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The Centre for Australian Weather and Climate Research
A partnership between the Australian Bureau of Meteorology and CSIRO

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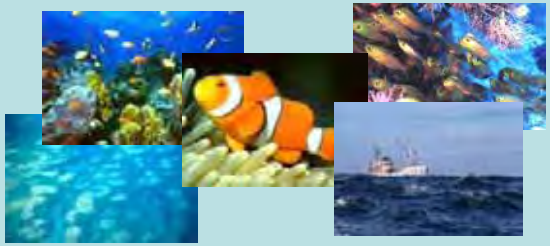
Greenhouse 2011
Cairns, 4-8 April 2011

The Role of Dynamical Seasonal Forecasting in Marine Applications and Management

Claire Spillman, Oscar Alves, Debbie Hudson, Alistair Hobday & Jason Hartog

c.spillman@bom.gov.au

Warming Oceans



Observed Global Mean Sea Surface Temperature Anomalies

How to best manage our marine resources under climate change?

Reefbase;
ftp://ftp.ncdc.noaa.gov/pub/data/anomalies/monthly.ocean.90S.90N.df_1901-2000mean.dat

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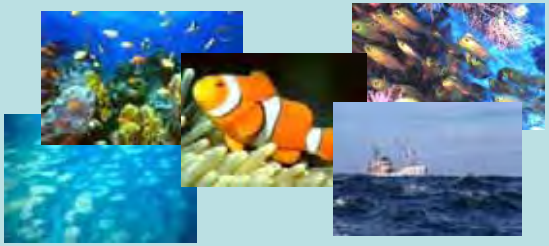
Marine Management



- Satellite based now-casts
- High resolution daily model forecasts

→ Minimal warning time

→ Reactive responses

- Climate modelling

→ Decadal timescales

→ Long term planning

What is best for proactive marine management?

Images Commonwealth of Australia (GBRMPA), L Chambers, A Hobday

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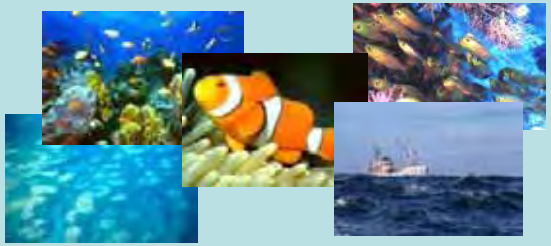
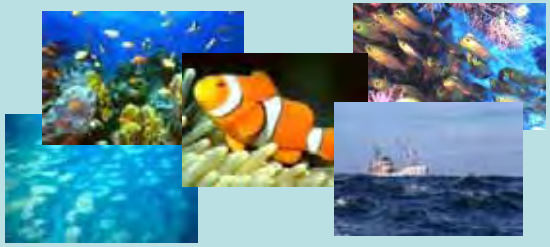
Seasonal Forecasting

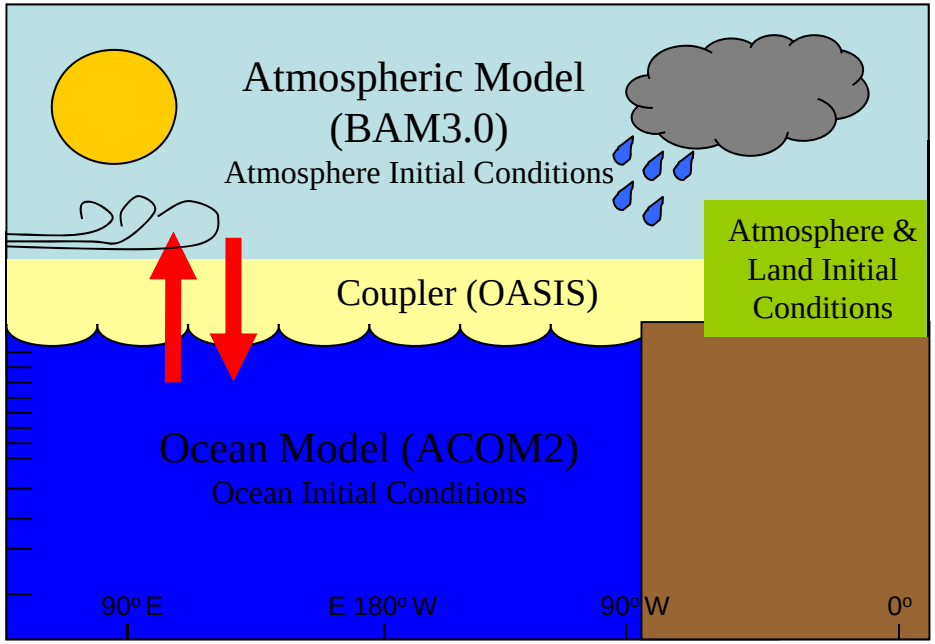


- Seasonal timescale most useful for managers
- Provides an early window for implementation of management strategies to minimise impacts
- Dynamical models can incorporate climate change signals unlike statistical models
- Better managed marine resources have improved resilience under climate change
- Anticipation of climate variability and change is proactive adaptation

POAMA



- Global coupled ensemble ocean-atmosphere and data assimilation prediction system
- Seasonal forecasts up to 9 months ahead



- 30 member ensemble hind-casts 1960-2010
- Probabilistic forecasts
- Run in real-time since 2002

http://poama.bom.gov.au

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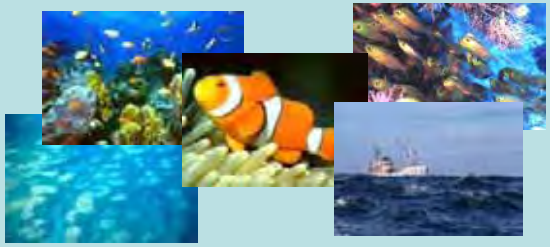
POAMA Applications



- Coral bleaching risk
  -  The Great Barrier Reef
- Commercial long-line fisheries
  -  Southern bluefin tuna
- Aquaculture
  -  Salmon farms in Tasmania
- Seabird colony management
  -  Phillip Island penguin colony

Use forecasts of sea surface temperature (SST) anomalies

Operational & experimental products

Images Commonwealth of Australia (GBRMPA), L Chambers, A Hobday

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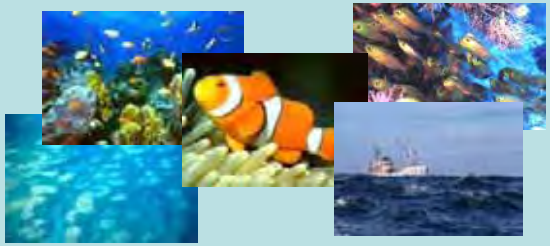
Coral Bleaching



Water temperature increases

Prolonged temperature stress

Days to weeks

Days to weeks

Healthy coral

Bleached coral

Dead coral

Weeks to months

Temperature returns to normal

Images Commonwealth of Australia (GBRMPA). Adapted from Marshall & Schuttenberg 2006

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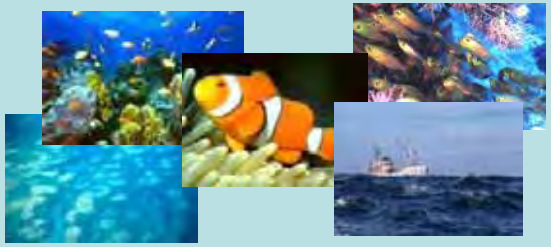
Bleaching Forecasts

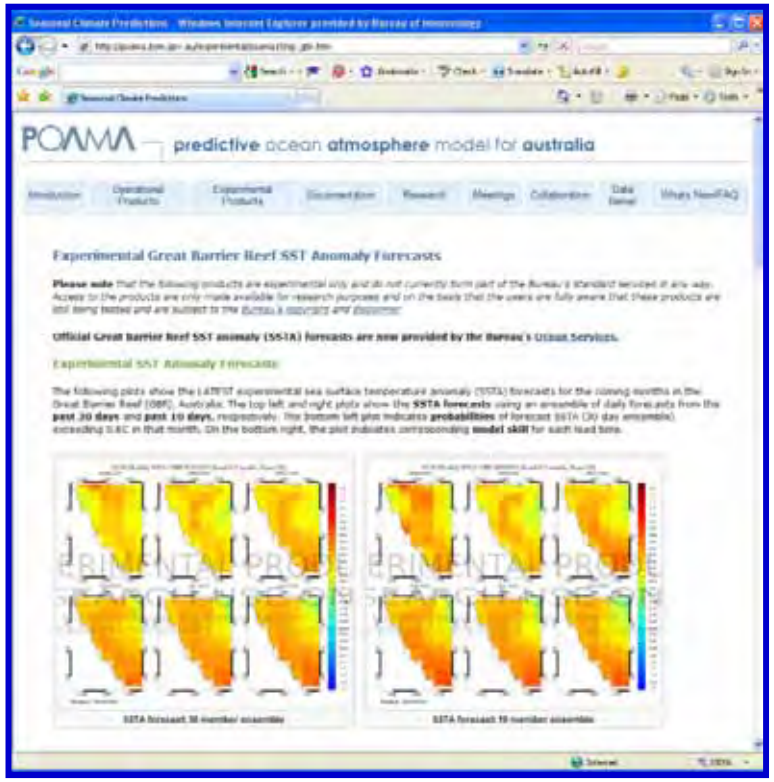


Operational:

- Spatial GBR SSTA
- GBR SSTA Index

Experimental:

- Degree Heating Months
- Probabilistic forecasts
- Google Earth products for the tropical oceans



http://poama.bom.gov.au

Spillman & Alves (2009); Spillman et al. (2011)

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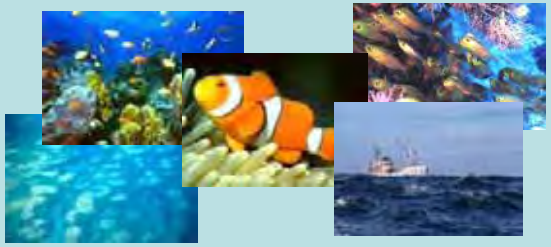
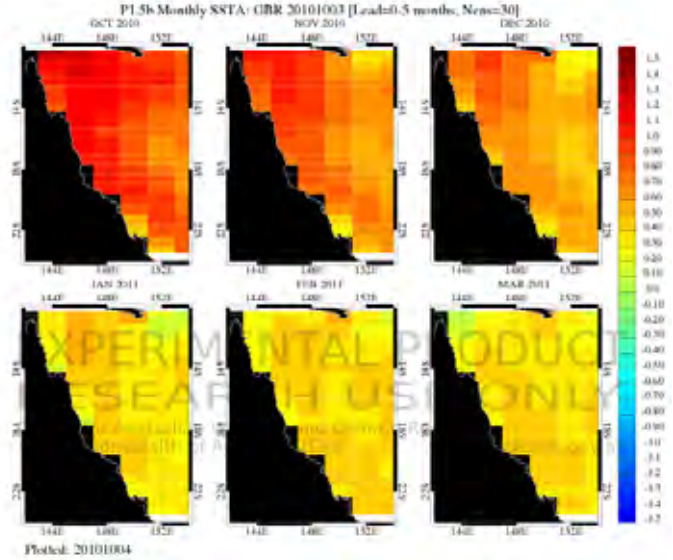
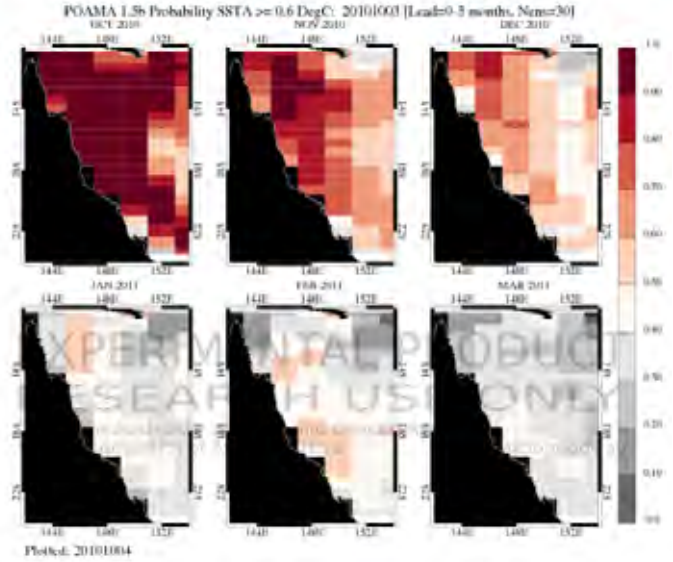
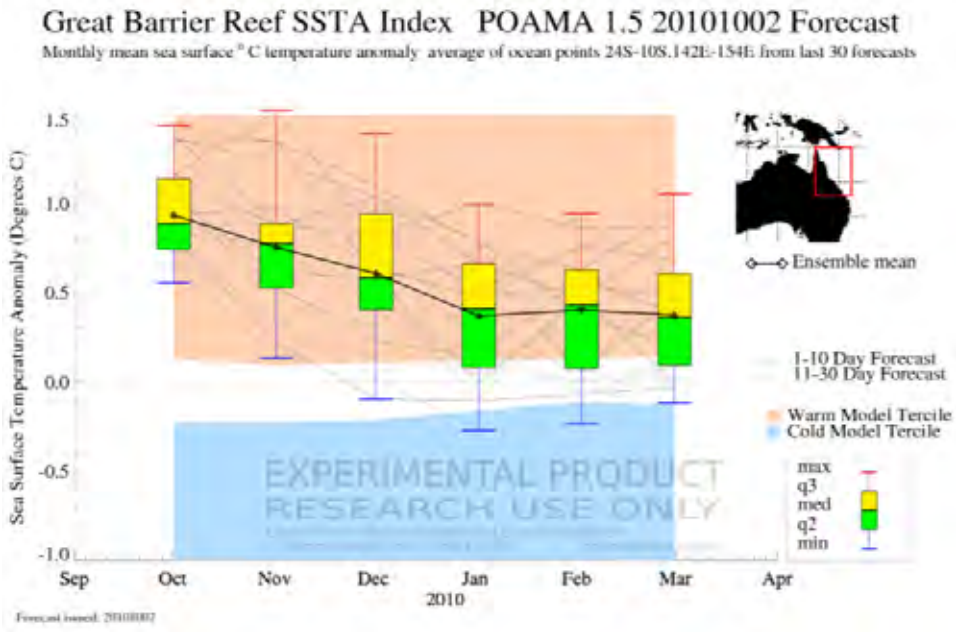
GBR Forecasts



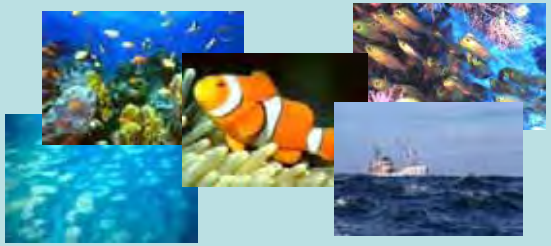




- Real-time SSTA forecasts for up to 6 months ahead
- Important part of GBRMPA Early Warning System



Using Reef Forecasts



- Brief government, tourist operators and public
- Improve recovery times by reducing stress on affected areas e.g. limited access
- Allow time to relocate resources for monitoring of bleaching
- POAMA addresses a current deficit in seasonal dynamical forecasts for bleaching

Spillman & Alves (2009), Spillman (2011). Commonwealth of Australia (GBRMPA)

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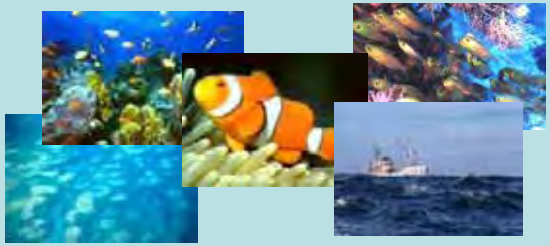
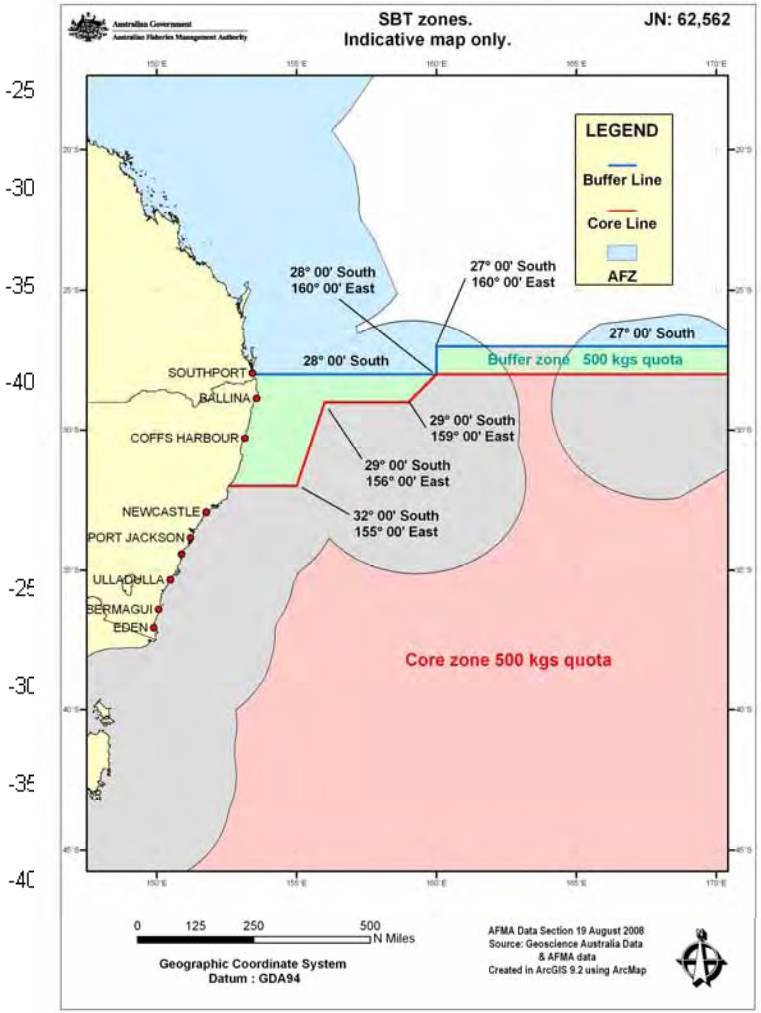
Commercial Fisheries





- Multi-species long-line fishery on east Aust coast
  - Primarily Yellowfin Tuna desired
  - Some Southern Bluefin Tuna (SBT) targeting
  - SBT must be discarded unless limited quota held
- SBT habitat preference linked to water masses
- Temperature forecasts used to drive habitat model
- Information to allow AFMA to set management zones

Hobday & Hartmann 2006; Hobday et al. 2010

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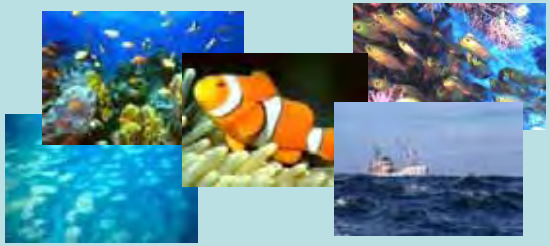
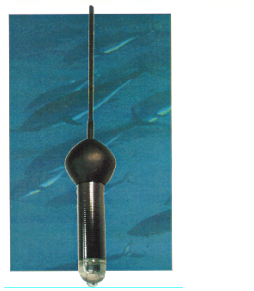
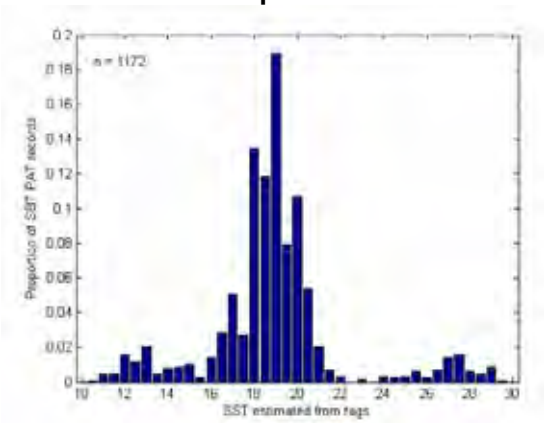
Commercial Fisheries





Habitat preferences



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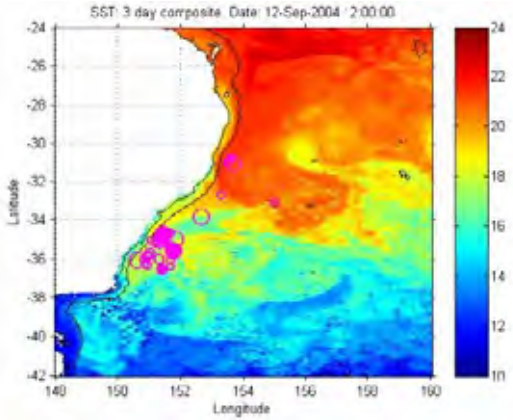
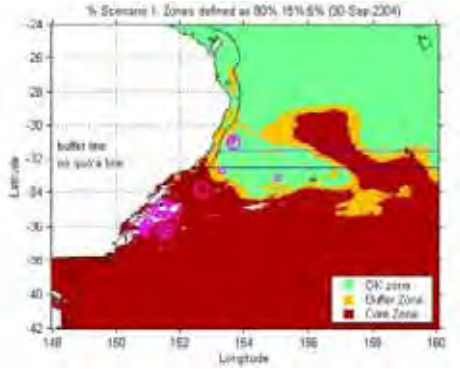
3D ocean info



Hobday and Hartmann (2006)
Hobday et al (2009)
Hartog et al (2010), in press
Hobday et al (2010), in press

Habitat prediction



Management decision

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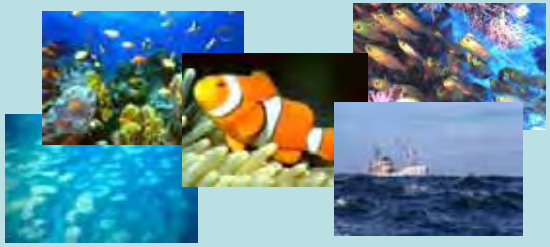
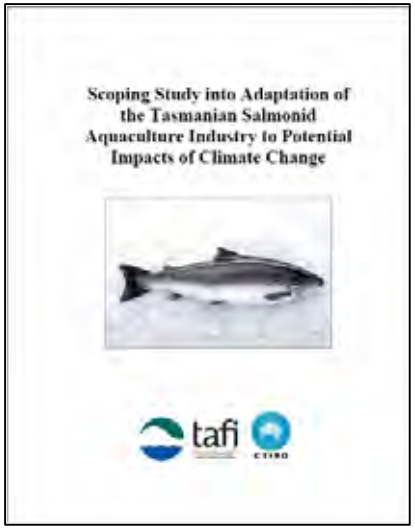
Aquaculture



- Salmon farms in Tasmania
- Fish grown towards their upper thermal limit in summer
- Sea temperatures linked to salmon growth and health
- Vulnerable to climate change
- Adaptation strategies:
  - Reduce exposure through predictive modelling
  - Improve salmon performance at higher temperatures
  - Select alternate species



Images: Tourism Tasmania; Huon Aquaculture

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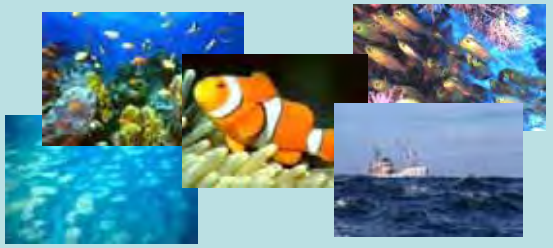
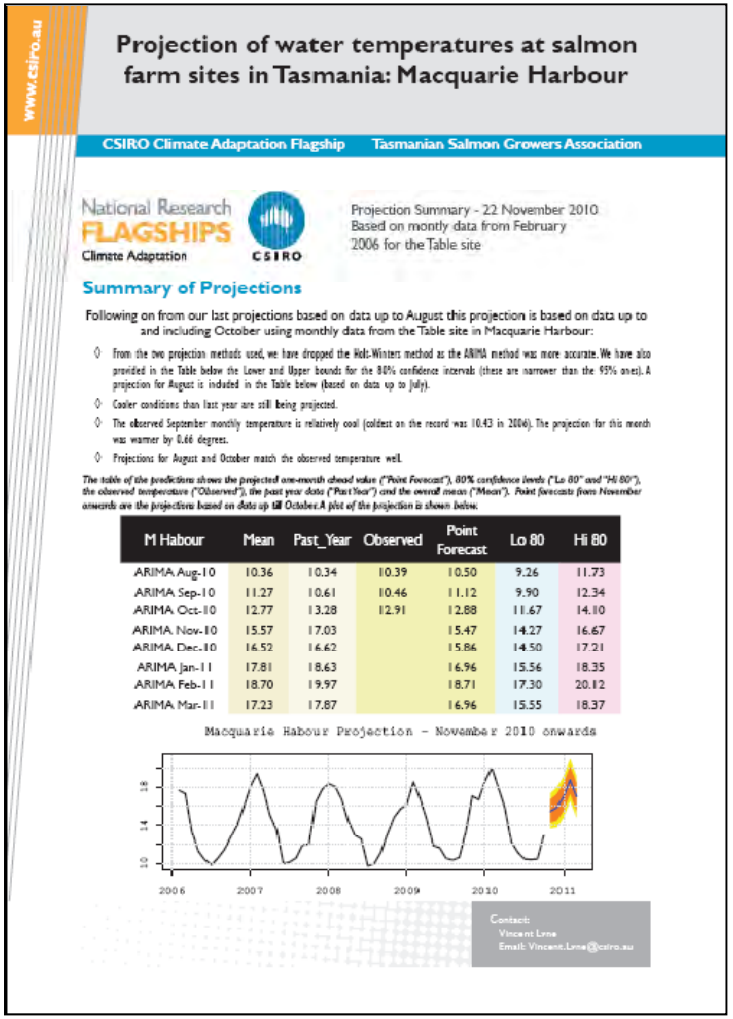
Aquaculture



- Seasonal predictions of regional ocean conditions up to four months ahead
- Downscaling to farm site
- Inform management decisions & stakeholders
- Interest from other aquaculture industries
- Profitable businesses are adaptable businesses



www.csiro.au

Projection of water temperatures at salmon farm sites in Tasmania: Macquarie Harbour

CSIRO Climate Adaptation Flagship Tasmanian Salmon Growers Association

National Research FLAGSHIPS Climate Adaptation CSIRO

Projection Summary - 22 November 2010
Based on monthly data from February 2006 for the Table site

Summary of Projections

Following on from our last projections based on data up to August this projection is based on data up to and including October using monthly data from the Table site in Macquarie Harbour:

- From the two projection methods used, we have dropped the Holt-Winters method as the ARIMA method was more accurate. We have also provided in the Table below the Lower and Upper bounds for the 80% confidence intervals (these are narrower than the 95% ones). A projection for August is included in the Table below (based on data up to July).
- Cooler conditions than last year are still being projected.
- The observed September monthly temperature is relatively cool (coldest on the record was 10.43 in 2004). The projection for this month was warmer by 0.66 degrees.
- Projections for August and October match the observed temperature well.

The table of the predictions shows the projected one-month ahead value ("Point Forecast"), 80% confidence levels ("Lo 80" and "Hi 80"), the observed temperature ("Observed"), the past year data ("Past Year") and the overall mean ("Mean"). Point forecasts from November onwards are the projections based on data up till October. A plot of the projection is shown below.

M Habour	Mean	Past_Year	Observed	Point Forecast	Lo 80	Hi 80
ARIMA Aug-10	10.36	10.34	10.39	10.50	9.26	11.73
ARIMA Sep-10	11.27	10.61	10.46	11.12	9.90	12.34
ARIMA Oct-10	12.77	13.28	12.91	12.88	11.67	14.10
ARIMA Nov-10	15.57	17.03		15.47	14.27	16.67
ARIMA Dec-10	16.52	16.62		15.86	14.50	17.21
ARIMA Jan-11	17.81	18.63		16.96	15.56	18.35
ARIMA Feb-11	18.70	19.97		18.71	17.30	20.12
ARIMA Mar-11	17.23	17.87		16.96	15.55	18.37

Contact:
Vincent Lyne
Email: Vincent.Lyne@csiro.au

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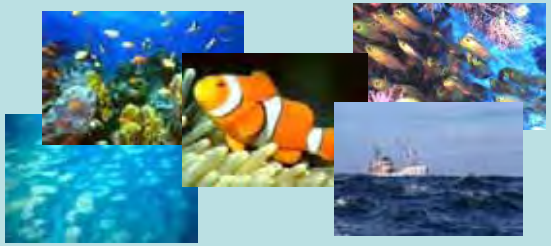
Seabirds



- Correlation between SST & mean laying date of Little Penguins at Phillip Island
- POAMA SST forecasts to drive statistical model
- Allows for the planning of management activities e.g. banding chicks, monitoring
- Penguin Island colonies?
- Other seabirds?

Dann & Chambers (2009) Images courtesy of Lynda Chambers.

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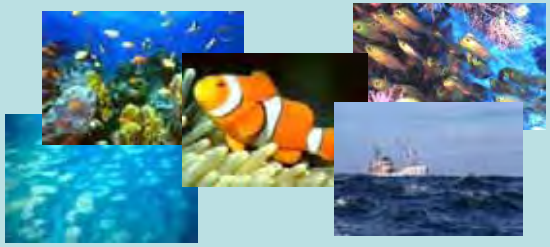
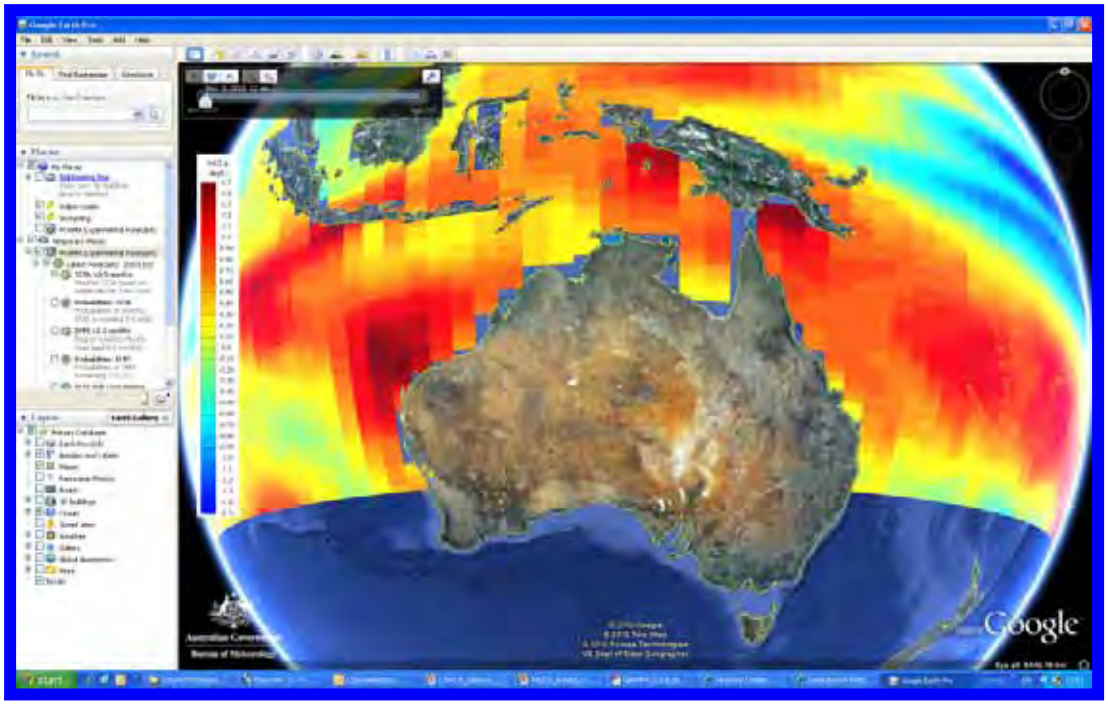
Forecast Delivery



- Real-time forecasts available online daily
- Products also available in Google Earth
- Tailored reports and briefings



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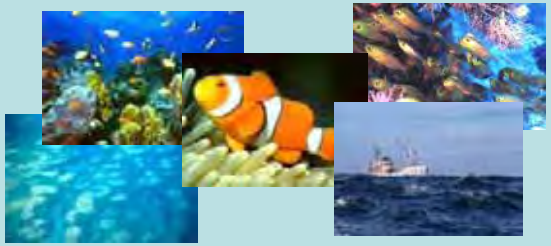
The Future



- POAMA forecast products valuable tools for proactive marine management
- Probabilistic forecasts important for risk analysis & management
- Potential for a variety of marine and climate applications
- Tools for better management of sensitive or at risk marine systems under climate change

Image courtesy of Michele Benoy-Westmorland (www.photomediaonline.com)

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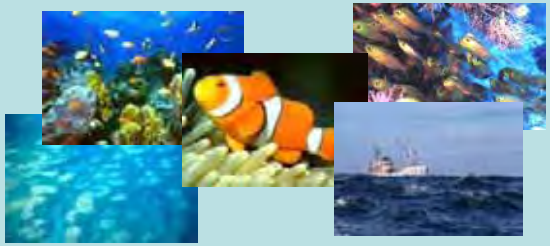
Further information



- Ocean Services: www.bom.gov.au/oceanography/
- POAMA: http://poama.bom.gov.au
- GBRMPA: http://www.gbrmpa.gov.au
- Spillman (2011) J Oper Ocean, 4:13-22.
- Spillman et al. (2011) MWR, 139:317-331
- Spillman et al. (2011) Int J Clim, *in press.*
- Spillman et al. (2010) CAWCR Res Lett, 4:11-19.
- Spillman et al. (2009) Coral Reefs, 28:197-206.
- Spillman et al. (2009) CAWCR Res Lett, 2:30-34.
- Maynard et al. (2009) J Env Manage, 44:1-11.

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