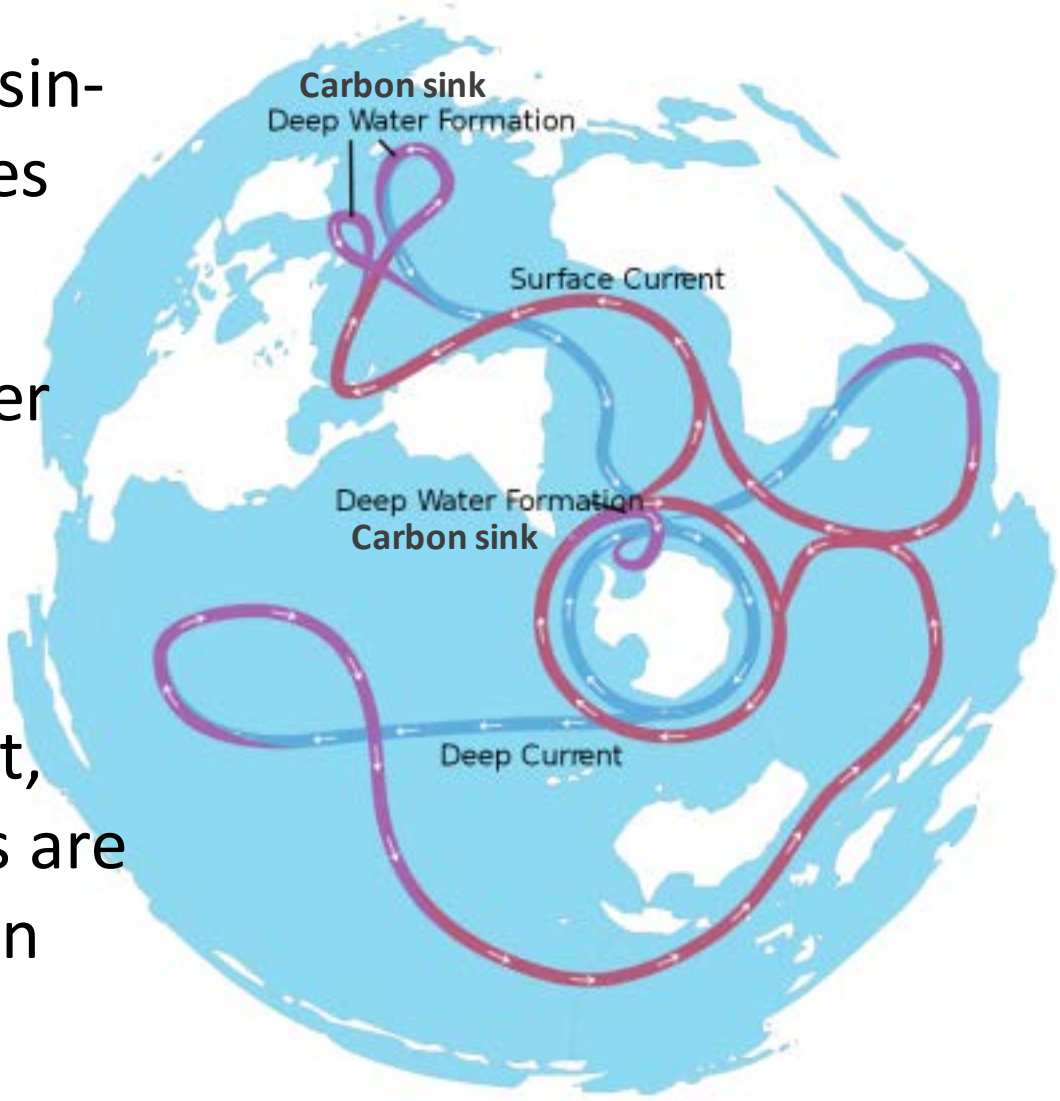
Critical research and exploration supported by innovative ship-based research.

"***From little things, big things grow***"

- The role of localised turbulence and mixing in the Global Ocean
- Sub-mesoscale processes and shelf ecosystem response.

Turbulence and mixing in the Global Ocean

- Mixing is required to maintain observed basin-scale T and S structures
- support the pathways for dense abyssal water back to the surface
- Critical role in climate
- Controls rate that heat, CO_2, and other tracers are absorbed and stored in the ocean



It's a problem of scales

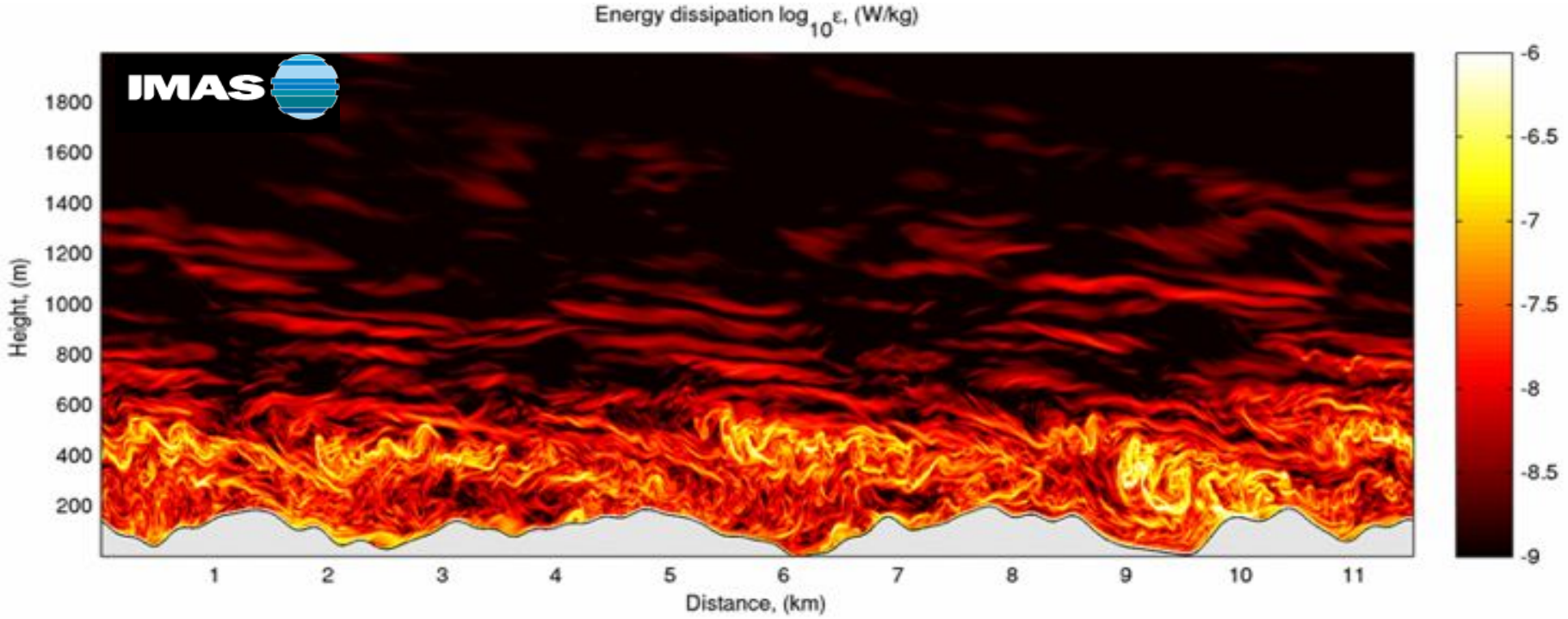
- Ocean is primarily circulation forced at the large (basin) scales

- Circulation is damped and dissipated at much smaller scales down to those of centimetre-sized turbulence.

Challenge to understand how ocean dynamics connect these very different scales of forcing and dissipation.

Turbulent mixing

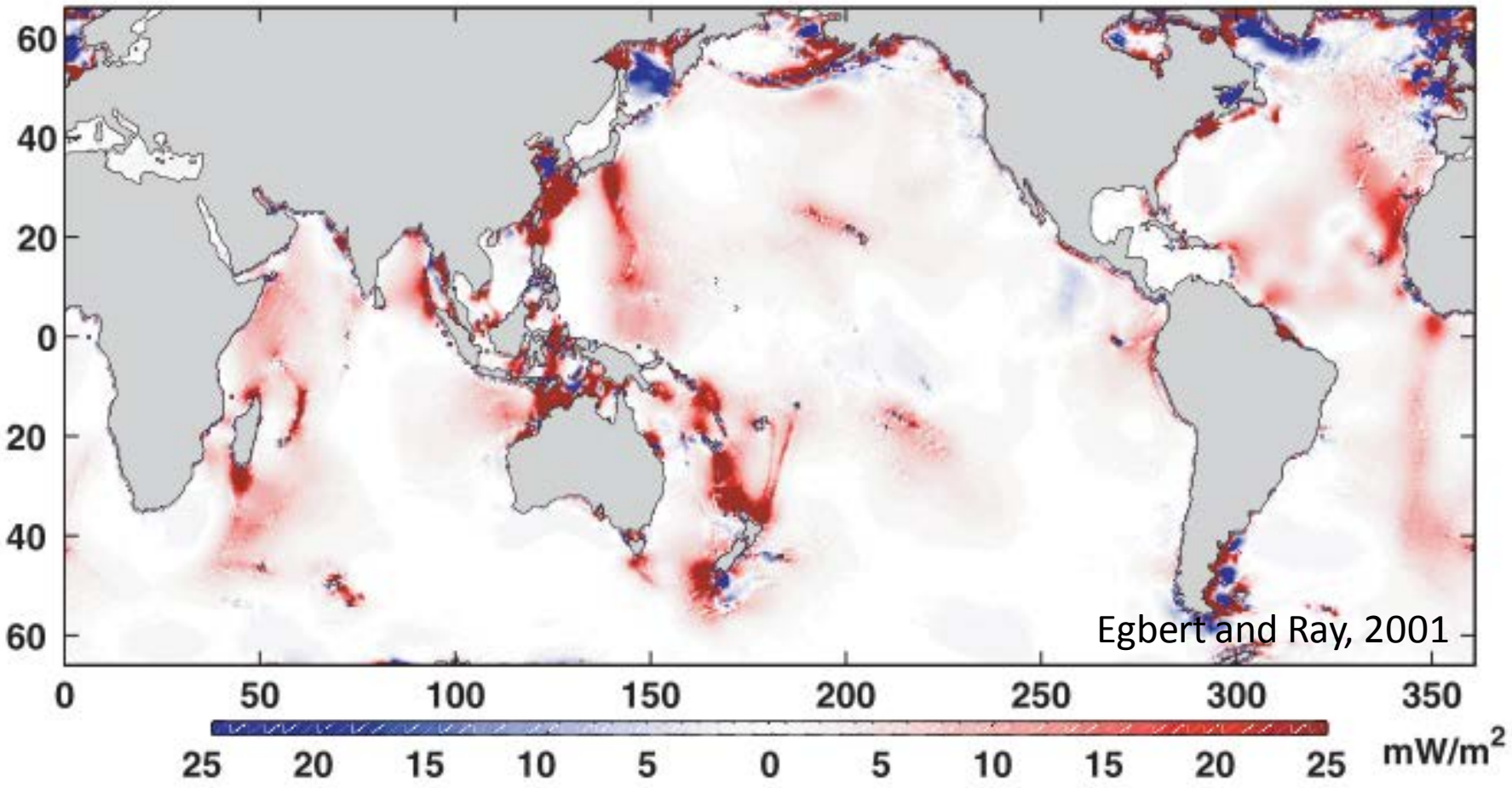
- Dissipation processes are too small to be resolved in present and future climate models and must be parameterised – currently by constant coefficients tuned to present climate.



Enhancement of turbulence at rough seafloor topography in the deep ocean from a high-resolution numerical simulation

Nikurashin, Phillips, Sloyan

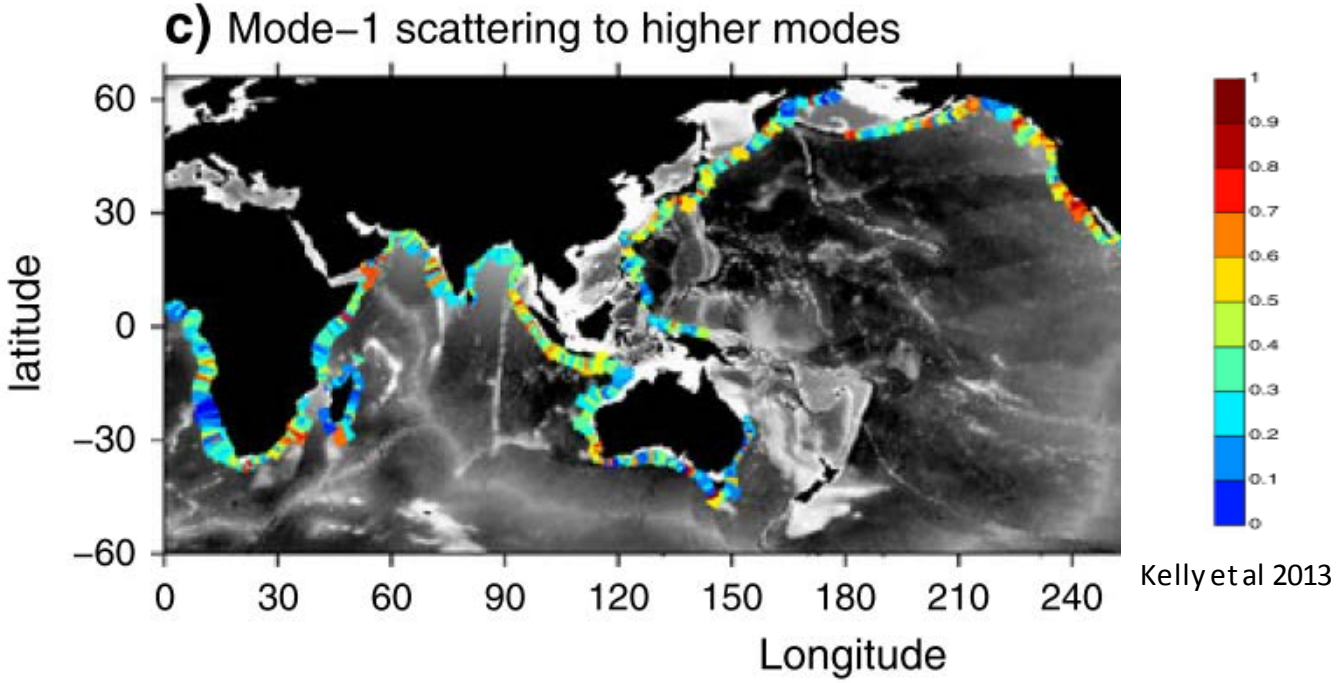
Turbulent mixing



Dissipation (red) of surface tide collocated with regions of steep topography, typically associated with the generation of large amplitude internal waves.

Turbulent mixing

- internal tides lose about 60% of their energy upon impacting the continental margins → drives elevated turbulent mixing.



Kelly et al 2013

- uncertainties associated with interior mixing parametrisations
  - small for projections over a few decades
  - **considerable over longer time scales**

…and from yesterday's discussion

Malcolm

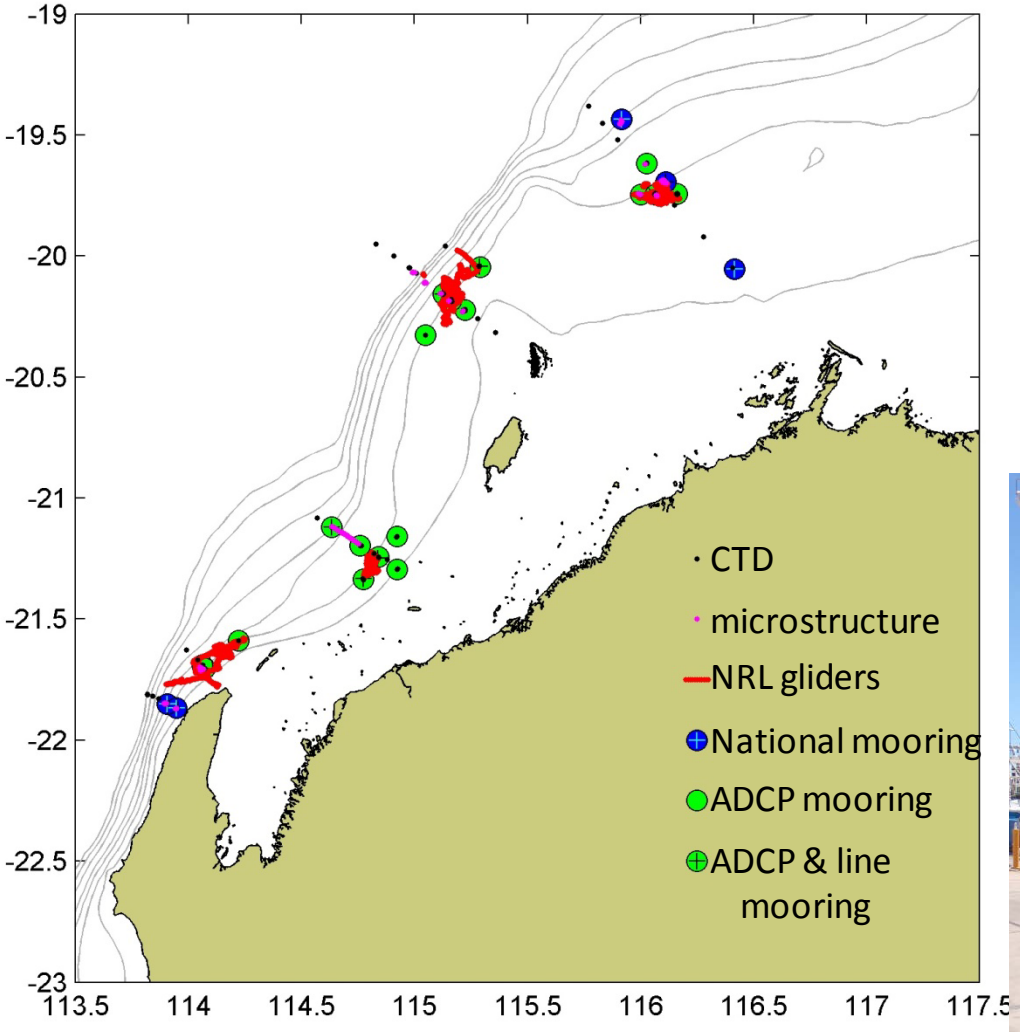
- *"need to better understand mixing of surface and deep waters. …and shoaling of aragonite and calcite saturation horizons."*

Breakout sessions summary – Climate Change

- *"Cheaper sensors (swarms) -* ***Higher resolution data feeds higher resolution models for societal needs****"*
- *"Find the cause of the heating hiatus 'the missing heat' – mechanisms for trapping/releasing heat from deep ocean".*

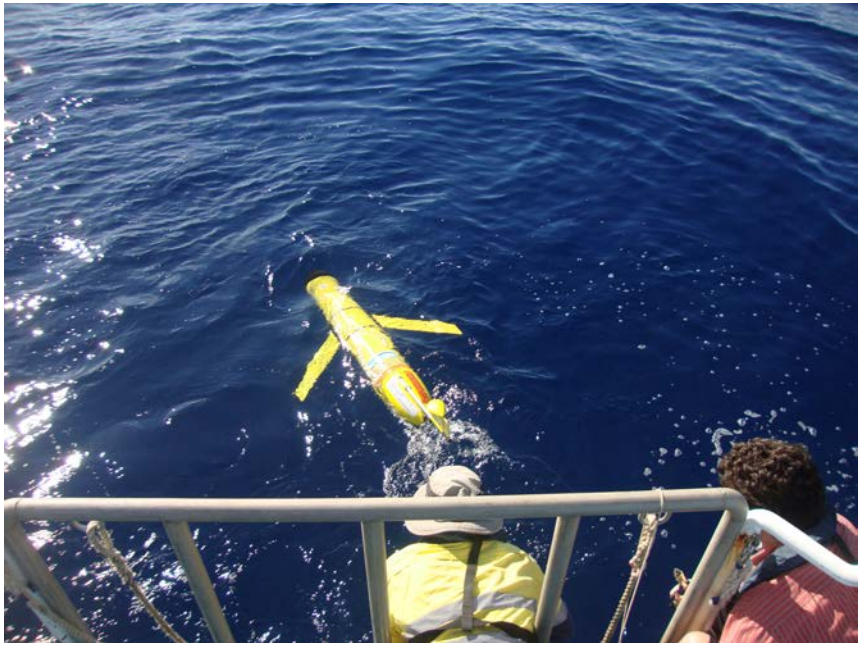
Observations and Modeling of the North West Shelf of Australia

March/April, 2012

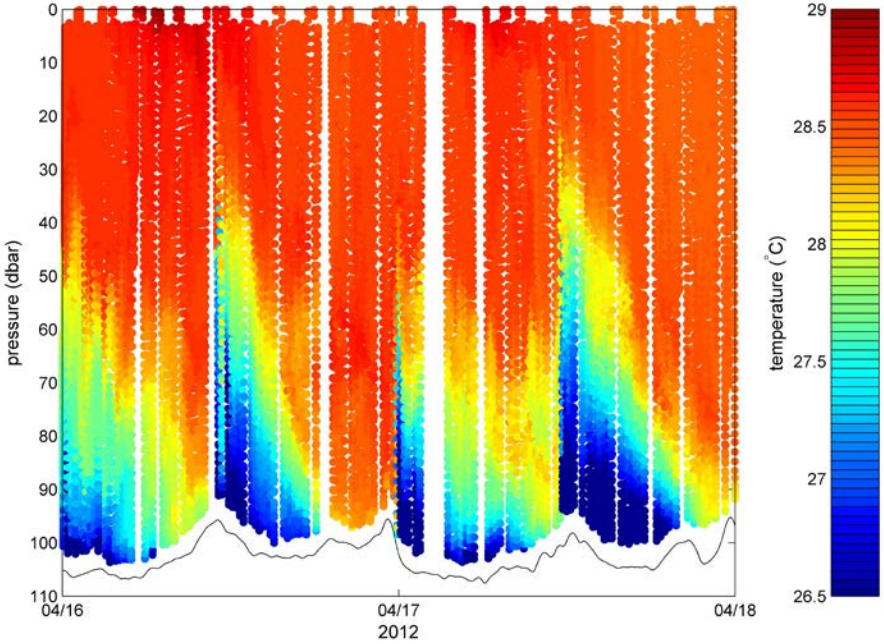


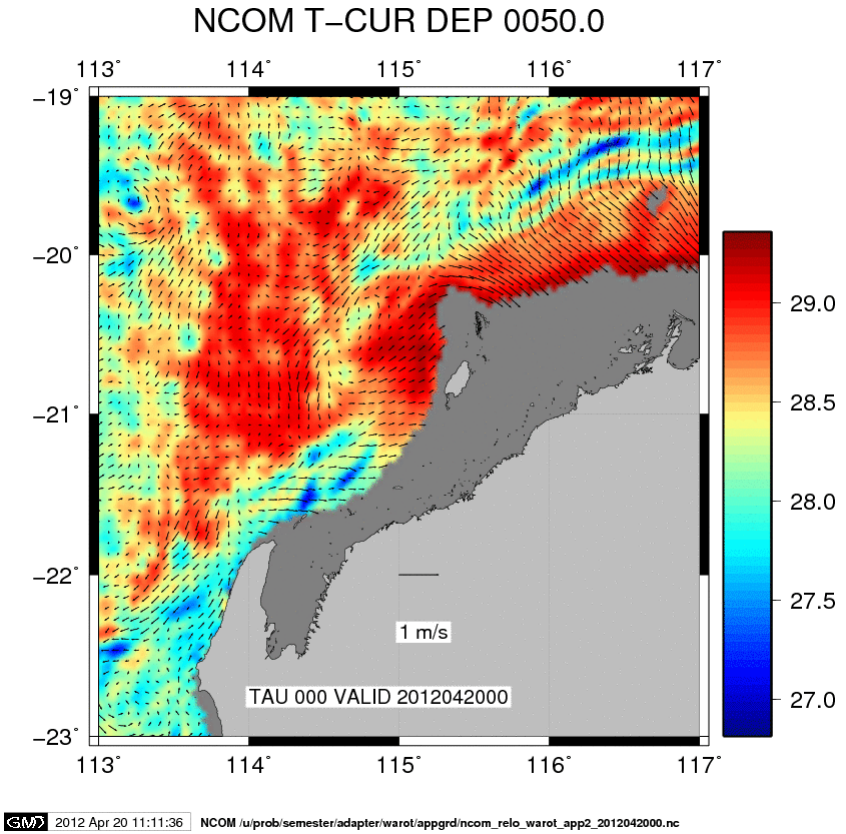
Book , *Brinkman, Burrage, Ivey, Jones, Kelly, Lowe, Pattiaratchi, Rayson, Rice, Richman, Rowley, Steinberg, Strutton*

Evaluating Glider data impact on NCOM solutions



Glider 82





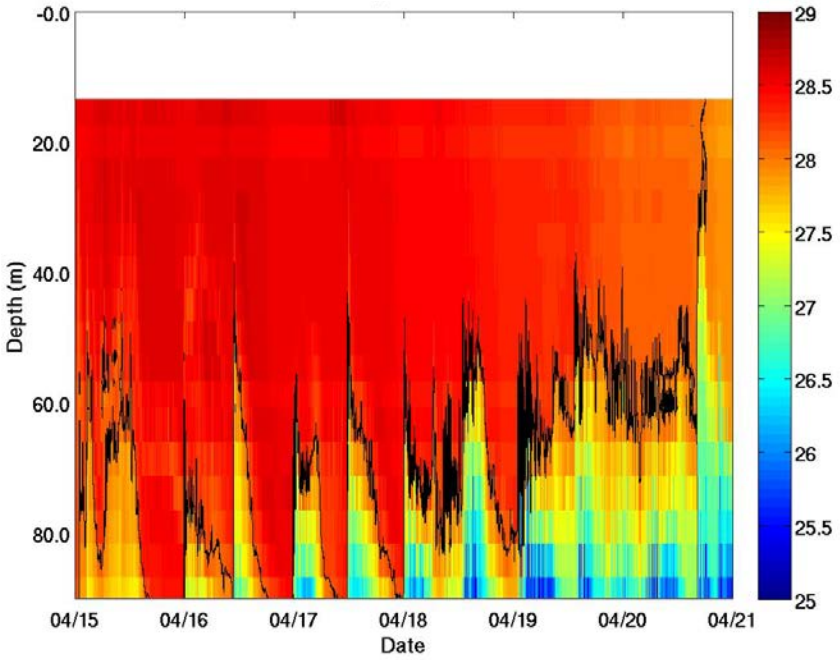
NCOM Temperature and Velocity at 50 m depth

Australian Government

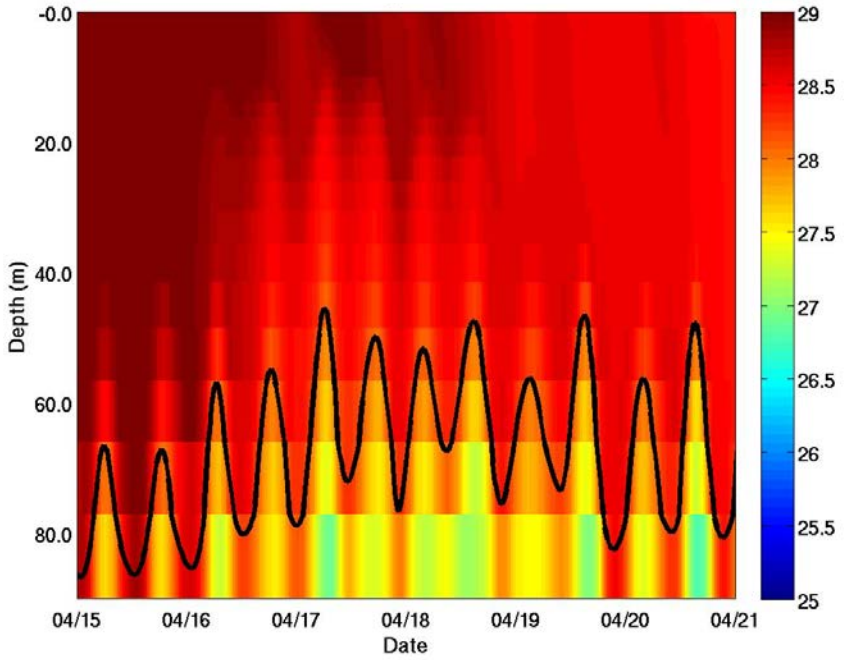
Australian Institute of Marine Science

Evaluating Glider data impact on NCOM solutions

Observed N2C temperature



Modeled N2C temperature

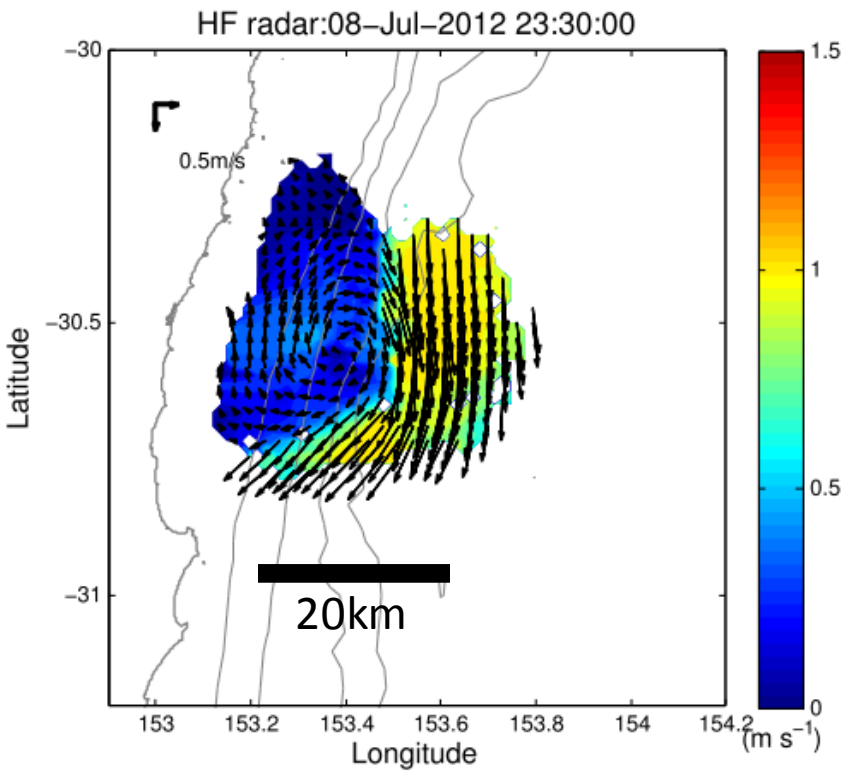


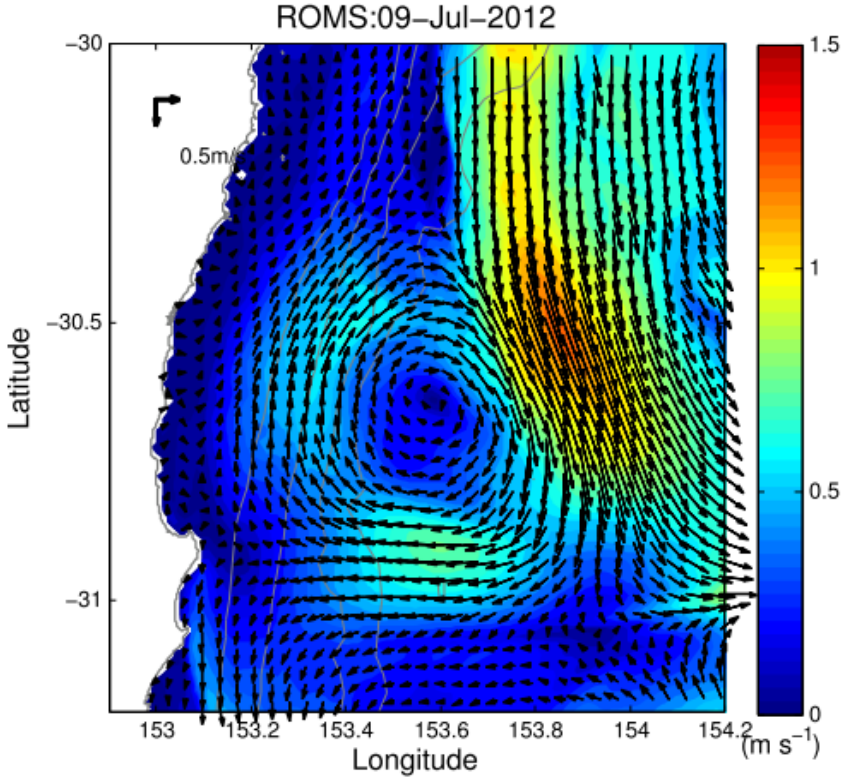
Comparing NCOM results after assimilation with withheld mooring observations

Sub-mesoscale processes and shelf ecosystem response

Following his 41-G space mission in October 1984, Scully-Power (1986) wrote: "The almost ubiquitous occurrence (of spiral eddies), whenever submesoscale dynamics was revealed in the sun glitter, indicates that they are perhaps the most fundamental entity in ocean dynamics at this scale. The difficulty is in explaining their structure."

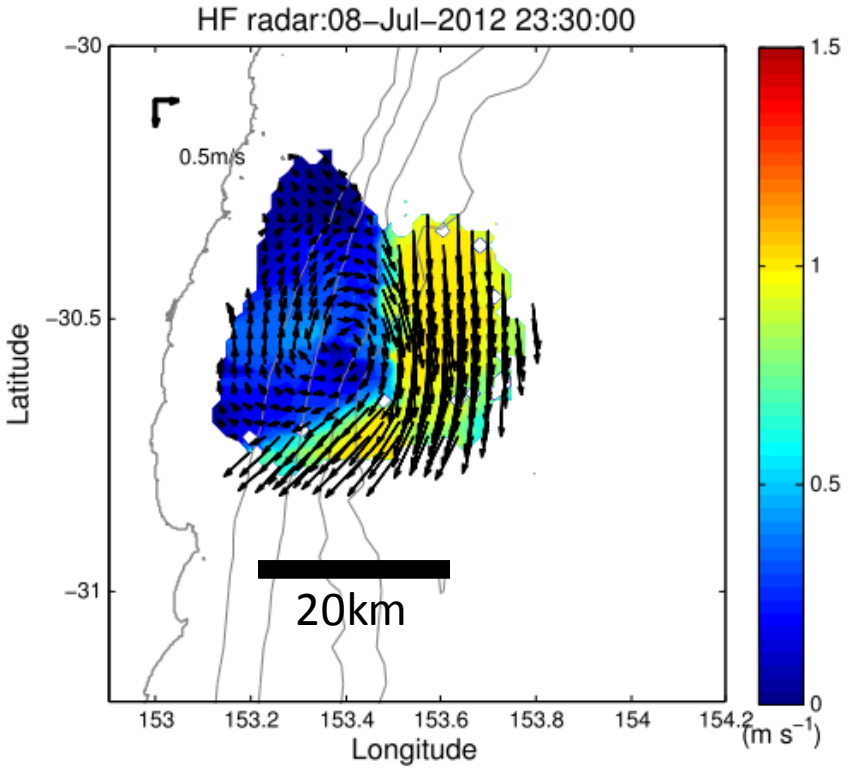
Sub-mesoscale processes and shelf ecosystem response

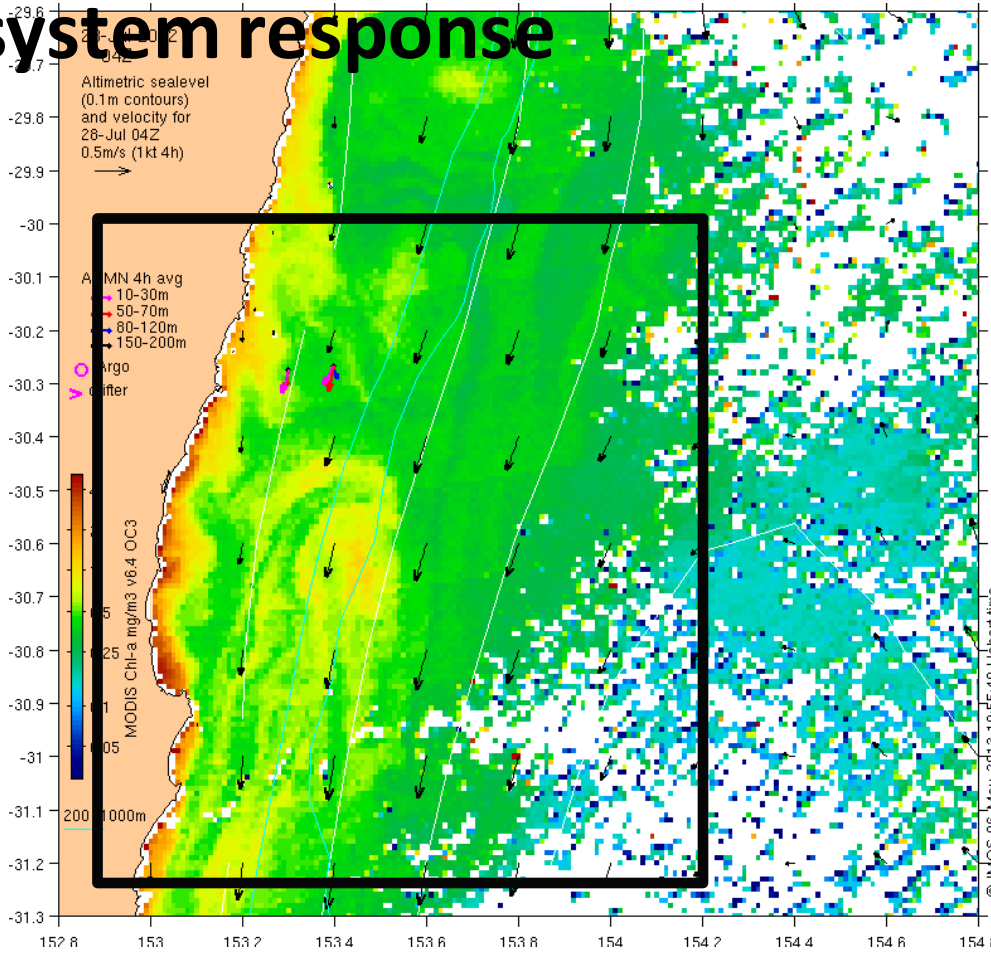




Eddies visible in SST, but not Altimetry

Sub-mesoscale processes and shelf ecosystem response





Pelagic response visible from MODIS

…and from yesterday's discussion

Breakout sessions summary - Fisheries

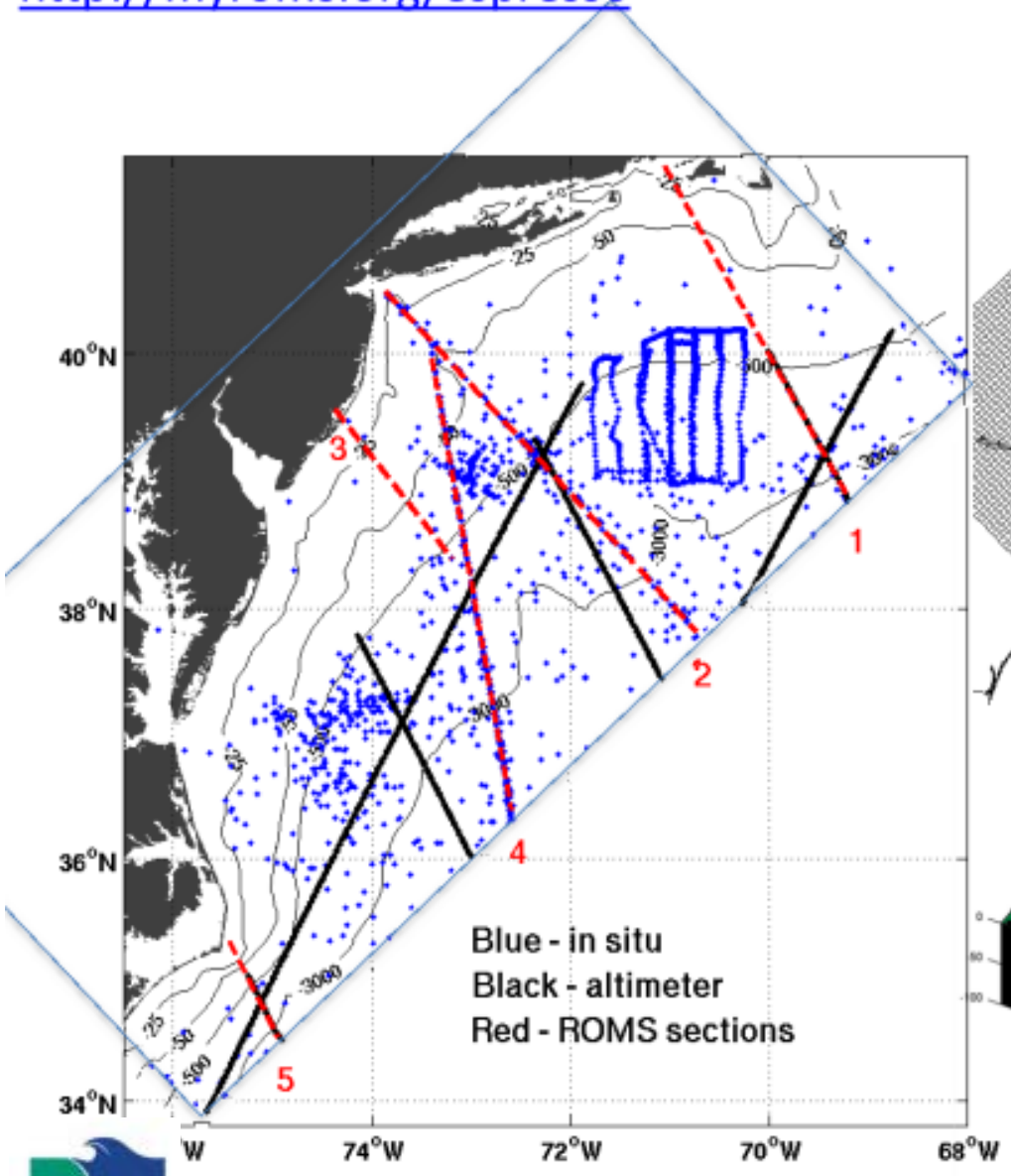
"*Fisheries respond to physical oceanography, fronts and eddies and meso and sub-mesoscale processes for larval dispersal and recruitment*"

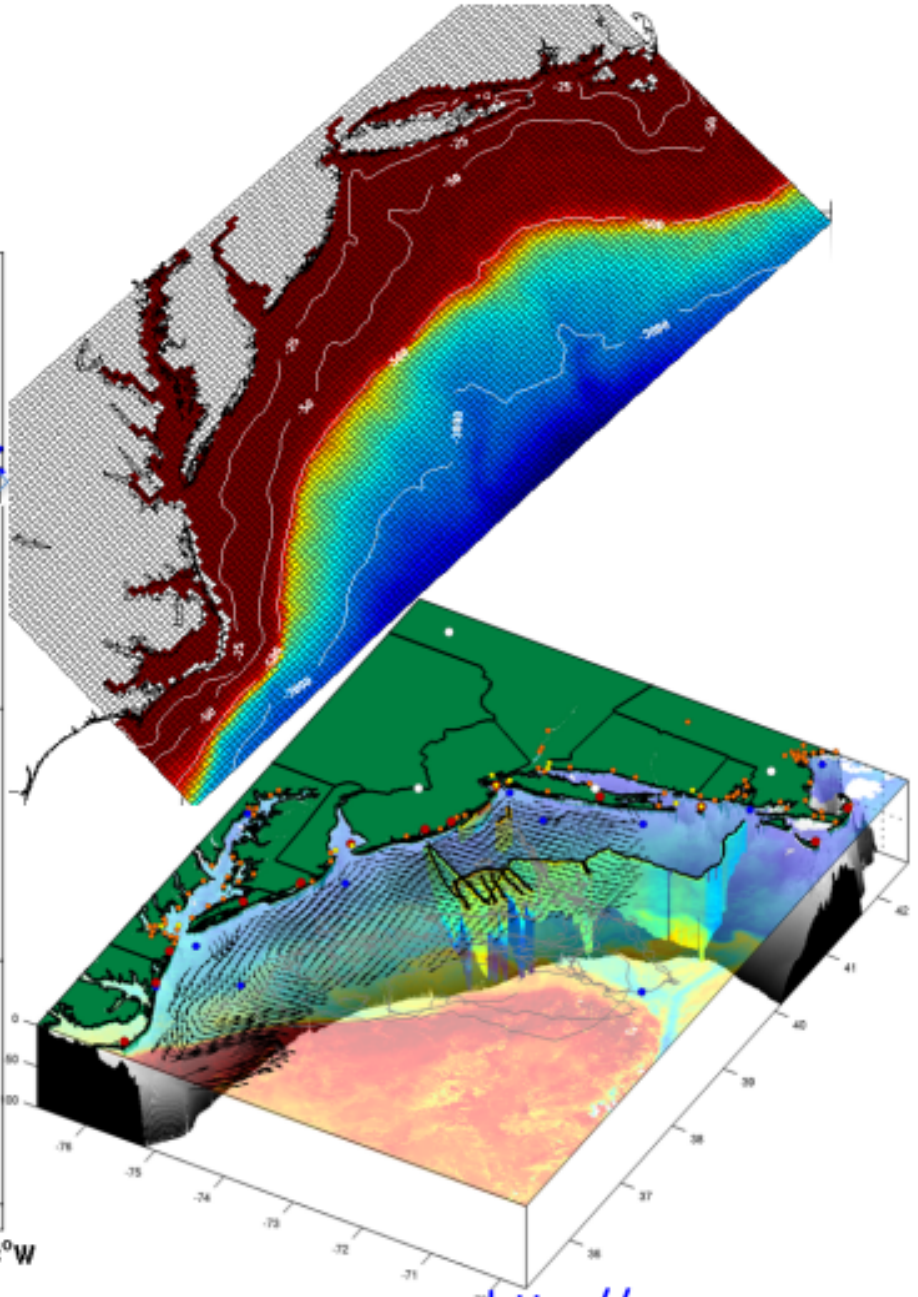
Iain:

"Future of Fisheries is on the continental shelf – need better knowledge of sub-mesoscale small cyclonic eddies on both west and east coast transport larvae offshore."

ESPreSSO real-time ROMS system

http://myroms.org/espresso





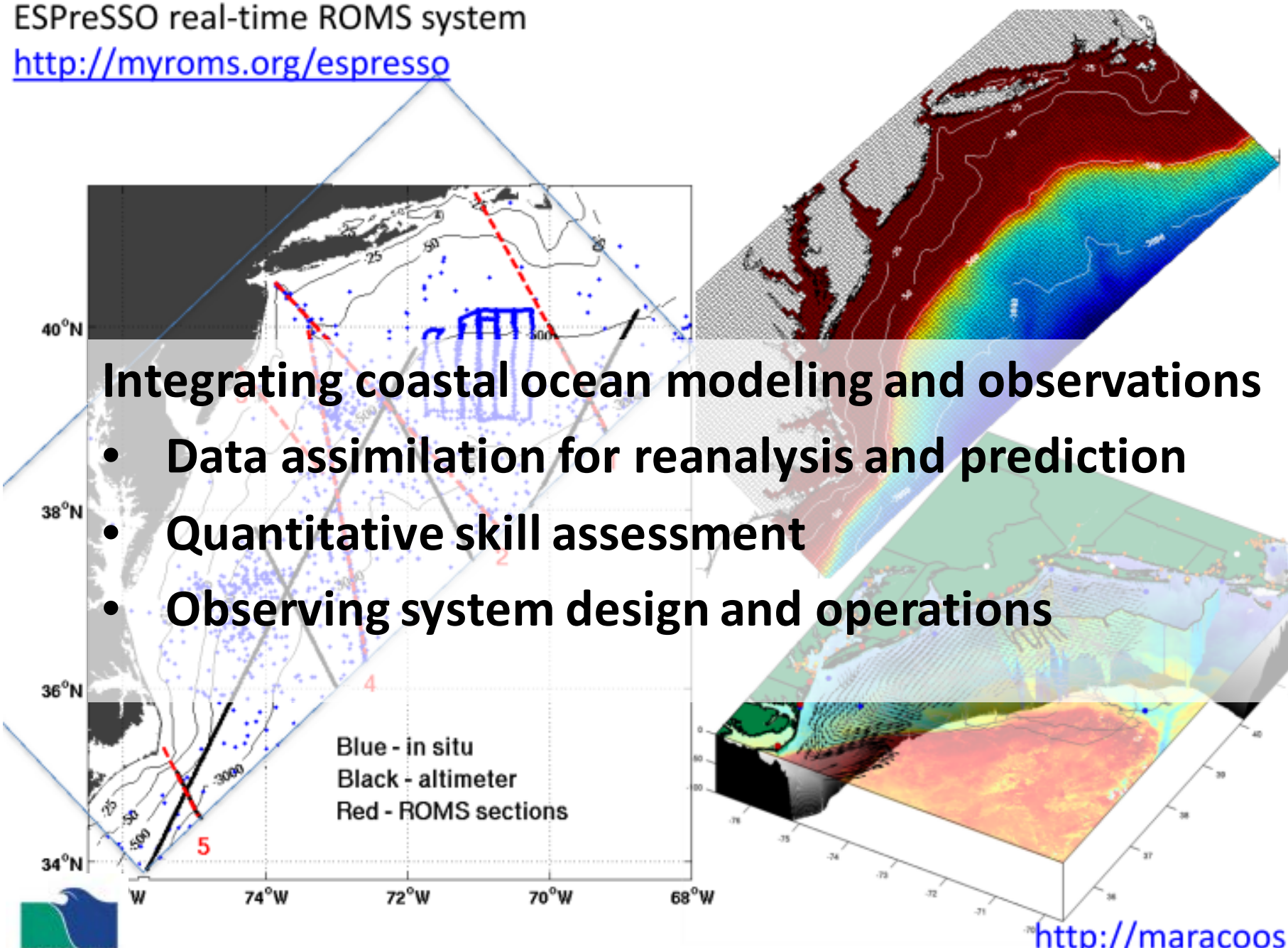
http://maracoos.org

MARACOOS Observing System

Wilkin

ESPreSSO real-time ROMS system

http://myroms.org/espresso



Integrating coastal ocean modeling and observations

- Data assimilation for reanalysis and prediction
- Quantitative skill assessment
- Observing system design and operations

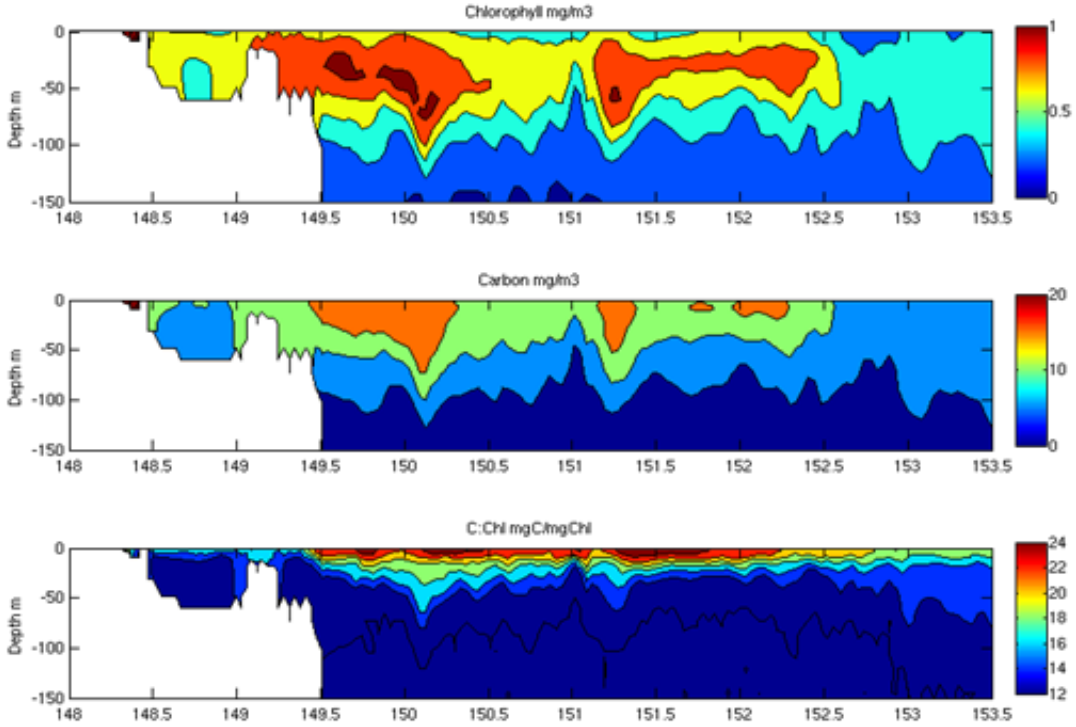
http://maracoos.org

MARACOOS Observing System

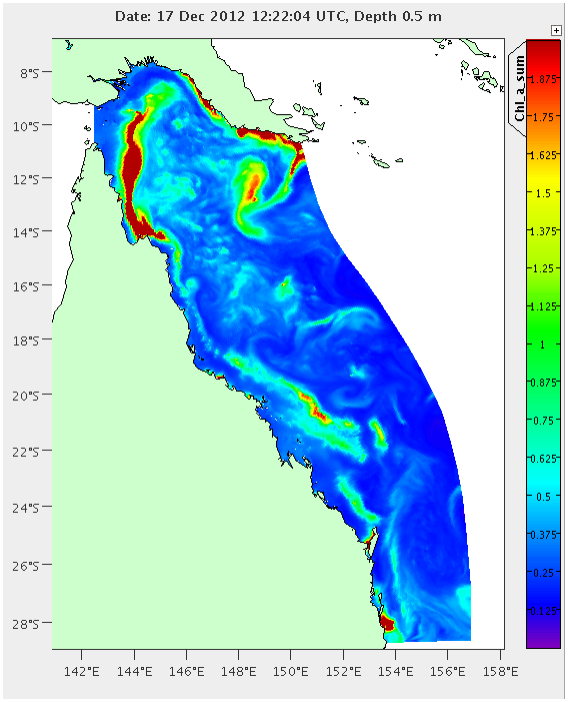
RUTGERS MARINE & COASTAL SCIENCES

Wilkin

Coupling to BGC and ultimately ecosystem response



Cross section of simulated total phytoplankton chlorophyll, carbon and the dynamically varying C:Chl ratio on the 18th October 2012.



Simulated uncalibrated surface chlorophyll

High Resolution Nutrient Observations off Heron Island

• Karen Wild-Allen • Lindsay MacDonald • Simon Allen

WEALTH FROM OCEANS
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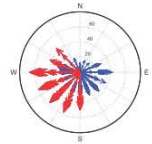
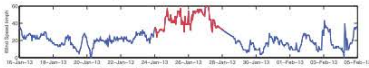
Summary

An optical nitrate sensor was deployed on an autonomous profiling glider in the southern Great Barrier Reef during the passage of ex-cyclone Oswald. Repeat transects confirm the influence of coastal freshwater across the shelf and the introduction of chlorophyll and nitrate to surface waters.

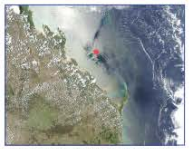
Cyclone Oswald was a category 1 tropical storm that formed in the Gulf of Carpentaria on the 21st January 2013 and tracked southeast across Queensland in the following week. Wind speeds > 120kmph were reported together with very heavy rainfall and flooding in catchments along the coast. The ex-cyclone passed close to our glider deployment off Heron Island in the Southern Great Barrier Reef on 26th January 2013.



Above right: Track of ex-cyclone Oswald across Queensland.



Above: Wind speed and direction at Heron Island during the Glider mission.



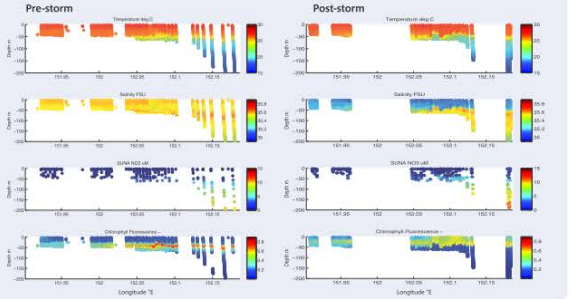
Above: MODIS/Aqua 250m resolution true colour image from 19 Feb 2013 showing plumes of river water crossing the shelf.

An Autonomous Profiling Sloccum Glider was augmented with a SUNA optical nitrate sensor and deployed on 16th January 2013 on cross shelf missions near Heron Island in the Southern Great Barrier Reef. Mission instructions were telemetered to the glider from the lab and decimated samples of data were received in near real time during the mission. On 5th Feb the glider was lost, likely due to ship strike in the busy alongshore shipping channel.

Telemetered SUNA data were processed using a pre-mission lab calibration, however this did not take into account any systematic variation due to temperature and salinity. Data presented are indicative of conditions in the region and rates of change, however their absolute accuracy cannot be confirmed. Future missions would benefit from onboard temperature-salinity correction to improve the accuracy of telemetered data.

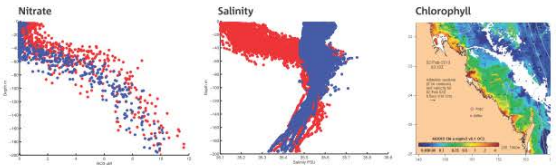
Glider Sections across the shelf prior to the storm show a stably stratified water column with a thermocline at 50m and subsurface chlorophyll fluorescence maximum at ~40m. Nitrate determined optically was undetectable on the shelf and at depths <50m.

Following the storm the surface waters were fresher and the thermocline was slightly shallower. The fluorescence maximum on the shelf was elevated to 20m with chlorophyll mixed throughout the surface layer offshore. The nutricline was elevated by ~10m with nitrate concentrations of ~1uM detectable in surface waters. A MODIS Aqua image of surface chlorophyll taken on the 2nd February 2013 shows plumes of enhanced chlorophyll (including suspended sediment and CDOM) adjacent to the coast extending offshore to surround the Heron Island Group.



Concluding Remarks

These glider data provide a remarkable insight into the evolving subsurface dynamics of the shelf during the passage of a severe tropical storm. The data will be used to assess the skill of the CSIRO eReefs hydrodynamic, sediment and biogeochemical model of the region with further deployments forming a key component of our near real time modelling system.



Right: Pre-cyclone (blue) and post-cyclone (red) nitrate and salinity profiles.

eReefs is a collaboration between CSIRO and the following:

Supported by:

ACKNOWLEDGEMENTS
The technical support of Rob Gregor, Sascha Frydman, Farhan Rizwi, Louise Bell was received with thanks.

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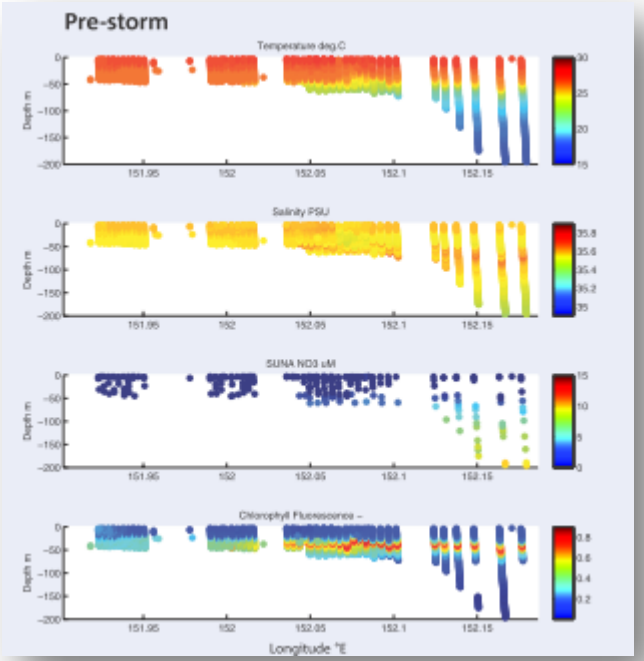
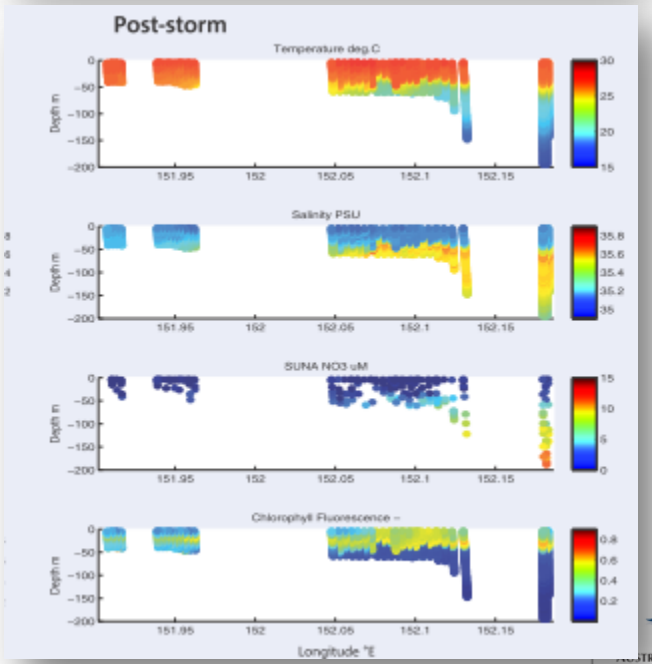
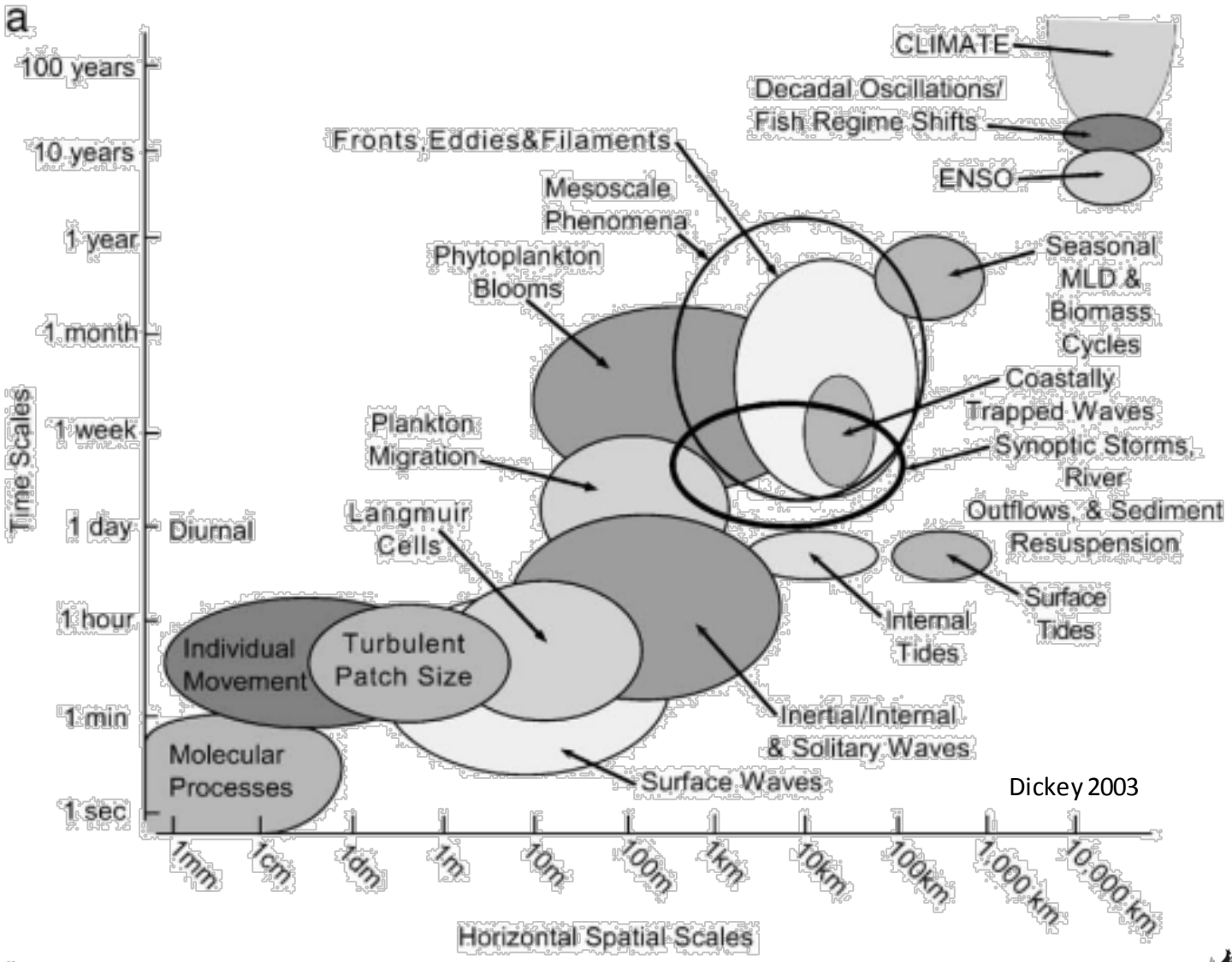




Wild-Allen

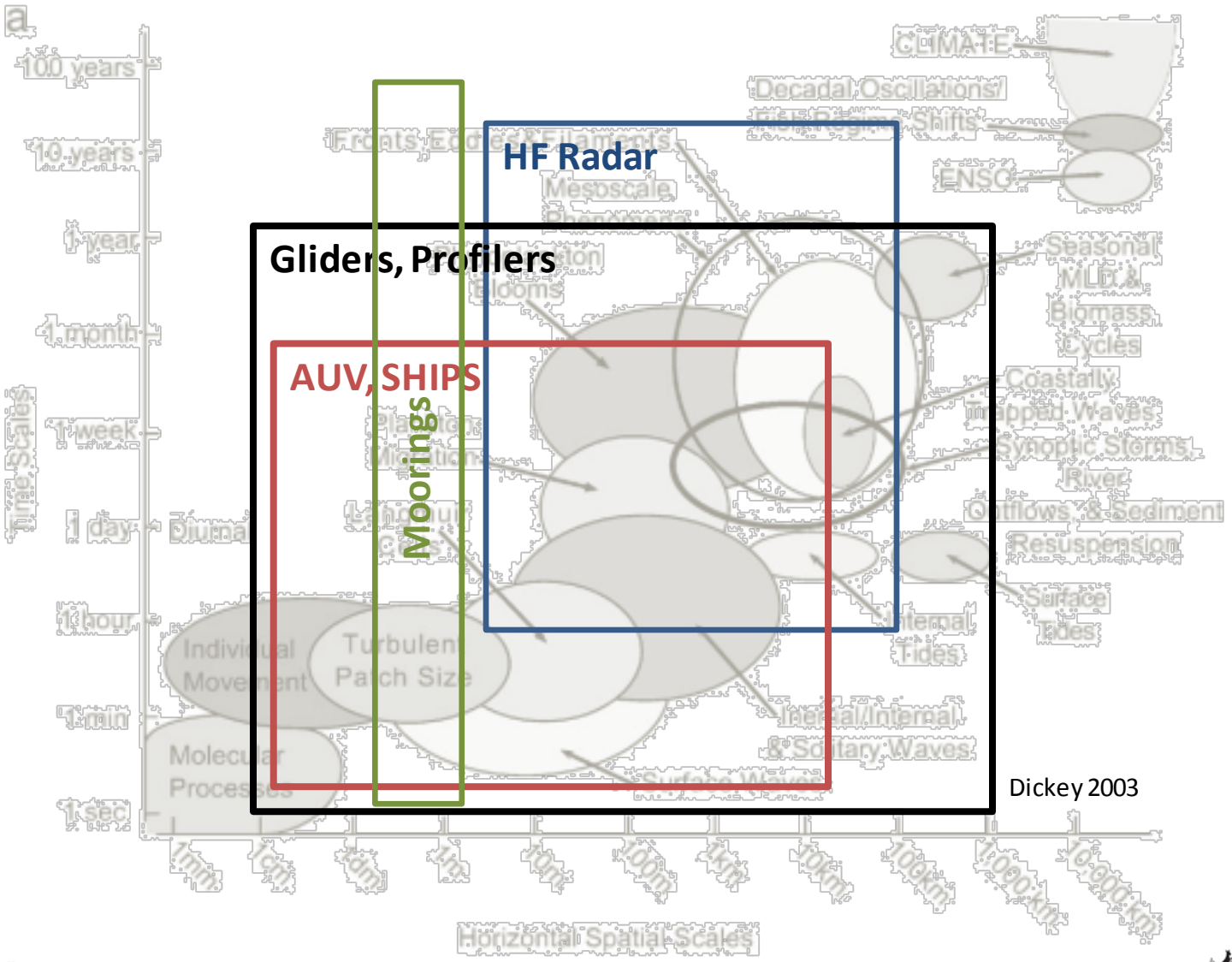
Australian Government | Australian Institute of Marine Science

Processes and Platforms



Dickey 2003

Processes and Platforms



Observational needs

- Leverage ocean observation through integration with numerical simulation models

- Process studies anchored to long term observational sites

- essential *in-situ* observations
  - cal/val & data assimilation

- Observation System Simulation Experiments (OSSE)
  - design/evaluate impact of observation systems