The Australian National Shelf Reanalysis: the ANSR

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on behalf of the ANSR Technical task team and the ANSR Steering Committee

CSIRO

IMOS
Integrated Marine Observing System

Australian Government
Bureau of Meteorology

UNSW AUSTRALIA

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

AUSTRALIAN INSTITUTE OF MARINE SCIENCE

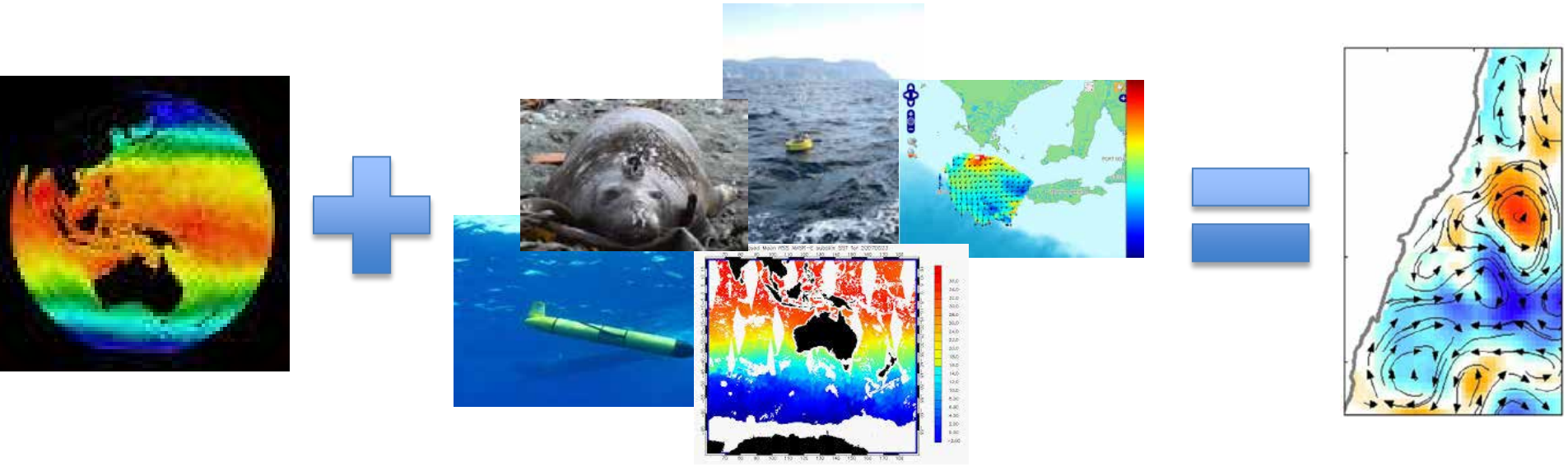
THE UNIVERSITY OF WESTERN AUSTRALIA

Talk Outline

- What is an ocean reanalysis?
- Why we *need* a national shelf scale reanalysis (ANSR)?
- Applications of a shelf scale reanalysis
- Present Capabilities: Observation and Modelling
- The ANSR Process and Products to date

What is an Ocean Reanalysis

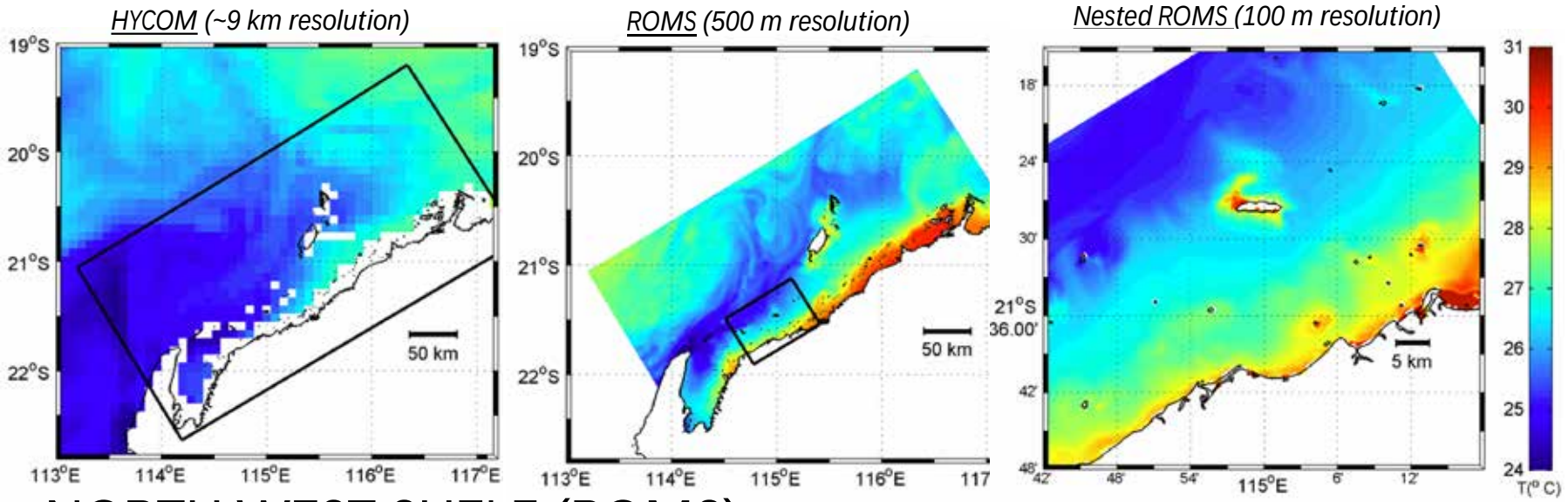
- A comprehensive estimation of the ocean state over some past time period (Primarily: temperature, salinity, sea level and ocean currents)
- Calculated by merging ocean models and all available observations using data assimilation.
- An ocean reanalysis (synthesis) is critical for understanding the past in order to predict the future (and future change).



Why do we need an Australian National Shelf Reanalysis?

- The presently available global reanalysis products (e.g Hycom, Bluelink)
  - Have inadequate resolution for the shelf (~10km)
  - Lacking important dynamics (e.g tides)

NINGALOO –PILBARA REGION *(Xu et al., 2013, JGR)*



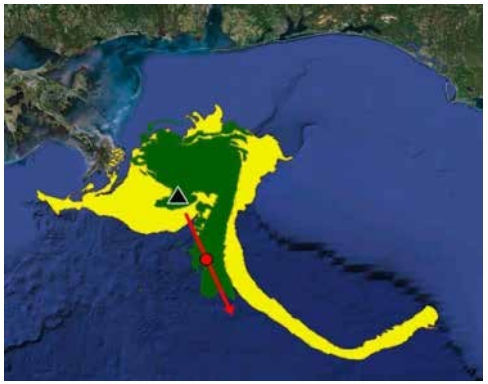
NORTH WEST SHELF (ROMS)

Source: R. Lowe, University of Western Australia

Applications of a Shelf Reanalysis

- Initial and boundary conditions for hydrodynamic models
  - High resolution local area models (downscaling)
- Study of ocean-atmosphere interactions (heat balance, global water cycle etc).
- Computation of transports in major currents and basins (along and across the shelf) – transport of mass, heat, biota
- Understanding coastal processes and shelf circulation

Trajectory Modelling



Extreme Event Statistics

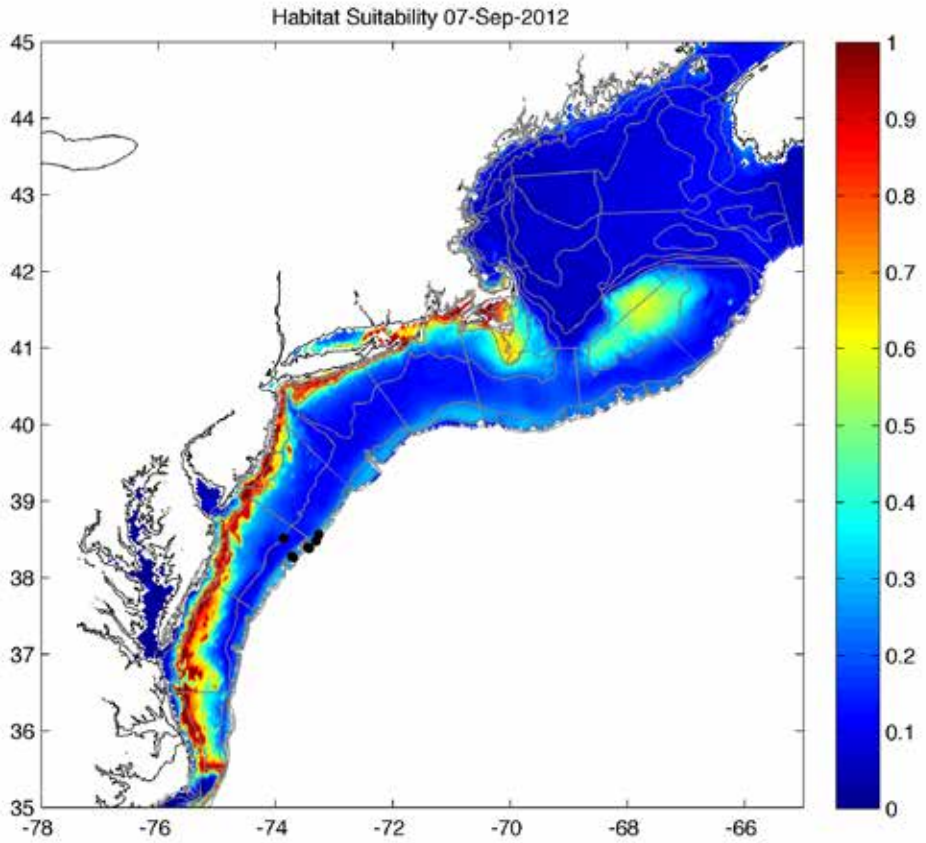
Environmental Stress

Extreme Events (Seds/ Waves)

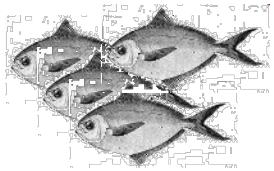
HABs

Applications of a Reanalysis: Fisheries Modelling

Proportion of suitable thermal habitat surveyed affects estimate of population availability



Good habitat



Habitat Suitability Index (HIS)

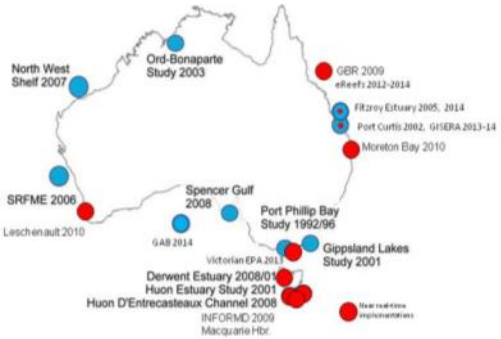
Poor habitat

Source: J. Wilkin, Rutgers University

Present Capability - Models

- Bluelink (Global Model) Excludes key shelf processes:
  Tides, Rivers and coarse resolution
- Numerous regional modelling activities

CSIRO
(Environmental Modelling Group)



AusROMS
(UWA)

OceanMAPS & eReefs
(BOM)

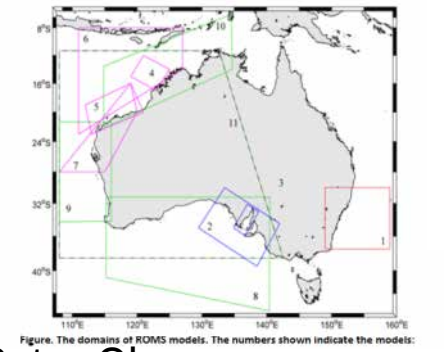


Figure. The domains of ROMS models. The numbers shown indicate the models:

1) South-East ROMS - NSW,
2) Southern Australian Regional Ocean Model - SARDI,
3) High Resolution Spencer Gulf Model (hydrodynamic, waves, particles, NPZD -SARDI)
4) Kimberley (internal tides) –Ivey
5) Pilbara (internal tides) – Ivey
6) Cyclone impacts – Ivey
7) Ningaloo upwelling – Lowe
8), 9) and 10) – Pattiaratchi.
11) WA/SA very large scale model (dashed) – Pattiaratchi

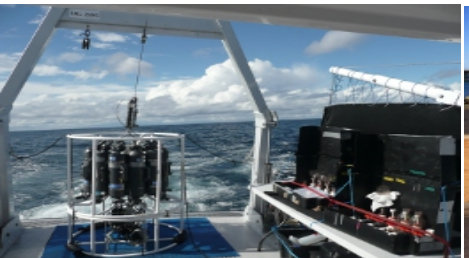
See Talk by Peter Oke

Adapted from Middleton et al. ACOMO2012

Present Capability – Shelf Observations

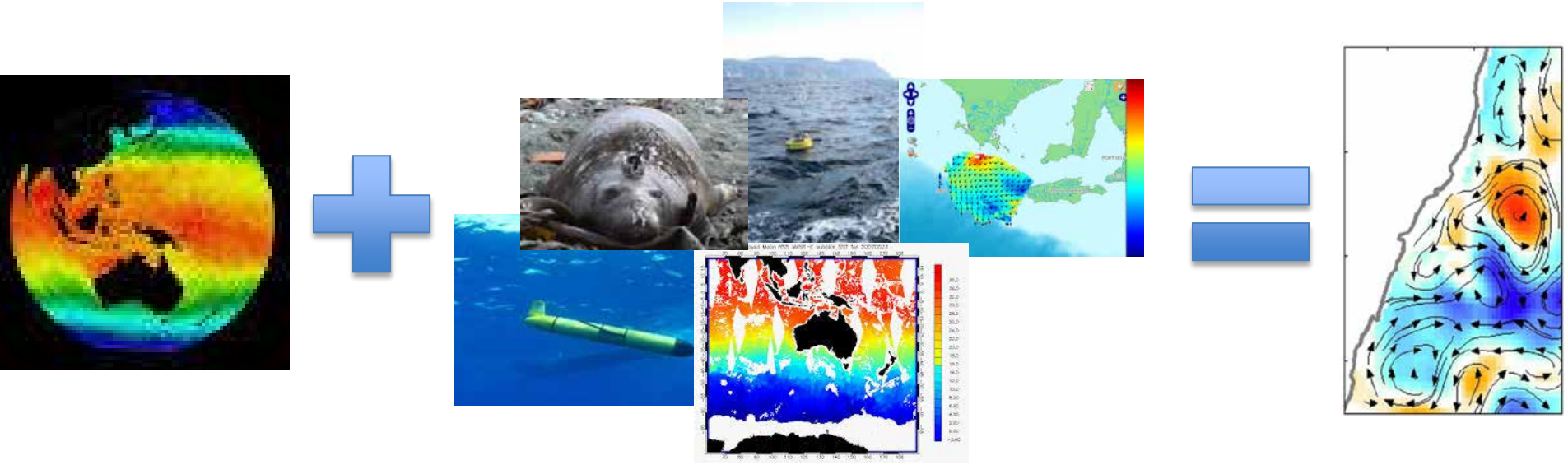
- Tide Gauge Network
- Satellite Remote Sensing
- IMOS: unprecedented levels of shelf-scale observations
  - Moorings, 7 NRS plus > 50 shelf moorings 5 min sampling > 5 yrs
  - HF radar 12 stations, 6 sites, surface currents, waves & wind direction.
  - Gliders 27 platforms, 171 deployments, 418k profiles, 146M new obs.
  - Seals as samplers, 213k profiles, 3.5M new obs
  - ARGO
- MARVL 3 – Shelf Seas Climatology (0 – 500m) 25 Million Obs
  - However, still only 6% of potential grid boxes have data….

See Talks by Tim Moltmann and Roger Proctor

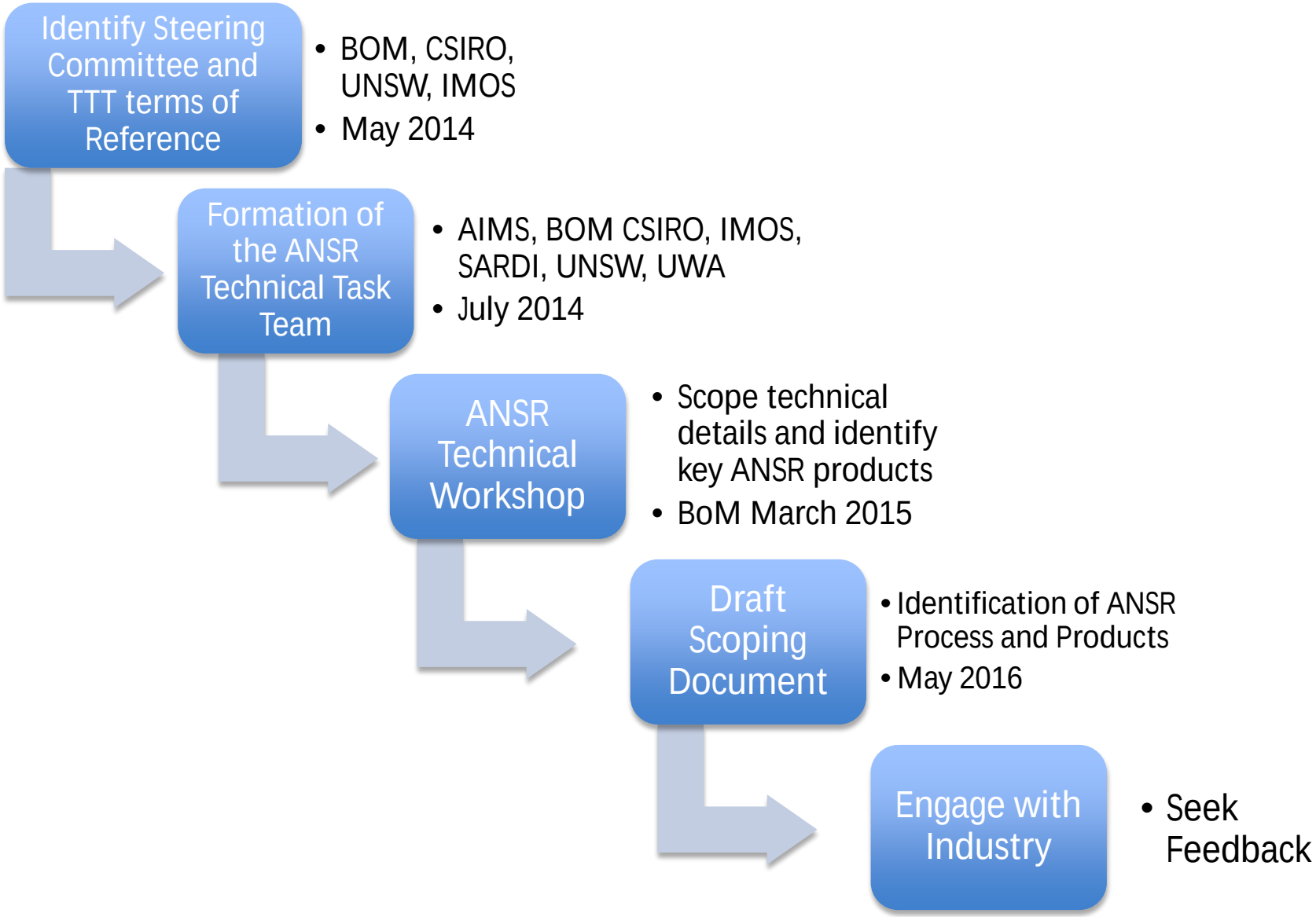



Now is the time for a Shelf Scale Reanalysis

- We have all the components of a high resolution shelf scale reanalysis.



The ANSR Process to date



What Dynamics do we need to include

Version V0

- Meso & Sub-meso Scale
- Baroclinic and Barotropic
- Tides
- Boundary Currents
- 3D Density Structure
- Upwelling
- River Plumes

Version V1

- Wave Driven Circulation?
- Internal Tides?
- Storm Surge?
- Sediments?

Version V2

- Biogeochemistry?

Forecasting

ANSR V0 Products

Product1
- Versioned ANSR Observation database stored on NCI

Product 2
- High-resolution observation based Shelf Climatology derived from product 1.

Product 3
- Non-Assimilating Control Run of the National Model with evaluation metrics reported.

Product 4
- ~20 year reanalysis including comprehensive community validation and published documented.

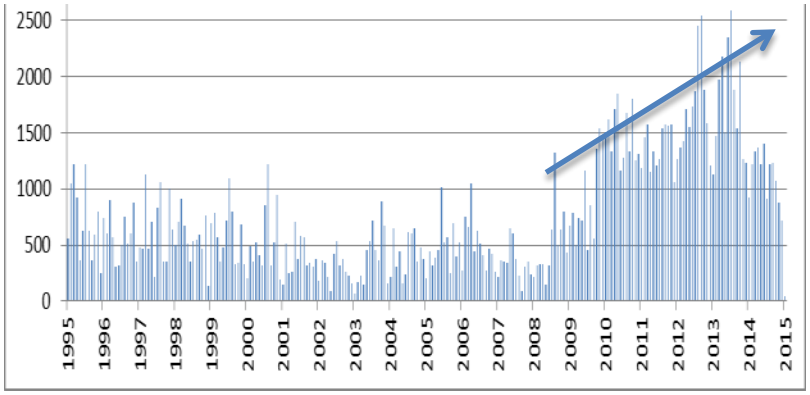
Product 5
- Demonstration regionally focussed very high resolution (~1km) products developed by regional experts.

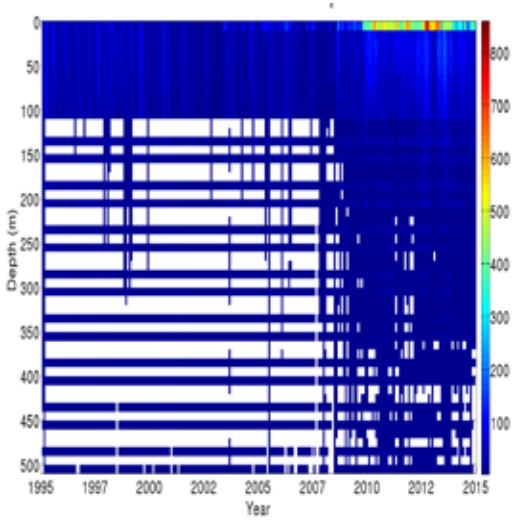
ANSR V0 Product 1

Product1

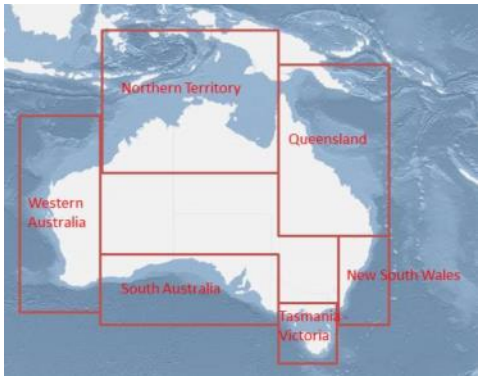
- Versioned ANSR Observation database stored on NCI

Temperature – total number of bins with data





Impact varies from region to region, greater in QLD, SA & Tas-Vic



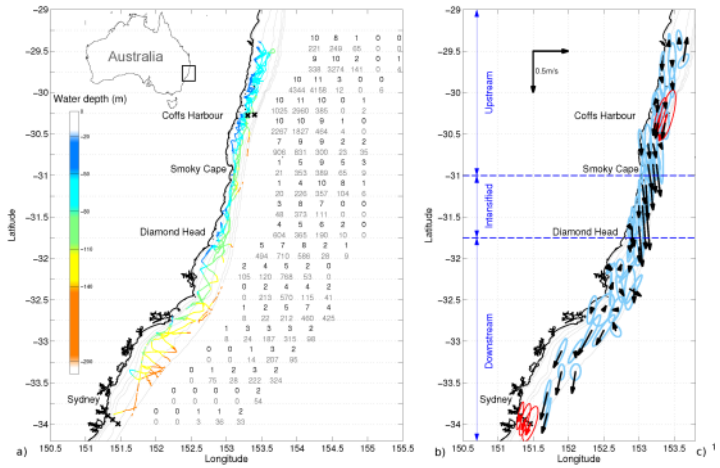
Impact of IMOS clearly seen from 2009 onwards

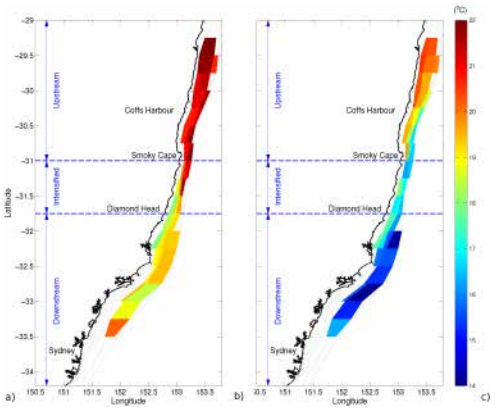
Source R. Proctor IMOS

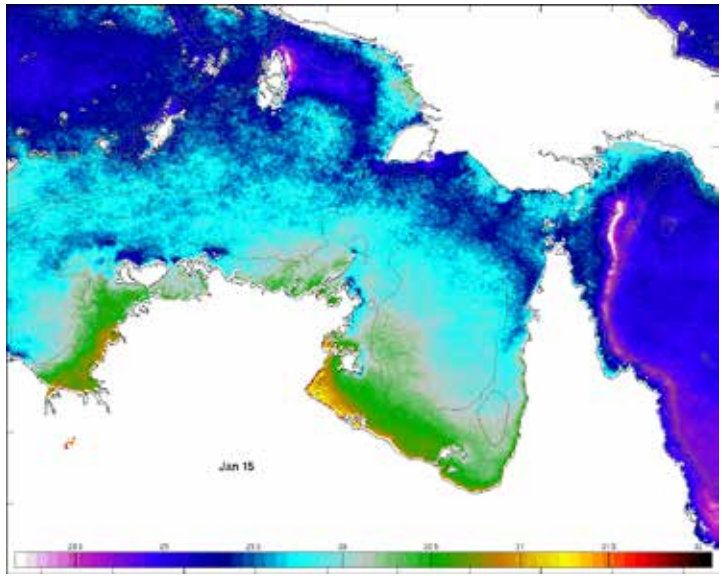
ANSR V0 Product 2

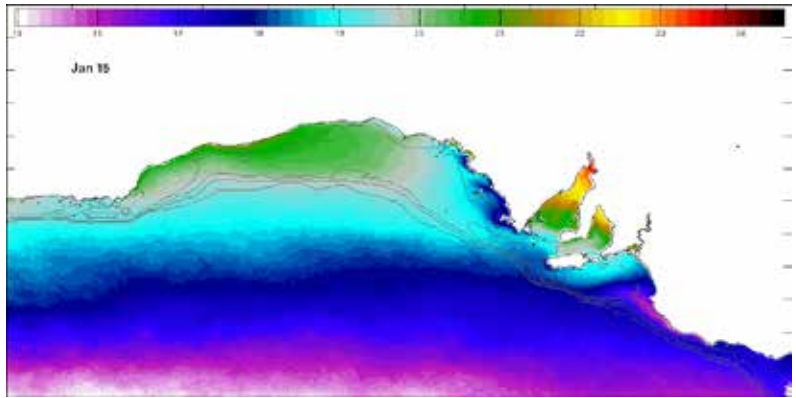
Product2

- High-resolution observation based Shelf Climatology derived from product 1.









Source: Glider - Schaeffer and Roughan GRL 2015
Hi Res SST - Wijffels (CSIRO)

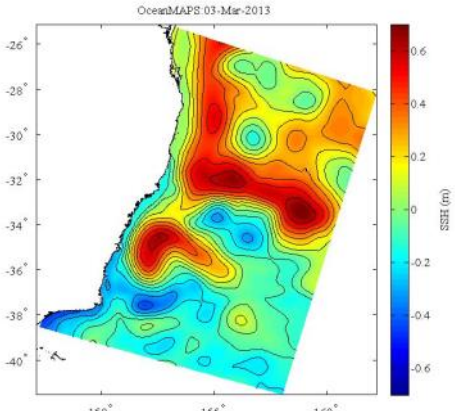
ANSR V0 Products 3 & 4

Product4

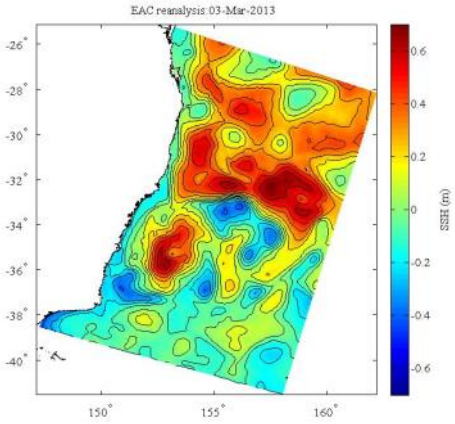
- Validated Control run
- ~20 Year High resolution reanalysis including validation.

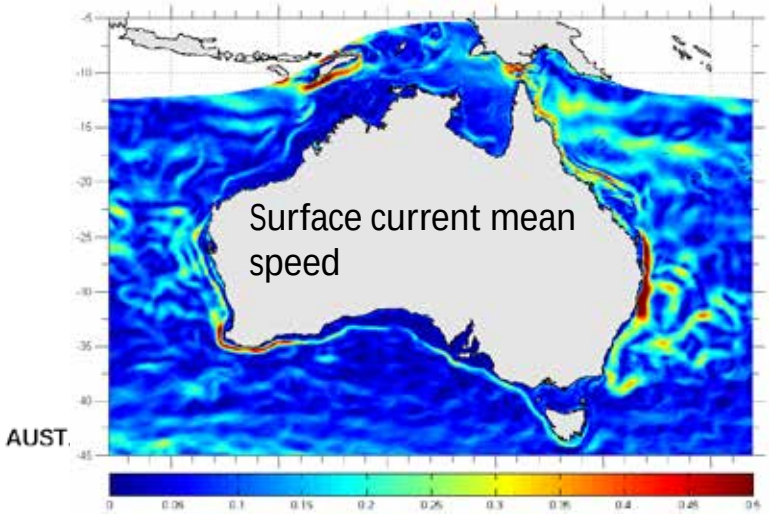
SSH Fields

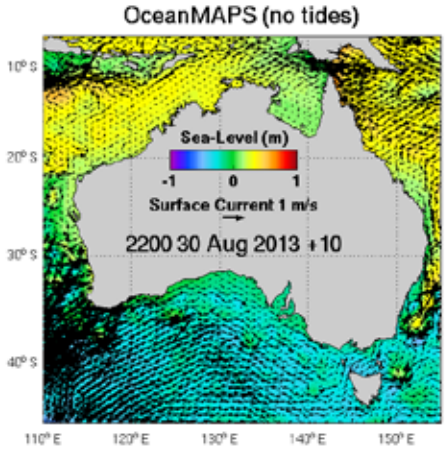
Ocean Maps 10km forecast for the EAC

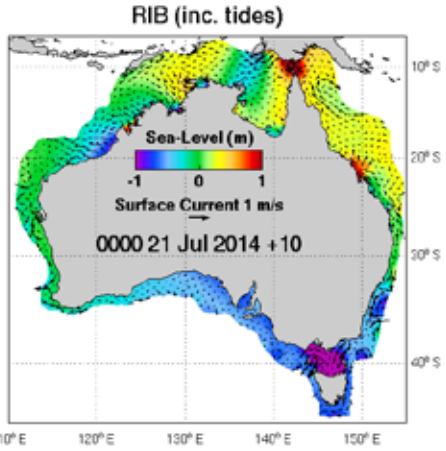


2.5-6km Resolution reanalysis for the EAC 2012-2013: 4-dVar Assimilation









Source: Kerry and Roughan (UNSW), OzROMS (UWA), OceanMaps(BoM) RIBBON (CSIRO)

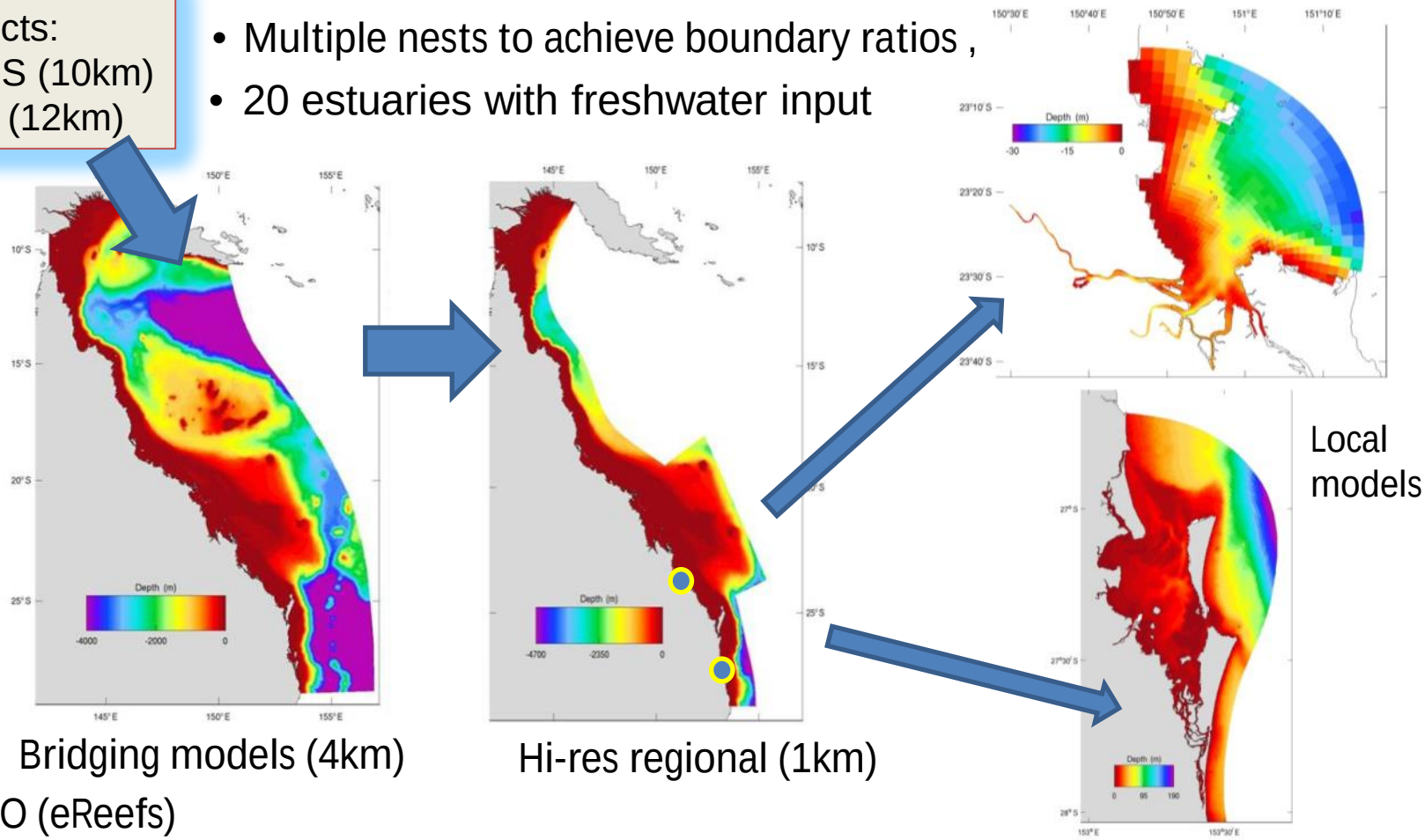
ANSR V0 Product 5

Product 5

Demonstration regionally focussed very high resolution (~1km) products developed by regional experts.

Global products:
- OceanMAPS (10km)
- ACCESS-A (12km)

- Downscaling to the reef/estuary scale
- Multiple nests to achieve boundary ratios ,
- 20 estuaries with freshwater input



Bridging models (4km)

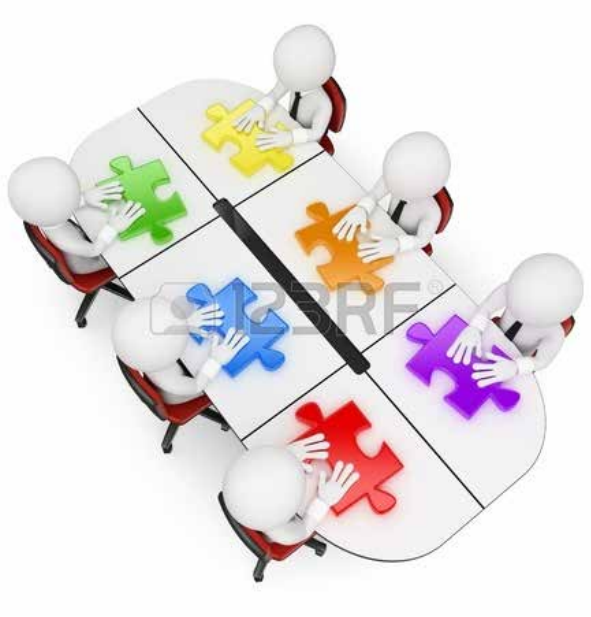
Hi-res regional (1km)

Local models

Source: CSIRO (eReefs)

Summary

- ANSR has multiple benefits and beneficiaries
  - primarily fundamental understanding of the physics that benefits all applications
- The capability to undertake ANSR exists.
  - Modelling and Observations
- ANSR Technical Task Team has scoped ANSR (V0).
  - Identified key products dependencies
- We now need feedback and continued dialogue with the MetOcean community to shape the ANSR products



ANSR V0 Outline