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

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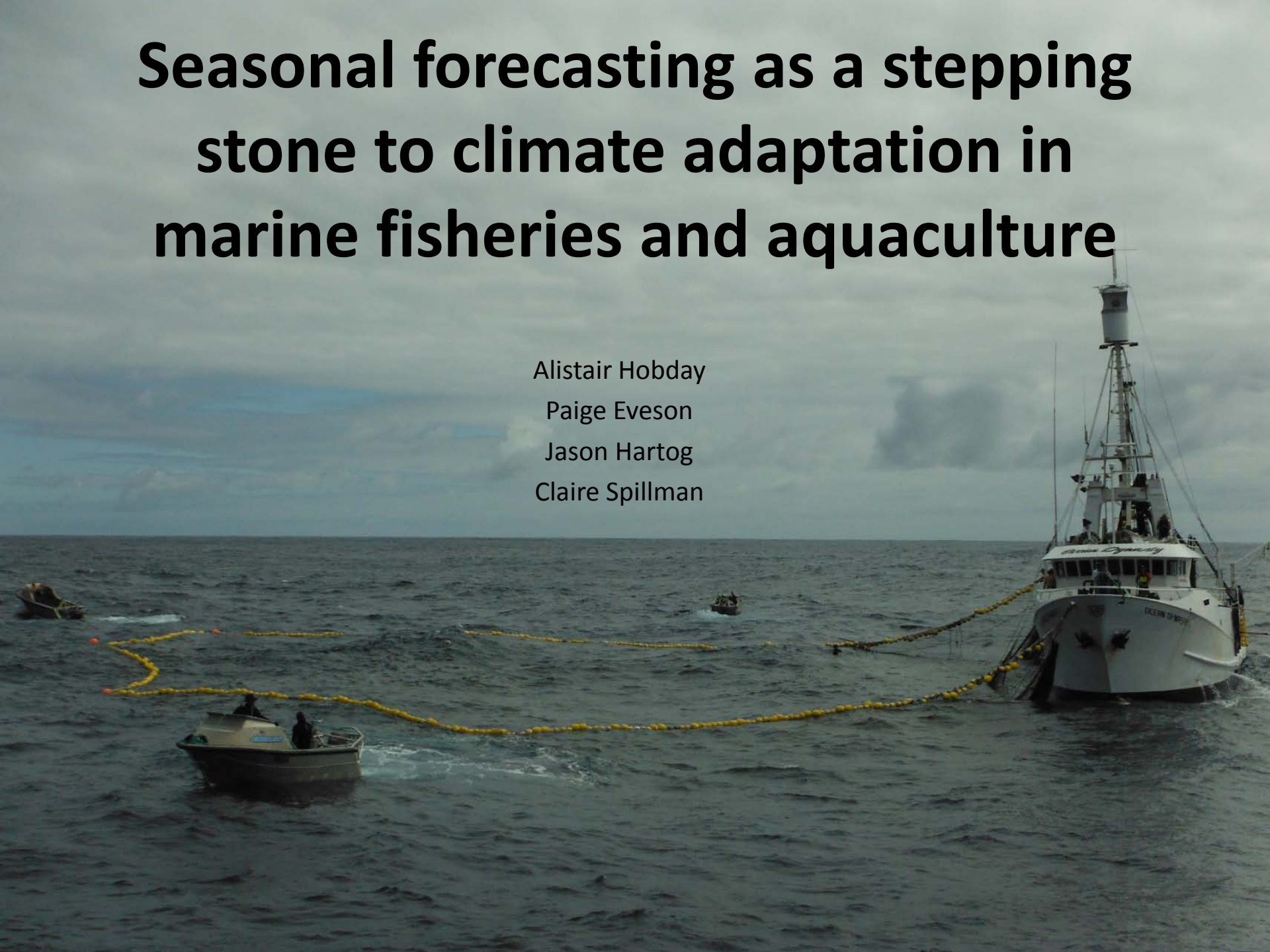
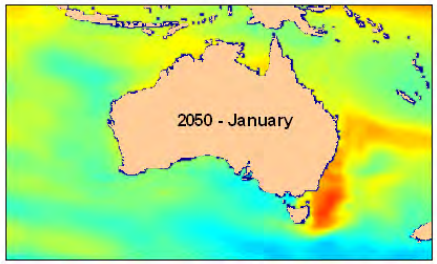
Claire Spillman

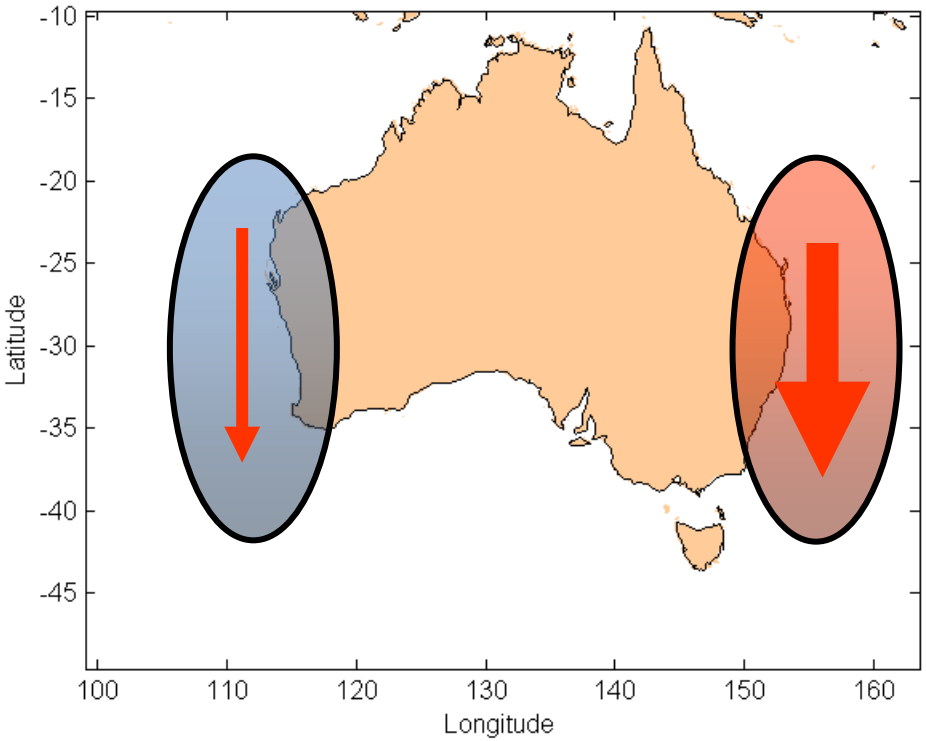


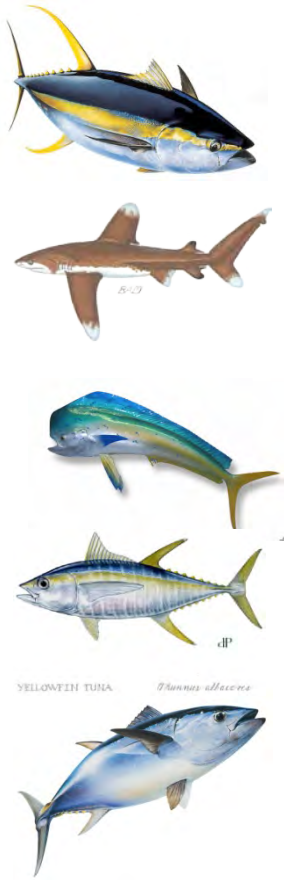
Projected changes (e.g. distribution)



Hobday and Lough 2011

11 species in Australian longline fisheries





Hobday 2010

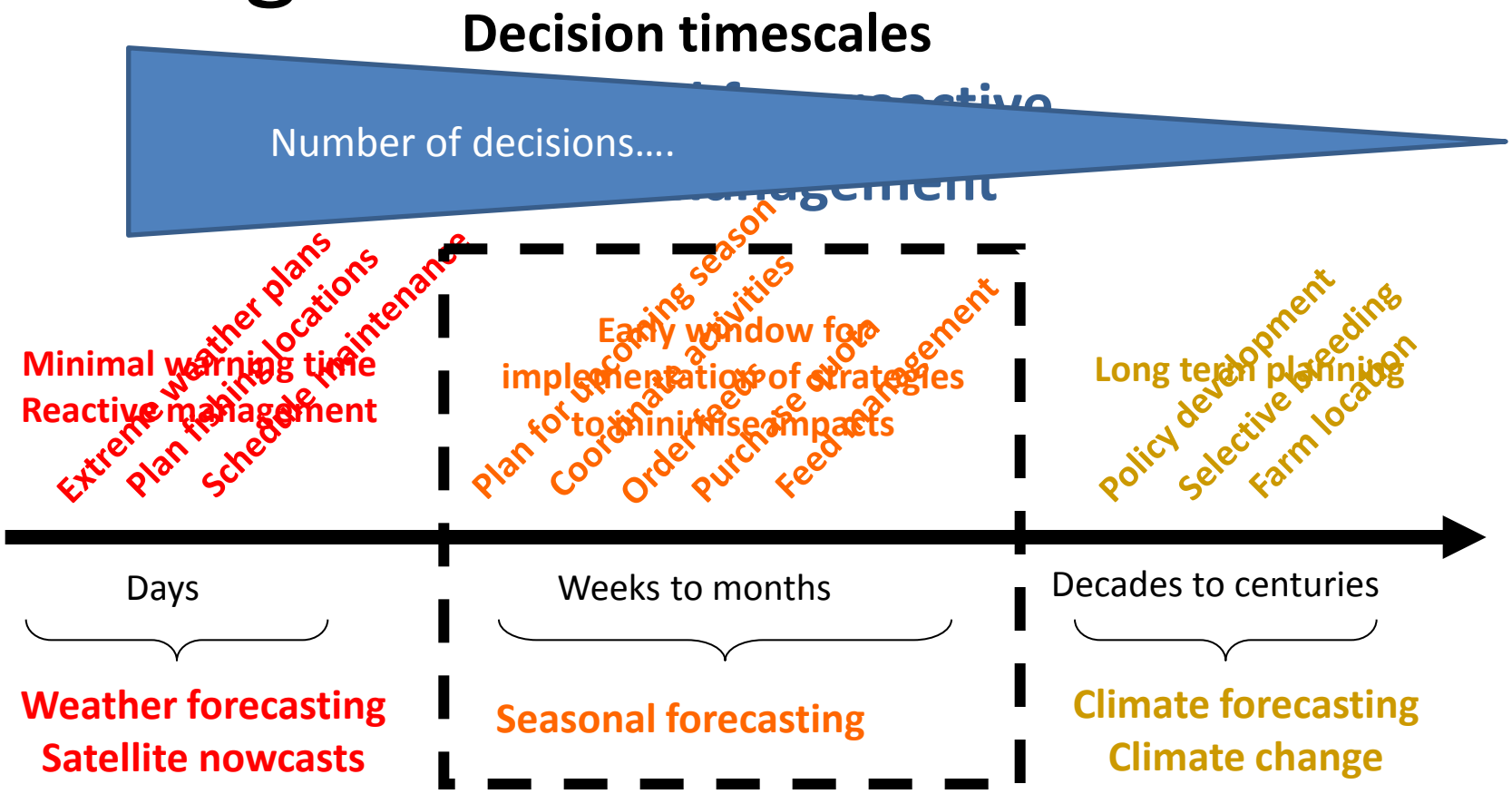
The future will be different…

- 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



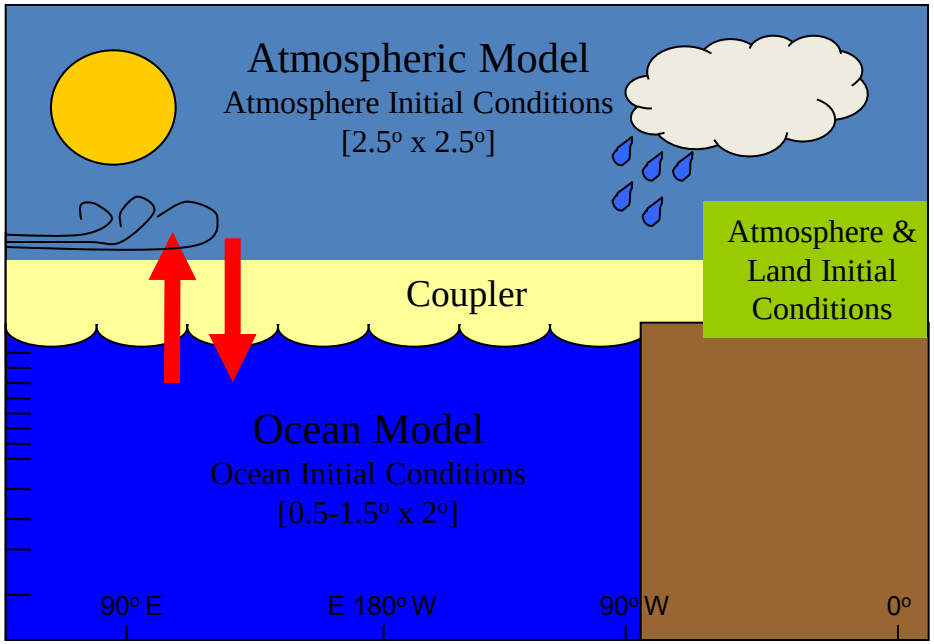
Better managed marine resources have improved resilience under climate change

Hobday et al, in press

Seasonal forecasting

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

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

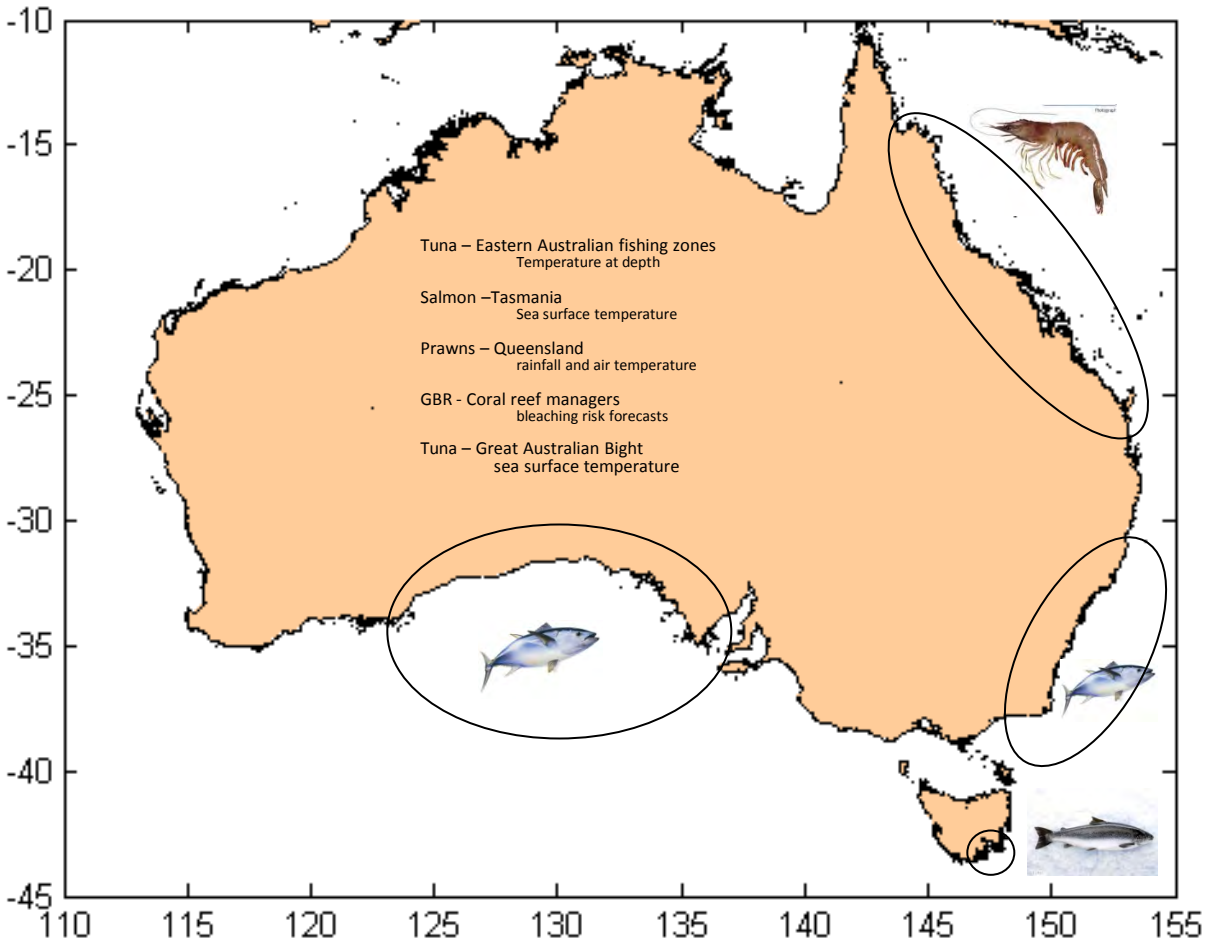


- Forecasts out to 9 months
- Weekly to seasonal multi-model predictions
- Ocean and atmosphere products available
- 33 member ensemble
- Probabilistic forecasts
- Run operationally x2 weekly

http://poama.bom.gov.au

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

Who is using our seasonal forecasts?



Hobday et al (in press) Fish. Oceanog.

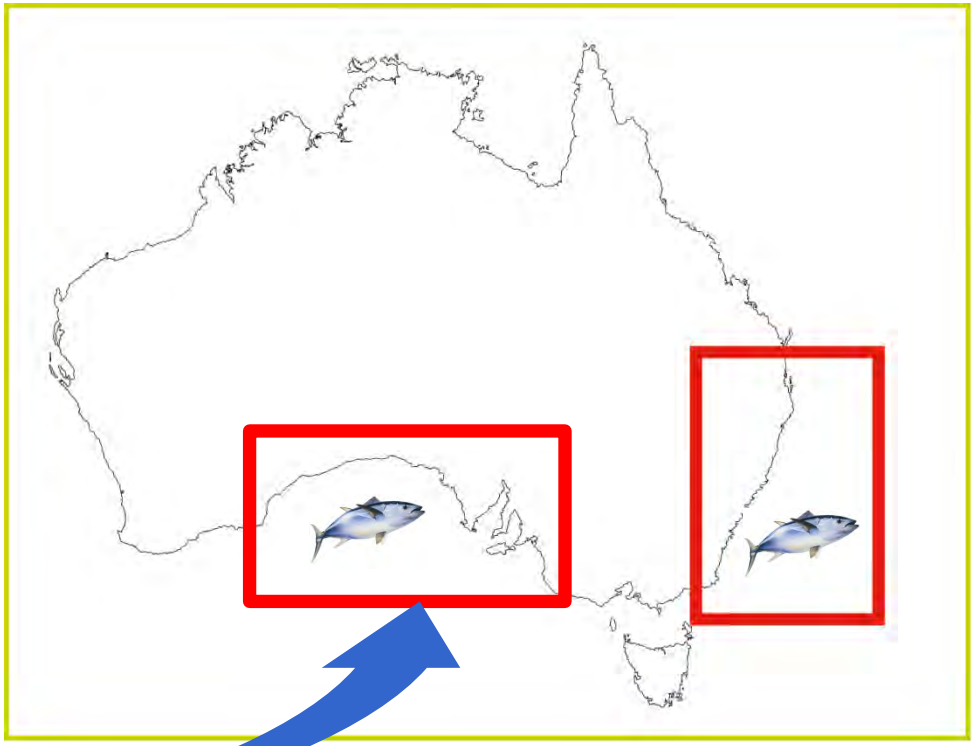
Southern bluefin tuna - Purse-seine

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



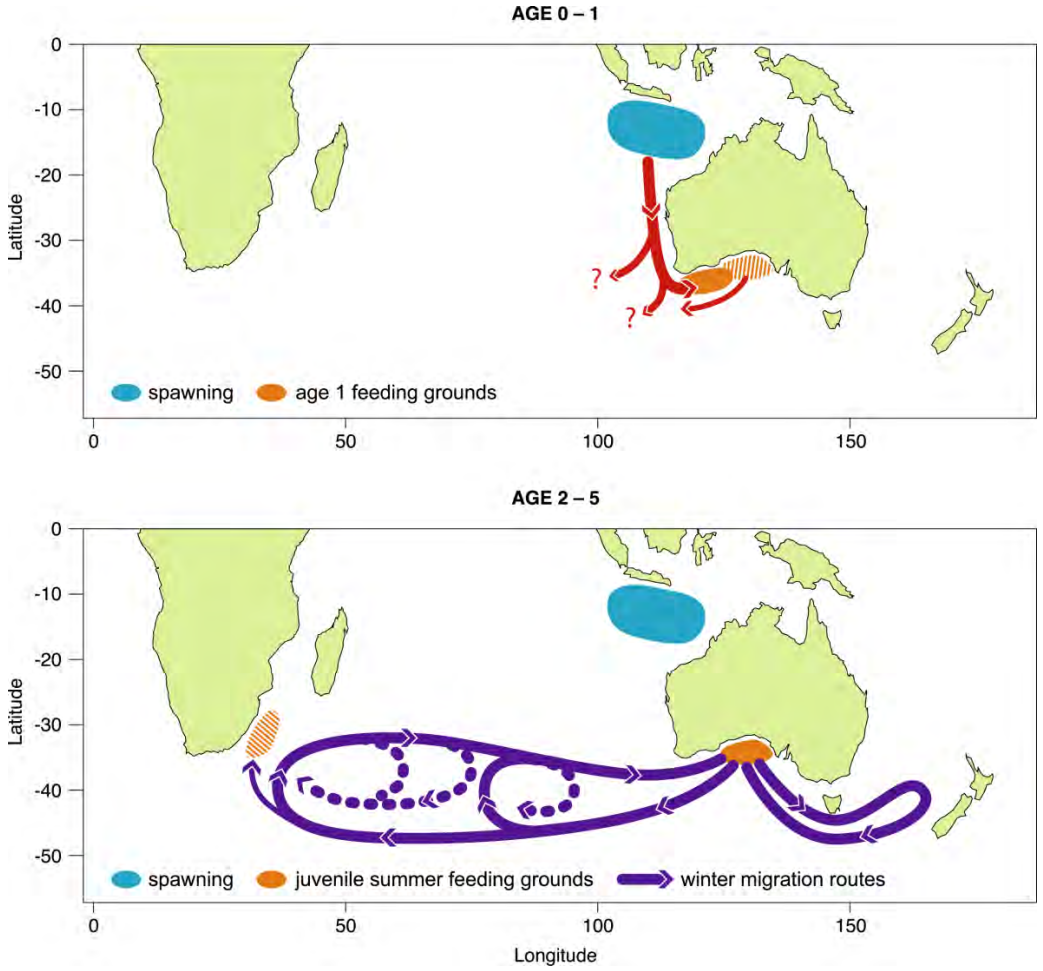
Quota limited fishery

Australian Government
Bureau of Meteorology

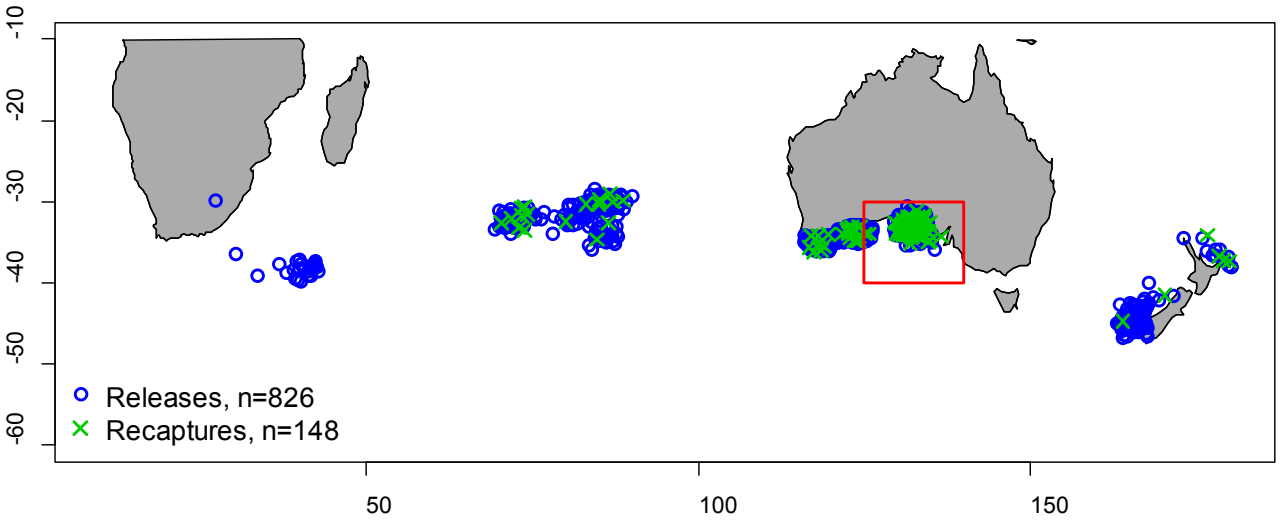
CSIRO

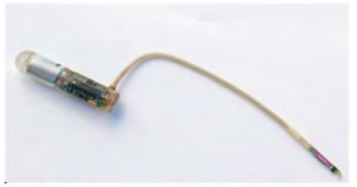
Juvenile southern bluefin tuna

- 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

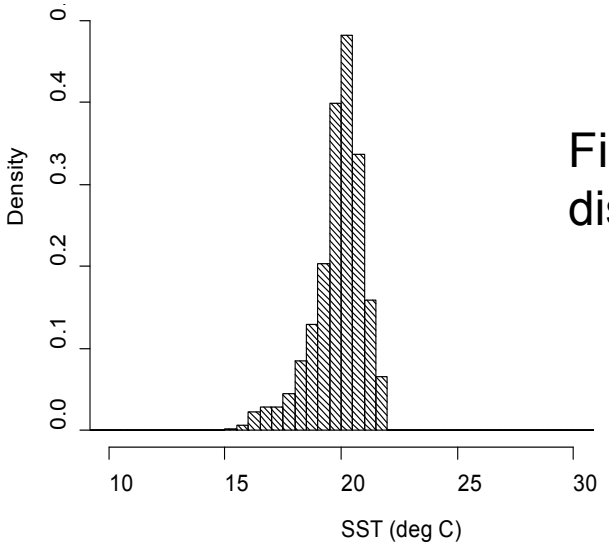




- Archival tags released in 1998-2008
  - Released at ages 1-4 (n=826)
  - Recaptured at ages 2-6 (n=148)
- 42% of releases and 78% of recaptures occurred in the GAB (red box)
- Provide daily environmental data

Basson, Hobday, Eveson and Patterson (2012) *Spatial interactions among juvenile SBT at the global scale: a large scale archival tag experiment*. FRDC Final Report 2003/002.

2. Build Habitat Model - SST preference



Fish distribution

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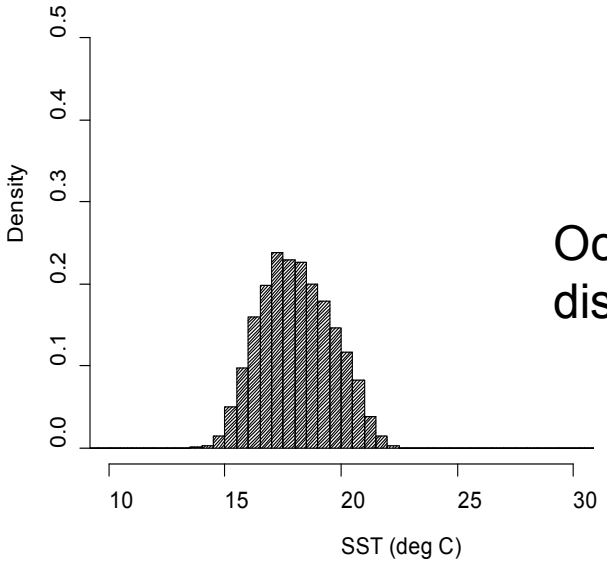
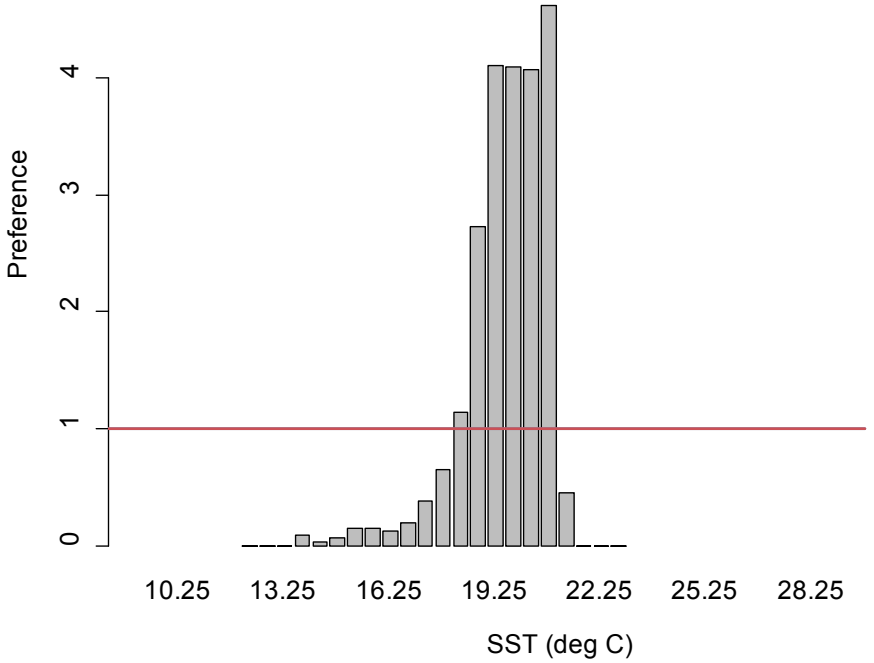


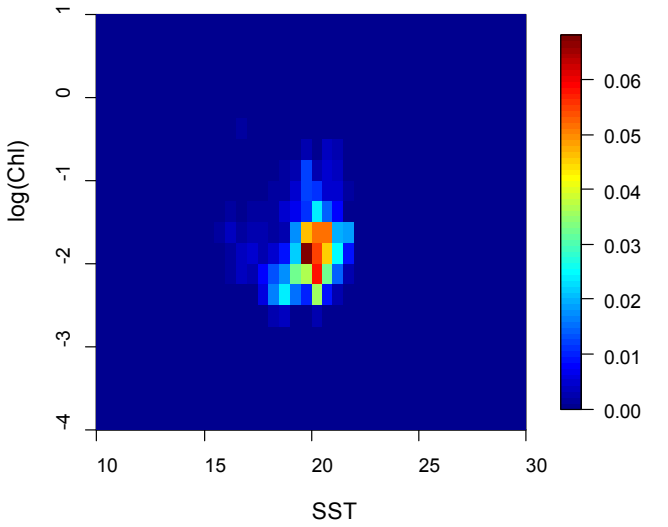
Ocean distribution

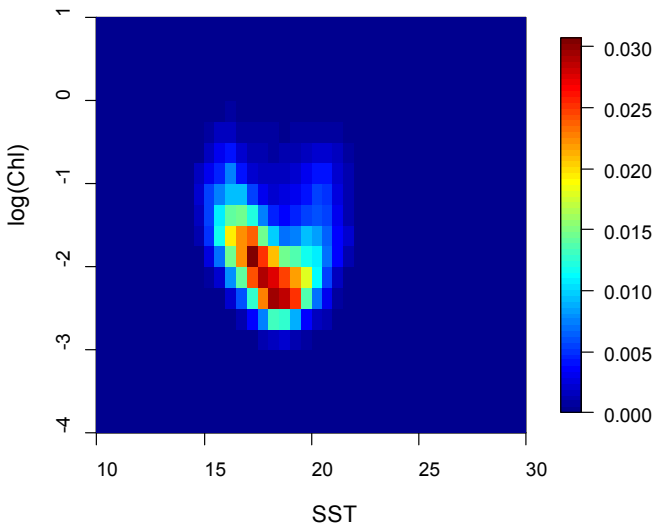
Preference curve



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

2. Build Habitat Model - SST & chlorophyll





Fish distribution

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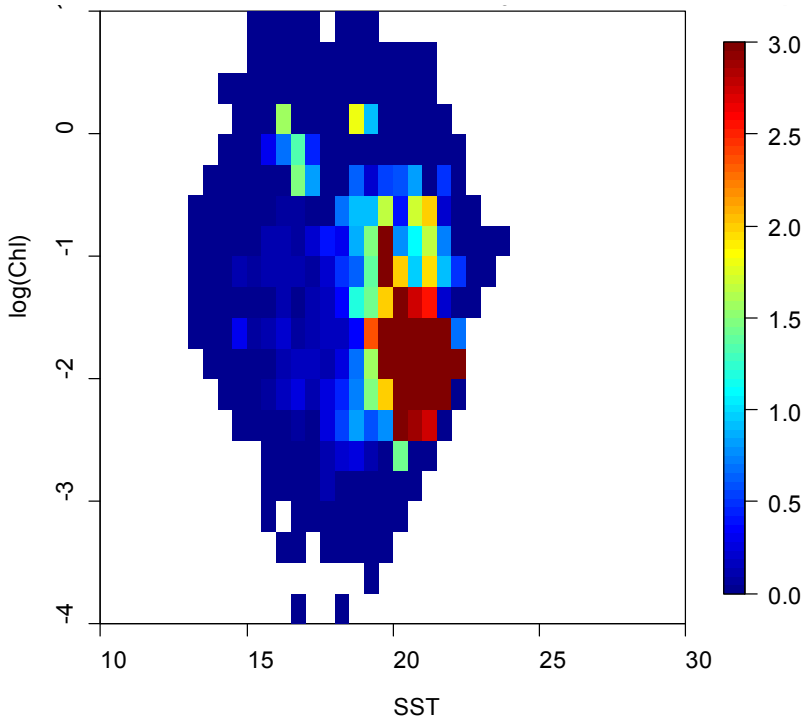
Ocean distribution

Preference surface

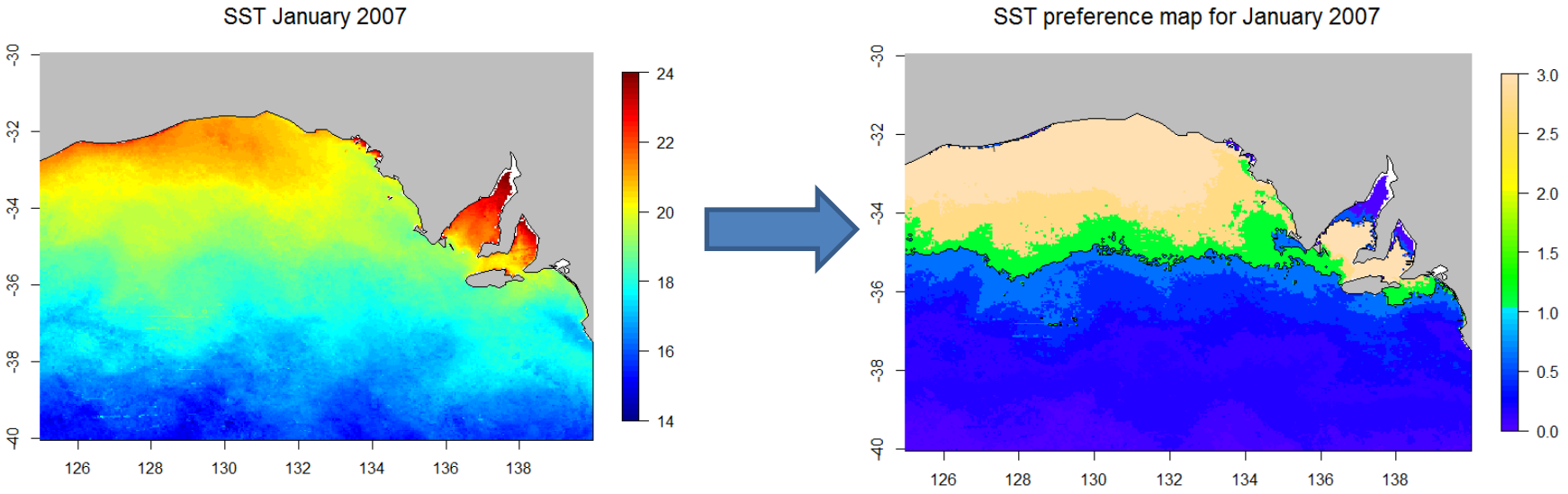


1998-2009, Jan-Mar, [-40 -30 125 140]

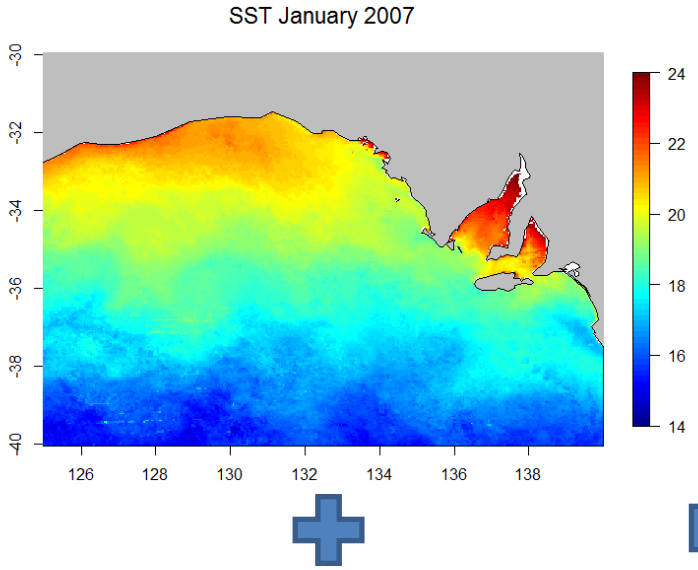
3. Preferred habitat maps - historical

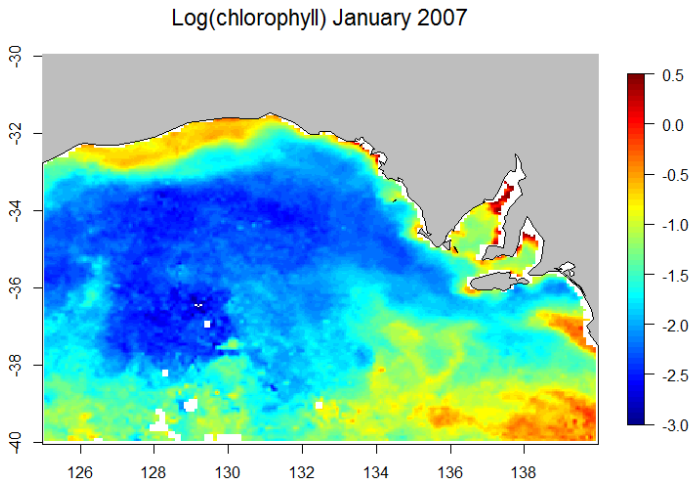
- Get environmental conditions for time period (e.g. Jan 2007)
- Look up preference value corresponding to environmental conditions at each location in region

SST only

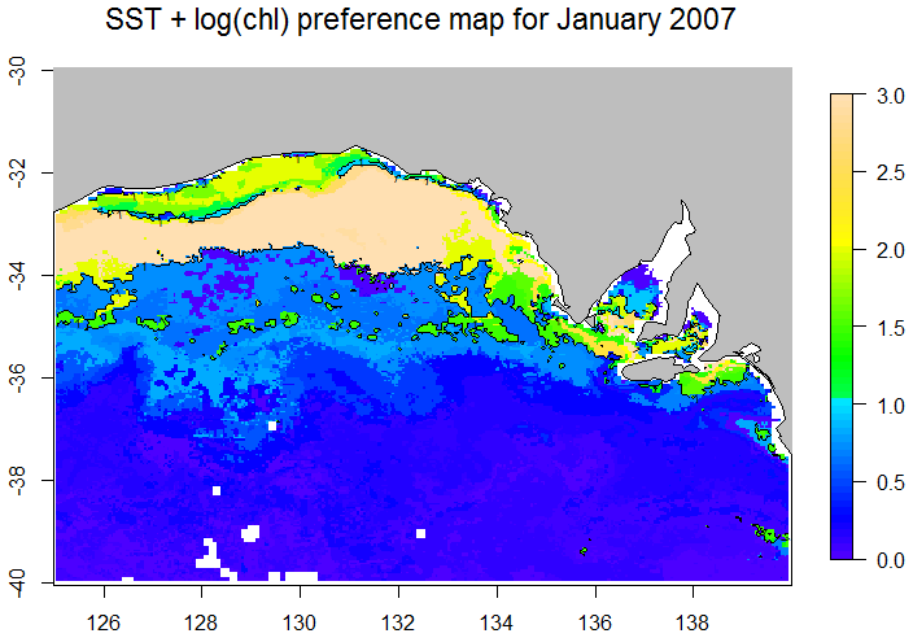


3. Preferred habitat maps - historical



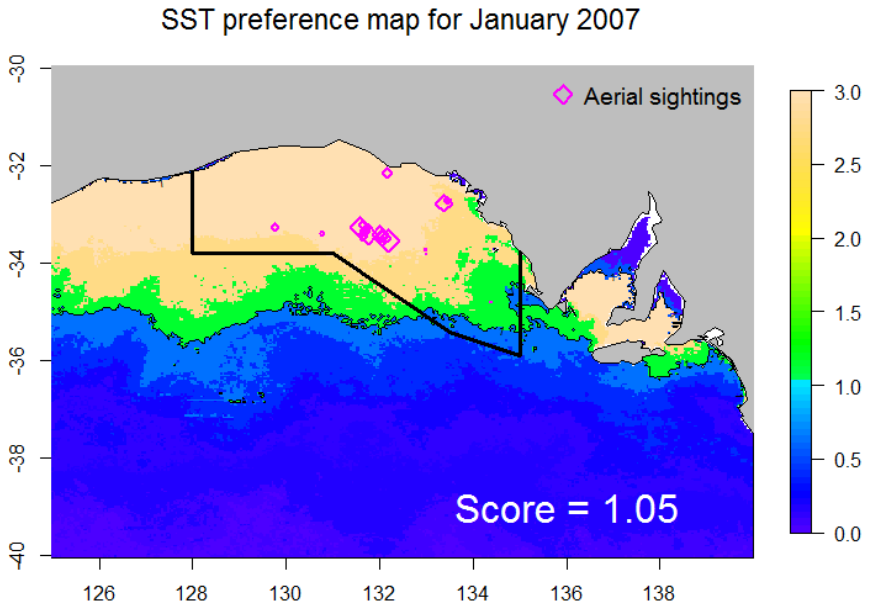


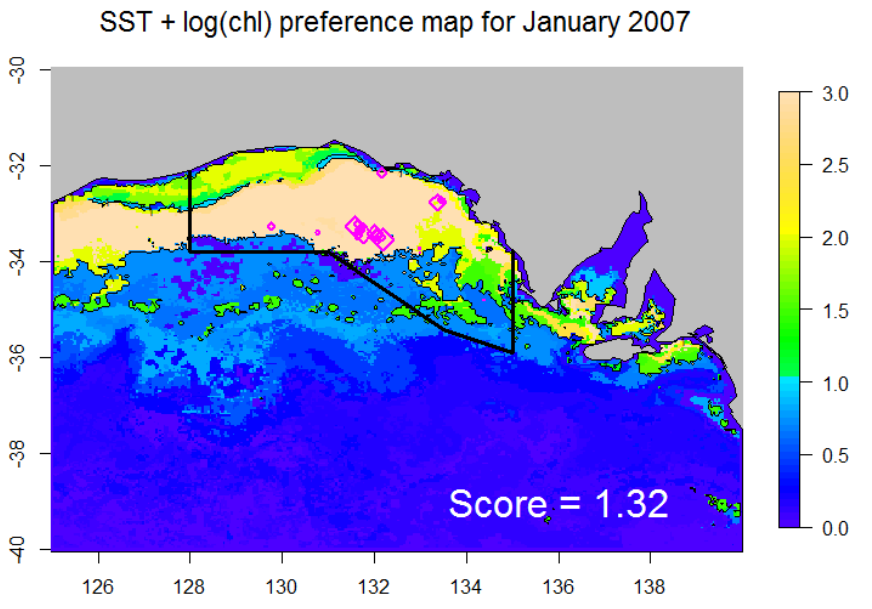
SST + chlorophyll *a*



4. Validate habitat preferences

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

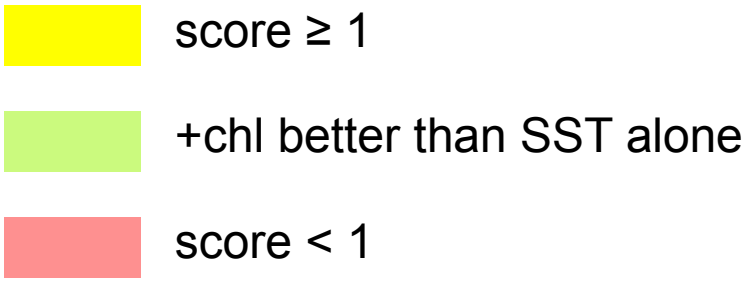




4. Validate habitat preferences

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

	JANUARY		FEBRUARY		MARCH	
YEAR	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



5. Forecasting preferred habitat

- Use POAMA forecasts of SST to predict regions of preferred habitat in future

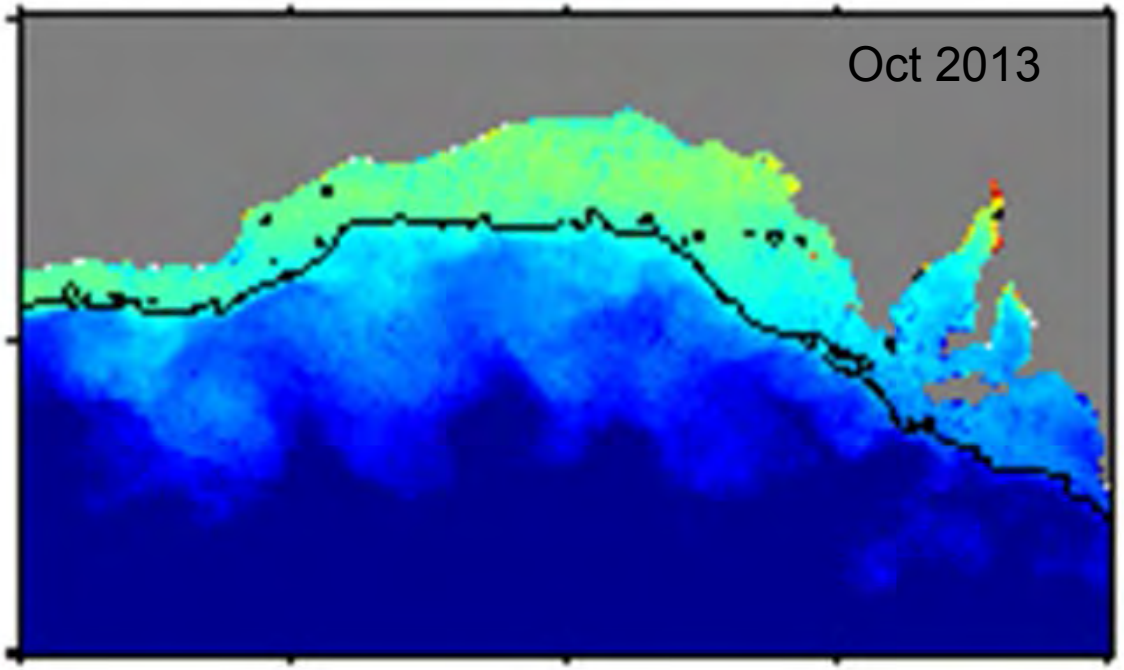
- POAMA does not currently forecast chl *a*, so can only provide SST-based forecasts

- Forecasts are issued for next 2 fortnights and next 6 calendar months
    - Has skill for 3 months in this region for SST

Resolution

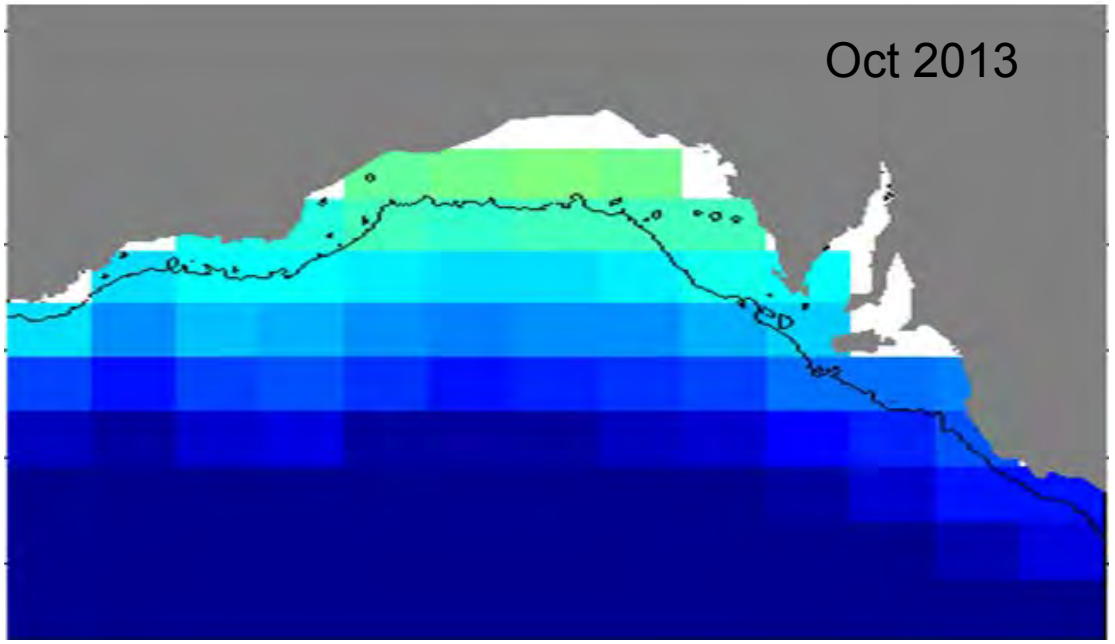
Satellite SST

- Fine scale - 4-9 km
- eddies



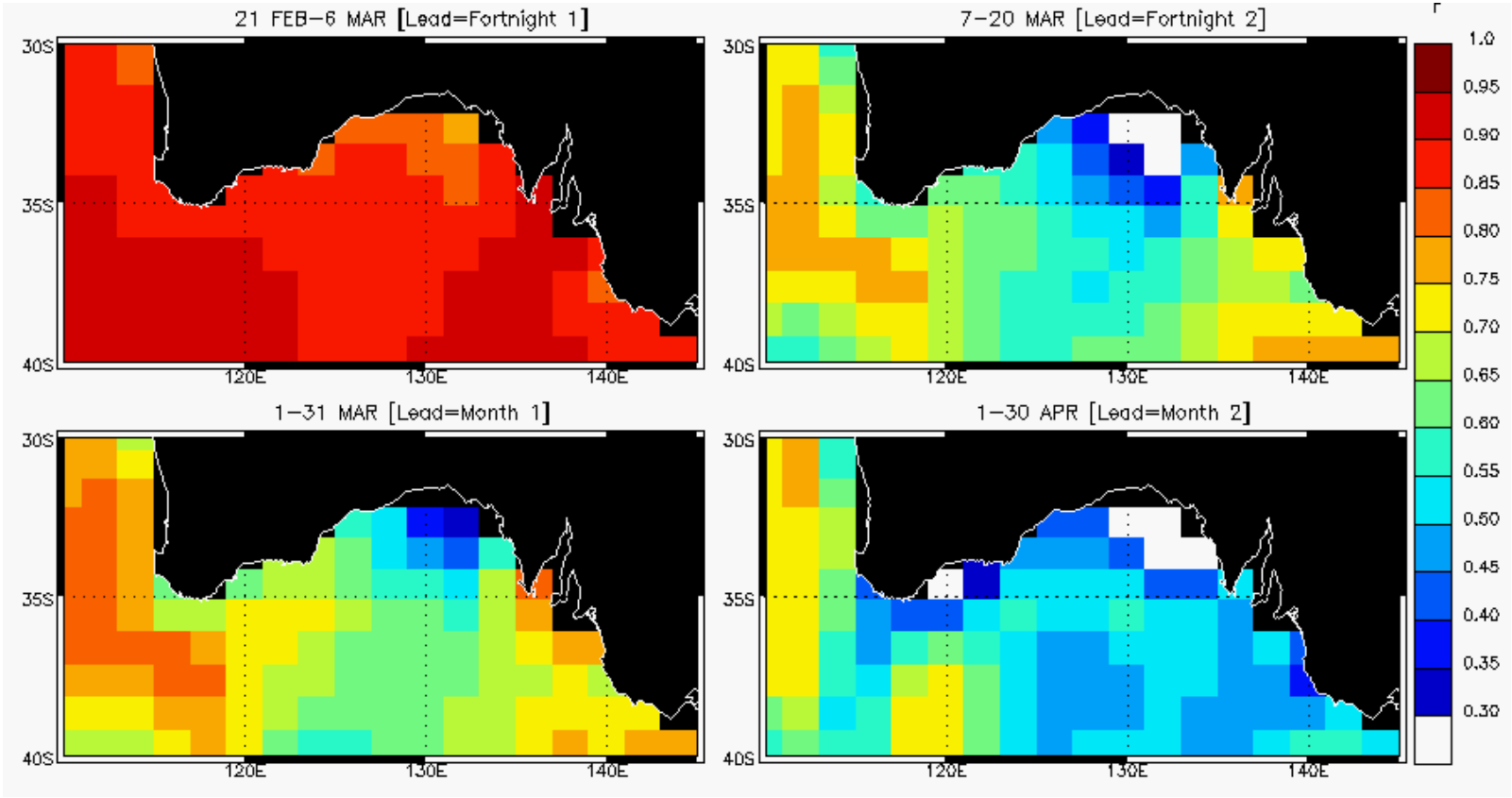
Model SST

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

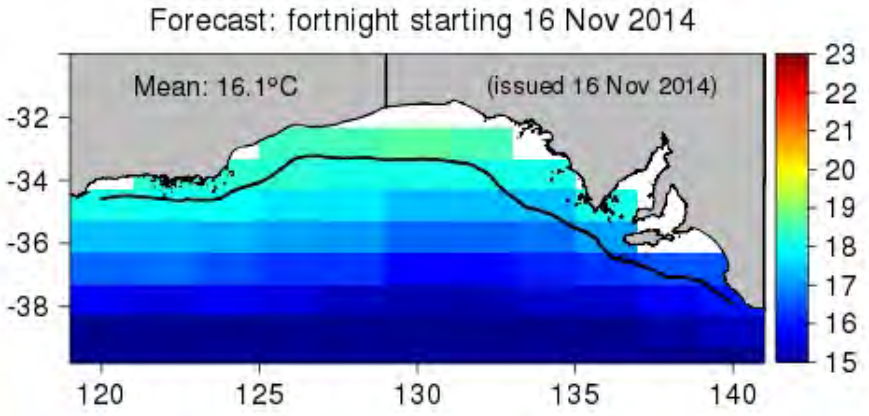


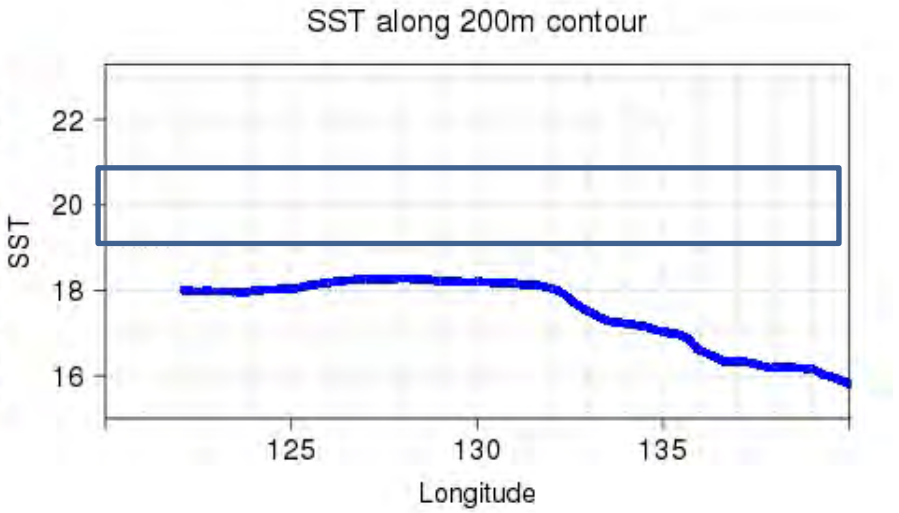
Forecast skill in Great Australia Bight

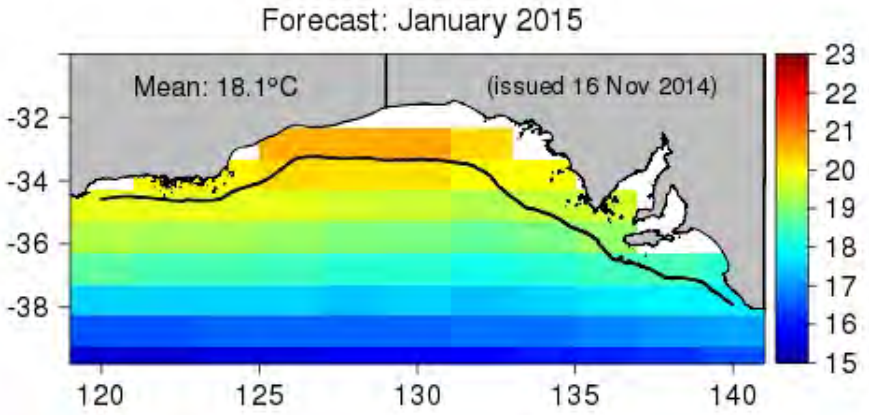
- Usefulness - depends on forecast skill
- SST forecasts have skill up 2-3 months in future

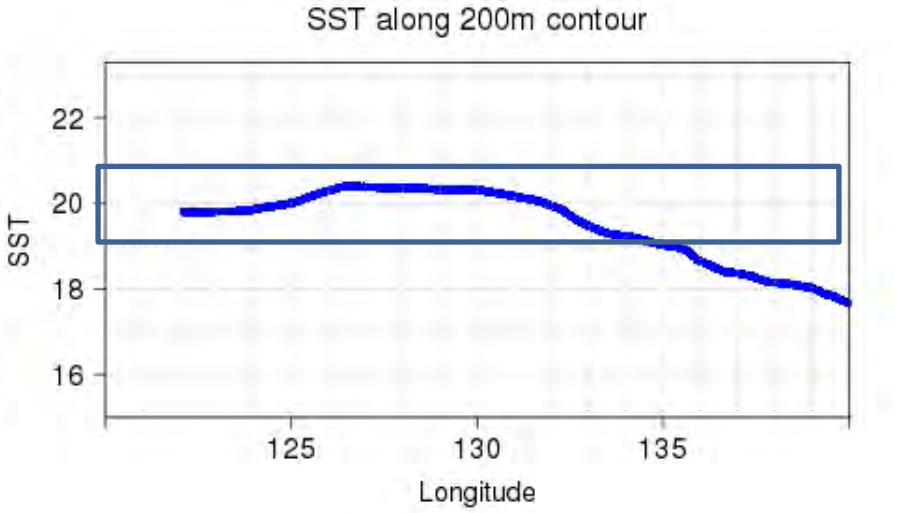


Option 1: SST forecasts









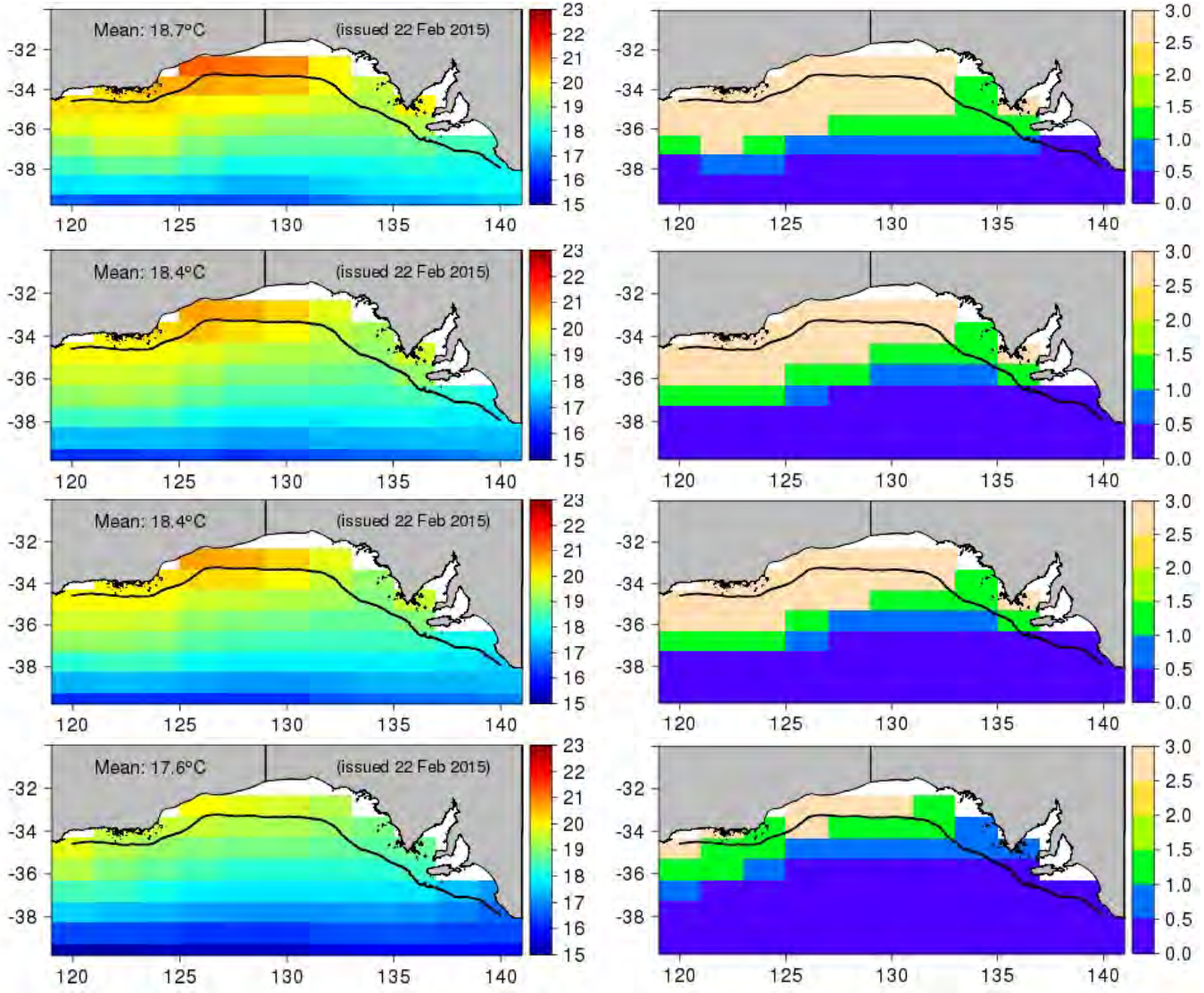
Option 2: Habitat forecasts

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

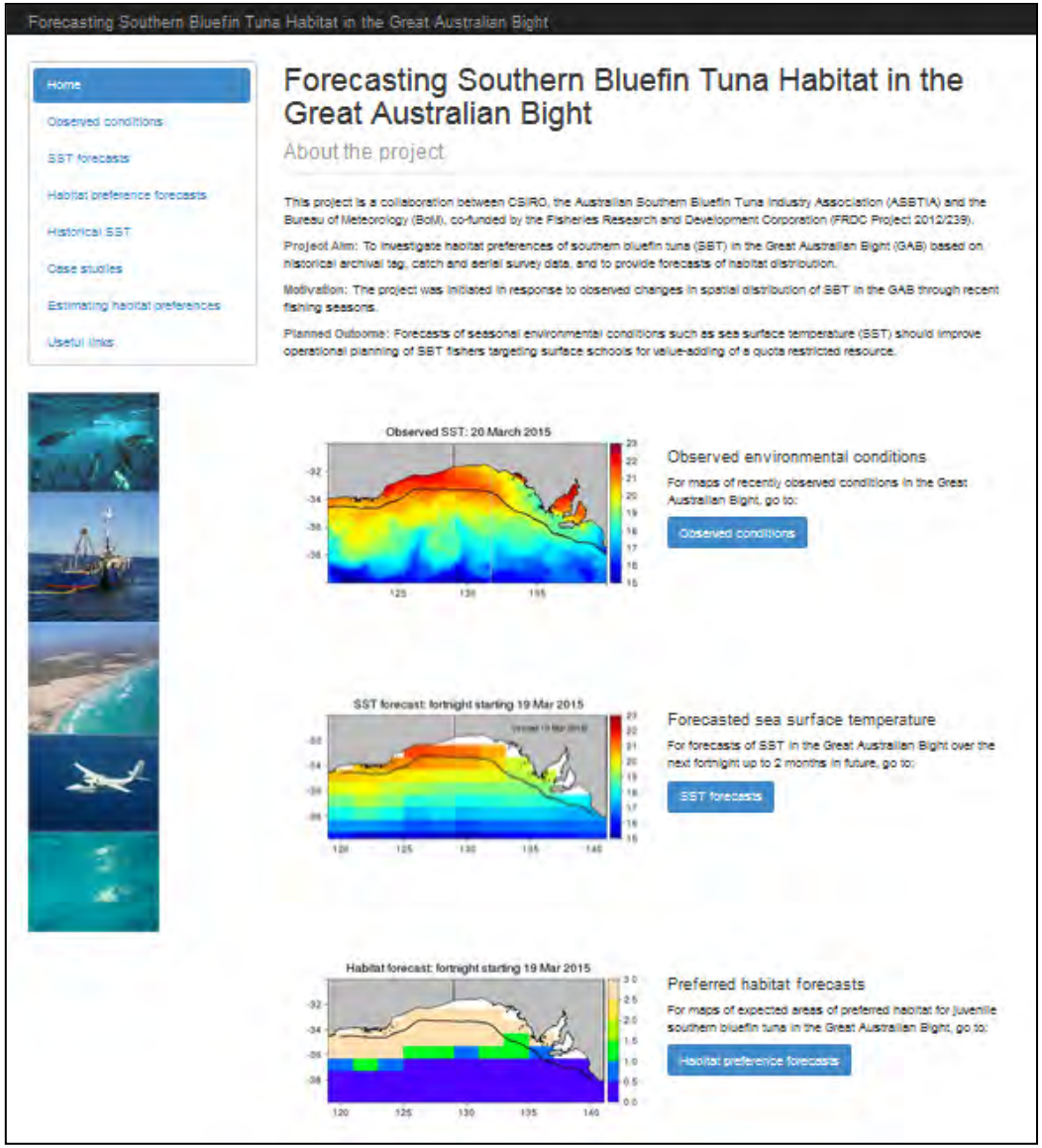
- All used website

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)



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

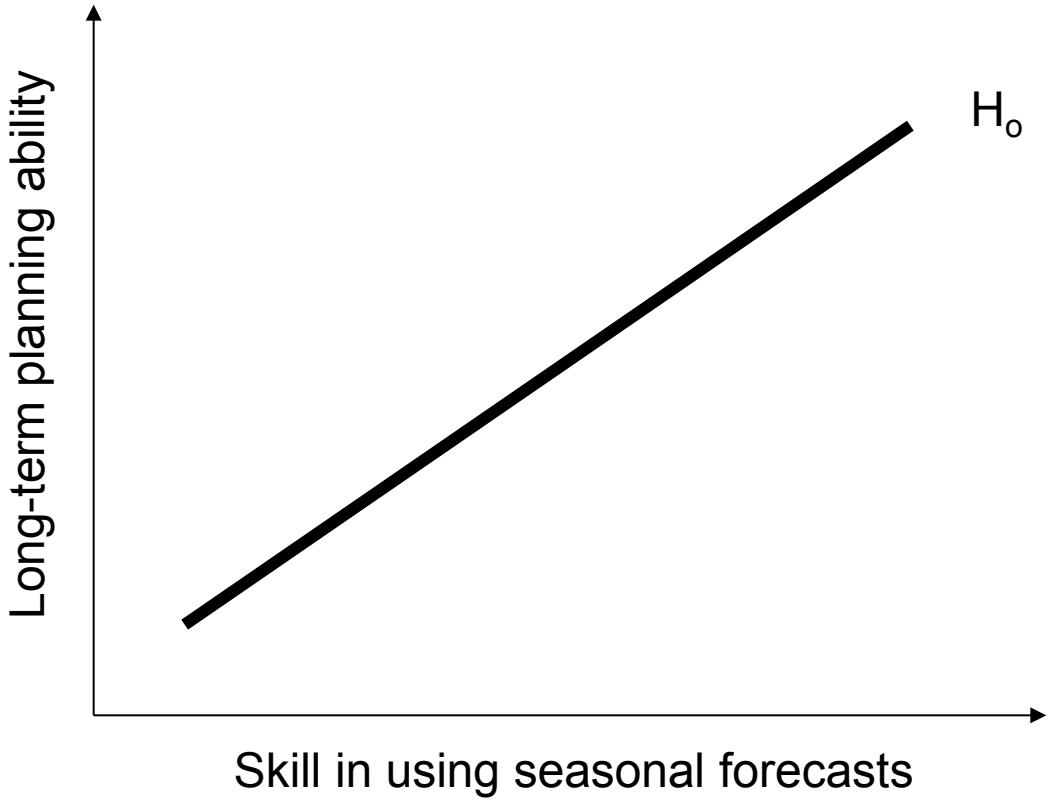
Very useful:

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

Hobday et al in press.

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?) <–> 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.