Seabed multi-beam backscatter mapping of the Australian continental margin

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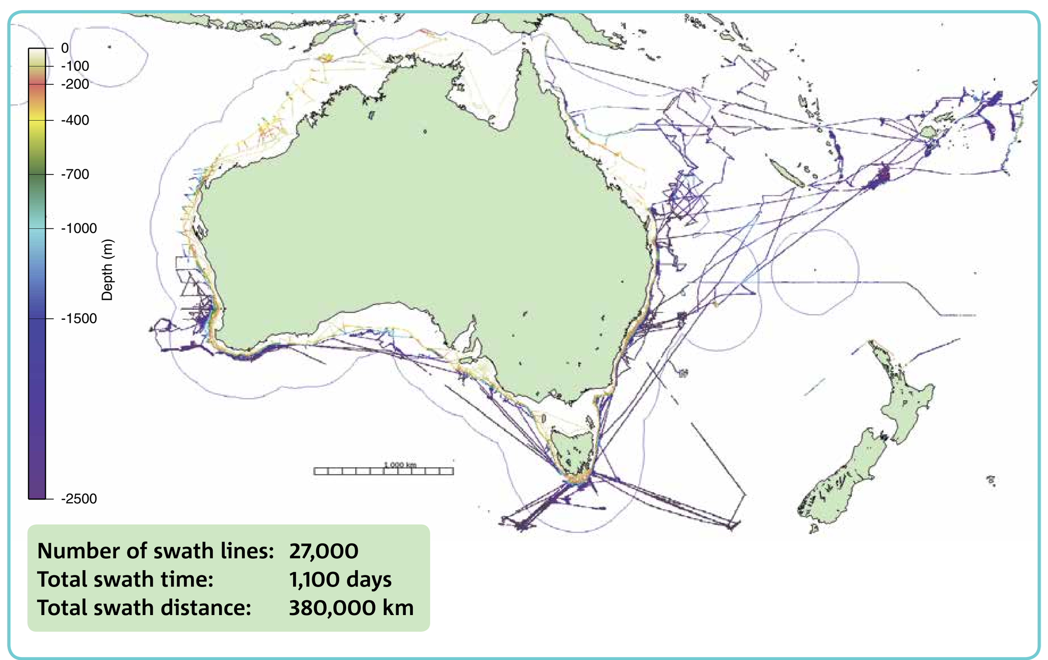
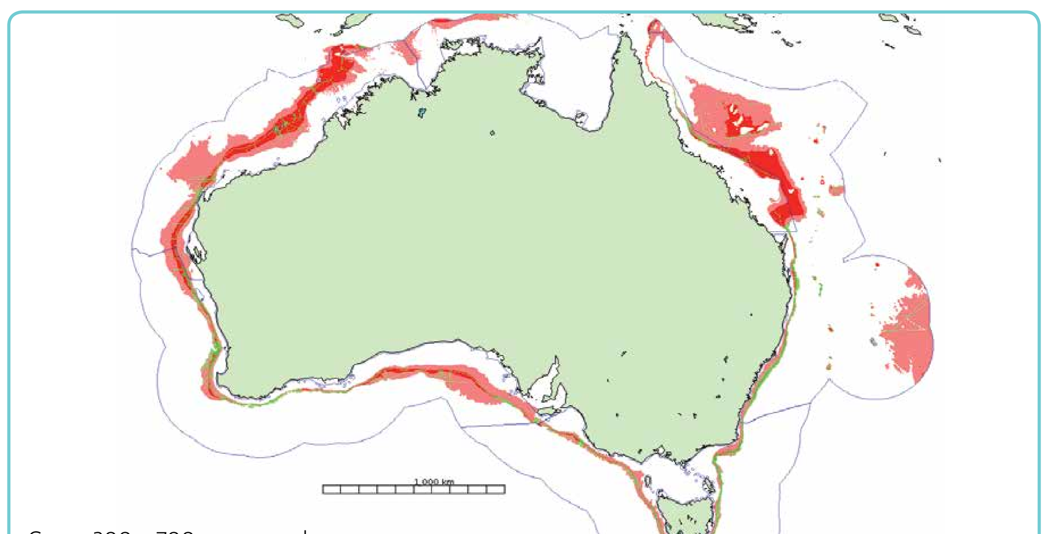
The Australian Marine National Facility, RV *Southern Surveyor*, was fitted with a Simrad EM300 multi-beam echosounder (swath mapper) at the end of 2003. Since then it has been mapping the seafloor around Australia on a variety of research and transit voyages, we have concentrated on mapping the continental margin (100 m – 1500 m) with emphasis on the upper slope (200 m – 700 m depth).

This national data set is a useful resource for large scale marine management. Data on key ecological features, such as submarine canyons and seamounts, is available as is information on the distribution of hard and soft substrate that provide habitats suitable for attaching and burrowing fauna, respectively.





Green 200 – 700 m mapped
Light green 100 – 1500 m mapped
Red 200 – 700 m unmapped
Light red 100 – 1500 m unmapped

Area 1000 km^2	East	North	North West	South East	South West	Total
Total	2,000	630	1100	1200	1300	6200
100 m - 1500 m	500	45	400	86	210	1200
200 m - 700 m	110	4	130	16	45	300
Mapped area total	120	7	29	88	110	350
100 m - 1500 m	39	1	24	32	44	140
200 m - 700 m	12	0	13	12	16	54
Proportion	5.9%	1.1%	2.7%	7.6%	8.4%	5.7%
100 m - 1500 m	7.8%	2.3%	5.9%	37.4%	21.1%	11.3%
200 m - 700 m	11.1%	0.0%	10.0%	75.0%	36.0%	17.7%

The strength of the acoustic echo off the seabed (backscatter) is a function of the seabed's roughness and hardness. To consistently measure the backscatter from a swath mapper requires a correction for a number of parameters.

The EM300 swath mapper calculates the backscatter using the formula:

$$BS(\theta_{ie}) = EL(\theta_{ie}) - SL(\theta_{ie}) + 20logR + 2\alpha R - 10log_{10}A(\theta_{ie})$$

BS – Backscatter - the value of interest
EL – Echo level measured by the instrument
SL – Source level transmitted by the instrument
R – Range = travel time measured by the instrument / sound speed input to the instrument
α – mean absorption input to the instrument
A – area insonified calculated by the instrument

Bathymetry processing

Removing spurious bathymetry values is an important first step in backscatter processing since bad bottom picks occur when noise hides the true bottom signal. This noise generally appears as spurious high backscatter.

We also generate a 50 m resolution topology model from the bathymetry for calculating the bottom slope and incident angles. The 50 m grid size is chosen to be optimum for the upper slope, having sufficient resolution to be meaningful while smoothing out outliers.

Absorption

Swath operators on board provide the instrument with sound absorption, α, profiles calculated from CTD (Conductivity Temperature Depth) and XBT (expendable Bathythermograph) probe casts and the World Ocean Atlas (WOA) 1998 model.

In post processing we can correct the data using sound absorption profiles from post processed CTD and XBT casts from both before and after the swath line and Synthetic Temperature and Salinity hindcasts derived from CARS (CSIRO Atlas of Regional Seas) with observed Sea Surface Temperature (SST) anomalies applied.

Area insonified

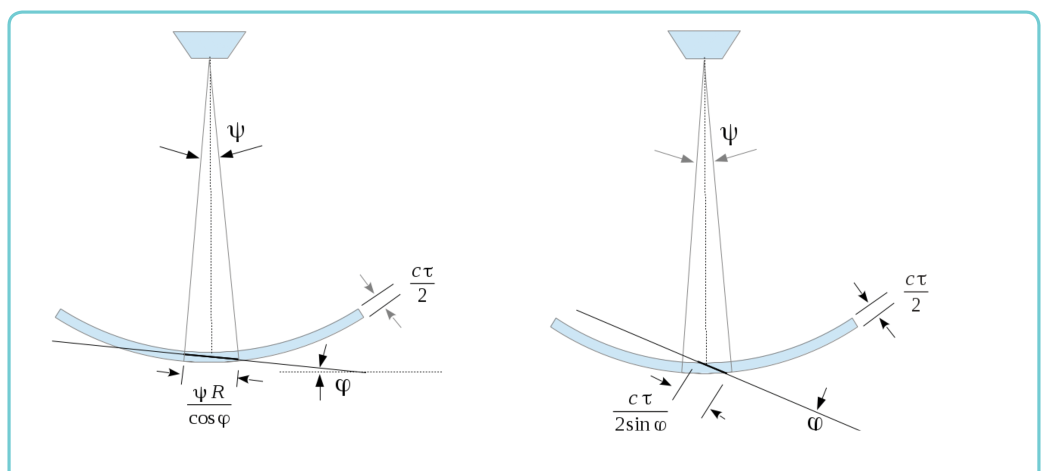
A correction of the instrument's simplified real time approximation of the insonified area

$$A_i = min\left(\frac{\psi_x R_i}{cos(\theta_{xi}-\theta_{xn})}, \frac{c\tau}{2sin(\theta_{xi}-\theta_{xn})}\right).\psi_y R_i$$

is required to account for seabed slope where the insonified area for each beam, i, is:

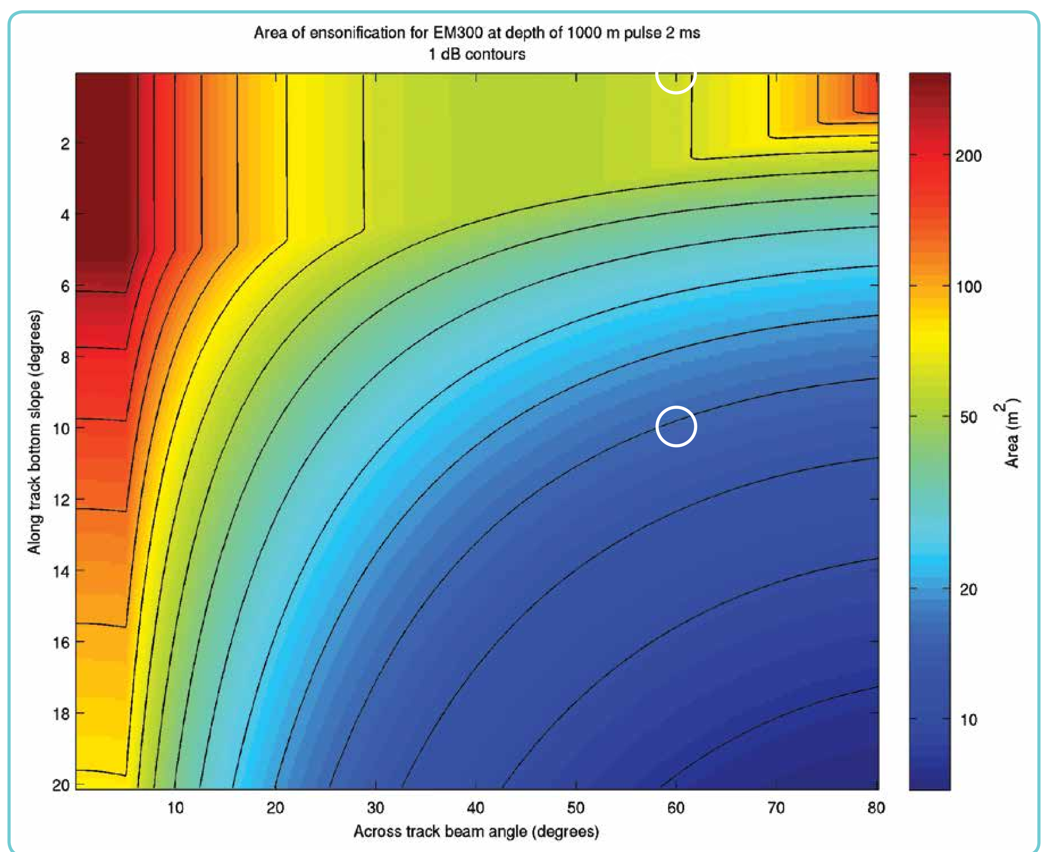
$$A_i = min\left(\frac{\psi_x R_i}{cos(\theta_{xi}-\phi_{xi})}, \frac{c\tau}{2sin(\theta_{xi}-\phi_{xi})}\right).$$
$$min\left(\frac{\psi_y R_i}{cos(\theta_{yi}-\phi_{yi})}, \frac{c\tau}{2sin(\theta_{yi}-\phi_{yi})}\right)$$

ψ is the beam width in radians, θ the beam angle and ϕ the bottom slope, θ_{xn} the beam with nearest bottom pick.



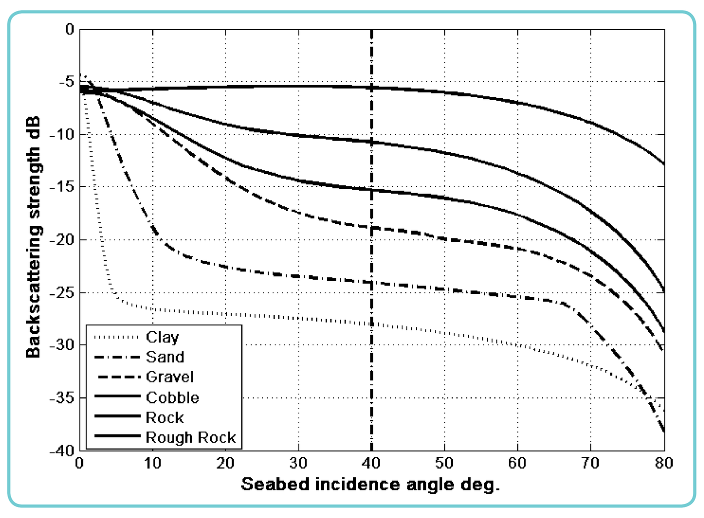
$$\frac{\psi R}{cos(\theta-\phi)} \qquad \frac{c\tau}{2sin(\theta-\phi)}$$

The difference can be significant, for example it can give a 6 dB difference for a seabed slope along the ship's track, φ_{yi}, of 10° at 60° across track, θ_{xi}.



Mapping: Incident angle response

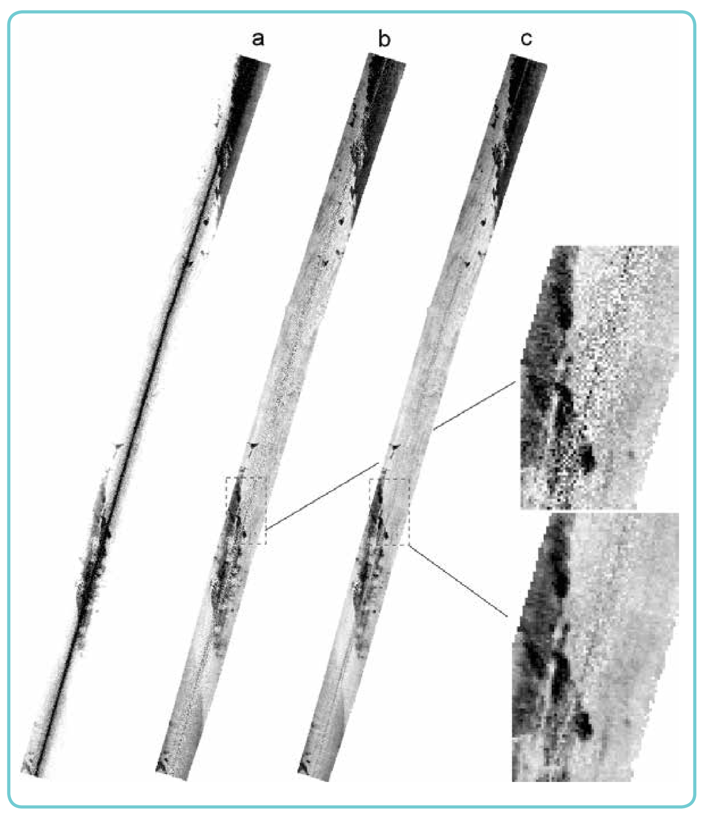
We calculate the backscatter incident angle anomaly compared to the average of 1000 pings referenced to the backscatter at 40°. $bs'(\theta)=bs(\theta)-\overline{bs}(\theta)+bs(40)-\overline{bs}(40)$ The large bin size (1000 pings) prevents aliasing of seabed features parallel to the ship's track, as many transects run parallel to the continental slope.



Estimated seabed backscatter at 31.5 kHz based on APL94 seabed model for various bottom types, greatest differentiation is at 40°.

Filtering

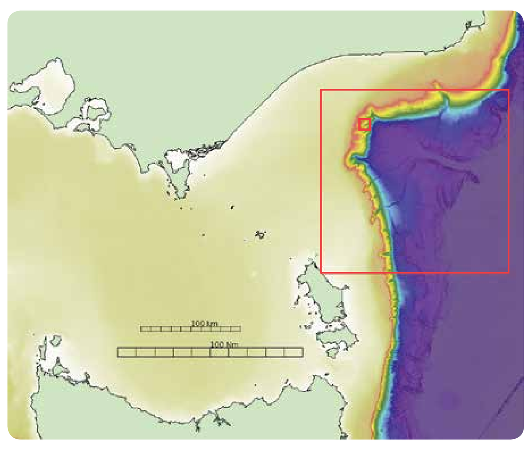
To "despeckle" the data and smooth fine scale echo statistics variability and decrease artefacts from aeration we apply a simple 3 ping by 3 beam median boxcar filter.



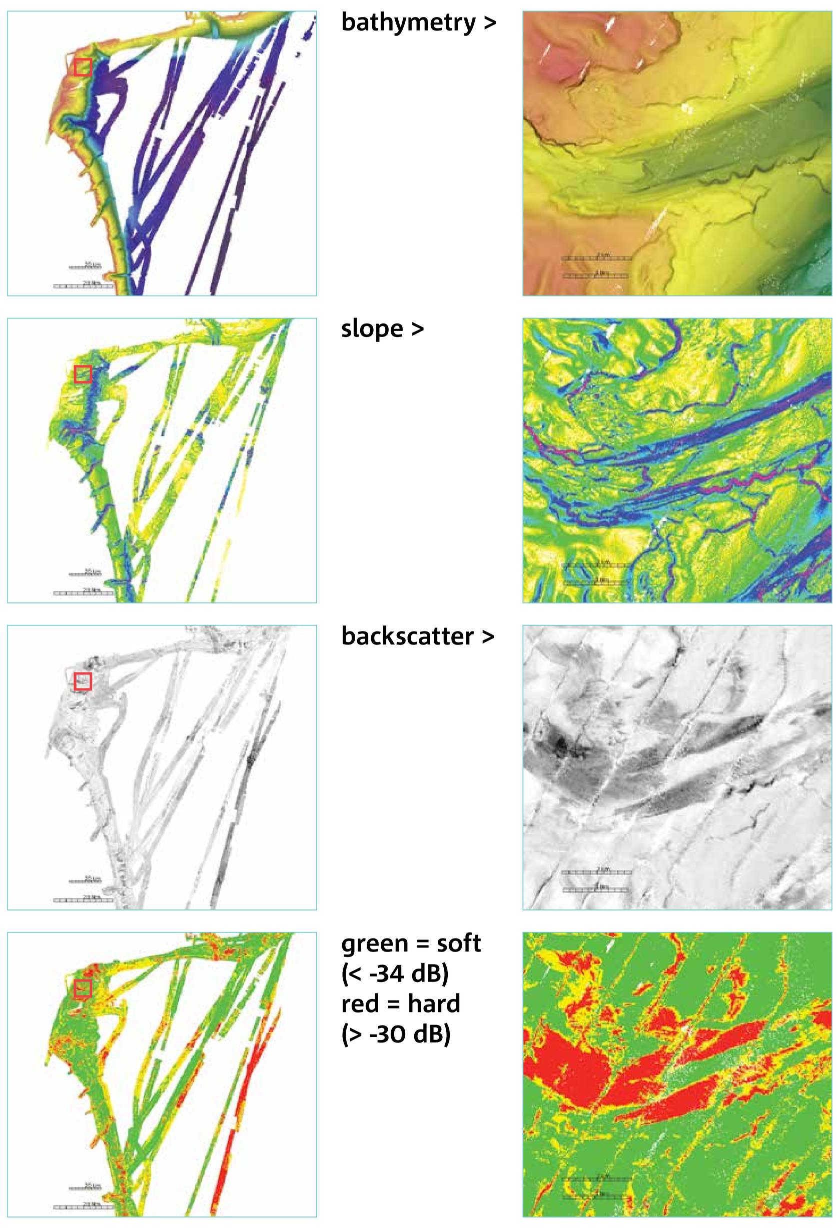
EM300 backscatter for a track at ~ 200 m depth a) raw, b) reference to 40°, c) filtered.

WMS

We map bathymetry, slope, backscatter and classified backscatter at resolutions from 4096 pixels per degree (~20 m) to 64 pixels per degree. The maps are available via a Geoserver Web Mapping Service at http://www.marine.csiro.au/geoserver



Bass Canyon



Software

http://www.mb-system.org/
http://svn.mb-system.org/listing.php?repname=MB-System&path=%2Fbranches%2Fcsiro-trunk
http://geoserver.org

Reference

Kloser, R.J., and Keith, G. (2013) Seabed multi-beam backscatter mapping of the Australian continental margin. Acoustics Australia, 41, 70-77.

Acknowledgements

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