Submarine Canyons: Their role in shaping biodiversity patterns on the Australian margin

Introduction

Submarine canyons are recognised as potential areas of high biological productivity and marine life aggregation, in Australia ranging from deep water corals to foraging blue whales. While factors such as nutrient upwelling and the presence of hard substrate can account for the biodiversity of particular canyons, the variability of these characteristics between canyons at the national scale is poorly understood.

This leads to the question, are all canyons the same?

To address this question and better understand the relationship between canyons and biodiversity, researchers in the Marine Biodiversity Hub have re-mapped and measured Australia's submarine canyons, classified canyons on the basis of their physical form and examined the degree of connectivity between canyons.

This fact sheet summarises these mapping results and presents case studies that identify the potential connectivity between canyons.

Canyon Mapping

Based on updated bathymetry datasets, a total of 713 submarine canyons are now identified and mapped for the Australian continental margin (Fig. 1; Huang et al., 2014). An additional 40 canyons are within external territorial seas surrounding Norfolk and Cocos Islands (31 and 9 canyons, respectively). Canyons are located on all sides of the continent but occur in greater numbers in the South-west (204), South-east (206) and Temperate East (124) marine regions (Table 1).

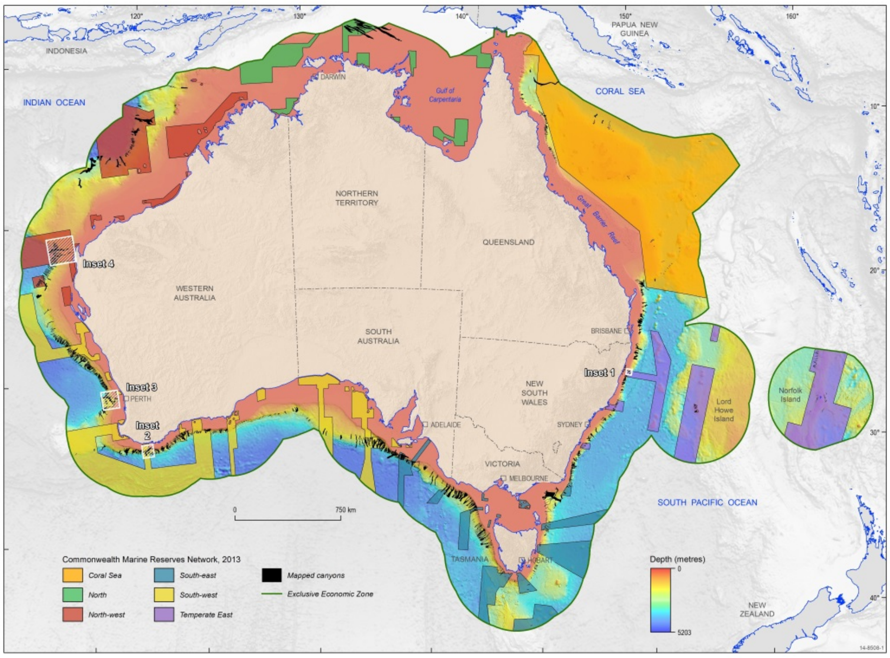

Fig.1: Submarine canyons of the Australian margin shown in relation to Commonwealth Marine Reserves.

	Number of Canyons		
Marine Region	Total	Within a CMR	Shelf-incised
North	6	5	6
North-West	90	65	1
South-West	204	60	9
South-East	206	54	51
Temperate East	124	62	21
Coral Sea	39	39	0
GBR	75	N/A	7
Outside*	9	0	0
TOTAL	**753#**	**285**	**95**

Table 1: Canyon count by marine planning region, including Great Barrier Reef Marine Park. Notes: # - Canyon total includes 31 canyons within Norfolk CMR and 9 canyons around Cocos Island; *- Outside denotes territorial seas around Cocos Island.

Overall, canyons are well represented in the national network of Marine Protected Areas, with 38% (n=285) of Australia's 753 canyons falling within a Commonwealth Marine Reserve (whole or in part).

Ninety-five canyons extend onto the continental shelf as shelf-incising canyons that potentially connect the deep ocean to the shelf via upwelling. The remaining 618 canyons are confined to the continental slope and are termed 'blind canyons'. All 40 canyons in external seas are also blind canyons.

In some areas of the marine estate, canyons are defined as a Key Ecological Feature (KEF), typically as groups of canyons such as the Albany Canyons (South-west), canyons offshore Cape Range Peninsula (North-west) and canyons on the eastern continental slope (Temperate East). However, there remain a large number of canyons around Australia for which insufficient information is available to define them as a KEF.

This new mapping and analysis of Australia's submarine canyons can be used to support a re-appraisal of potential KEFs and potentially refine the descriptions of conservation values for existing canyon KEFs.

Are Canyons Connected?

A key question to understanding the role that canyons play in influencing patterns of marine biodiversity is whether, and to what extent, are canyons connected to the deep ocean, to the continental shelf and to other canyons nearby?

To address this question, researchers in the Marine Biodiversity Hub are building a dynamic model of larval dispersal for the entire EEZ. Driven by ocean currents, the model shows the three-dimensional patterns of larval movement for the period 2009-2012 and displays areas of potential larval settlement, and the pathways to settlement.

An important measure provided by the dispersal model is the 'relative source capacity' of an area of seabed, applied here to submarine canyons. Thus, canyons with a high source capacity are more likely to function as a contributing environment for larvae thereby acting as a potential supplier of benthic organisms.

The dispersal model can be used to explore patterns of connectivity at the regional scale as shown in the following case studies.

Canyon Case Studies

Albany Canyons

The new canyon map shows that there are 81 canyons in the Albany Canyon Group in the South-west region (Fig. 2). The Group extends ~900 km as a near continuous chain from 114.2° to 125° E. Among the 81 canyons, eight are shelf-incising that extend to water depths of 4000 m on the lower continental slope. Most of the other canyons span similar depths but terminate just below the shelf edge and are therefore blind canyons. Nineteen canyons intersect (whole or in part) a Commonwealth Marine Reserve, including two of the larger canyons, Wilson Canyon (South-west Corner CMR) and Bremer Canyon (Bremer CMR).

The connectivity model shows that, as a group, the Albany Canyons function as an important source for marine larvae transported eastward by the Leeuwin Current (Fig. 2). Thus, 25 canyons are modelled to have medium to high source capacity, most of which are the larger more topographically complex canyons, such as Wilson Canyon and Bremer Canyon. In contrast, smaller canyons tend to have a low relative source capacity, particularly those in the east of the Albany Group which are at the downstream end of the Leeuwin Current dispersal path and outside CMRs.

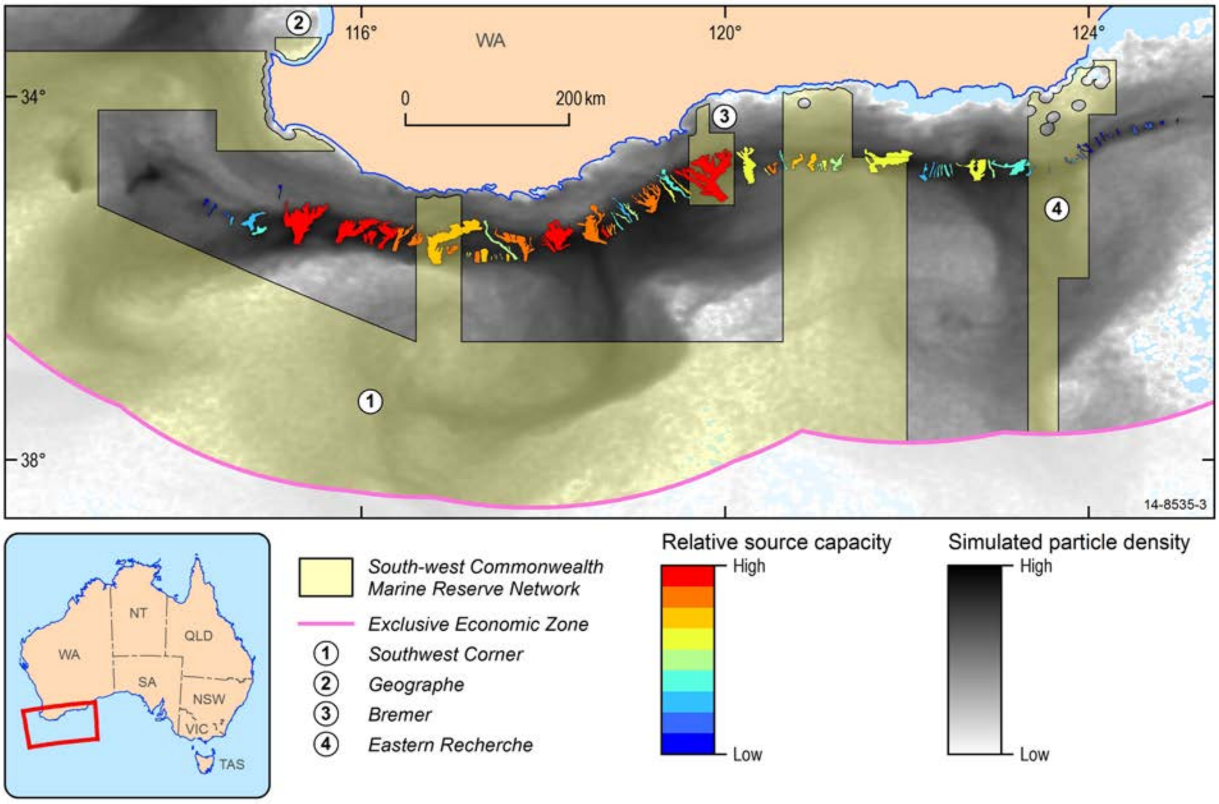

***Fig. 2:** Albany Canyons showing the capacity for each canyon to act as a source for marine larvae, modelled for larval release across the Southwest marine region in September 2009 (represented by the grey dispersal cloud). Numbers and letters refer to canyons and CMRs mentioned in the text, as follows: 1- Wilson Canyon; 2- Albany Canyon; 3 – Kalgan Canyon; 4 – Bremer Canyon*

For canyons with high source capacity the implication for biodiversity is not that they may be particularly unique or supporting high endemism (although this is possible). Rather, it indicates that these canyons have high potential to contribute to resilience of the protected area network by exporting larvae to other connected locations. In the case of the Albany Canyons, this strong connectivity is driven by the Leeuwin Current and augmented by secondary flows that recirculate the dispersal cloud westward and provide additional opportunity for larval settlement.

Direct observations of benthic communities within the Albany Canyons are limited to underwater video transects at two canyon heads, Wilson Canyon and Kalgan Canyon. At the head of Wilson Canyon, located just outside South-west Corner CMR, rocky outcrops are colonised by rich assemblages of sponges, soft corals and bryozoans in ~100 m water depth. An assessment of seabed hardness for this canyon, based on sonar backscatter data, indicates that 26 percent of the 25.7 km^2 occupied by the canyon head (to 700 m depth) is hard and therefore potential habitat for these biota. Similar benthic communities were observed in Kalgan Canyon where 17 percent of the canyon head area of 65.3 km^2 is classified as hard substrate. As such, these observations support the classification of these particular canyons as moderate (Wilson) to high (Kalgan) source capacity canyons.

Cape Range Canyons

Cape Range Peninsula and Ningaloo CMR (North-west region) sit along the narrowest part of Australia's continental shelf and the canyons that extend toward the abyss are recognised as a Key Ecological Feature, specifically as pathways for upwelling of nutrients.

The new canyon mapping shows that only one of the Ningaloo CMR canyons (Cloates Canyon) extends from the shelf to slope, with Cape Range Canyon now mapped as a blind canyon that terminates in 1500 m water depth. The mapping also identifies a total of 42 canyons on the continental slope, of which 18 sit within Gascoyne CMR and 11 within Carnarvon Canyon CMR. Previously, only Carnarvon Canyon had been mapped for this area.

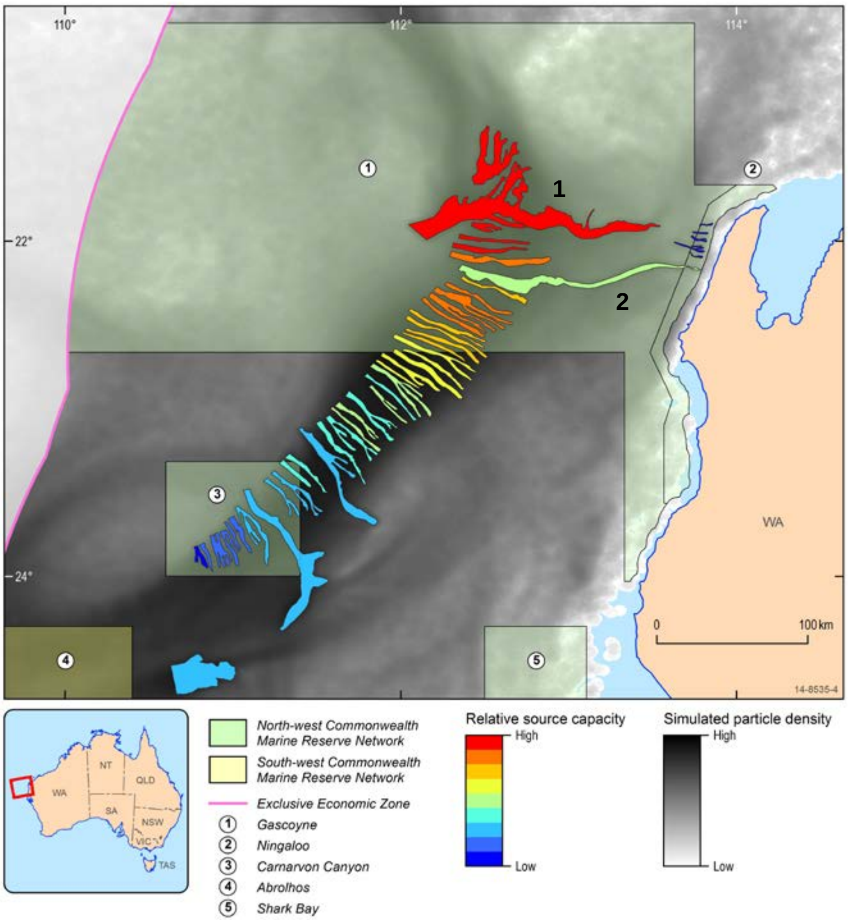

Fig. 3: *Cape Range Canyons showing the relative capacity of each canyon to act as a source for marine larvae, modelled for larval release across the Northwest marine region for September 2009. Numbers and letters refer to canyons and CMRs mentioned in the text, as follows: 1- Cape Range Canyon; 2- Cloates Canyon*

The connectivity model for the Cape Range Canyons shows a higher source capacity for canyons in the northern half of the group, with most of those canyons intersecting the Gascoyne CMR (Fig. 3). In contrast, all of the canyons within Carnarvon Canyon CMR have low source capacity for marine larvae. This gradient in source capacity across a relatively small area is a result of consistent southerly flow across the canyons. The shelf-incising canyons that intersect Ningaloo CMR have low source capacity due to their location along the eastern margin of the Leeuwin Current which only crosses the shelf intermittently. Video observations at the head of one of the smaller shelf-incising canyons in Ningaloo CMR support the notion that they are low net receivers of larvae, with only isolated benthic organisms found (Fig. 4).

Fig. 4: *Isolated sponges (white) growing on rock outcrop at the head of an unnamed shelf-incising canyon (113^{o} 49' E, 21^{o} 59' S) within Ningaloo CMR (source: CSIRO).*

The connectivity model also highlights the 'trapping' effect that canyons can have. In the case of the Cape Range canyons, the model shows a concentration of larvae at 3000-3500 m water depth located within the 18 canyons that sit within Gascoyne CMR, including Cape Range and Cloates Canyons (Fig. 5). In contrast, the larval cloud at the sea surface is dispersed more widely and in lower concentrations. Again, this highlights the accessible niche that canyons provide for potential larval settlement.

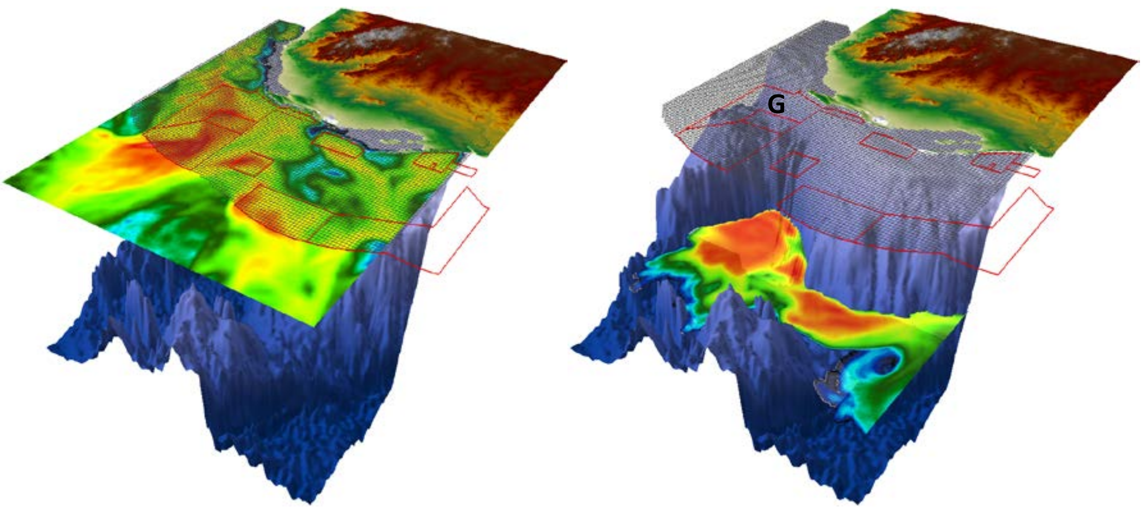

Fig. 5: *Depth slice through the 3D larval dispersal cloud at the sea surface (left) and 3000-3500 m water depth (right) spanning Gascoyne, Carnarvon Canyon and Abrolhos CMRs. Warm colours represent higher larval concentrations. Note the broader dispersal at the sea surface and trapping effect of canyons at depth. CMR boundaries are also shown (G – Gascoyne CMR).*

These case studies demonstrate that canyons play a key role influencing marine biodiversity at the local (CMR) scale to regional (KEF) scale, and the modelling allows us to explore the dynamics of these patterns in canyons. Importantly, we now have the information for what is likely the entire population of Australia's submarine canyons and can assess their relative significance at the national scale.

Additional Information

National Submarine Canyons of Australia dataset published by Geoscience Australia

Huang, Z., Nichol, S.L., Harris, P.T., Caley, M.J. 2014. Classification of submarine canyons of the Australian continental margin. Marine Geology. DOI: 10.1016/j.margeo.2014.07.007

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