aerial survey data
 - SST alone: scores > 1 in all but two year/month
 - SST + chl α : scores > SST alone in all but two year/month

YEAR	JANUARY		FEBRUARY		MARCH	
	SST	+CHL	SST	+CHL	SST	+CHL
1998	1.39	1.42	1.05	1.11	1.11	1.42
1999	1.17	1.28	1.26	1.40	1.55	1.72
2000	1.73	1.83	1.05	1.15	1.06	1.09
2005	1.20	1.42	1.01	1.38	1.41	1.83
2006	1.16	1.30	1.32	1.59	1.08	1.26
2007	1.05	1.32	1.05	1.10	1.08	1.19
2008	1.10	-	1.57	-	1.02	-
2009	1.01	1.09	1.10	1.21	0.93	1.17
2010	1.02	1.18	1.22	1.33	1.10	1.12
2011	1.00	0.53	1.07	1.29	2.31	2.28
2012	1.01	1.27	1.02	1.13	1.01	1.09
2013	1.06	1.22	1.02	1.24	1.03	1.01
2014	1.02	1.02	1.03	1.08	1.03	1.06



score ≥ 1



+chl better than SST alone



score < 1

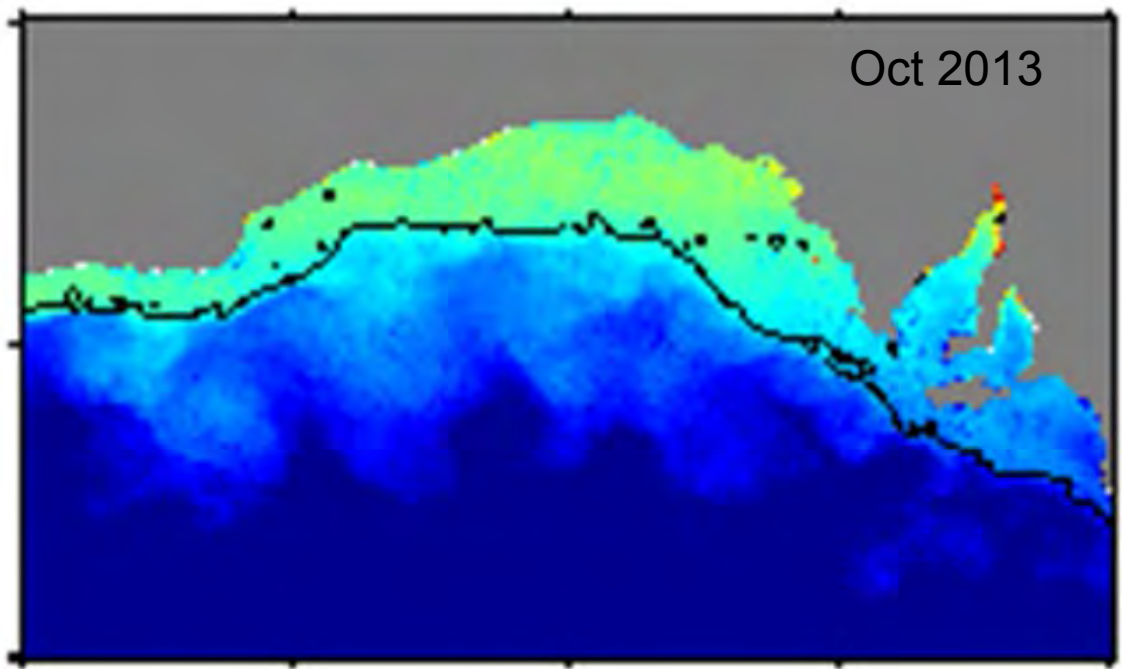
5. Forecasting preferred habitat

- Use POAMA forecasts of SST to predict regions of preferred habitat in future
- POAMA does not currently forecast chl a , so can only provide SST-based forecasts
- Forecasts are issued for next 2 fortnights and next 6 calendar months
 - Has skill for 3 months in this region for SST

Resolution

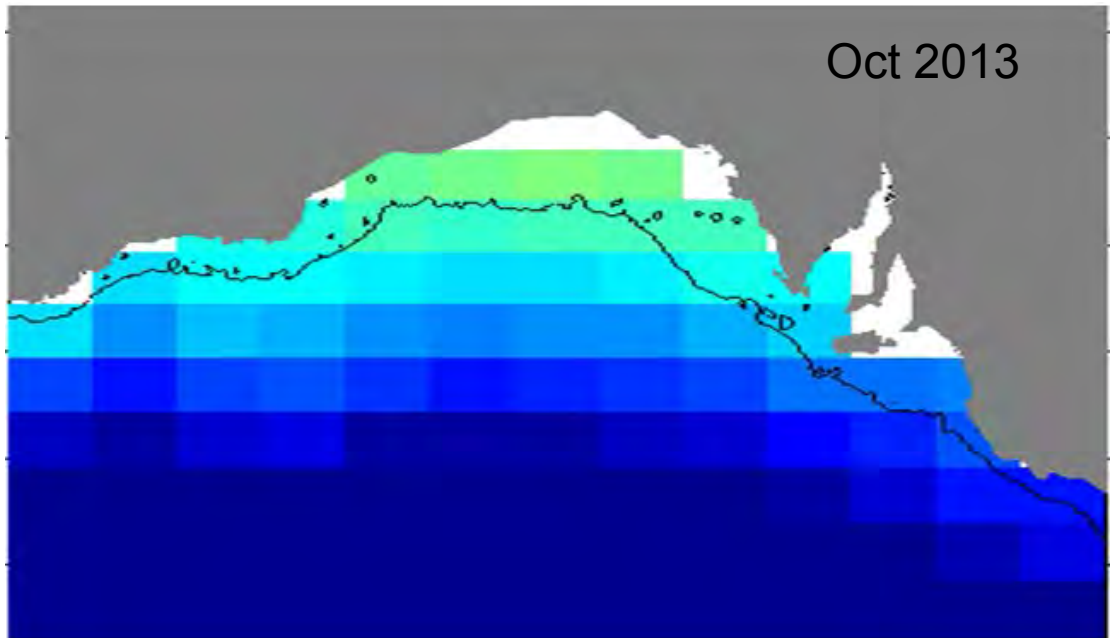
Satellite SST

- Fine scale - 4-9 km
- eddies



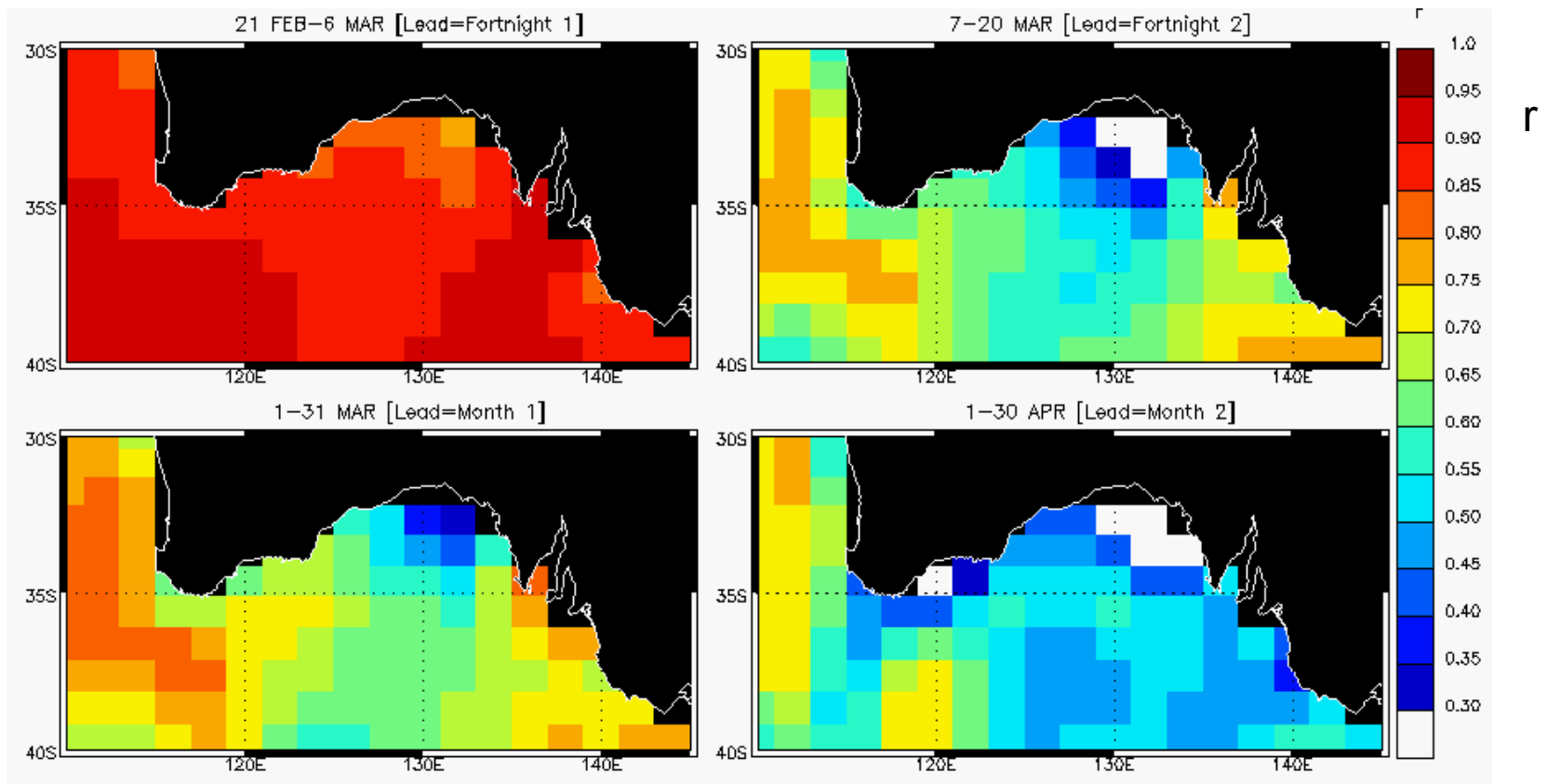
Model SST

- 2° in east-west,
- 0.5° – 1.5° north-south

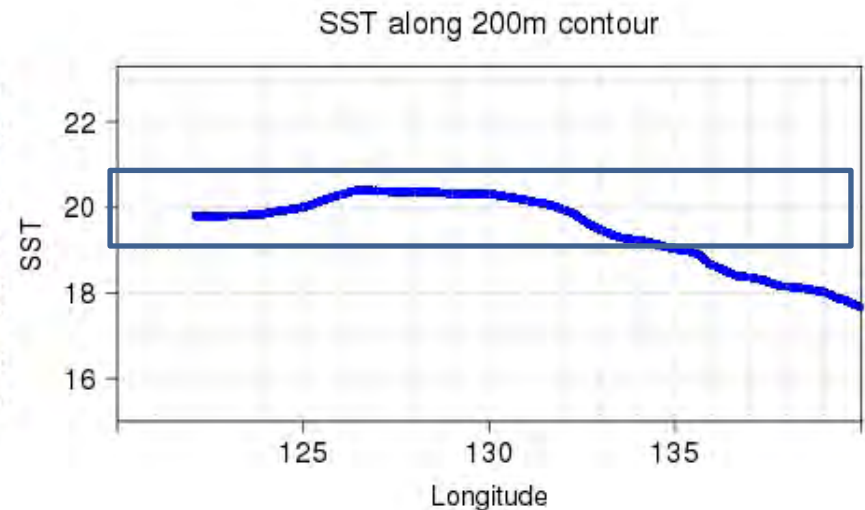
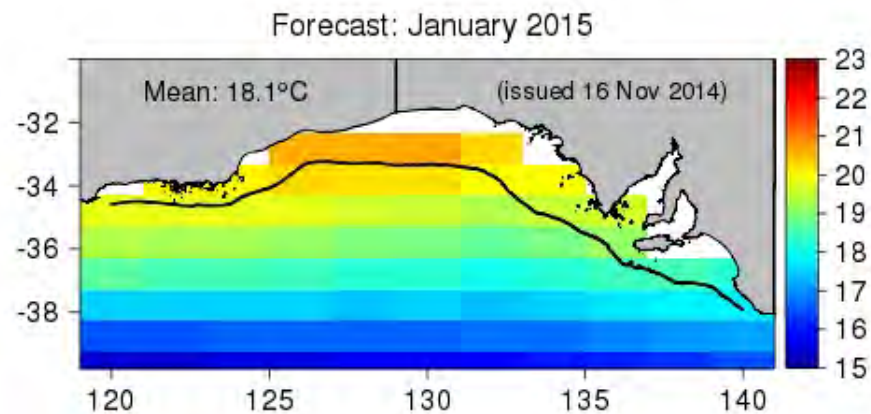
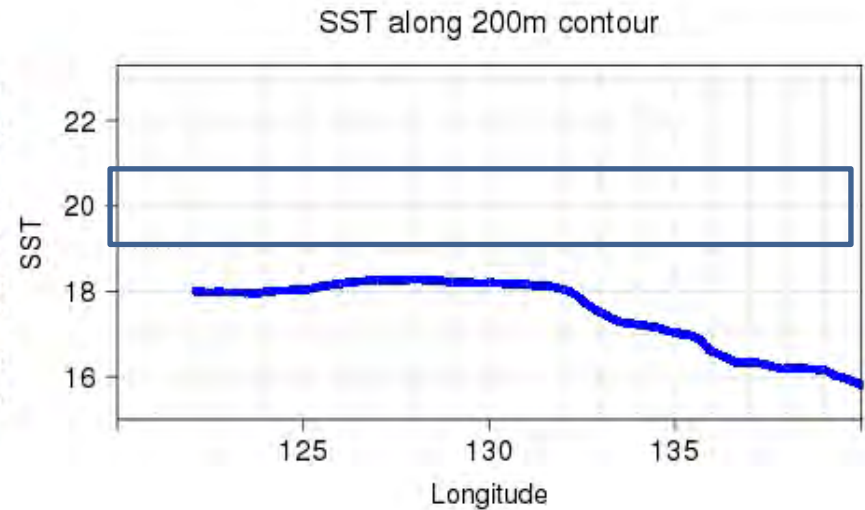
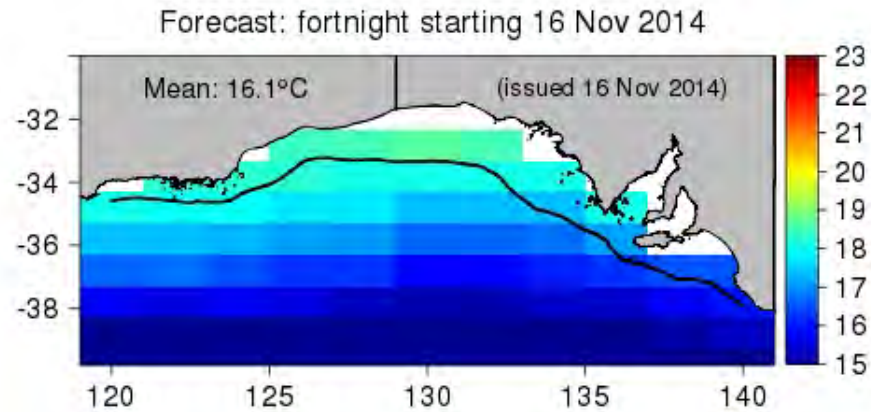


Forecast skill in Great Australia Bight

- Usefulness - depends on forecast skill
- SST forecasts have skill up 2-3 months in future

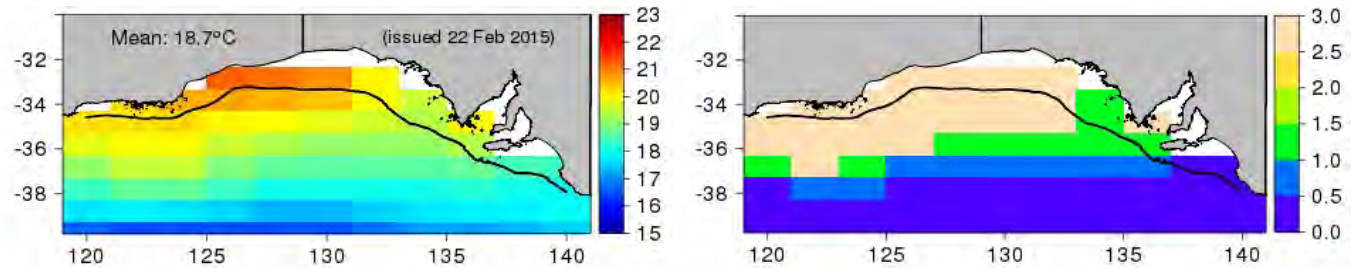


Option 1: SST forecasts

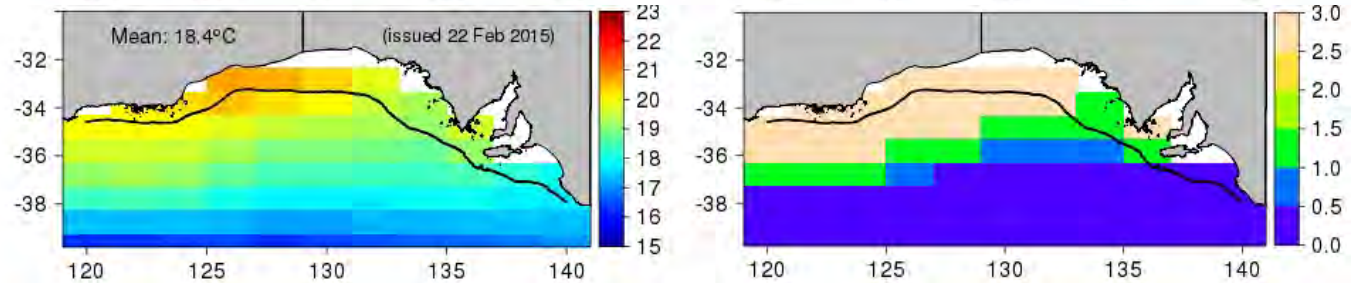


Option 2: Habitat forecasts

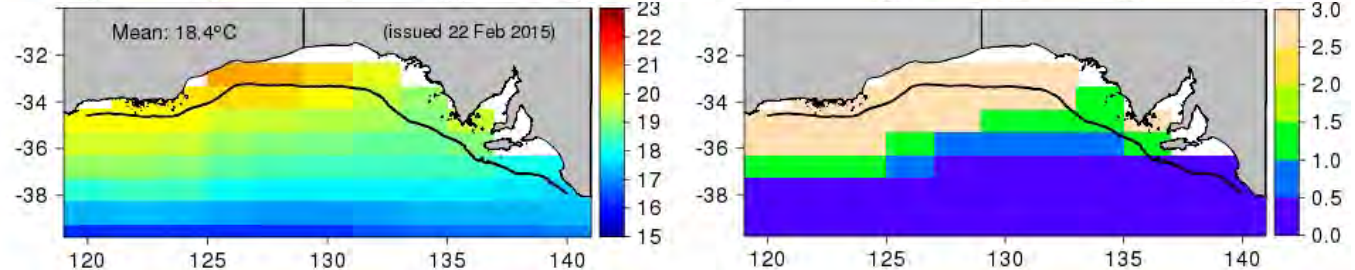
Fortnight 1:
22 Feb – 7 Mar



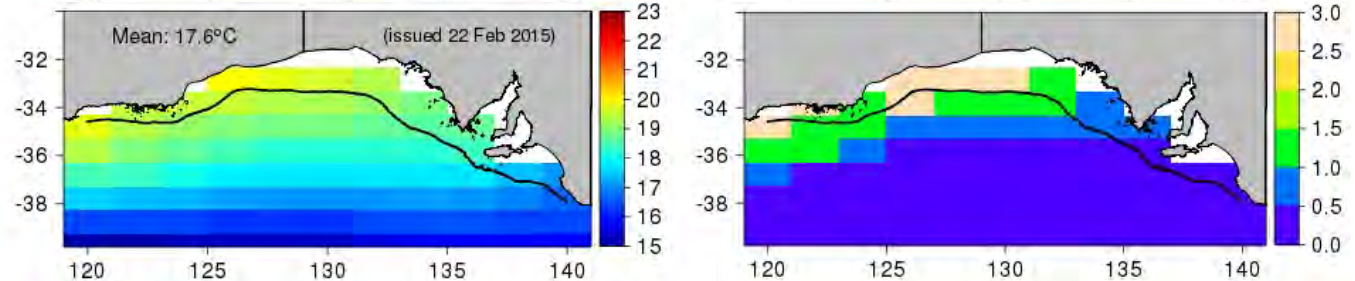
Fortnight 2:
8 Mar – 21 Mar



Month 1:
March



Month 2:
April



6. Delivery - www.cmar.csiro.au/gab-forecasts

Adaptation yet?

In the first year

10 major fishing companies

- All used website

8 used in decision-making

- 6 made different decision
- 2 made “do nothing different” decision
- (when and where to fish)
- (economic benefits)

Eveson et al (in review)

Forecasting Southern Bluefin Tuna Habitat in the Great Australian Bight

Home

Observed conditions

SST forecasts

Habitat preference forecasts

Historical SST

Case studies

Estimating habitat preferences

Useful links

Forecasting Southern Bluefin Tuna Habitat in the Great Australian Bight

About the project

This project is a collaboration between CSIRO, the Australian Southern Bluefin Tuna Industry Association (ASBTIA) and the Bureau of Meteorology (BoM), co-funded by the Fisheries Research and Development Corporation (FRDC Project 2012/238).

Project Aim: To investigate habitat preferences of southern bluefin tuna (SBT) in the Great Australian Bight (GAB) based on historical archival tag, catch and aerial survey data, and to provide forecasts of habitat distribution.

Motivation: The project was initiated in response to observed changes in spatial distribution of SBT in the GAB through recent fishing seasons.

Planned Outcome: Forecasts of seasonal environmental conditions such as sea surface temperature (SST) should improve operational planning of SBT fishers targeting surface schools for value-adding of a quota restricted resource.

Observed environmental conditions
For maps of recently observed conditions in the Great Australian Bight, go to:
[Observed conditions](#)

Forecasted sea surface temperature
For forecasts of SST in the Great Australian Bight over the next fortnight up to 2 months in future, go to:
[SST forecasts](#)

Preferred habitat forecasts
For maps of expected areas of preferred habitat for juvenile southern bluefin tuna in the Great Australian Bight, go to:
[Habitat preference forecasts](#)

Lessons learned

Essentials:

- Strong industry engagement and partnership
- A clear understanding of the end user skills and how they might use forecast product
- A model with useful skill in the region of interest
- Forecast product delivery mechanism that suits the end user
- Industry feedback for refinement of forecast products

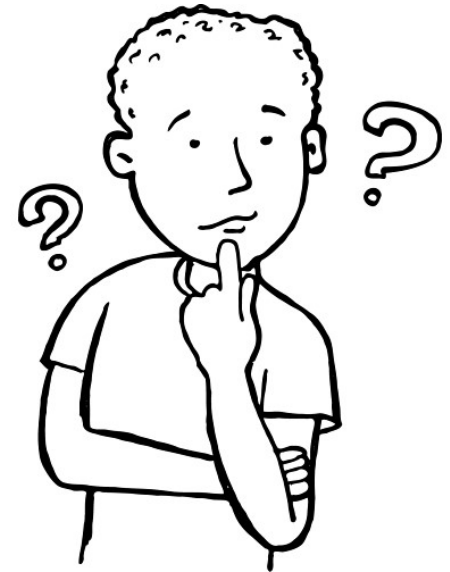
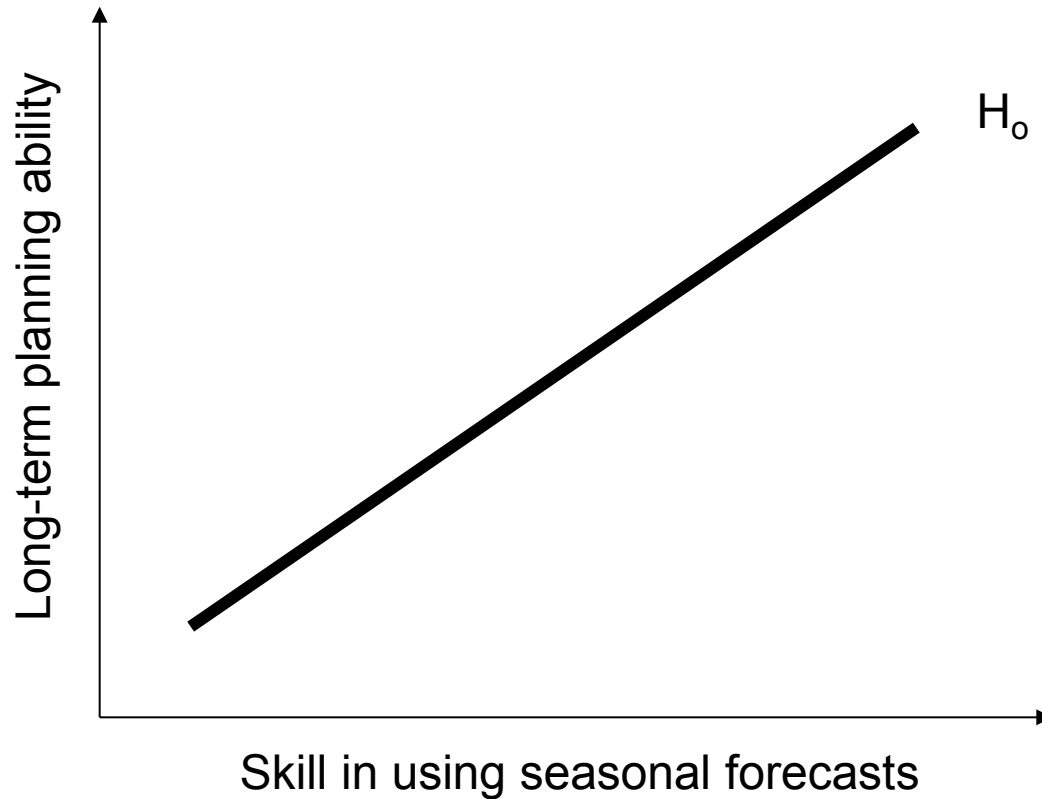
Very useful:

- Industry advocate or liaison officer
- Face-to-face end user meetings
- Historical industry data



Engaging at a relevant timescale....

- Does thinking more about the future lead to better long term skills?



Testing planned

Translating impact to adaptation

Strategy 1 – avoid future impacts (coming decades)

1. Discover some historical impacts
2. Make some future projections
3. Develop some adaptation options
4. Implement with stakeholders (too soon?) \leftrightarrow Barriers analysis

But, balance the portfolio (it's about risk management)

Strategy 2 – learn, based on current issues (CC already here)

1. Consider relevant time scales
2. Understand decision context
3. Co-develop forward looking solutions
4. Implement with stakeholders

Further information

Forecasts: www.cmar.csiro.au/gab-forecasts

- Hobday & Hartmann (2006) Fisheries Management and Ecology
- Hobday et al (2010) Fisheries Oceanography.
- Hobday et al. (2011) Can. J. Fish. Aquat. Sci
- Spillman & Hobday (2014) Climate Risk Management
- Spillman et al. (2015) Aquaculture
- Hobday et al. (2015) Fisheries Oceanography,
- Eveson et al (in review) Fisheries Research.