SOI CRUISE
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PERTH CANYON ROV EXPLORATION & SAMPLING

University of Western Australia

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KAUST, Saudi Arabia

SCHMIDT OCEAN INSTITUTE CRUISE FK150301

ROV exploration of the Perth Canyon and assessing the vulnerability of deep-sea corals to climate change and ocean acidification

Malcolm McCulloch[1,2,3], Julie Trotter[1,3], Jim Falter[1,2,3], Chari Pattiaratchi[1,4], Paolo Montagna[5,6], Marco Taviani[5], Ron Thresher[7], Andrew Hosie[8], Lara Garcia-Corral[3,9], David Haig[3], Federica Foglini[5], Susan Agusti[1,9] and Carlos Duarte[1,9].

[1]Oceans Institute, The University of Western Australia, Crawley, Western Australia, AUSTRALIA

[2]ARC Centre of Excellence in Coral Reef Studies, The University of Western Australia, AUSTRALIA

[3]School of Earth Sciences, The University of Western Australia, AUSTRALIA

[4]School of Engineering, The University of Western Australia, AUSTRALIA

[5]Istituto di Scienze Marine (ISMAR, CNR) Bologna, ITALY

[6]Laboratoire des Sciences du Climat et de l'Environnement, Av. de la Terrasse, 91198, Gif-sur-Yvette, FRANCE.

[7]Commonwealth Scientific and Industrial Research Organization (CSIRO), Marine and Atmospheric Research, Hobart, Tasmania, AUSTRALIA

[8]Western Australian Museum, Perth, AUSTRALIA

[9]King Abdullah University of Science and Technology (KAUST), Thuwal, SAUDI ARABIA

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1. Summary

This report describes the main scientific outcomes of the first ROV exploration of the Perth Canyon, which was conducted from March 1st to 12th 2015. This expedition was made possible by resources provided by the Schmidt Ocean Institute — its ocean research vessel the R/V Falkor equipped with ROV, their crews, and both on-board as well as shore-based scientific support. The primary focus of the expedition was to document and strategically collect mainly calcareous deep-sea corals, which were found along parts of the Canyon walls, and determine their relationship to the specific physical-chemical conditions of their deep-sea environment. Investigations also included regional-scale oceanographic measurements of the Leeuwin current conducted simultaneously using ocean gliders, deep-water sampling using CTD casts, and an assessment of net community production from measurements of surface water productivity. Additionally, geological investigations were conducted on rock samples collected from the Canyon to improve our understanding of the longer-term geological processes that formed the Canyon.

Five canyon and one nearby shelf sites were studied with high-resolution ROV video imaging that revealed spectacular geomorphology with, for example, numerous vertical walls forming ideal deep-water coral habitats especially towards the top of the canyon walls. The observations and samples collected spanned depths of ~600 to ~1800 m. Solitary live and fossil scleractinians (e.g. *Desmophyllum dianthus*, *Caryophyllia* sp., and *Polymyces* sp.) as well as colonial species (*Solenosmilia variabilis*) were found on cliff faces and in fossil graveyards in fine sediment deposits. Antipatharians and octocorals (e.g. *Corallium, Lepidisis, Keratoisis*) were also common, living species observed at depths of ~1800m. Representatives of other biota that were frequently observed include various echinoderms, glass sponges, anemones, crustaceans, fish, and worm tubes. Some of the scleractinian corals collected (*Caryophyllia, Desmophyllum, Polymyces,* and *Solenosmilia*) have been analysed by uranium-thorium (U-Th) dating, which indicate ages from 29,000 to 30 years before present (i.e. from year 1950). Temperature and salinity CTD data indicates that the corals have grown in Antarctic Intermediate Waters (AAIW), Northwest Indian Intermediate Waters (NWIIW), and Indian Deep Waters (IDW), having occurred over both recent and longer (Last Glacial Maximum) timescales. A comprehensive geochemical analytical program of the coral skeletons is ongoing, which will enable reconstructions of the composition and environmental conditions (e.g. temperature, pH) of these water masses.

The foraminiferal biostratigraphy determined from sediments sampled by ROV, indicate that the depositional ages of the canyon strata range from Early Paleocene (~60 Ma) at the base to Early Miocene (~22 Ma) in the upper parts of the Canyon walls. These ages are consistent with previous dredge samples from the canyon (Marshall et al., 1989), indicating it formed after the Early Miocene.

2. Cruise Participants

The following scientific personnel (non-SOI members) participated in this research cruise to the Perth Canyon aboard the SOI R/V Falkor in March 2015.

2.1 The University of Western Australia

- Professor Malcolm McCulloch
- Dr Julie Trotter
- Dr James Falter
- Professor Chari Pattiaratchi
- Dr Lara Garcia-Corral
- Dr Verena Schoepf
- Mr Carlin Bowyer
- Mr Anton Kuret
- Ms Claire Ross

2.2 Istituto di Scienze Marine (ISMAR CNR), Bologna, Italy

- Dr Marco Taviani
- Dr Paolo Montagna

2.3 CSIRO

- Dr Ron Thresher (Hobart)

2.4 Western Australian Museum

- Dr Andrew Hosie

2.5 Post-cruise Contributors

A number of researchers who did not participant on the cruise have contributed to the preparation of this report: Dr David Haig (UWA) contributed the foraminifer biostratigraphy and geological history; Dr Federica Foglini (ISMAR) processed bathymetry data to generate the maps; Susan Agusti and Carlos Duarte (KAUST) contributed to the plankton productivity section.

3. Exploration of the Perth Canyon

3.1 Introduction

The deep-sea canyons that occur along the shelf-edge of continents are some of the most important, but least studied features of our marine landscape. Upwelling of nutrient rich water from these deep-sea channels makes them one of the most highly productive (evidenced by whale aggregations during the summer/autumn months) and prospective zones for discovery and exploration of new life. The vast majority of these canyons have never been explored using modern marine technology (e.g. Remotely Operated Vehicles or ROVs), and genuinely represent a new frontier for exploration and science discoveries. However, despite their relative isolation, the deep-sea ecosystems that inhabit these canyons are now being subject to the combined impacts of both rapid warming and acidification from subducted continental shelf waters, which raises the question of the vulnerability and resilience of these systems to ongoing climate change.

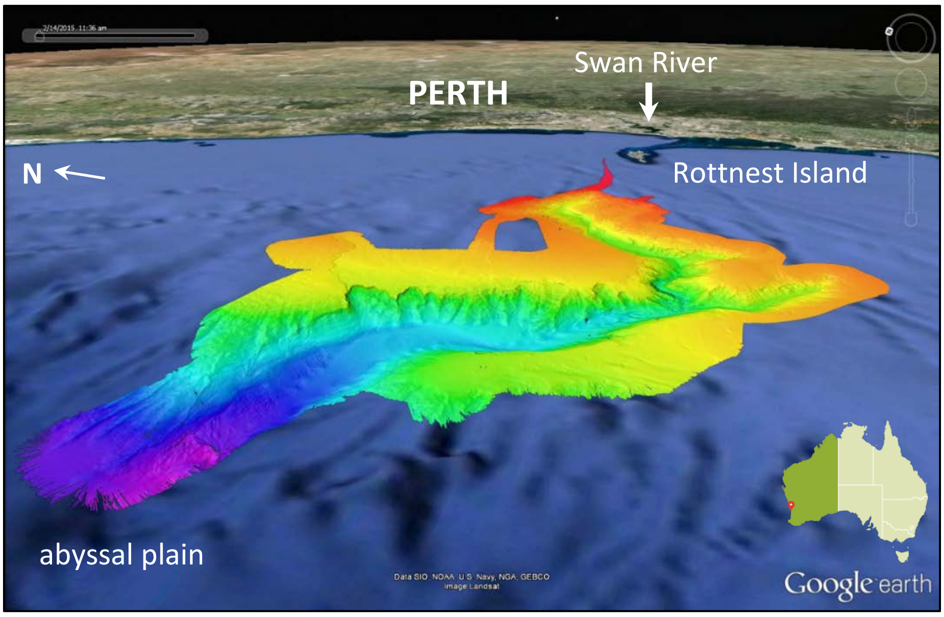

FIGURE 1 — *Location of the Perth Canyon offshore Perth, Western Australia.*

Between the 1st and 11th of March 2015, we (UWA and SOI) undertook the first ROV based exploration of the Perth Canyon (http://schmidtocean.org/story/show/3036), just 20-60 km offshore Perth, the capital city of Western Australia (Figure 1). Although partly reconnaissance in nature, the expedition was highly successful, both scientifically as well as generating tremendous public interest (http://schmidtocean.org/story/show/3036) via both live streaming of the ROV video footage and direct public engagement. Here we describe some ground-breaking research outcomes from the cruise, although many faunal samples collected remain the focus of ongoing longer-term projects, the results of which will be published in peer-reviewed scientific journals. The expedition had four main aims: (1) to map the Perth Canyon using multi-beam imaging; (2) systematically determine the depth dependent carbonate chemistry of the Perth Canyon waters, as well as the influence of both upwelling and surface currents on their compositions; (3) examine and sample the deep-sea ecosystems in-situ using ROV, particularly targeting corals with carbonate skeletons; and (4) to determine the longer-term geological history of the canyon. Ongoing geochemical analyses of the corals together with the seawater data, ultimately aims to ascertain the impact of declining carbonate-saturation (particularly aragonite) on the viability of carbonate based life in the Perth Canyon, which also has global implications for similar environments.

3.2. The Perth Canyon

The Perth Canyon, is located ~40 km offshore Perth, the capital city of Western Australia. Although being directly offshore from the mouth of the Swan River (Figure 1), there is no evidence for any direct connection between the Canyon and the Swan River. The Canyon has been previously referred to as the Swan Canyon or the Fremantle Canyon, but here we follow the now common usage of "Perth Canyon". The Perth Canyon is one of the largest sub-sea canyons on the Australian continental margin (Heap and Harris, 2008), being a sinuous feature of ~120 km in total length. Importantly, it is one of the few canyons that cuts back into the continental shelf, its head starting at the ~500 m depth contour and its mouth reaching a depth of over 4 km as it opens onto the broad abyssal ocean plains (Figures 1 and 2).

The canyon "head" refers to the canyon's shoreward section, and the "tip" refers to the head's closest point to the coast. At distances of ~10 km, 40 km, 50 km and ~100 km from the tip, there are a series of approximately right-angle bends marking major changes in the canyon's orientation. The canyon's orientation from 0-10 km is ~SE-NW, at 10-40 km is SW-NE, at 40-50 km runs ~W-E, at 50-100 km is ~SW-NE, and then finally from ~100-120 km the mouth follows a more westerly direction as it opens onto the abyssal ocean plain. The ~50 km bend also coincides with a junction where the canyon is joined by its southern arm, which is a ~15 km long trench with a similar morphology to the main (inshore) canyon head (Figure 2). In the region of ~40-50 km from the tip, there is also a morphologically more complex zone, referred to here as the "Dog-Leg", where there are abrupt changes in the canyon's orientation with its floor also narrowing in parts to <1 km in width.

Slopes on the canyon walls typically have a gradient of ~30° to 40°, but in some parts are also near vertical, such as in the "Dog-Leg Valley" and "Amphitheatre Waterfall" sites. These steep vertical walls sometimes >100m high were key targets for our ROV exploration (Figure 2). The width of the canyon is highly variable being ~2-5 km wide near the head, broadening to ~10 km in the 10-40 km region, narrowing again to ~ 5-8 km in the Dog-Leg region, and finally widening to ~20 km as the canyon reaches its mouth. The Perth Canyon with its long, deep, and in some parts narrow and very steep-sided walls, can be aptly described as one of the most profound geomorphological features of the Australian continental margin.

This now thorough characterisation of the morphology of the Perth Canyon was determined from data generated during the comprehensive multi-beam mapping programme conducted during the cruise. Mapping was generally undertaken in the evenings and initially focussed on the six dive sites (Figure 2 and section 3.2.1), then was broadened to fill the remaining unmapped zones across the region. The multi-beam echo-sounder data was re-processed post-cruise using CARIS HIPS and SIPS 7.0 software to generate a suite of bathymetry maps, providing an overall image of the canyon (Figure 2) and high spatial resolution maps of all sites which will be reported in future publications.

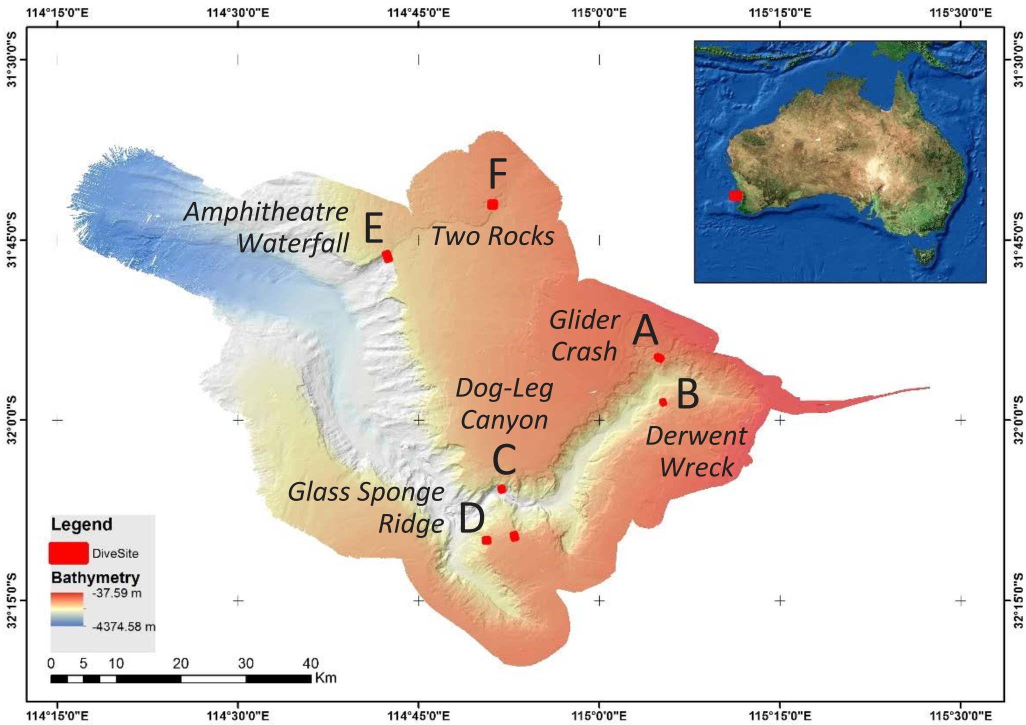

FIGURE 2 — *Multi-beam map of the Perth Canyon with ROV faunal collection sites indicated: Site A (dives D02 and D08), B (dive D04), C (dive D06), D (dive D07), E (dive D05), and F (dive D09).*

3.2.1 Overview of ROV dive sites

The cruise began at the head of the Perth Canyon and progressed in a westerly (i.e. seaward) direction towards the mouth of the canyon. Our basic strategy was to commence ROV operations in the relatively shallow waters (500-700 m) of the canyon head, then progressively work down to the more challenging conditions of the deeper waters closer to the mouth of the canyon. Habitat sites were initially grouped into three regions of interest, the sites within each region being separated by ~10-20 km from one another, or ~1-2 hour steaming (Figure 2). A general overview of the sites is given below, with more detailed descriptions of their habitats presented in section 3.3.

Dive site A: is one of the shallow water sites (~600-800 m) where a slocum glider was previously lost, and hence upon its discovery the site is referred to as the "Glider Crash". Here our initial high-resolution multi-beam bathymetry identified local topography that could support the growth of deep-sea corals.

Dive site B: is an intermediate water depth site (~600-1000 m) located on the southern side of the canyon opposite site A. It is described as the "Derwent Wreck" site because HMAS Derwent was scuttled nearby on the shelf in ~200 m of water in 1994.

Dive site C: is the most topographically extreme site, referred to as the "Dog-Leg", where multi-beam maps indicated near vertical and high cliff walls. This site provided some of the best examples of deep-water habitats (~1800-1500 m).

Dive site D: is distal to the mouth of the canyon and represents an intermediate depth site (~800-1200 m), with cliff walls and outcrops where megabenthos would likely colonize. Here along a ridge (~1000 m) we found beautiful specimens of glass sponges, thus named "Glass Sponge Ridge" site.

Dive site E: represents a deep-water amphitheatre type structure (~1200-1700 m) that contains topographically interesting features with many similarities to a terrestrial waterfall, hence designated "Amphitheatre Waterfall". Here, topographic features on the shelf also extend across to the Canyon plateau at site F.

Dive site F: is a shallow-water site (~600-800 m) on the canyon plateau, northeast of site E (Amphitheatre Waterfall) and in close proximity to the site known as "Two Rocks". The site has significant ridges and ledges indicative of a lithological erosional scarp.

3.2.2 Geological history

Although the Perth Canyon is only a short distance directly offshore the major city of Perth, there are surprisingly few studies focused on understanding its longer-term geological history. Dredge samples of the canyon walls were first recovered by the Australian Bureau of Mineral Resources (Marshall et al., 1989) in the Rig Seismic expedition of 1988. Samples were collected from depths ranging from ~650-2400 m, and their biostratigraphy was determined from foraminifera, nannofossils, and palynology studies. The nannofossil assemblage from those samples were also described and dated subsequently by Shafik (1991). Prior to this work, the only other relevant study is descriptions of cuttings from a core that was drilled at Challenger 1 (Quilty, 1978), a drill site located at the edge of the continental shelf in a water depth of ~200 m, about 50 km south of the Perth Canyon.

Our study is based on nine geological samples collected from different water depths in the Perth Canyon during the FK150301 cruise. Although far from representing the entire stratigraphy of the Canyon, these samples nevertheless provide some relevant stratigraphic information. Seven friable to partly friable samples were disaggregated in water and the washed sand fractions examined under a stereomicroscope. Indurated samples of wackestone and chert were examined in thin section. The samples investigated ranged from 1603 m (FPC-15 D05-S01), 1241 m (FPC-D05-S08), 1032 m (FPC-D07-S05), 746 m to 716 m (FPC-15 D09-S01, S02, S04) and 701 m (D08-S03). The biostratigraphy of these samples has been determined from planktonic foraminiferal assemblages, and the palaeobathymetry from the benthic foraminiferal associations.

We have identified a roughly 900 m section of Upper Paleocene to Lower Oligocene strata in the Perth Canyon, which comprises four distinct facies:

(1) a wackestone, from 1603 m of Late Paleocene (~56-56.5 Ma) age, was deposited at water depths probably between ~200-700 m;

(2) a wackestone, from 1241 m of Middle Eocene (~40-43 Ma) in origin, was deposited at similar upper bathyal water depths;

(3) a wackestone, from 1032 m is either of late Middle Eocene or Late Eocene in origin (probably ~34-40 Ma); and

(4) wackestones between 700 m and 746 m are Early Oligocene (~31-33 Ma) in origin, which were deposited at water depths probably between ~200-700 m.

Notably, our Upper Paleocene to Lower Oligocene succession (> 900 m) is much thicker than the condensed section of equivalent age (~240m thick) described from the Challenger 1 study (Quilty, 1978). The palaeobathymetry for our samples remained probably within the upper bathyal to upper middle bathyal depth range (200-700 m) throughout the Late Paleocene to Early Oligocene. The Oligocene samples were probably deposited at a water depth similar to the present-day water depth at this site. There is no evidence of down-slope movement of sediment from a neritic shelf environment. To accommodate this succession described above, significant subsidence took place during the Eocene (56-34 Ma) with little subsidence during the Neogene (23-2.6 Ma).

3.3 Canyon habitats surveyed and faunas collected by ROV

A general description of each dive site and a brief synopsis of the habitats surveyed are given below. More emphasis is given to the corals because they were specifically targeted for collection, being a key goal of the expedition that underpins an extensive, ongoing, analytical program (see section 3.4).

3.3.1 Site A: Glider Crash

Overview

Two ROV dives at Site A (Figure 3), where a UWA oceanographic glider was suspected to have become stranded several years prior, were undertaken on March 4th (sample collection dive D02) and a return dive later in the cruise on the 10th (sample collection dive D08 = SOI dive 9). The depths surveyed ranged between 743 to 663 metres. The highly bioturbated muddy substrate with sparse benthos sharply transitioned to a coarse bedded vertical cliff-face with fissures and prismatic jointing. Changes in lithology during the dive comprised intervals of brecciated rock, mudstone and chalky layers of varying thickness, to thin lenses of nodular beds and slump-like structures. The biota observed and/or collected included echinoderms, crustaceans, cephalopods, sponges, sea anemones, corals, bivalves, gastropods, polychaetes, and fish.

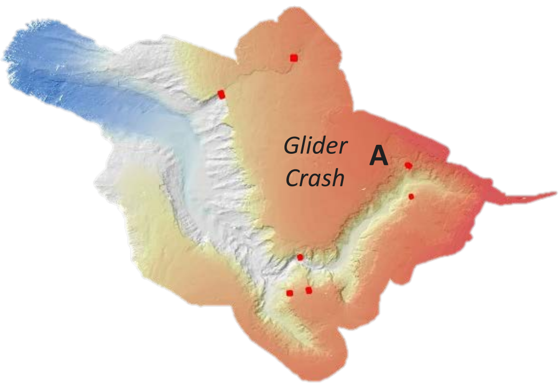

FIGURE 3 — *Multi-beam map of canyon showing ROV site A (sample collection dives D02 and D08).*

Cnidarians

Both ROV dive tracks at this site began at a silty, gently sloping and bioturbated plain at the deepest point of each dive (~740 m), and then moved to the base of a near vertical sand/mudstone cliff with a base of ca 700 m on dive D02, and 720 m on D08. Benthic biota was overall very sparse on the cliff face below 710 m, with the first cnidarians seen at 716 m (sea anemone and cup coral *Polymyces*). Species richness and cnidarian abundance increased as the top of the cliff was approached, with a number of black corals (antipatharians) in particular, common just below the top of the cliff. Solitary live and sub-fossil scleractinians (*Desmophyllum dianthus*, *Caryophyllia* sp., and *Polymyces* sp.) were common on the cliff face, some being large specimens. The cup corals were typically hanging downwards and outwards from the seemingly harder and darker strata within the mudstone cliff, and were present to just below the top of the cliff face. Specimens of *D. dianthus*, *Caryophyllia* sp., and *Polymyces* sp. were collected between 716 m and 674 m. There were no signs of colonial scleractinians of any kind along any of the hard substrata found. Soft corals were not common at the site. One specimen of *Narella* sp. was collected from the cliff face at 695 m, a single non-branching bamboo coral (nominally *Lepidisis* sp.) ~2 m in length was collected at 679 m from among a group of antipatharians present just below the top of the cliff face, and one large antipatharian was collected at 678 m.

Other Taxa

The silty plain at the beginning of this dive presented little in the way of sessile benthos, the commercially important snow (or crystal) crabs, *Chaceon albus*, were the most abundant benthic species observed. Near the base of the cliff, three carrier crabs were observed in close proximity to each other. Observed demersal species included grenadiers (Macrouridae) and deep-sea dories (*Neocyttus* sp.) as well as the pelagic sea cucumber, *Enypniastes* sp. At the base of the cliffs, a solitary carrier crab (Homolidae) was observed. Sessile marine life was more abundant on the cliff face, with polychaete worm tubes and glass sponges attached to the vertical walls. Moving up the wall, life was patchy with much of the primary space unoccupied. Echinoderms including urchins, crinoids and sea stars were rare, as was the occasional squat lobster. The deep-sea spiny lobster *Projasus parkeri* was observed to be relatively common between depths of 670–720 m during D08. A new species of glass sponge, *Amphidiscella* sp. nov., was collected from the site attached near the base of the specimen of *Narella*.

3.3.2 Site B: Derwent Wreck

Overview

The ROV dive Site B (Figure 4) is near the shipwreck HMAS Derwent. This dive (dive D04) was undertaken on the 6th of March and surveyed depths from 1092 to 911 metres. From the seabed, a steep muddy slope led to a mud-draped cliff, showing 'corniche-like' features, cavernous overhangs, and profuse muddy aprons, as well as well-bedded mudstone units. The biota observed and/or collected were echinoderms, crustaceans, sponges, sea anemones, corals, cephalopods, hydroids, brachiopods, polychaetes, and fish.

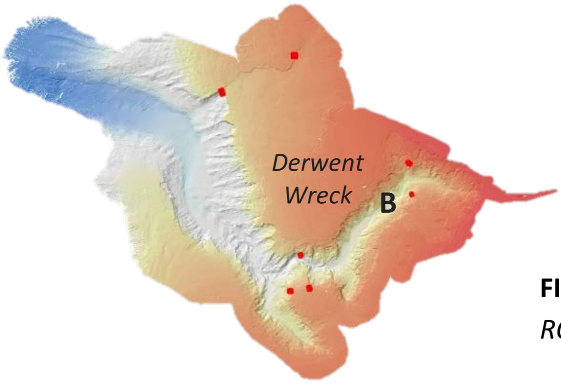

FIGURE 4 — *Multi-beam map of canyon showing ROV site B (sample collection dive D04).*

Cnidarians

At this site, the ROV approached the base of a mudstone cliff fronting an extensively bioturbated silt bottom, reaching cliff at a depth of 1083 m. The deepest cnidarians observed were a sea anemone at 1079 m and a gorgonian (probably *Narella* sp.) at 1010 m. The diversity and abundance of cnidarians increased markedly at depths shallower than ~950 m, and remained high to the top of the cliff face at 930 m. Within that depth range we observed five live *Desmophyllum dianthus*, along with about 20 apparently long-dead ones (as indicated by a ferromanganese coating on their residual skeletons) and an apparently dead colony of *Solensomilia variabilis* at 936 m (also largely ferromanganese coated). This colony also contained a number of live and sub-fossil *D. dianthus*. Close inspection of the colony, which was collected, showed a single apparently live *S. variabilis* polyp, along with a large number of newly settled scleractinians, apparently *D. dianthus*. The newly settled corals were small round dots of live tissue covering a thin initial skeleton characterized by well defined, if small, radiating septa. The newly settled corals were very abundant on the lips of the dead *D. dianthus* (consistent with pseudo-colonialism in the taxon) and, in smaller numbers, on parts of the *S. variabilis* colony that were not coated with a ferromanganese skin. Within the depth range of 930-950 m, we observed a moderately large number of bamboo corals (nominally *Keratoisis*), one collected at 933 m, with gold corals (*Chrysogorgia* and *Iridogorgia)* and a purple soft coral observed between 937-930 m.

Other Taxa

This dive is where the first of the stunning *Walteria* glass sponges were encountered near the edge of the ridge. The footage of these animals represents the first records of this genus in Australian waters and the Indian Ocean, having previously been reported only from Japan, Kermadec Ridge, and Hawaii. Specimens collected from among the dead *Solenosmilia variabilis* matrix at this site include two species of serpulid tube worms, a small brachiopod, and the veruccid barnacle *Altiverucca* sp. A pair of *Chaceon albus* were observed mating on the canyon wall at 944 m; the female was being carried underneath the male in the typical copulatory position. Only two representatives of mobile fauna were collected — a squat lobster of the genus *Munidopsis* and a polynoid scale worm found living commensally with a hexactinellid sponge.

3.3.3 Site C: Dog-Leg Valley

Overview

Two ROV dives were undertaken at Site C (Figure 5). The first dive was conducted on the 5th of March (D03), which was aborted when the ROV manipulating arm malfunctioned, and the return visit (D06) occurred on the 8th of March. Depths surveyed ranged from 1821 to 1512 metres. The steep muddy seabed transitioned to a towering cliff, comprising massive blocky and jointed strata, often well-bedded and sometimes steeply dipping, their surfaces relatively smooth to coarsely textured (and striated), with frequent intervals of large muddy aprons between the cliff walls. Bioturbation was common in the muddy substrates but otherwise were sparsely populated by megabenthos. Biota observed and/or collected included crustaceans, sponges, corals, bivalves, echinoderms, sea anemones, sea pens, barnacles, polychaetes, and fish. Rubble deposits of dead cup corals were partially buried within the muddy deposits.

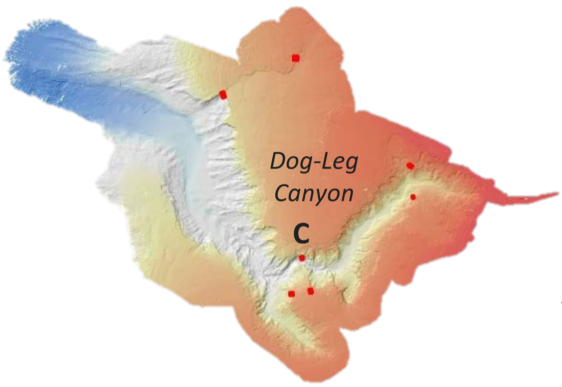

FIGURE 5 — *Multi-beam map of canyon showing ROV site C (dive D03 and sample collection dive D06).*

Cnidarians

Two ROV dives were conducted at this site (D03 and D06). They began at a consolidated mudstone bottom up to the base of an essentially vertical cliff that ran from roughly 1800 to 1500 m. On the first dive (D03, 1598-1640 m), we observed relatively few megabenthos to about 1580 m. On the second and deeper dive (D06, 1512-1821 m), however, cnidarians were seen over essentially the entire depth range of the dive. Depth ranges for different, widely distributed taxa included sea anemones (1537-1817 m), live bamboo corals (nominally *Acanella*, *Keratoisis* and *Lepidisis* at 1536-1816 m), live black corals (1572-1789 m) and live *Desmophyllum dianthus* (1556-1773 m). Other taxa observed, but over smaller depth ranges or in smaller numbers, included *Narella* (1749-1766 m), the gold corals *Chrysogorgia* and *Metallogorgia* (1605-1796 m; a specimen of the former collected at 1793 m), *Anthomastus* spp. (1567 m), sea pens (Pennatulidae, at 1528-1612 m), *Paragorgia* (collected at 1739 m), *Corallium* (1574-1690 m), a large purple soft coral (1561 m), a number of unidentified soft corals (1548-1606 m), and gorgonians (1568-1577 m). The area also showed evidence of an extensive fossil coral community. From roughly 1600 to 1800 m, aprons of fine sediments between the rocky outcrops contained potentially thousands of ferromanganese-coated sub-fossil cup corals, apparently *D. dianthus* (collected at 1788 m), testifying to an extensive reef in the past. Similarly, scattered on the cliff face were a large number of bases of sub-fossil bamboo corals (1550-1795 m), much larger than the live specimens observed. One large *Corallium* sample collected at 1557 m was overgrown by diverse biota (e.g. Venus flytrap sea anemone, *Acesta* bivalve, basket stars, crinoids). No colonial scleractinians (either alive or dead), such as *Solenosmilia variabilis* as found elsewhere in the canyon, were observed on this dive.

Other Taxa

This site exemplified the patchy distribution of organisms in the canyon, with vast areas of near empty rock face punctuated with small areas of dense and diverse communities. One particular area resulted in the most diverse collection of the expedition (FPC15_D06-S07). The community present was found attached to a large *Corallium*. Of note here is *Acesta* sp. nov., a new species of bivalve mollusc which was collected from this site. Among this small diverse community were numerous echinoderms, such as ophiuroids (Op*hioplinthaca* and *Ophiocamax*) and basket stars (Gorgonocephalidae), and one crinoid.

3.3.4 Site D: Glass Sponge Ridge

Overview

The ROV dive at Site D (Figure 6) was undertaken on the 8th of March and surveyed depths from 1210 to 834 metres (collection dive D07 = SOI dive 8). The highly bioturbated muddy substrate transitioned to a well-bedded cliff draped with mud. Layered mudstones, cherts, large collapsed blocks, and steep cliffs, (sometimes intensely bioeroded) featured throughout the dive. The biota observed and/or collected included echinoderms, crustaceans, sponges, sea anemones, corals, bivalves, polychaetes, hydroids, and fish. A recovery line was also observed reflecting signs of human impact. The site name reflects the numerous spectacular glass sponges (Demospongidae) on the top of the cliff face.

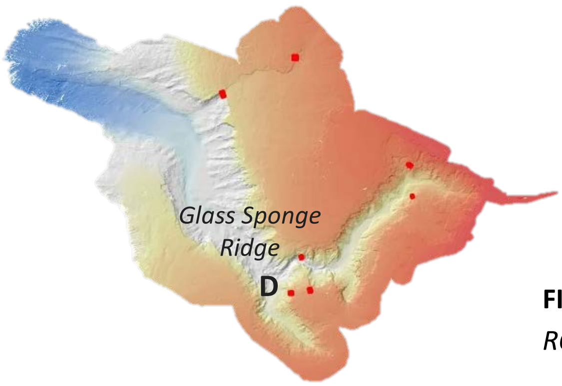

FIGURE 6 — *Multi-beam map of canyon showing ROV site D (sample collection dive D07).*

Cnidarians

The dive depth range was 1210 to 987 m. The ROV hit bottom on a silty, gently sloping, bioturbated plain before ascending to reach a near vertical cliff face at ~1200 m. The mudstone/sandstone cliff face below ~1080 m was virtually barren of megabenthos, the exceptions being the very occasional sea anemone (max depth 1209 m), black coral (1186 m), and an unidentified "soft coral" (1131 m). As at other sites, sea anemones were the most widely distributed cnidarian group (at this site from 993-1209 m), which likely included a number of different species. The diversity and abundance of megabenthos increased markedly at ~1080 m depth and remained high until the top of the cliff face at ~990 m. Within that depth range were observed numerous live *Anthomastus* spp. (1004-1072 m), a stylasterid (1022 m), gold coral (*Metallogorgia* spp. at 1077 m), a moderately large number of live bamboo corals (nominally *Keratoisis* and *Lepidisis* at 1046-1077 m), and other octocoral species (probably *Corallium* spp. at 988 m); live and dead octocoral samples were collected at 1049 and 1040 m. Several large, sub-fossil bamboo corals were observed at the base of the cliff, apparently having fallen off the cliff face. Among the scleractinians, some dead cup corals (apparently *Desmophyllum dianthus*) were observed (1049-1178 m), along with what appeared to be long-dead colonies of the colonial *Solenosmilia variabilis* (1040-1073 m). Part of an apparently recently dead colony of *S. variabilis* was collected at 1050 m.

Other Taxa

Few specimens were collected from this dive, however, one specimen of the tall *Walteria* glass sponges was successfully collected and retrieved mostly intact from 986 m. The sponge even still had a commensal shrimp, a single individual of an undescribed species of *Paralebbeus*. The collected glass sponge was one of many that were observed along the crest of the cliff. This specimen is the first collected in the Indian Ocean and likely belongs to a new species. Demersal animals, such as oreodories and grenadiers, were often observed during this dive.

3.3.5 Site E: Amphitheatre Waterfall

Overview

The ROV dive at Site E (Figure 7) was undertaken on the 7th of March and surveyed depths from 1728 to 1241 metres (dive D05). The bioturbated muddy substrate transitioned to predominantly silty and mudstone bedded outcrops, fractured sandstone cliffs, with intermittent pebbly layers and slumped rocky blocks. The biota observed and/or collected included echinoderms, crustaceans, sponges, sea anemones, corals, brachiopods, hydroids, polychaetes, sea pens, and fish.

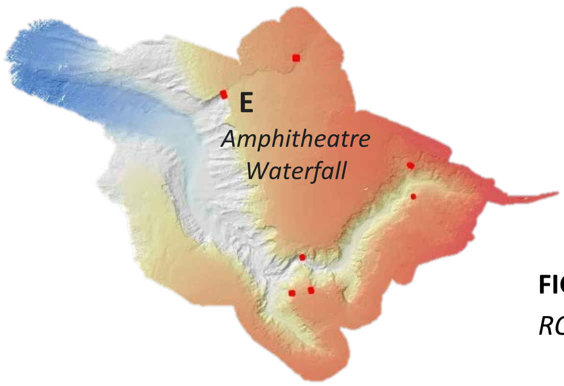

FIGURE 7 — *Multi-beam map of canyon showing ROV site E (sample collection dive D05).*

Cnidarians

The dive tracked along the south facing steep wall of the outer canyon, from roughly 1900 to 1200 m. The consolidated mudstone bottom transitioned to an essentially vertical wall at 1850 m. Megabenthos below roughly 1600 m was sparse, consisting mainly of an occasional whip-like black coral. Sparse numbers of live cup corals (*Desmophyllum dianthus* and *Vaughanella*?) were observed between 1357 to 1603 m, along with a scattering of dead specimens. A live specimen of *Vaughanella*? was collected at 1472 m, and dead specimens of *D. dianthus* were collected at 1498 and 1444 m. The deepest live bamboo coral (nominally *Keratoisis* and *Lepidisis*) were seen at 1381 m, one was collected at 1377 m, and scattered individuals were moderately abundant up to to the shallowest survey depth of the dive (1228 m). A *Corallium* was collected at 1357 m, onto which had grown a mixed benthos assemblage, including a live *D. dianthus* and a small colony of *Solenosmilia variabilis*. Otherwise, no colonial scleractinians, live or dead, were observed during the dive. A dead manganese-coated octocoral basal stump was collected at 1247 m.

Other Taxa

Associated fauna found attached to the *Corallium* collected at 1357 m included a hexactinellid glass sponge along with its commensal polynoid scale worm, the large ophiuroid *Ophioplinthaca*, stalked barnacle *Glyptelasma orientale*, and squat lobster *Munidopsis*. This collection again illustrates how marine life in the deep sea tends to be found clumped together around habitat forming species.

3.3.6 Site F: Two Rocks

Overview

The ROV dive at Site F (Figure 8) was undertaken on the 11th of March and surveyed depths from 760 to 682 metres (dive D09). The rocky seabed and adjacent cliffs featured rough eroded surfaces, and mud-draped slopes together with small blocks, pebbles, and rubble deposits. The biota observed and/or collected included echinoderms, crustaceans, sponges, sea anemones, corals, gastropods, polychaetes, barnacles, and fish. Extensive coral 'graveyards' were observed within the rubble deposits.

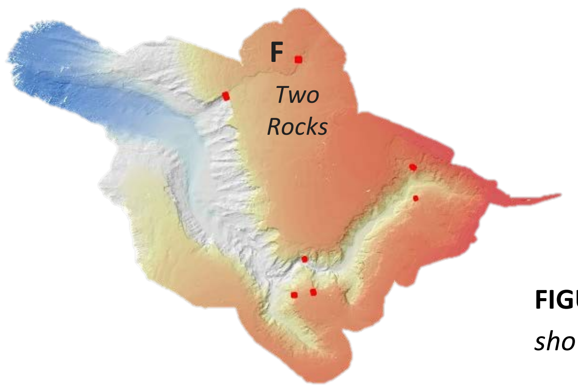

FIGURE 8 — *Multi-beam map of canyon showing ROV site F (sample collection dive D09).*

Cnidarians

This site consisted of an undulating hard rock bottom adjacent to a low (752-698 m) cliff face. There were large amounts of plankton in the water, but sparse megabenthos. The most widely distributed live cnidarians were stylasterids, which were seen over essentially the full depth range of the dive (~684-750 m). Other live taxa included a few black corals (742-745 m), sea anemones (702-751 m), two soft corals, several unidentified octocorals (682-747 m), and few live cup corals (*Polymyces* sp. collected at 739 m). The cnidarians were predominantly represented by an extensive sub-fossil reef that in places constituted 100% of the bottom cover; between 750 to 688 m (above the top of the cliff), extensive patches of sub-fossil reef were scattered among barren areas. The reef consisted primarily of *Solenosmilia variabilis* but also contained large numbers of sub-fossil *D. dianthus*, as well as what appeared to be *Caryophyllia*. Scoops of fossil rubble of *S. variabilis* and *D. dianthus* were collected from 746-691 m; the associated skeletal hash contained a variety of associated taxa including gastropod, bivalve, and pteropod shells. We also observed a sub-fossil *Corallium* at 690 m (no live specimens observed) and the bases of a pair of very large sub-fossil bamboo colonies (possibly *Keratoisis magnifica*) at 682 m; one octocoral base was collected at 684 m. No live bamboo corals were observed at the site. These observations suggest that a very extensive and diverse reef assemblage existed at this site in the past, which has been replaced by a modern, low biomass and low diversity benthic assemblage.

Other Taxa

The dominant sessile invertebrates observed during this dive were two potential species of hexactinellid sponges, which were found in high densities in certain parts of this site. Representative specimens were collected from 690 m. This dive was also notable for the school of krill observed when the ROV first reached the seafloor at 740 m. Among the school were ctneophores and several chains of salps. This was the only site where such aggregations of large planktonic organisms were seen. The mobile benthos included a variety of crustaceans including squat lobsters, hermit crabs of the genus *Sympagurus* with the commensal zoanthid, *Epizoanthus*, and a solitary king crab *Paralomis dofleini* (683 m) which is the southernmost record of the species. The echinoderm fauna was sparse, several individuals of the many-armed brisingid sea stars were observed near the beginning of the dive and cidarid sea urchins were observed near the end (680 m). Among the collected rubble were a rare crab species *Mathildella serrata*, a polychaete, and three ophiuroids.

3.4 Geochemical analysis of deep-sea corals

Faunal sampling during the cruise targeted corals in particular, and specifically those that secrete carbonate skeletons. These coral samples form the basis of an ongoing, extensive research project that is focused on the geochemical analysis of their skeletons, which record environmental changes in ambient seawater. Both scleractinian (aragonitic) and octocoral (calcitic) representatives were collected, the scleractinians being especially well suited to geochemical proxy studies.

The deep-sea corals were collected from a depth range of 674-1815 m, and represent species of scleractinians, octocorals, and an antipatharian (Appendix 2, Table A2). The samples recovered were live, recently dead, or as fossilised calcareous skeletons often with manganese coatings. Live-caught scleractinians comprise cup corals (*Caryophyllia, Desomphyllum, Polymyces,* and *Vaughanella*?) and colonial species (*Solenosmilia*); the octocorals are represented by isidids, primnoids (*Narella*), *Paragorgia*, *Chrysogorgia*, and *Corallium*. Recently dead and/or older fossil scleractinian samples (*Caryophyllia, Desmophyllum, Polymyces* and *Solenosmilia*) were either removed directly from the canyon walls, or as large fossilised deposits scooped from aprons of fine sediments on the slopes between canyon walls (Sites C and F).

A large geochemical program is currently underway in order to establish the ages of fossil specimens, the lifespan of live-caught species, species growth rates, and temporal changes in ambient seawater conditions recorded during growth of the skeletons. Geochemical dating includes both uranium-thorium (U-Th) decay series and radiocarbon (^{14}C) systems. A suite of elemental and isotopic ratios that serve as proxies of seawater temperatures (Li/Mg, $\delta^{18}O$) and carbonate chemistry ($\delta^{11}B$, B/Ca) are also being determined. The wide depth range of coral species collected will enable environmental reconstructions from Antarctic Intermediate Water (AAIW), the Northwest Indian Intermediate Water (NWIIW), and Indian Deep Water (IDW) over recent and long timescales (Figure 9). A key aim of this research is to determine the rates and extent of environmental change within these deeper water masses, which are an important component of the Earth's climate system.

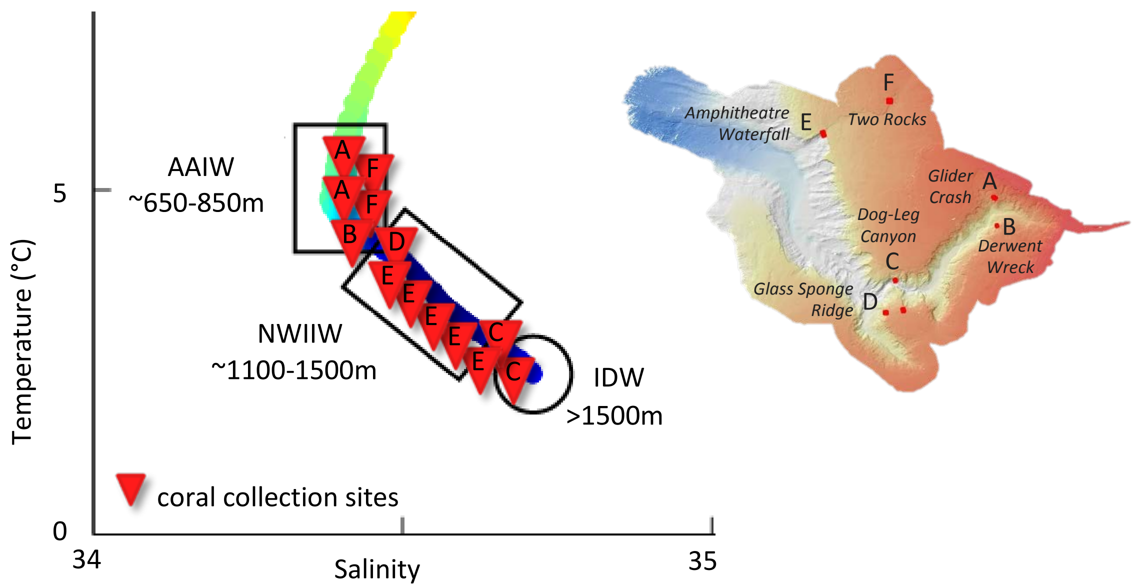

FIGURE 9 — *Schematic showing the general distribution of corals collected from Sites A to E in the context of the different water masses and approximate depth, as determined by temperature, salinity, and dissolve oxygen. AAIW = Antarctic Intermediate Water, NWIIW = Northwest Indian Intermediate Water, and IDW = Indian Deep Water.*

3.4.1 Fossil corals

A selection of recently dead and/or fossil scleractinian corals (*Caryophyllia, Desmophyllum, Polymyces, and Solenosmilia*) from all six collection sites (A to F), have been dated using uranium-thorium (U-Th) decay series. Coral ages range from ~29 kyrs to 30 years before present (i.e. calculated from year 1950) and cluster as two age groups within ~29-22 kyrs and ~2kyrs to 30 years. These corals thus lived during the Marine Isotope Stage 3-2 transition, the Last Glacial Maximum (LGM), and recent Holocene intervals. Geochemical proxy records preserved within these corals will be especially useful for understanding ocean-climate interactions and long-term responses during these periods, which are characterised by major shifts in global temperature. Further work will utilise a suite of elemental and isotopic environmental proxies (see above) to reconstruct changes in seawater conditions over long timescales in these deep waters of the Indian-Southern Ocean system.

3.4.2 Live-caught cup corals

The carbonate skeletons of a suite of cup corals were analysed by U-Th dating. The ages of the basal and sometimes mid-portions of each calyx enabled the approximate growth rate of vertical extension to be calculated. The thickness (density) of calcification does however vary significantly between species and individual specimens, and different polymorphs of the same species can yield different growth rates.

The basal portions of two large specimens of the cup-coral *Desmophyllum dianthus*, collected live from ~670 m, gave U-Th ages of ~75 and ~40 years. The calculated annual growth rates indicate extension rates between ~1 to ~1.5 mm yr^{-1}. Such growth rates are typical of *Desmophyllum*, being similar to those reported previously for this species from the Atlantic (Cheng et al., 2000; Risk et al., 2002), Southern Pacific Ocean (Cheng et al., 2000; Adkins et al., 2004; Hassenrück et al., 2013), and Mediterranean Sea (Orejas et al., 2011). Interestingly, a basal subsample from a very long slender polymorph of *Desmophyllum* from similar depths yielded an age of ~260 years, which suggests a much slower growth rate of ~0.2mm yr^{-1}. Basal subsamples extracted from the very thin skeletons of various sized *Polymyces* specimens collected from ~700 m, yielded ages from 17 to 60 yrs, and indicates a growth rate of ~1-2mm yr^{-1}, hence very similar to those typical of *Desmophyllum*. A very short, stubby, calyx of *Vaughanella*?, collected from much deeper waters (~1470 m) is ~330 yrs old, which suggests that skeletal growth was very slow at ~0.1mm yr^{-1}.

Ongoing elemental and isotope proxy work aims to extract recent (post-industrial), continuous, high temporal resolution environmental records from a suite of coral specimens, to identify potential changes in conditions within the different water masses of the canyon.

3.5 Oceanography

Investigations of the oceanography of the Perth Canyon encompass both chemical and hydrographic analyses via the deployment of CTD casts and ocean gliders, together with other satellite remote sensing datasets. An integrated synopsis of the ocean currents and circulation patterns is given in section 3.5.1, seawater compositions of the different water masses are fully parameterised and described in 3.5.2, and the productivity of the surface water plankton is summarised in 3.5.3.

3.5.1 Hydrographic setting

Field measurements (Rennie et al., 2009a) and numerical studies (Rennie et al., 2009b) have been used to describe the circulation in the Perth Canyon; these findings are summarised below with additional information gathered from satellite remote sensing (sea surface temperature and surface chlorophyll; CTD transects from ships and ocean gliders; and surface currents using HF Radar).

The circulation in the canyon was temporally variable with few repeated patterns (Rennie et al., 2009b). Strong vertical stratification and current shear were present at 300–350 m depth — the interface between the southerly flowing Leeuwin current and the northward flowing Leeuwin undercurrent. Thus, the canyon's influence on the Leeuwin current dynamics was limited to the canyon head. However, the curvature of the continental shelf in the vicinity of the canyon and the separation of the Leeuwin current from the continental shelf formed anticlockwise eddies at the surface, particularly during the winter.

The Leeuwin undercurrent that interacted with the canyon generated eddies. These eddies were formed over five to ten days, migrated offshore, and other eddies would form in the canyon. Eddies were clockwise, and thus favoured upwelling in their centre. Eddies sometimes recurred within the canyon, suggesting the canyon regulated the circulation, with several circular eddies present, both spatially and at different depths, in the canyon at any given time. Eddies formed in the canyon were first confined to the canyon and then migrated offshore; however, at least one eddy, even if it was weak, was present in the canyon at any given time.

Supplementary oceanographic data collected during the cruise indicated the presence of an anti-clockwise eddy with the southward flowing Leeuwin Current located further offshore, west of 114.7°E (Figures 10-11). The strong southerly winds were responsible for the colder northward flowing Capes current on the continental shelf. Time series of the currents and temperature from the shelf region indicated a period of energetic diurnal currents through the water column generated by the local sea breeze system (Mihanović et al., 2016), which also resulted in strong wind driven upwelling (Fig. 12).

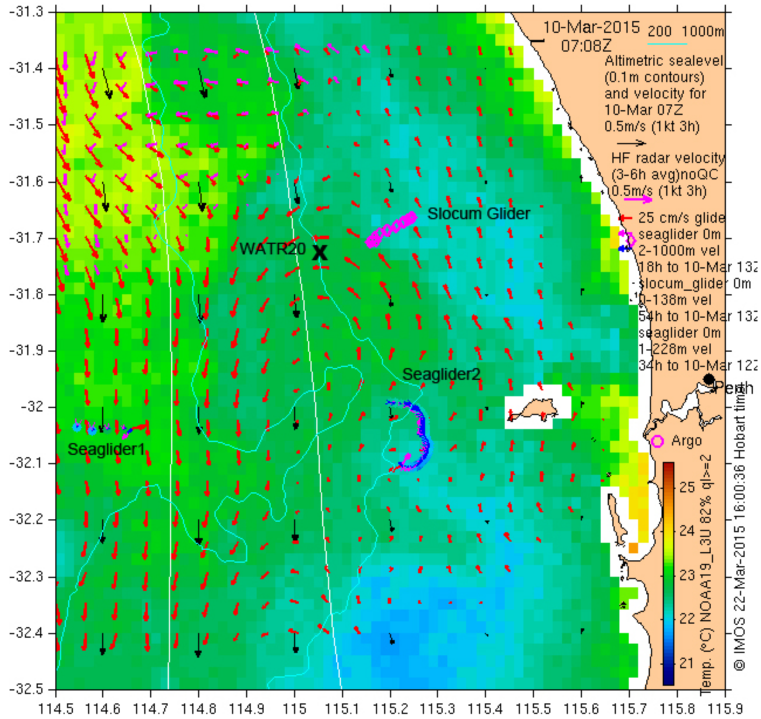

FIGURE 10 — *Satellite derived sea surface temperature map of the study region obtained on 10 March 2015 towards the end of the voyage. The red/magenta arrows indicate surface currents as measured by HF Radar. Locations of 3 ocean gliders (1 Slocum and 2 Seagliders) are shown. The WATR20 is the location of an oceanographic mooring along the 200m depth contour from which data shown on Figure 12 is derived.*

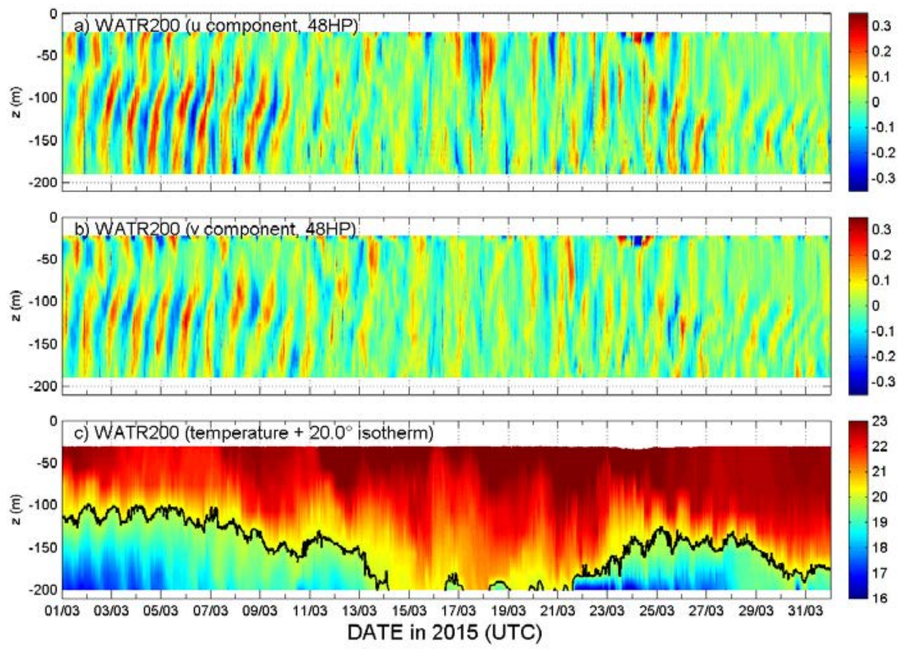

FIGURE 11 — *Surface currents measured by HF Radar systems overlain on satellite derived sea surface temperature map of the study region obtained on 2 March 2015. The colder water represents the northward flowing Capes Current whilst the warm water represent the Leeuwin Current. An eddy is located in the vicinity of the Perth Canyon. Small white squares represent the location of moorings (current meters and thermistor chains).*

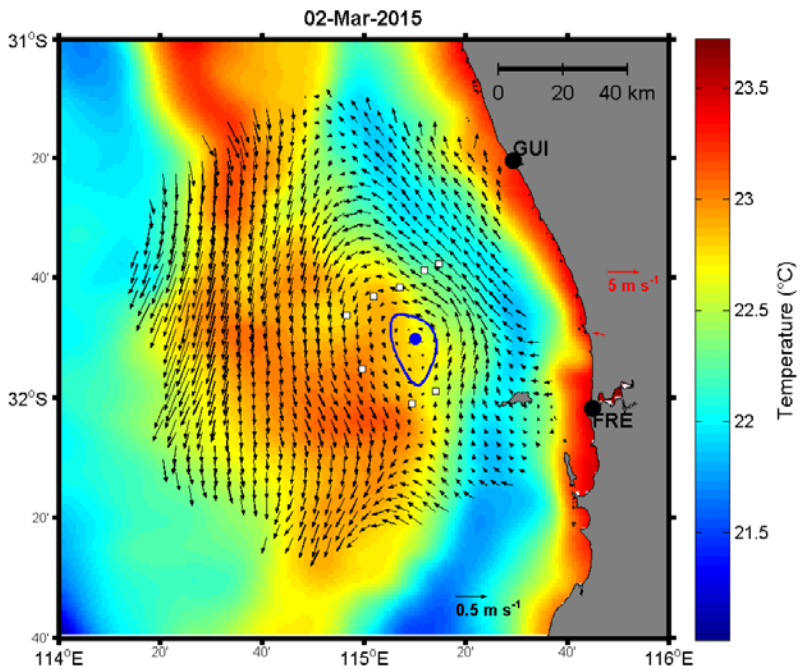

FIGURE 12 — *Time series of low passed currents (a,b) and temperature (c) at the WATR20 station during March 2015 showing a period of strong diurnal currents through the water column and associated upwelling during the period of the voyage (1-12 March).*

3.5.2 Seawater composition and origins

During the FK150301 cruise, 59 water samples were retrieved from 6 rosette CTD casts (Table A1), which were deployed across 5 of the 6 ROV dive sites (A-C, E-F). The seawater compositions of the different water masses comprising the water column (see section 4.2) were determined from those representative samples that spanned the full depth range at each site, or to a maximum depth of 2000 m. Their compositions are based on chemical analyses of temperature, salinity, oxygen, chlorophyll, alkalinity, DIC, pH, pCO_2, carbonate saturation state, nitrogen, phosphorous, as well as the isotopic compositions of carbon, oxygen, and hydrogen.

General vertical structure of Perth Canyon waters

The fundamental physical and chemical structure of the water column was very similar across the five study sites (A-C, E-F). Temperatures ranged from around 2°C in the deepest waters (2000 m) to around 23-24°C in the shallowest waters of the well-mixed surface layer (Figure 13). Salinities ranged from a minimum of 34.4 at mesopelagic depths (600-700 m) to a maximum of nearly 35.8 just below the well mixed layer (100-250 m, Figure 13). The vertical structure of dissolved oxygen was also very similar between canyon sites ranging from a minimum of just under 150 µmol kg^{-1} below 1000 m to a subsurface maximum of just over 250 µmol kg^{-1} between 300 and 550 m (Figure 14). Nonetheless, there appeared to be variation on the order of 10-20 µmol kg^{-1} in the upper 700 m between canyon sites. Profiles of total chlorophyll a (as measured by the rosette-mounted Wetlabs fluorometer) were far more variable than either temperature, salinity, or dissolved oxygen, but generally exhibited sub-surface maxima of between 0.25 and 1.0 mg m^{-3} that was confined within a depth range of between roughly 60 and 90 m. However, we did observe a deeper subsurface chlorophyll maximum of around 0.36 mg m^{-3} at the Two Rocks site, which peaked at a greater depth of around 150 m (Figure 14).

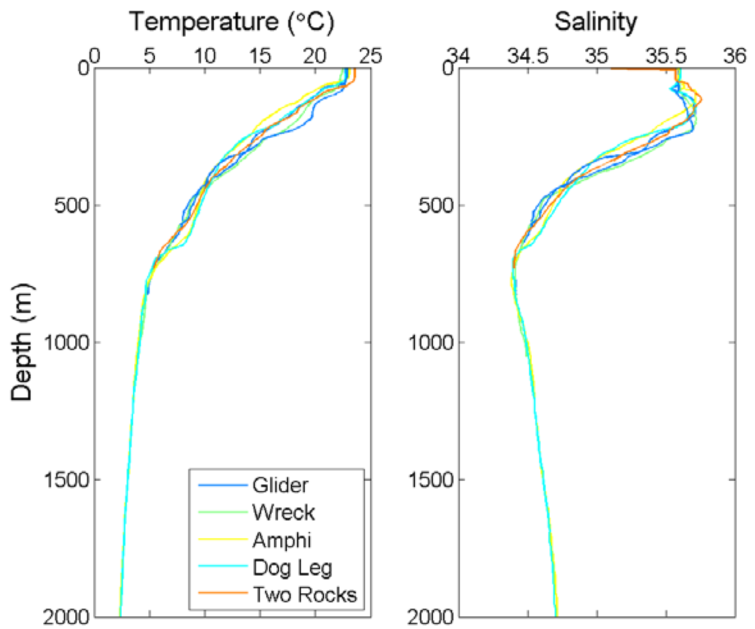

FIGURE 13 — *Vertical profiles of Temperature (left) and Salinity (right) recorded by the CTD at each dive site.*

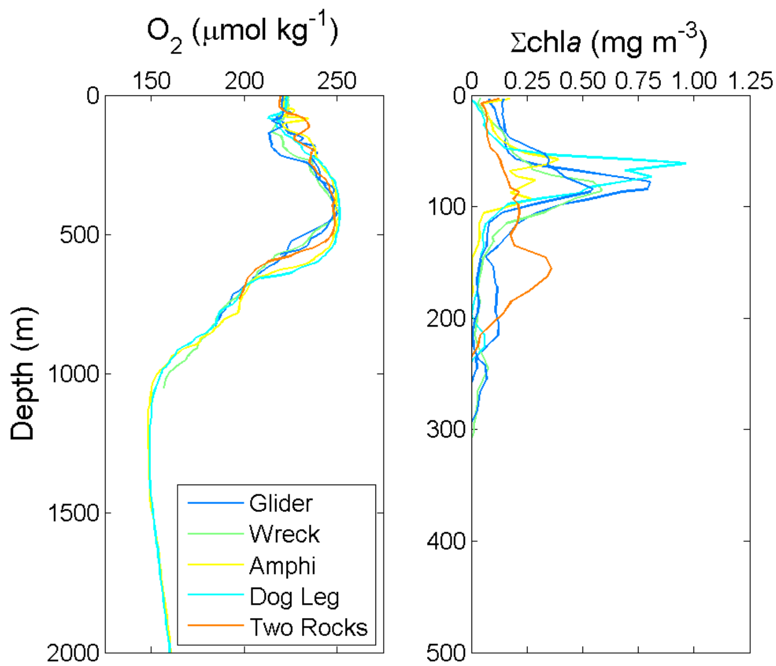

FIGURE 14 — *Vertical profiles of dissolved oxygen (left) and total chlorophyll a (right) recorded by the CTD at each dive site. Note the shallower vertical scale on the plot of chlorophyll a.*

The general consistency of the vertical structure in temperature, salinity, and dissolved oxygen allowed us to identify the key water masses from which waters of the Perth Canyon originated, by comparing it with prior studies of the southwest shelf (Woo et al., 2006) and Perth Canyon (Rennie et al., 2009a). The warm, sub-maximal salinities of the well-mixed surface layer approximately 50 m deep consisted mainly of tropical surface waters being transported poleward by the Leeuwin Current. Below this surface mixed layer (including part of the underlying thermocline) is South Indian Central Water (SICW) at depths between roughly 100 and 250 m as indicated by maximal salinities of between 35.6 and 35.8. Note that the subsurface chlorophyll maximum is generally confined to a zone within the transitory thermocline separating the SICW and the well-mixed layer above it (50-100 m); however, there are still measurable but relatively low levels of chlorophyll in the SICW. Just below the SICW is the Subantarctic Mode Water (SAMW), which extends from just below 250 m to a depth of almost 550 m and is characterized by maximal dissolved oxygen concentrations exceeding 250 µmol kg^{-1}. Below the SAMW lies the Antarctic Intermediate Water (AAIW) that extends from around 650 to 850 m, and is characterized by consistent salinity minima. However, the weak gradients in both temperature and salinity at those depths make it difficult to define precisely the top and bottom of the AAIW. Below the AAIW lies the Northwest Indian Intermediate Water (NWIIW), which extends from around 1100 m to roughly 1500 m and is characterized by dissolved oxygen minima of just under 150 µmol kg^{-1}. Although the waters lying between the ~850-1100 m would appear to be a transitional mixture of AAIW and NWIIW in terms of their salinity, temperature, and oxygen content, at present we cannot determine whether this layer constitutes an, as yet, unidentified water mass sourced from elsewhere in the Indian or Southern Oceans. At depths below 1500 m, the reversal and then rise of dissolved oxygen concentrations would suggest a transition into the colder and more saline Indian Deep Waters. However, much like the AAIW, it is difficult to precisely identify the transition to NWIIW and then to IDW given the very weak vertical gradients in temperature, salinity, and dissolved oxygen below 1000 m.

Water column nutrient and carbonate chemistry

Both nitrate plus nitrite (herein referred to simply as 'nitrate' or NO_X^-) and soluble reactive phosphorus (SRP, predominantly in the form of HPO_4^-) increase monotonically with depth (Figure 15), reflecting the increasing cumulative amount of organic matter decomposed with water age and depth. Ammonium concentrations are generally less than 0.5 µM throughout the water column, reflecting the tight coupling between rates of organic nitrogen remineralization and nitrification, and show no apparent vertical structure (data not shown). The fact that the ratio of total dissolved inorganic nitrogen (nitrate + ammonium) to total dissolved inorganic phosphorus (SRP) is so close to the idealized Redfield-Richards ratio (17.4 ±0.4 vs. 16: Figure 16) suggests that water column nutrients throughout the Perth Canyon are almost entirely planktonic in origin. Water column profiles of total alkalinity (TA) and dissolved inorganic carbon (DIC) were also determined and found to be similar for all the Canyon sites (section 4.2).

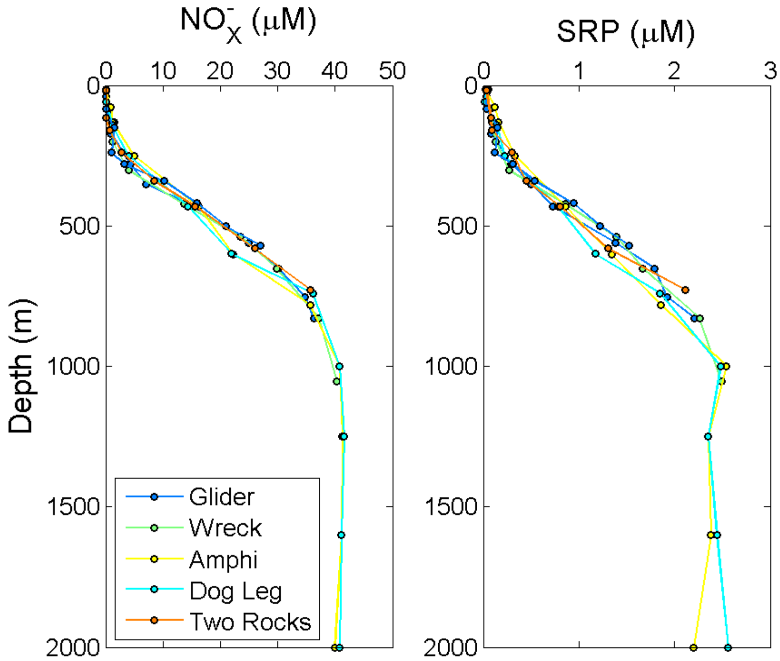

FIGURE 15 — *Dissolved nitrate plus nitrite (NO_X^- , left) and soluble reactive phosphorus (SRP, right) vs. depth at each dive site in the Perth Canyon. 95% of all nutrient samples had ammonium concentrations less than 0.5 µM.*

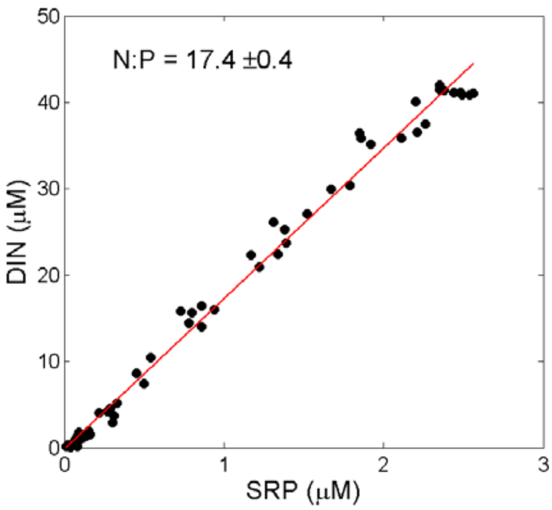

FIGURE 16 — *Dissolved inorganic nitrogen versus soluble reactive phosphorus from all casts at all sites.*

The carbon, oxygen and hydrogen isotopic compositions of seawater

Stable isotope analyses of the dissolved inorganic carbon, oxygen (seawater) and hydrogen were undertaken post-cruise (see section 4.2). The $\delta^{13}C$ compositions (PDB scale) have very similar profiles as found in the GEOSEC and WOCE cruises of the 1970's and 1990's but offset towards lower $\delta^{13}C$ values indicative of the ingress of low $\delta^{13}C$ fossil fuel carbon into the upper oceans (e.g. Quay et al. 2003). The $\delta^{18}O$ profile (SMOW scale) has a very similar depth dependent trend as the salinity with the upper ~200 m waters being characterised by both high salinity Tropical Seawater (TSW) and South Indian Central Waters (SICW) as well as high $\delta^{18}O$, a consequence of the tropical source and evaporative history of these upper water masses. This is confirmed by the good correlation between salinity and $\delta^{18}O$ (Figure 17) with the high salinity end-member represented by the TSW and SICW waters. The hydrogen isotope profile shows a similar pattern as the $\delta^{18}O$, consistent with the higher salinity of the upper ~200 to 300 m water masses having elevated δH.

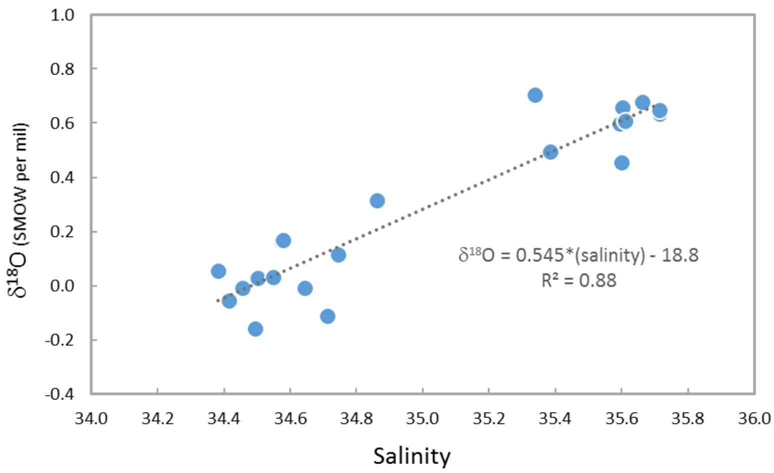

FIGURE 17 — *Plot of seawater $\delta^{18}O$ isotope versus salinity for Perth Canyon waters.*

3.5.3 Productivity of surface water plankton communities

The general aim of this work was to analyse the response of the net trophic status of planktonic communities to multiple concurrent stressors associated with global climate change. Aboard the R/V Falkor, we measured the net community production (NCP) of planktonic communities in the surface waters of the Perth Canyon, and quantified the effect of UV-B radiation on Gross Primary Production (using additions of water labeled with $H_2^{18}O$). For these experiments, of particular interest was how exposure to UV-B radiation and increased temperature affected the rates of plankton metabolism, and thus affected the net trophic status of pelagic communities through their combined influence on NCP.

Net Community Production (NCP) is the difference between gross primary production (GPP) and community respiration (R), hence *NCP = GPP – R*. A shift in the net trophic status can occur either through changes in R or GPP. Thus, NCP describes the net trophic status of any community or ecosystem where NCP > 0 describes a net autotrophic community or system, and NCP < 0 describes a net heterotrophic community or system. NCP is therefore a measure of how much pelagic communities act as a source or sinks of CO_2 (Duarte et al., 2013).

Measurements of NCP are still lacking from large areas of the oceans (Duarte et al., 2013), with only 32 of the 4,799 NCP estimates available pertaining to the Indian Ocean. There are also very few studies on the effect of UV radiation on the net production of pelagic plankton communities (García-Corral et al., 2014a; Godoy et al., 2012; Vidussi et al., 2011), with most NCP estimates made by incubating plankton in borosilicate glass containers that filter out all UV-B and part of the UV-A radiation. Thus, most published rates of in-situ NCP have been conducted only in the presence of un-naturally low ultraviolet radiation (mostly UV-B), which may have biased the estimates of true NCP in ocean surface waters, as has been observed in other studies in the Pacific and the Arctic oceans (García-Corral et al., 2014a; Godoy et al., 2012).

Current 'Metabolic Theory' predicts that respiration rates should rise more rapidly than photosynthesis as temperature increases (Brown et al., 2004). Recent studies indicate that the activation energy (a metric derived from the Arrhenius equation describing the temperature dependence of a process) is higher for R than for GPP (Duarte et al., 2013; García-Corral et al., 2014b; López-Urrutia et al., 2006; Regaudie-de-Gioux and Duarte, 2012). R is thus more sensitive to rising temperature than GPP, implying that NCP should decline with increasing temperature due to ocean warming. Furthermore, a negative correlation has been reported between temperature and the ratio GPP:R of oceanic plankton communities (Regaudie-de-Gioux and Duarte, 2012), indicating that communities tended to become less autotrophic with increasing temperature (i.e. NCP decreases) and tended to be net heterotrophic (NCP < 0) in waters warmer than 21°C.

Offshore Western Australia, the Leeuwin current strongly influences the coastal waters, which become warmer than otherwise expected at the higher latitudes (e.g. Perth Canyon), and generates important temperature gradients along and across the coastal zone. These conditions provide an excellent environment to examine how the net trophic status of pelagic communities respond to both increasing temperature and increasing UV radiation, and whether these two factors interact with additive, antagonist, or synergetic effects (Garcia-Corral et al., 2015).

During the Perth Canyon cruise, we experimentally evaluated the metabolic rates of plankton communities at 5 stations. NCP, GPP, and R were determined at three depths: 1) surface waters (mean

≈ 5 m), 2) the deep chlorophyll maximum (DCM, mean ≈ 80 m), and 3) an intermediate depth where incident PAR was ~20% of that just below the ocean surface (mean ≈ 40 m). There was substantial variability observed in rates of NCP in the upper ~100 m of the water column across the 5 stations, with 3 stations being net heterotrophic (NCP < 0; stations 2, 6 and 7) and the remaining two being net autotrophic (NCP > 0; stations 4 and 5). In contrast, at only one station the plankton communities were net heterotrophic at the depth of the DCM while the other four stations were either net autotrophic (stations 6 and 7) or in a state of trophic balance (NCP = 0, stations 4 and 5) (Figure 18).

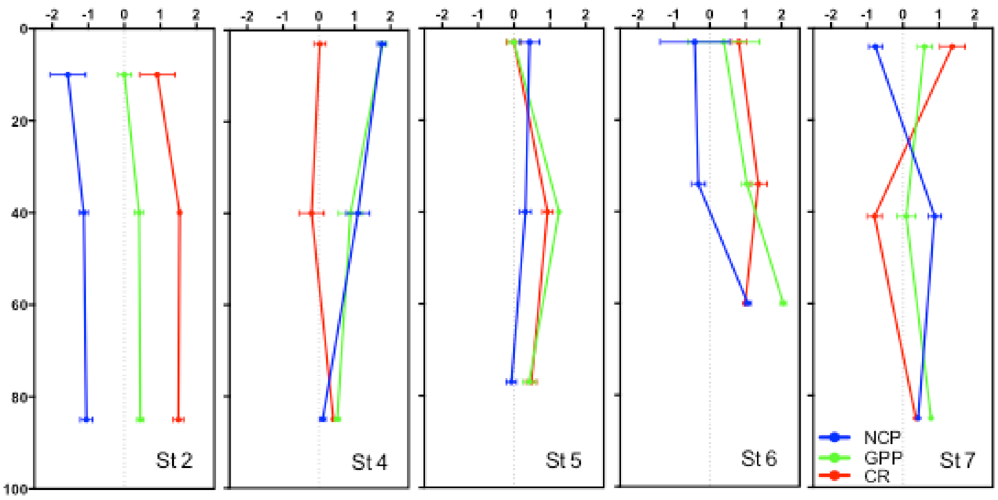

FIGURE 18 — *Net community production (NCP), gross primary production (GPP) and community respiration (R) for each sampled depth (metres) during the five experiments performed onboard. Note, units for NCP, GPP, and R in mmol* O_2 *m*$^{-3}$ *d*$^{-1}$*.*

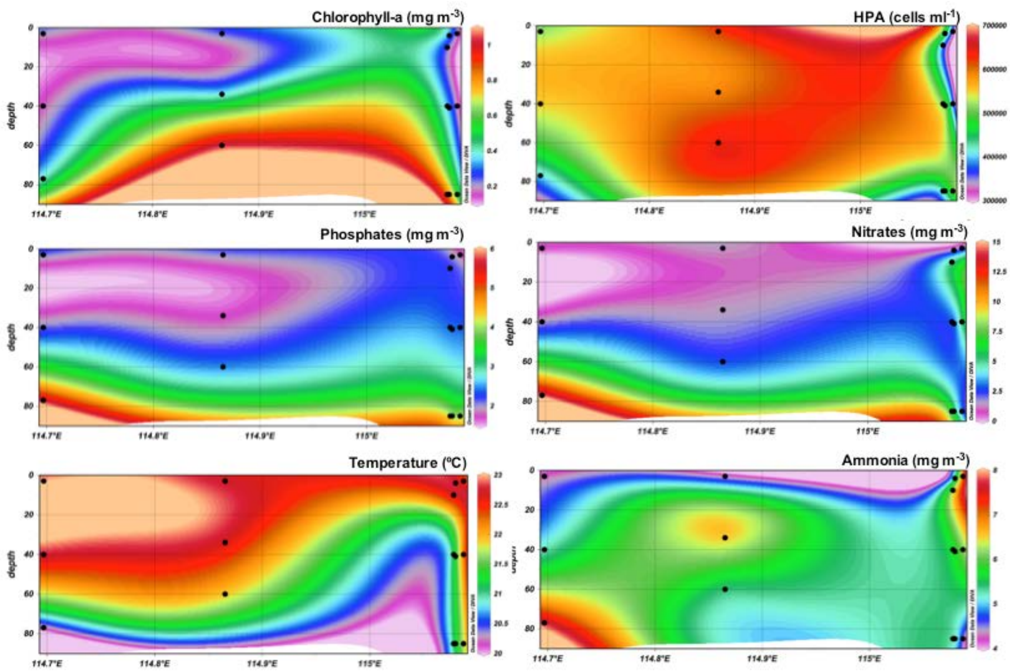

FIGURE 19 — *Patterns in chlorophyll-a concentrations, heterotrophic prokaryote abundance, phosphates, nitrates, temperature, and ammonia in the sampled stations. Black circles indicate the sample depths at each station: from left to right UWA cast # 4, 5, 2, 6, 3 (i.e. Falkor cast # 5, 6, 2, 7, 4).*

Overall, the biomass density of pelagic primary producers in the Perth Canyon surface waters is low (roughly 0.16 – 1.06 mg m^{-3}), as indicated by the low chlorophyll-a concentrations of 0.41 ± 0.07 mg m^{-3} (mean ± SE), although phytoplankton biomass was generally higher at depths closer to the DCM (i.e. <50 m). In contrast, heterotrophic biomass, as indicated by heterotrophic prokaryote abundance (HPA), seems more homogeneously distributed throughout the upper ~100 m of the water column (Figure 19).

We found no significant relationships between water temperature and metabolic rate, however, this is likely due to the small temperature range over which GPP, R, and NCP were measured (20.3–23°C). Furthermore, there was little variation in UV-B radiation (reported here as the UV Index) between any of the stations and onboard incubations (UV Index = 9.0-9.5). Consequently, we observed no apparent relationship between any metabolic rate and levels of UV-B radiation. Nevertheless, these data collected from the Perth Canyon surface waters will be useful when combined with a larger data set, as part of a wider regional study spanning much of the WA coastal communities.

The level of net productivity of plankton communities is the most important factor controlling the amount of particulate biomass they export from the well-lit surface waters to deeper waters. These organic particles are an important food source for a wide range of deep-sea benthic organisms, such as the myriad of hard coral, gorgonians, sponges, and sea fans, which we discovered at all of our survey sites in the Perth Canyon.

4. Data & Sample Storage

4.1 Hydrographic and bathymetric data

Acoustic backscatter, swath bathymetry, and navigation data from the R/V Falkor, and CTD and oxygen data from Comanche ROV are available via the links below.

Rolling Deck to Repository (all data collected by sensors embedded in the ship):

http://www.rvdata.us/catalog/FK150301

Data collected by external vehicles or echosounders:

http://www.marine-geo.org/tools/search/entry.php?id=FK150301

4.2 Physical and chemical composition of the water column

All data on water column temperature, salinity, carbonate chemistry, nutrient concentrations, as well as the isotopic composition of total hydrogen, carbon, and oxygen can be found at the following URL sponsored by the Australia Ocean Data Network:

http://146.118.96.76:8080/geonetwork/srv/eng/metadata.show?uuid=579fc6fe-3f22-4101-94d1-3dc85b7d0b36

The same site provides a link to the raw CTD data collected during each Rosette cast.

4.3 Archives of samples collected by ROV

Faunas, rocks, and sediments collected during the cruise have been archived by the Western Australian Museum (WAM) and the University of Western Australia (UWA). Samples collected specifically for geochemical analysis reside with the cruise Chief Scientist, Professor Malcolm McCulloch, at UWA (malcolm.mcculloch@uwa.eu.au). See Appendix 2 (section 8.2) for a summary of sample collection events for each ROV dive and representative images from these collections. Table 1 (below) summarises the samples archived at both WAM and UWA.

TABLE 1 — *Samples collected by ROV that are archived at the University of Western Australia (UWA) and the Western Australian Museum (WAM).*

Sample / Event Name	Taxon / Sample	UWA	WAM
FPC15_D02_S01	*Narella*	Y	Y
FPC15_D02_S01	*Amphidiscella* sp. nov.		Y
FPC15_D02_S01	Actiniaria		Y
FPC15_D02_S02	*Desmophyllum*	Y	
FPC15_D04_S01	*Desmophyllum*	Y	
FPC15_D04_S01	*Solenosmilia*	Y	Y
FPC15_D04_S01	Hydrozoa		Y
FPC15_D04_S01	Hexactinellida		Y
FPC15_D04_S01	Hexactinellida		Y
FPC15_D04_S01	Brachiopoda		Y
FPC15_D04_S01	Zoanthidae		Y
FPC15_D04_S01	Demospongiae		Y
FPC15_D04_S01	Zoanthidae		Y
FPC15_D04_S01	*Munidopsis*		Y
FPC15_D04_S01	*Altiverruca*		Y
FPC15_D04_S01	Polynoidae		Y
FPC15_D04_S01	Serpulidae		Y
FPC15_D04_S01	Serpulidae		Y
FPC15_D04_S02	*Keratoisis*	Y	Y
FPC15_D05_S01	rock	Y	
FPC15_D05_S02	*Desmophyllum*	Y	
FPC15_D05_S03	*Vaughanella?*	Y	
FPC15_D05_S04	*Desmophyllum*	Y	
FPC15_D05_S05	Isididae	Y	
FPC15_D05_S05	Crinoidea		Y
FPC15_D05_S06	*Desmophyllum*	Y	
FPC15_D05_S06	*Caryophyllia*	Y	
FPC15_D05_S06	Hydrozoa		Y
FPC15_D05_S06	*Solenosmilia*		Y
FPC15_D05_S06	Ophioplinthaca		Y
FPC15_D05_S06	*Corallium*	Y	Y
FPC15_D05_S06	Hexactinellida		Y
FPC15_D05_S06	Amphipoda		Y
FPC15_D05_S06	*Glyptelasma orientale*		Y
FPC15_D05_S06	*Munidopsis*		Y
FPC15_D05_S06	Polynoidae		Y
FPC15_D05_S07	*Corallium*? (stump)	Y	
FPC15_D05_S08	rock	Y	
FPC15_D05_S08	*Stichopathes*		Y
FPC15_D05_S08	Ophiuroidea		Y
FPC15_D05_S08	Crinoidea		Y
FPC15_D05_S08	Plexauridae		Y

Sample / Event Name	Taxon / Sample	UWA	WAM
FPC15_D06_S01	Isididae	Y	
FPC15_D06_S02	*Chrysogorgia*		Y
FPC15_D06_S03	*Desmophyllum*	Y	
FPC15_D06_S05	Crinoidea		Y
FPC15_D06_S05	*Paragorgia*		Y
FPC15_D06_S06	Isididae	Y	
FPC15_D06_S07	*Acesta* sp. nov.	Y	
FPC15_D06_S07	Gorgonocephalidae		Y
FPC15_D06_S07	*Ophioplinthaca*		Y
FPC15_D06_S07	*Ophiocamax*		Y
FPC15_D06_S07	Ophiuroidea		Y
FPC15_D06_S07	Crinoidea		Y
FPC15_D06_S07	Hexactinellida		Y
FPC15_D06_S07	Zoanthidae		Y
FPC15_D06_S07	Actiniaria		Y
FPC15_D06_S07	*Actinoscyphia*		Y
FPC15_D06_S07	*Corallium*	Y	Y
FPC15_D06_S07	Hormathiidae		Y
FPC15_D06_S07	Isopoda		Y
FPC15_D06_S07	*Glyptelasma orientale*		Y
FPC15_D06_S07	Polynoidae		Y
FPC15_D07_S01	Brachiopoda	Y	Y
FPC15_D07_S02	*Solenosmilia*	Y	Y
FPC15_D07_S03	*Lepidisis*	Y	Y
FPC15_D07_S04	Coral base	Y	
FPC15_D07_S05	rock	Y	
FPC15_D07_S06	*Walteria*		Y
FPC15_D07_S06	*Paralebbeus* sp. nov.		Y
FPC15_D08_S01	*Polymyces*	Y	Y
FPC15_D08_S02	*Desmophyllum*	Y	Y
FPC15_D08_S03	*Polymyces*	Y	
FPC15_D08_S04	*Desmophyllum*		Y
FPC15_D08_S04	*Acesta*		Y
FPC15_D08_S04	Hexactinellida		Y
FPC15_D08_S05	*Acesta*	Y	
FPC15_D08_S05	*Desmophyllum*	Y	
FPC15_D08_S05	*Caryophyllia*	Y	
FPC15_D08_S06	*Desmophyllum*	Y	Y
FPC15_D08_S07	*Lepidisis*	Y	Y
FPC15_D08_S08	Antipatharia	Y	Y

Sample / Event Name	Taxon	UWA	WAM
FPC15_D09_S01	*Solenosmilia*	Y	
FPC15_D09_S01	Stylasteridae		Y
FPC15_D09_S01	*Mathildella serrata*		Y
FPC15_D09_S02	*Polymyces*	Y	Y
FPC15_D09_S03	*Solenosmilia*	Y	
FPC15_D09_S04	*Solenosmilia*	Y	
FPC15_D09_S04	*Desmophyllum*		Y
FPC15_D09_S04	Ophiuroidea		Y
FPC15_D09_S04	Demospongiae		Y
FPC15_D09_S05	*Desmophyllum*	Y	
FPC15_D09_S05	Ophiuroidea		Y
FPC15_D09_S05	Hexactinellida		Y
FPC15_D09_S05	Hexactinellida		Y
FPC15_D09_S05	*Solenosmilia*	Y	Y
FPC15_D09_S06	octocoral stem?	Y	
FPC15_D09_S06	Ophiuroida		Y
FPC15_D09_S07	octocotal stump & stylasterid	Y	
FPC15_D09_S07	Ophiuroida		Y
FPC15_D09_S07	Polychaete		Y

5. Media & Outreach

There were 42 media outreach events, which occurred before, during, and after the Perth Canyon Cruise. Each of these events is listed below (Table 5.1).

TABLE 2 — *Media coverage of the Perth Canyon cruise*

	Date	Source	Title	Medium	URL	Comments
1	17 Feb	UWA	Deep sea expedition into the unexplored Perth Canyon abyss	Television	www.news.uwa.edu.au/201502177357/research/deep-sea-expedition-unexplored-perth-canyon-abyss	
2	17 Feb	ARC Centre of Excellence for Coral Reef Studies	Deep sea expedition into the unexplored Perth Canyon abyss	Web	www.coralcoe.org.au/news/deep-sea-expedition-into-the-unexplored-perth-canyon-abyss	Reprint from media release – webpage linking to blog entries and media
3	17 Feb	Phys.Org	Deep sea expedition into the unexplored Perth Canyon abyss	Web	http://phys.org/news/2015-02-deep-sea-unexplored-perth-canyon.html	Reprint from media release
4	17 Feb	ISMAR	Perth Canyon – Australia: First Deep exploration	Web	www.ismar.cnr.it/events-and-news/news/1-esplorazione-degli-ecosistemi-profondi-del-canyon-di-perth-australia	ISMAR researcher taking part in cruise
5	18 Feb	Just Marine News	Deep sea expedition into the unexplored Perth Canyon abyss	Web	www.justmarinenews.com/deep-sea-expedition-into-the-unexplored-perth-canyon-abyss	Reprint from media release
6	19 Feb	ABC 720 Mornings (radio)	Scientists will explore a Canyon as big as the Grand Canyon off Perth	Radio	Phone interview occurred on at 0645 on 19-2-15 (no recording as yet) www.abc.net.au/radio/stations/local_perth/live?play=true	Interview with Eoin Cameron
7	19 Feb	WAMSI website	Deep sea expedition dives into Perth Canyon	Web	www.wamsi.org.au/news/deep-sea-expedition-dives-perth-canyon	Reprint from media release

	Date	Source	Title	Medium	URL	Comments
8	20 Feb	Study Options	UWA scientists to lead expedition into unexplored Perth canyon abyss	Web	www.studyoptions.com/news/201502/uwa-scientists-lead-expedition-unexplored-perth-canyon-abyss	Reprint from media release
9	22 Feb	Wake Wind and Surf	Deep ocean off Perth holds secrets	Web	http://wakewindandsurf.com/environment-wildlife/deep-ocean-canyon-off-perth-holds-secrets/17921	
10	23 Feb	Training.com.au	UWA team unlocking secrets of the deep	Web	www.training.com.au/ed/uwa-team-unlocking-secrets-deep	
11	24 Feb	ABC Radio South-west	Researchers head out to sea to find underwater canyon off Perth	Radio	https://soundcloud.com/abcwa/deep-sea-canyon	Interview with Barry Nicholls
12	25 Feb	Youtube	Deep sea expedition into the unexplored Perth Canyon abyss	Web	https://www.youtube.com/watch?v=9doUx4NXjfE	UWA video
13	27 Feb	The West Australian	Scientist seeks canyon's secrets	Print	https://au.news.yahoo.com/thewest/a/26453277/scientists-seek-canyons-secrets	Katherine Fleming
14	27 Feb	ABC News Online	Perth Canyon research could provide crucial climate change information, researchers say	Web	www.abc.net.au/news/2015-02-27/deep-sea-canyon-study-could-reveal-climate-change-information/6269672	Laura Gartry
15	27 Feb	ABC News	Perth Canyon interview	Television	Electronic copy available	Interview with Laura Gartry
16	28 March	Weekend Australian	Advetorial Malcolm McCulloch research expedition	Print	Electronic copy available	UWA advetorial
17	1 March	Science Network WA	Research cruise delves into Perth Canyon's depths	Web	www.sciencewa.net.au/topics/fisheries-a-water/item/3367-research-cruise-delves-into-perth-canyon-s-depths/3367-research-cruise-delves-into-perth-canyon-s-depths	Michael Hopkin

	Date	Source	Title	Medium	URL	Comments
18	1 March	PhysOrg	Research cruise delves into Perth Canyon's depths	Web	http://phys.org/news/2015-03-cruise-delves-perth-canyon-depths.html	Reprint Science Network article
19	1 March	Aus-ROV	Scientists seek canyon's secrets	Web	www.aus-rov.com.au/ocean-update/scientists-seek-canyons-secrets-katherine-flemming	Katherine Fleming – The West update
20	2 March	Marine Link	First Deep Sea Exploration of the Perth Canyon Begins Today	Web	www.marinelink.com/news/exploration-canyon-begins386860.aspx	Josh Keefe
21	2 March	eScience News	Research cruise delves into Perth Canyon's depths	Web	http://esciencenews.com/sources/physorg/2015/03/02/research.cruise.delves.perth.canyons.depths	Reprint Science Network article
22	2 March	#fnews	Research cruise delves into Perth Canyon's depths	Web	https://fnews.com/research-cruise-delves-into-perth-canyons-depths-e7yy	Reprint Science Network article
23	10 March	The Conversation	We are finally learning the Perth Canyon's secrets	Web	http://theconversation.com/we-are-finally-learning-the-perth-canyons-deep-sea-secrets-38377	Malcolm and Chari's article for The Conversation
24	10 March	ABC Radio	Interview with Malcolm McCulloch	Radio	http://www.abc.net.au/perth/programs/720_drive	Drive Program
25	10 March	ABC News Online	Interviewed Chari Pattiaratchi	Web	www.abc.net.au/news/2015-03-10/ocean-glider-research-tool-missing-for-two-years-found-off-wa/6295842	Laura Gartry
26	10 March	Customs Today	Underwater research device found after 2 years	Web	http://customstoday.com.pk/underwater-research-device-found-after-2yrs	Customs Today
27	11 March	6PR	Interviewed Chari Pattiaratchi	Radio	www.6pr.com.au/news/6pr-mornings-with-gary-adshead-20141113-11lup7.html	Gary Adshead Breakfast Program
28	12 March	ABC	Interview at Henderson Port – return of Falkor	Television	ABC News	Laura Gartry

	Date	Source	Title	Medium	URL	Comments
29	13 March	UWA	Deep-sea secrets of the cryptic Perth Canyon unveiled	Multiple	www.news.uwa.edu.au/201503137408/events/deep-sea-secrets-cryptic-perth-canyon-unveiled	
30	13 March	ABC Radio South-west	Interviewed Malcolm McCulloch	Radio	-	Barry Nicholls program
31	13 March	Channel 9 News	Footage of Perth Canyon expedition	Television	Can be ordered via UWA Media Office	
32	13 March	Unmanned Systems Technology	UWA explores Perth Canyon with ROV	Online	www.unmannedsystemstechnology.com/2015/03/university-western-australia-explores-perth-canyon-rov	
33	16 March	ABC 720 Mornings (radio)	Interviewed Malcolm McCulloch	Radio	-	Eion Cameron
34	16 March	2SER - NSW	Interviewed Malcolm McCulloch	Radio	www.2ser.com/component/k2/item/14100-what-secrets-does-perth-canyon-hold	
35	18 March	Science Network WA	We are finally learning the Perth Canyon's deep-sea secrets	Online	www.sciencewa.net.au/topics/perspectives/item/3410-we-are-finally-learning-the-perth-canyon-s-deep-sea-secrets/3410-we-are-finally-learning-the-perth-canyon-s-deep-sea-secrets	Reprint from The Conversation
36	6 April	ABC 1 and News 24 Sydney	Interview with Malcolm McCulloch in Perth studio	Television	KVS requested interview footage 7-4-15.	Jane Braslin Braslin.Jane@abc.net.au
37	23 March	Live Science	Huge Underwater Canyon Is Home to Amazing Deep-Sea Creatures	Online	www.livescience.com/50224-underwater-abyss-perth-canyon.html	Laura Geggel Includes video footage
38	25 March	RedOrbit	Undersea Perth Canyon explored for first time	Online	www.redorbit.com/news/science/1113358787/researchers-explore-massive-perth-canyon-off-western-australia-032515	Brett Smith

	Date	Source	Title	Medium	URL	Comments
39	26 March	Digitial Journal	Amazing deep-sea creatures found in an enormous underwater canyon	Online	www.digitaljournal.com/news/environment/amazing-deep-sea-creatures-found-in-an-enormous-underwater-canyon/article/429099#ixzz3VqfFyYI5	Megan Hamilton
40	7 April	Daily Plant Discovery Channel Canada www.discovery.ca/dailyplanet	Feature story to be filmed with Malcolm McCulloch 9am Interview at Cottesloe Beach 12.30pm Interview in B11 lab	Television	*Future Broadcast*	Producer – Heather Sherman Heather.Sherman@bellmedia.ca
41	12 March	Destination WA	Exploration of Perth Canyon	Television	http://www.destinationwa.tv/event.php?id=213&hit=1	Lee Steele
42	19 Feb	Sunday Times	Interview occurred – awaiting publication	Print	*Future release*	

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8. Appendices

8.1 Appendix 1: Log of seawater sampling

TABLE A1 — *Log of rosette CTD casts from the R/V Falkor. See section 4.2 for web links to data.*

SITE	**A** **Glider Crash**	**A** **Glider Crash (#2)**	**B** **Derwent Wreck**	**C** **Dog-Leg Canyon**	**E** **Amphitheatre Waterfall**	**F** **Two Rocks**
Date sampled	03-Mar-15	10-Mar-15	06-Mar-15	08-Mar-15	07-Mar-15	11-Mar-15
CTD Cast # (UWA)	2	6	3	5	4	7
CTD Cast # (Falkor)	2	7	4	6	5	8
water sample depth (m)	40	15	20	15	15	16
water sample depth (m)	85	85	85	60	77	115
water sample depth (m)	171	150	130	141	130	161
water sample depth (m)	280	240	200	250	251	240
water sample depth (m)	351	281	302	431	432	340
water sample depth (m)	430	340	423	600	602	431
water sample depth (m)	560	420	539	740	781	581
water sample depth (m)	651	501	651	1000	1000	728
water sample depth (m)	753	570	829	1250	1250	
water sample depth (m)	828		1053	1600	1600	
water sample depth (m)				2000	2000	
Total number of samples	10	9	10	11	11	8

8.2 Appendix 2: ROV dive sampling inventory

TABLE A2 — *Log of ROV sampling events*

Date (m-d-y)	Site	Collection Dive	Sampling Number	Bin	Samples Collected	Comments	Latitude / Longitude	Depth (m)
3/03/2015		DIVE 1: BUOYANCY TEST DIVE (no samples collected)						
3/04/2015	A	FPC15_D2	FPC15_D2_S1	G	*Narella* gorgonian coral	live	31 54.8270 S 115 5.0230 E	694.5
3/04/2015	A	FPC15_D2	FPC15_D2_S2	E	*Desmophyllum* cup coral	dead (half retrieved)	31 54.8208 S 115 5.0233 E	692.4
3/05/2015		DIVE 3: ROV MALFUNCTION (no samples collected)						
3/06/2015	B	FPC15_D4	FPC15_D4_S1	H	*Solenosmilia* & *Desmophyllum* corals	both spp live & dead	31 58.5248 S 115 5.3034 E	936.0
3/06/2015	B	FPC15_D4	FPC15_D4_S2	G	bamboo octocoral	live	31 58.5262 S 115 5.3012 E	933.3
3/07/2015	E	FPC15_D5	FPC15_D5_S1	D	rock		31 46.3940 S 114 42.3487 E	1602.6
3/07/2015	E	FPC15_D5	FPC15_D5_S2	D	*Desmophyllum* cup coral	dead	31 46.3614 S 114 42.3338 E	1498.5
3/07/2015	E	FPC15_D5	FPC15_D5_S3	B	*Vaughanella*? cup coral	live	31 46.3481 S 114 42.3259 E	1472.0
3/07/2015	E	FPC15_D5	FPC15_D5_S4	G	*Desmophyllum* cup coral	dead	31 46.3357 S 114 42.3139 E	1444.0
3/07/2015	E	FPC15_D5	FPC15_D5_S5	D	bamboo octocoral	live	31 46.3297 S 114 42.3635 E	1377.2
3/07/2015	E	FPC15_D5	FPC15_D5_S6	G	*Corallium* octocoral (L) & *Desmophyllum* (D)	live & dead)	31 46.3314 S 114 42.3524 E	1357.4
3/07/2015	E	FPC15_D5	FPC15_D5_S7	H	octocoral basal stump (Mn coated)	dead	31 46.3149 S 114 42.3940 E	1246.9
3/07/2015	E	FPC15_D5	FPC15_D5_S8	H	rock		31 46.3189 S 114 42.3972 E	1241.4
3/08/2015	C	FPC15_D6	FPC15_D6_S1	F	bamboo octocoral (*Lepidisis*)	live	32 5.6824 S 114 51.8192 E	1814.8
3/08/2015	C	FPC15_D6	FPC15_D6_S2	H	*Chrysogorgia* octocoral	live	32 5.7046 S 114 51.8219 E	1793.4
3/08/2015	C	FPC15_D6	FPC15_D6_S3	E	*Desmophyllum* cup coral	dead	32 5.7024 S 114 51.8195 E	1788.1
3/08/2015	C	FPC15_D6	FPC15_D6_S4	E	*Desmophyllum* cup coral (with sediment)	lost on collection	32 5.7024 S 114 51.8195 E	1788.1
3/08/2015	C	FPC15_D6	FPC15_D6_S5	G	*Paragorgia* octocoral	live	32 5.7041 S 114 51.8230 E	1738.7
3/08/2015	C	FPC15_D6	FPC15_D6_S6	A	bamboo octocoral	live	32 5.7119 S 114 51.8190 E	1732.5
3/08/2015	C	FPC15_D6	FPC15_D6_S7	G, A	*Corallium* coral, *Acesta* bivalve	live	32 5.6580 S 114 51.8885 E	1557.5
3/09/2015		DIVE 7: (SOI) = USBL BEACON DIVE ON PLATEAU (no samples collected)						

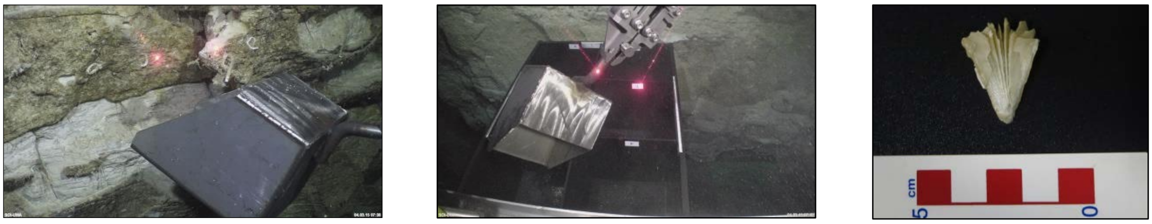
Date (m-d-y)	Site	Collection Dive	Sampling Number	Bin	Samples Collected	Comments	Latitude / Longitude	Depth (m)
3/09/2015		DIVE 7: SAMPLE COLLECTION (=SOI Dive 8) NEARBY USBL AT CANYON WALL						
3/09/2015	D	FPC15_D7	FPC15_D7_S1	A	brachiopod	live	32 9.9817 S 114 50.5454 E	1075.9
3/09/2015	D	FPC15_D7	FPC15_D7_S2	C	*Solenosmilia* fragments	live & dead	32 9.9883 S 114 50.5569 E	1072.5
3/09/2015	D	FPC15_D7	FPC15_D7_S3	G	bamboo octocoral	live	32 9.9861 S 114 50.5596 E	1049.6
3/09/2015	D	FPC15_D7	FPC15_D7_S4	B	octocoral base (Mn) on rock with serpulids	dead	32 9.9867 S 114 50.5653 E	1040.7
3/09/2015	D	FPC15_D7	FPC15_D7_S5	B	rock		32 9.9874 S 114 50.5556 E	1032.4
3/09/2015	D	FPC15_D7	FPC15_D7_S6	H	glass sponge	live	32 9.9698 S 114 50.6459 E	986.6
3/10/2015	A	FPC15_D8	FPC15_D8_S1	C	*Polymyces* cup coral	live	31 54.7935 S 115 4.8399 E	716.3
3/10/2015	A	FPC15_D8	FPC15_D8_S1	C	*Polymyces* & stylasterid on rock	live	31 54.7930 S 115 4.8406 E	718.3
3/10/2015	A	FPC15_D8	FPC15_D8_S2	A	*Desmophyllum* cup coral	live	31 54.7907 S 115 4.8447 E	708.6
3/10/2015	A	FPC15_D8	FPC15_D8_S3	A	*Polymyces* cup coral	dead	31 54.7799 S 115 4.8544 E	701.3
3/10/2015	A	FPC15_D8	FPC15_D8_S4	B	*Desmophyllum* cup coral	live	31 54.7869 S 115 4.8515 E	694.8
3/10/2015	A	FPC15_D8	FPC15_D8_S4	B	*Acesta* bivalve & sponge with rocks	live	31 54.7542 S 115 4.8545 E	695.4
3/10/2015	A	FPC15_D8	FPC15_D8_S5	D	*Acesta* bivalve	live	31 54.7564 S 115 4.8417 E	675.0
3/10/2015	A	FPC15_D8	FPC15_D8_S5	D	*Desmophyllum* (L & D?), *Caryophyllia* (L)	live & dead(?)	31 54.7606 S 115 4.8389 E	674.9
3/10/2015	A	FPC15_D8	FPC15_D8_S6	G	*Desmophyllum* (x2 large)	live	31 54.7636 S 115 4.8397 E	674.4
3/10/2015	A	FPC15_D8	FPC15_D8_S7	H	bamboo octocoral (*Lepidisis*)	live	31 54.7531 S 115 4.8404 E	678.7
3/10/2015	A	FPC15_D8	FPC15_D8_S8	H	black coral (antipatharian, massive)	live	31 54.7491 S 115 4.8318 E	678.2
3/11/2015	F	FPC15_D9	FPC15_D9_S1	A	*Solenosmilia* coral matrix	dead	31 42.0187 S 114 51.0869 E	746.2
3/11/2015	F	FPC15_D9	FPC15_D9_S2	C	*Polymyces* cup coral (with rocks)	live	31 42.0348 S 114 50.9864 E	739.3
3/11/2015	F	FPC15_D9	FPC15_D9_S3	D	*Solenosmilia* colony	dead	31 42.0312 S 114 50.9794 E	738.8
3/11/2015	F	FPC15_D9	FPC15_D9_S4	G	*Solen*., *Desm*., barnacles, brach., stylaster	dead coral	31 42.0441 S 114 50.9948 E	716.5
3/11/2015	F	FPC15_D9	FPC15_D9_S5	H	*Solenosmilia*, *Desmophyllum*, & sponges	dead coral	31 42.0457 S 114 51.0030 E	690.7
3/11/2015	F	FPC15_D9	FPC15_D9_S6	B	octocoral 'stem' (indet.)	dead	31 42.0506 S 114 51.0051 E	690.3
3/11/2015	F	FPC15_D9	FPC15_D9_S7	claw	octocoral basal stump on rock with stylaster	dead coral (eroded)	31 42.0367 S 114 51.0015 E	683.6

* *Note: ROV sample collection dives 7, 8, 9 listed above equate to SOI dives 8, 9, 10 respectively (due to USBL SOI dive 7 near site D)*

FIGURE A8.2 — Images of in-situ sampling by ROV

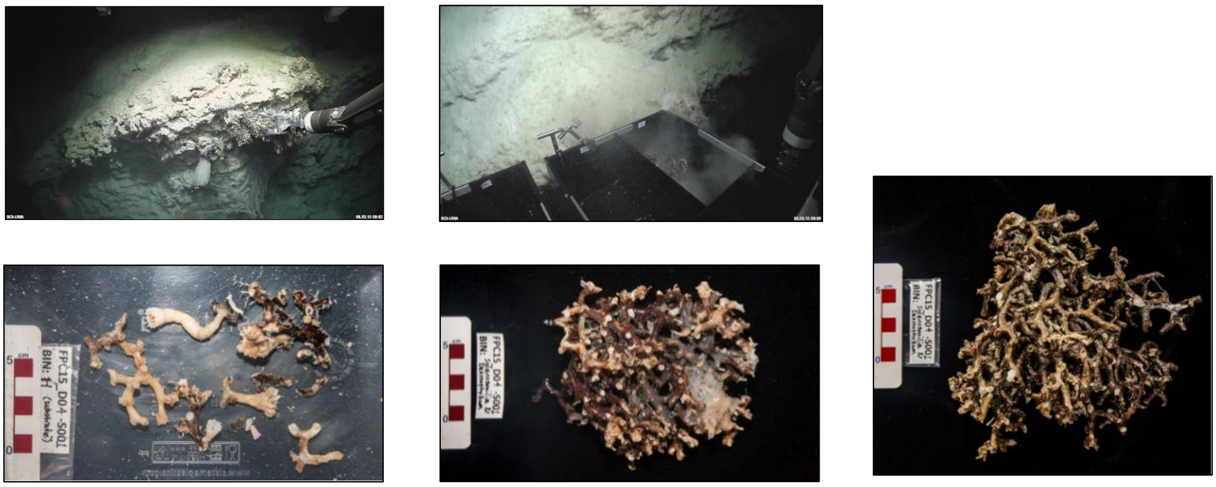
FPC15_D02: 4 March 2015

S01 *Narella* (live, Bin G)

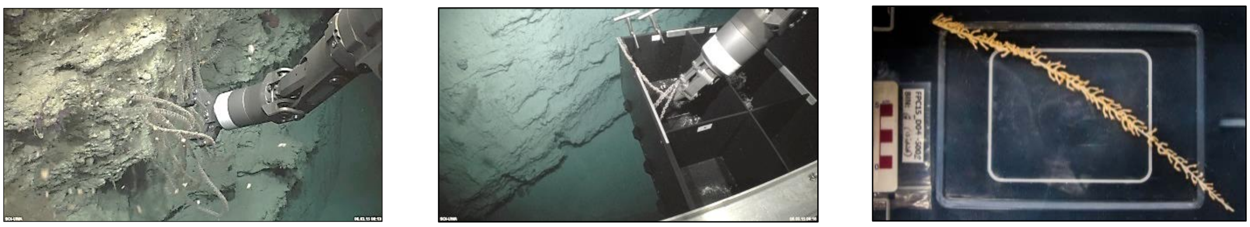


S02 *Desmophyllum* (dead, Bin E)

FPC15_D04: 6 March 2015



S01 *Desmophyllum & Solenosmilia* (live & dead, Bin H)

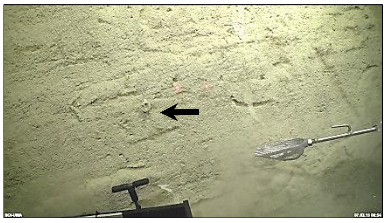
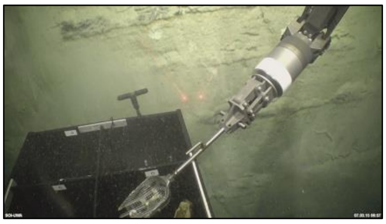


S02 Isidid (live, Bin G)

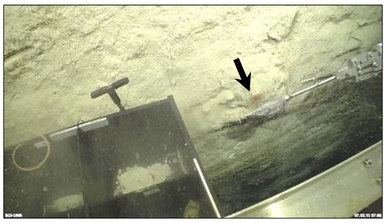
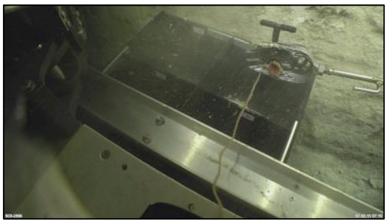
FPC15_D05: 7 March 2015



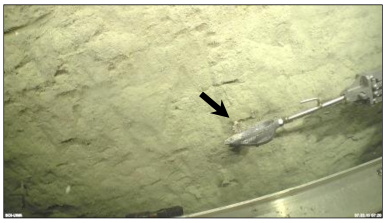
S01 Rock (Bin D)

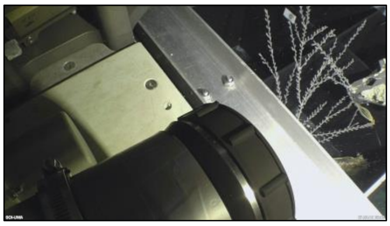

S02 *Desmophyllum* (dead, Bin D)


S03 *Vaughanella*? (live, Bin B)



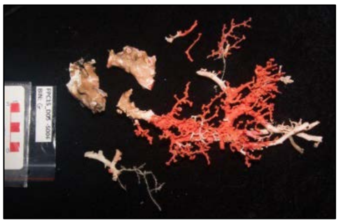
S04 *Desmophyllum* (dead, Bin G; note - S04 & S06 same bin hence mixed debris)


S05 Isidid (live, Bin D)

FPC15_D05: 7 March 2015 (*continued*)



S06 *Corallium* community (live, Bin G)

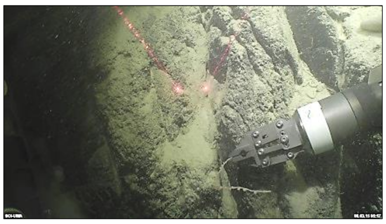
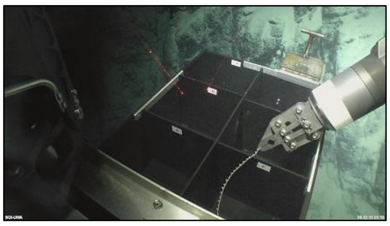
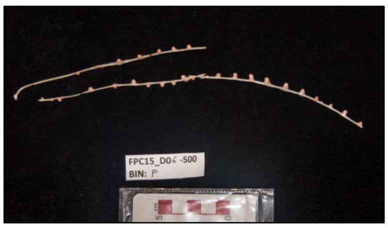


S07 Octocoral base (ie. dead, Mn coatedBin H)



S08 Rock (Bin H)

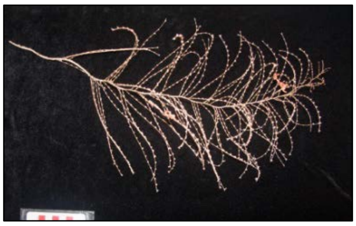
FPC15_D06: 8 March 2015

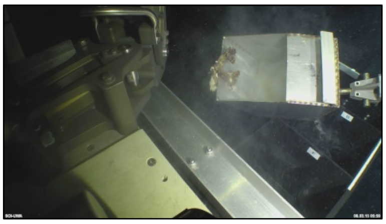
S01 Isidid (live, Bin F)

FPC15_D06: 8 March 2015 (*continued*)

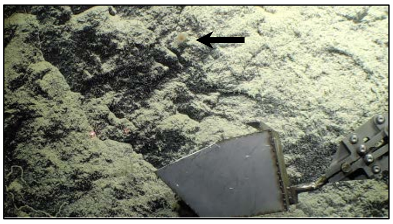


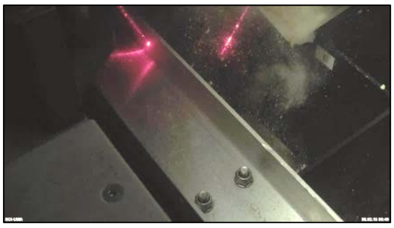


S02 *Chrysogorgia* (live, Bin H)

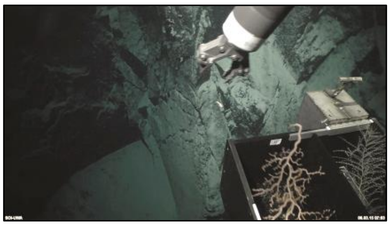
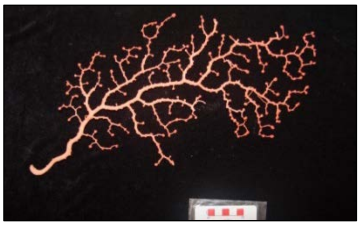



S03 *Desmophyllum* (dead, Bin E); (several scoops, slightly different levels)



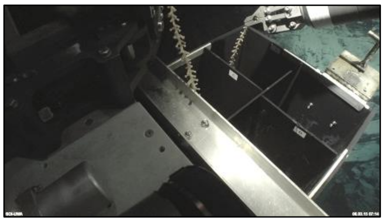


S04 *Desmophyllum* (live, Bin E); lost when retrieving from cliff base

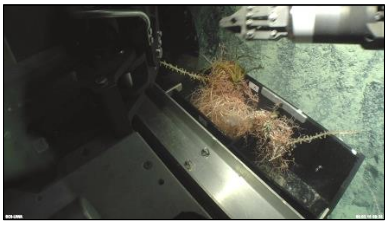
S05 *Paragorgia* (live, Bin G)

FPC15_D06: 8 March 2015 (*continued*)


S06 Isidid (live 'float', ie. not sampled *in-situ,* Bins A & C)



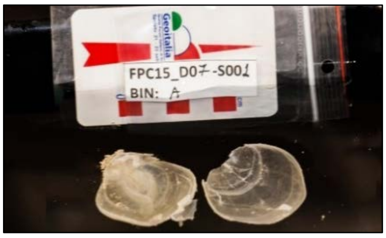




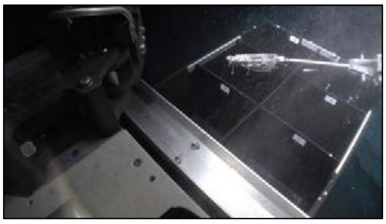
S07 *Corallium* community, includes associated taxa (live, 1^{st} half Bin G, 2^{nd} half Bin A)

FPC15_D07: 9 March 2015

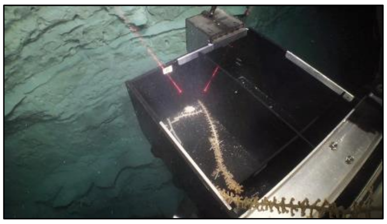




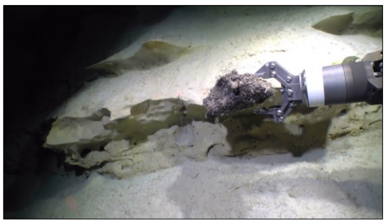
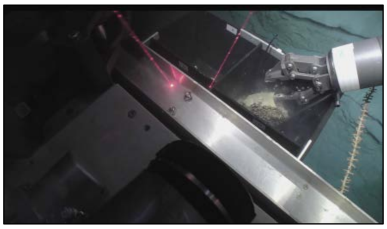
S01 Brachiopod (live, Bin A)


S02 *Solenosmilia* colony (Bin C)

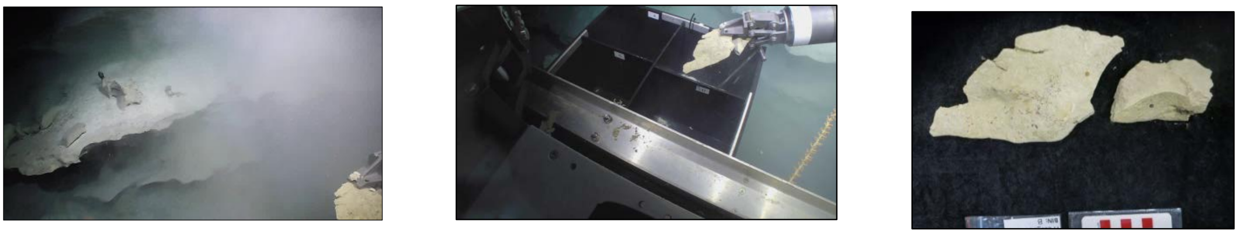




S03 Isidid (live, Bin G)

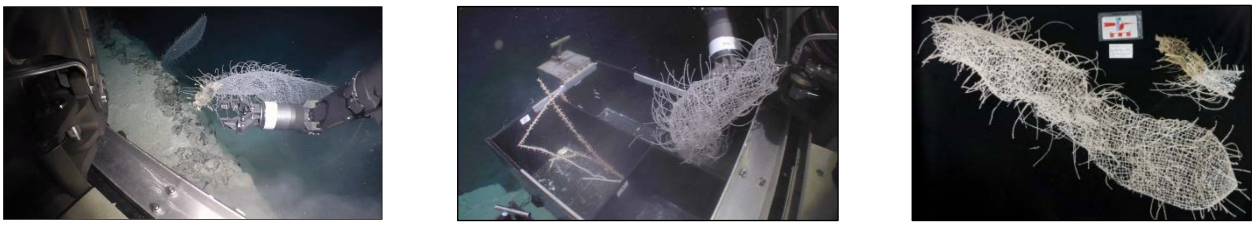




S04 Mn coated octocoral on rock (Bin B)

FPC15_D07: 9 March 2015 (*continued*)



S05 Rock (Bin B)



S06 Glass sponge (live, Bin H)

FPC15_D08: 10 March 2015

S01 *Polymyces* (live x2) & stylaster on rock (Bin C)

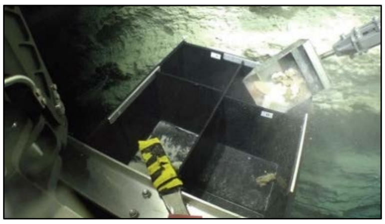
S02 *Desmophyllum* (live, Bin A)

FPC15_D08: 10 March 2015 (*continued*)

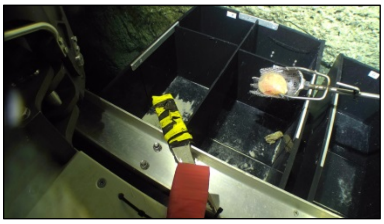
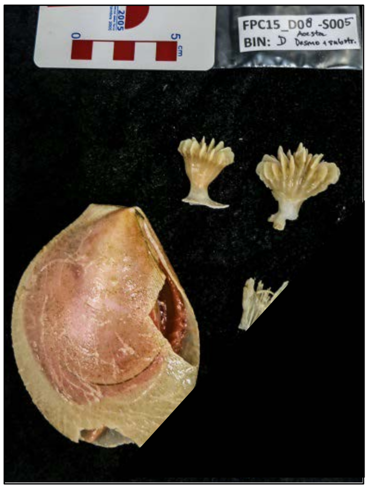


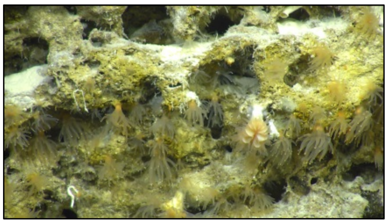
S03 *Polymyces* (dead, Bin A)



S04 *Desmophyllum* (1^{st} collection, Bin B); S04 *Acesta* & sponge (2^{nd} collection closeby, Bin B)

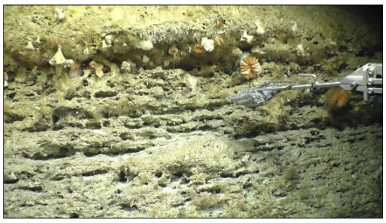






S05 *Acesta* (1^{st} collection, Bin D); S05 *Desmophyllum* x2 & *Caryophyllia* (2^{nd} collection closeby, Bin D)

FPC15_D08: 10 March 2015 (*continued*)

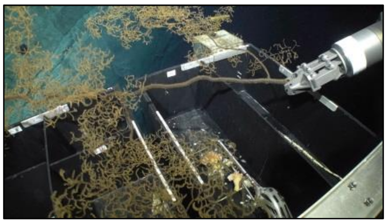


S06 *Desmophyllum* x2 & Caryophyllia (live & dead?, Bin G)

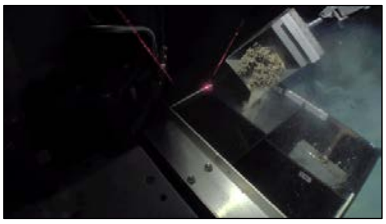


S07 Isidid (live, Bin H)

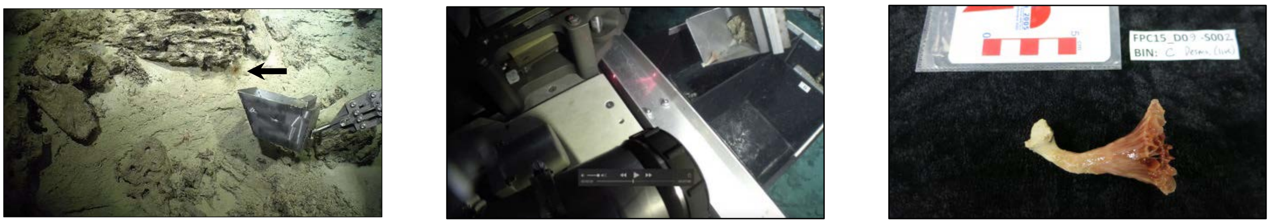

S08 Black coral (live, Bin H)

FPC15_D09: 11 March 2015


S01 *Solenosmilia* rubble (ie. dead, Bin A)

FPC15_D09: 11 March 2015 (*continued*)



S02 *Polymyces* (live, Bin C)

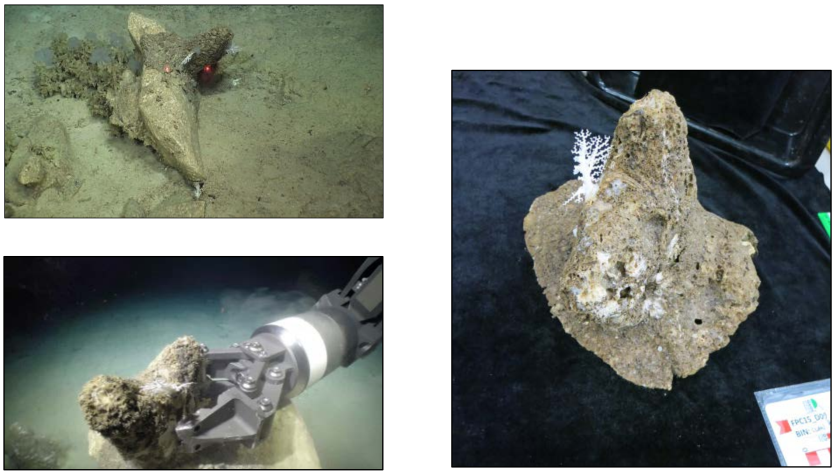
S03 Coral rubble (ie. dead, Bin D)

S04 *Solenosmilia, Desmophyllum* rubble (ie. dead, Bin G)

S05 Coral rubble & sponges (Bin H)

S06 octocoral 'stem', indet. (Bin B)

FPC15_D09: 11 March 2015 (*continued*)



S07 octocoral base (ie. dead) & stylasterid on rock (ROV claw)

8.3 Appendix 3: Preliminary report made to the Schmidt Ocean Institute

Schmidt Ocean Institute Cruise Report - FK150301

1. Ship Name: R/V Falkor

2. Cruise Dates

	DD	MM	YYYY
Day departed	01	03	2015
Day arrived	12	03	2015

3. Cruise Number

FK150301

4. Ports-of-Call

Ports-of-Call Departure Port	Henderson (Perth, WA)
Arrival Port	Henderson (Perth, WA)

5. Participating Organizations, Institutions, Foundations, Government Agencies, etc. (list all applicable)

Participating Organizations, Institutions, Foundations, Government Agencies, etc. (list all applicable)

The University of Western Australia (UWA)

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Istituto di Scienze Marine (ISMAR) Italy

The Western Australian Museum

BBC

6. Describe all of the geographical area(s) where the science occurred.

The cruise began at the head of the Perth Canyon and progressed in a westerly (ie. seaward) direction towards the mouth of the canyon. Our basic strategy was to first begin looking for deep-sea coral in relatively shallow water (200-500 m) since it is better to first operate the ROV in shallower water initially and then work down to deeper waters.

The entire length of the region of interest (Perth Canyon) is ~60 km, which equates to 5 hours total steam time. Habit sites were initially grouped into 3 regions of interest (see figure below), in the order that they will be visited. Sites within each region are all within ~10 km of one another, or ~1 hour steaming. The regions are separated by 10-40 km, or ~1-4 hours steaming. The sites are described below (for more details/locations etc see attachment 1):

Dive site A : a shallow water site (~700 m) where team member Chari Pattiaratchi believes the local topography could support the growth of deep-sea coral. This area was also where the slocum glider was found.

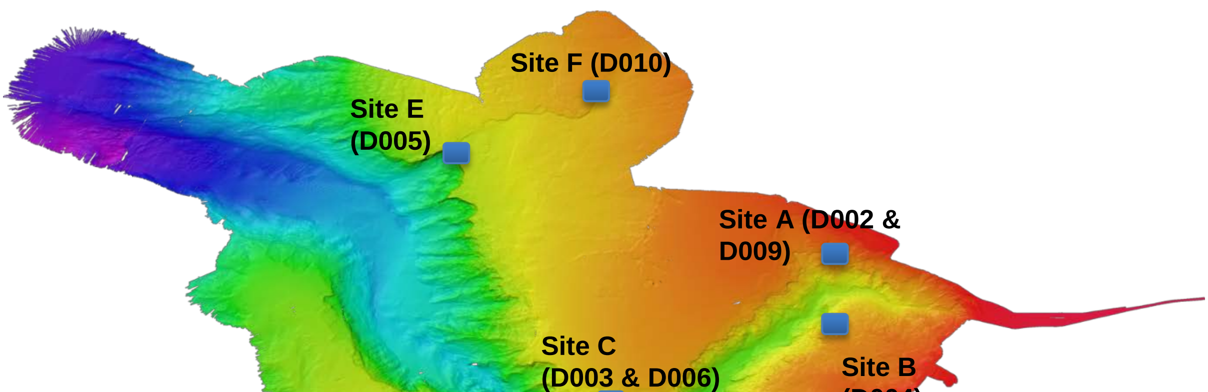
Dive site B: intermediate water depth site starting at ~1000 m to 600m. This area is on the southern side of the canyon opposite site A.

Dive site C: contains the most topographically extreme sites with 'dog-log' in canyon and multi-beam indicating near vertical walls of 500-600 m height. Site provided the best examples for deep to intermediate depth habitats (1000-400 m). Called 'Dog-Leg' site.

Dive site D: shows some intermediate structural features (<1000 m), which could support outcrops of hard substrates that benthic invertebrates would colonize. Is distal to the mouth of the canyon and a deeper habitat (>600 m). Here on the top of the walls we found beautiful examples of glass sponges. Hence called 'sponge' site.

Dive site E: deep-water amphitheatre type structure containing a topographically set of very interesting features including possible waterfall. Entrance linked to site F.

Dive site F: shallow-water site on the the Canyon rim. Has ridge/ledge structures suggestive of a former river type flood-plain. Features can be traced across to site F.



7. Names and addresses of the on board Chief Scientist

Professor Malcolm McCulloch

The University of Western Australia

(M004)

35 Stirling Highway

Crawley WA 6009

8. Cruise Objectives (These are the research program objectives, not marine operations)

Our primary research mission is to find and collect deep-sea hard coral over a range of depths accessible to the ROV Comanche (0-1800 m) and to characterize the environmental conditions in which they live (temperature, pH, and carbonate mineral saturation state). The overall strategy is as follows:

To identify likely habitats for deep-water coral within the Perth Canyon. We initially identified preliminary target sites based on steepness and rugosity criteria using bathymetric data provided by Geoscience Australia (~200 m resolution). Employ RV Falkor bathymetry measurements undertaken overnight while steaming to target additional potential sites; this exercise will need to allow for processing of that data.

To target sites and identify specific features (outcrops and steep walls) where sessile benthic invertebrates like coral are likely to colonize. The ROV will then be deployed to examine each of these small-scale sites to investigate whether hard coral are present, and if so, to collect representative specimens.

Sampling of benthos from the substrate is a key objective.

Use high resolution video imaging to characterise both the biota as well as canyon structures

Undertake public out-reach using live steaming, blogs and direct media presentations. The high-resolution video is key to this!

Specimens brought to the surface sorted, catalogued, photographed, and split into sub-samples for on-shore laboratory analyses of skeletal geochemistry and genetic identification. Remaining specimen splits (and likely whole samples) preserved and archived at the Western Australian Museum; these will be preserved as either dry or wet (ethanol or formalin) depending on sample specifics including size/mass.

Combined CTD/rosette casts will be made at each site where coral are collected to collect data on the vertical structure of water column chemistry (total chla pigments, dissolved oxygen, alkalinity, pH, dissolved inorganic carbon, trace-elements and dissolved inorganic nutrients) to best characterise chemically the environmental habitat where coral have been collected.

Simultaneously with the operations on the RV Falkor obtain glider temperature and salinity data to characterise the region more widely.

Our over-arching goal is to characterise the canyon wall environments, and collect coral samples to compare the internal chemistry of the coral skeleton with the chemistry of the ambient seawater over a range of depths, temperatures, and pH. Based on this information we aim to determine the ability of these corals to control their rate skeletal growth and adapt, acclimate, or otherwise withstand changes in their environment.

9. Cruise Summary (A)

Daily log of events for Perth Canyon cruise

Note: due to joint naval (Australia/USA operations 24 hour advance notice and restricted hours (7 am to 7 pm for underwater operations applied. This was however well co-ordinated and did not prove to be a significant limitation

Friday February 27th

Induction for RV Falkor

loading of equipment onto the RV Falkor at Henderson wharf (Fremantle).

Saturday February 28th

Completed loading and fixing of lab equipment.

Emergency & safety induction.

Introduction to crew and evening BBQ and presentation my MMc of cruise aims, objectives

Sunday March 1st

Departed port at 8.00 am to Perth Canyon.

Commenced multi-beam mapping enroute to plateau site.

At plateau site (115 04.716510 -31 55.223504)

USBL's deployed for calibration but rough weather made calibration difficult – incomplete

CTD cast #1 for water samples water temp, salinity etc.

Then continued multi-beam mapping but mediocre data due to rough weather.

Monday March 2nd

Continued multi-beam mapping through early am.

6 am steamed to pickup point offshore Rottnest Island to meet boat to with critical components for the ROV high resolution video system. (delayed in transit from the USA).

Fitting of video to ROV commenced

At plateau site (115 04.716510 & 31 55.223504)

Calibration of USBL's completed at plateau site (but one unit wasn't retrieved – see later).

Tuesday March 3rd

Continued multi-beam mapping around glider site

At glider site (115 04.716510 & 31 55.223504)

CTD cast #2 deployed for water samples, water temp, salinity etc (7.00 am)

ROV buoyancy test at ~ 2 pm – failed more weight needed

Then continued multi-beam mapping through evening.

<u>Wednesday March 4th</u>

Continued multi-beam mapping around glider site area and nearby

Returned to glider site (115 04.716510 & 31 55.223504)

Dive D001: ROV buoyancy test at ~ 10.50 am – failed more weight still needed

Dive D002: ROV buoyancy test at ~1.35 pm successful – ROV out-of cage @ 1.55 pm. Reached bottom at 710 m. Commenced filming, sampling etc but bottom time limited but overall success in first coral collections

Continued multi-beam mapping through evening.

<u>Thursday March 5th</u>

Continued multi-beam mapping around Dog-Leg area and nearby

Dog-Leg site (114 51.4938 & 32 55.223504)

CTD cast #3 failed (equipment failure repaired for next day).

Dive D003: ROV launched 11.35 out-of cage ok . Reached bottom at 1580 m . Commenced filming.

Hydraulic hose failure on ROV, dive D003 aborted before sampling could commence.

Continued multi-beam mapping through evening with repairs to ROV and CTD winch

<u>Friday March 6th</u>

Continued multi-beam mapping around Dog-Leg area and nearby

Derwent wreck site (115 05.250 & 31 58.500)

CTD cast #4 successful (equipment failure repaired ok) and deployed for water samples, water temp, salinity etc (10.00 am).

Spare hydraulic ROV hoses ferried to RV Falkor from mainland.

Dive D004: ROV launched 2.00 pm out-of cage ok and reached bottom at 1083 m . Commenced filming and sampling., Returned to cage at 5.30 pm. Although dive-time limited overall successful but ROV temperamental (air bubbles still in hydraulics)

Continued multi-beam mapping through evening, scoop remade over-night in workshop of RV Falkor

<u>Saturday March 7th</u>

Continued multi-beam mapping into deep-water arm of canyon

Amphi-theatre (water fall site 114 42.200 & 31 46.500)

CTD cast # 5 at 7.00 am successful and deployed for water samples, water temp, salinity etc.

Dive D005: ROV launched @ 11.10 am. Lost scoop on transit to bottom (used backup). Out-of cage ok at 1:07 pm and reached bottom at 1602 m . Commenced filming and sampling – successful deep dive.

Continued multi-beam mapping through evening.

<u>Sunday March 8th</u>

Continued multi-beam mapping of Canyon

Returned to Dog-Leg part of Canyon (114 51.823 & 32 05.687)

CTD cast # 6 at 7.00 am successful and deployed for water samples, water temp, salinity etc.

Dive D006: ROV launched @ 12.20 pm . Lost scoop on transit to bottom (used backup). Out-of cage ok at 12:50 pm and reached bottom at 1575 m . Commenced filming and sampling – successful deep dive. Dive completed at 5.40 pm, very successful although lost another scoop.

Continued multi-beam mapping through evening.

<u>Monday March 9th</u>

Continued multi-beam mapping of Canyon near plateau site and southern deep-water arm.

Returned to plateau site (114 52.140 & 32 09.982) to recover lost USBL beacon

Dive D007: ROV launched @ 9 am to recover lost beacon. Beacon recovered and ROV returned to surface @ 11. am.

Transited to site called ‘sponge ridge’ (114 50.580 & 32 09.9820) due west of previous site.

Dive D008: ROV launched @ 1:00 pm. Out-of cage ok at 1:50 pm and reached bottom at 950 m. Commenced filming and sampling – successful deep dive. Dive completed at 5.40 pm, very successful although lost another scoop. Operation now working smoothly with x2 dives completed in a day.

Continued multi-beam mapping through evening.

Tuesday March 10th

Continued multi-beam mapping

Returned to glider site with refined co-ordinates (115 04.805 & 31 54.727)

CTD cast # 7 at 7.00 am successful and deployed for water samples, water temp, salinity etc. Completed by 9.0am

Dive D009: ROV launched @ 9.20 pm . Lost scoop on transit to bottom (used backup). Out-of cage ok at 10:10 am and reached bottom at 743 m . Commenced filming and sampling – very successful dive. Discovered glider undertook extensive filming and sampling. Highly successful although lost yet another scoop. Excellent bottom time.

Continued multi-beam mapping through evening.

Wednesday March 11th

Continued multi-beam mapping

Two-rocks Canyon shelf site with co-ordinates (114 50.640 & 31 42.045)

CTD cast # 8 at 7.00 am successful and deployed for water samples, water temp, salinity etc. Completed by 9.0am

Dive D009: ROV launched @ 9.20 pm . Lost scoop on transit to bottom (used backup). Out-of cage ok at 10:15 am and reached bottom at 740 m . Commenced filming and sampling – very successful dive. Highly successful Excellent bottom time.

Thursday March 12th

Continued multi-beam mapping

Returned to port (Henderson) for unloading disembarkation etc. Encounter huge media interest, interviews etc.

10. Cruise Summary (B)

See attachment 1 for more details

11. Summary of Measurement and Samples Taken

Interim Data Summary report see attachment 2.

Ie see companion Excel spreadsheets <Attachment 2 FPC15-Interim-Report-Data-Summary-Table.xlsx> includes <UWA-Specimen-manifest.xlsx>

Classes of data collected

High-resolution bathymetry of the Perth Canyon

High-resolution bathymetric data of the Perth Canyon was collected using both a Kongsberg EM 302 and 710 multi-beam echo sounders mounted on board the R/V Falkor. All processing and analysis as well as construction of the final bathymetric image mosaic was done by Deborah Last_name of LIDOS acting as part of the R/V Falkor crew. All bathymetric data collected has been retained on board the R/V Falkor as well as being provided to the Chief Scientist. This data will ultimately be made freely available on a publicly accessible server as per the mission of the SOI (contact Viktor Zykov, Director of Research, for details). This data will allow us to better understand the geomorphology of the canyon as well as make broader determinations of potentially suitable habitat where other species of benthic organisms, similar to those collected at our specific dive sites, could be found.

ROV Video of deep Perth Canyon habitats and fauna

All video footage from each dive has been retained on board the R/V Falkor as well as being provided to the Chief Scientist. This data will allow us to accurately record the compositions of the benthic communities we surveyed as well as that of the habitat and substrate they occupy.

Biological samples collected

See attached spread sheet <UWA-Specimen-manifest.xlsx>

Seawater composition

Falkor CTD-Rosette Casts

Water column profiles of temperature (T), salinity (S), dissolved oxygen (DO), and chlorophyll a concentration (Σchl*a*, via water column fluorescence) were made at 6 of the 7 scientific dive sites (excluding recovery of the USBL) using the Falkor CTD (Seabird SBE 9plus CTD equipped with SBE 43 dissolved oxygen sensor and Wet Labs ECO-FLNTU). Select water samples were collected from 8-12 depths in each cast for the chemical analysis of the following species:

Total Alkalinity (TA) → already measured on board Falkor by single-point titration based on spectrophotometric measurement of the end-point pH (Yao and Byrne 1998). This was measured to help determine the overall seawater carbonate chemistry (see below).

Dissolved Inorganic Carbon (DIC) → already measured on board Falkor using an Apollo SciTech Dissolved Inorganic Carbon analyser. This was measured to help determine the overall seawater carbonate chemistry (see below).

pH, pCO_2, calcite saturation state, aragonite saturation state → preliminary calculations of these species were made from in situ measurements of T and S as well as on-board measurements of TA and DIC using the Matlab program CO2SYS.m; however, final calculations of these species will need to wait for the complete analyses of all dissolved inorganic nutrient concentrations since this data will affect all calculations of water column carbonate speciation. These measurements will be used to assess the thermodynamic difficulty of biomineralizing calcium carbonate skeletons in situ based on measurements of internal pH derived from boron isotopic composition ($\delta^{11}B$) of collected skeletal material (see below).

Dissolved inorganic nutrients including ammonium (NH_4^+), nitrate+nitrite (commonly referred to as just 'nitrate' or NO_3^-), phosphate (HPO_4^{2-}), and silica ($Si(OH)_4$) → To be analysed at the University of Western Australia on a Lachat autoanalyser using standard spectrophotometric methods. This was measured to produce more accurate calculations of in situ seawater carbonate chemistry parameters as well as indirectly assess determine the overall vertical structure of water column productivity.

Ba^{2+} concentrations in the water column → To be analysed at the University of Western Australia using the ICPMS laboratory of Chief Scientist McCulloch. These samples were collected so that we could better understand the general use of dissolved Barium as a tracer of nutrient-rich deep water throughout Western Australia.

$\delta^{11}B$ of dissolved boron in the water column → To be analysed at the University of Western Australia. Knowledge of the seawater $\delta^{11}B$ will allow us to make more accurate predictions of the interstitial pH of calcareous organisms derived from $\delta^{11}B$ of collected skeletal material.

$\delta^{13}C$ of DIC → To be analysed at the University of Western Australia by the UWA Biogeochemistry Centre. Knowledge of the seawater $\delta^{13}C$ will allow us to make more accurate predictions of the interstitial chemistry of calcareous organisms derived from $\delta^{13}C$ of collected skeletal material.

$\delta^{18}O$ of H_2O in seawater → To be analysed at the University of Western Australia by the UWA Biogeochemistry Centre. Knowledge of the seawater $\delta^{18}O$ will allow us to make more accurate predictions of the interstitial chemistry of calcareous organisms derived from $\delta^{18}O$ of collected skeletal material.

ROV CTDO logging

Temperature and Salinity recorded by Seabird SBE49 FastCAT CTD mounted on the ROV.

Dissolved oxygen was recorded by a Contros Hydroflash dissolved oxygen optode mounted on the ROV and logging into the micro-CTD.

All data recorded by the CTDO from each dive has been retained on board the R/V Falkor as well as being provided to the Chief Scientist. This data will be used to relate seawater chemistry at the site of collection to measurements made using the on board CTD-Rosette.

Slocum glider operations (IMOS)

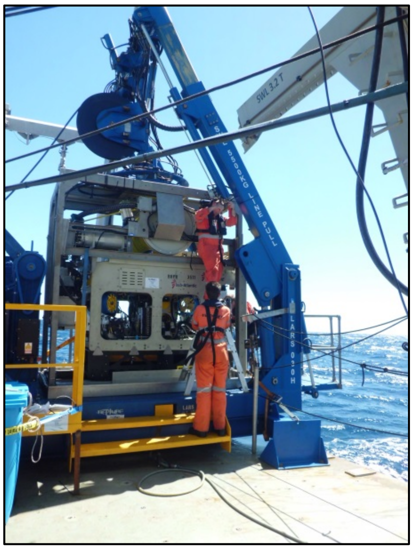
These were run independently but simultaneously with the Falkor cruise. See http://anfog.ecm.uwa.edu.au/index.php for details and data.

12. Moorings, Bottom Mounted Gear and Drifting Systems

Not applicable

13. Equipment Used

- ROV leased from Neptune by SOI (see below)



Please provide a detailed description of all special equipment used or new technologies tested by UWA.

pH Meters

Complete ocean chemistry system supplied by UWA for determining alkalinity and dissolved organic carbon, including coolers and equipment for analysis and sampling bottles

Rockland scientific VMP-250 Turbulence Profiler

2 F-size cylinder of high-purity Nitrogen

Deep water Nortek Vector ADV

Teledyne RDI Vector volume sampler

Seabird CTD and deep-sea DO probe

Shallow thermistor chain

6 PVC incubation chambers and tubing

24 Incubation bottles

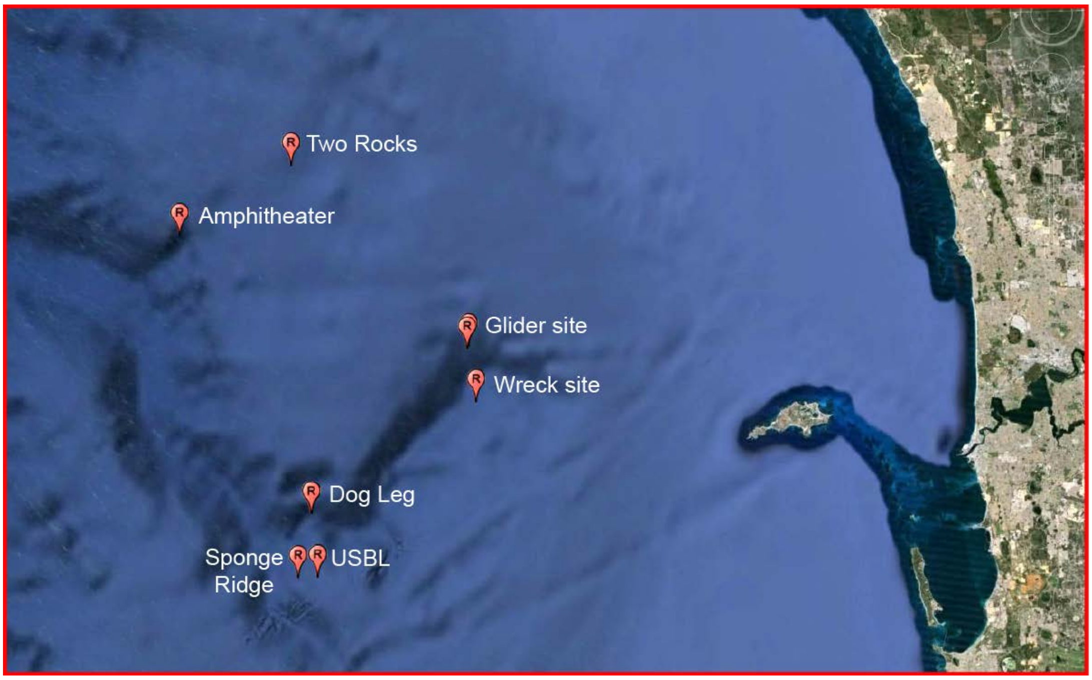
Winkler titration system

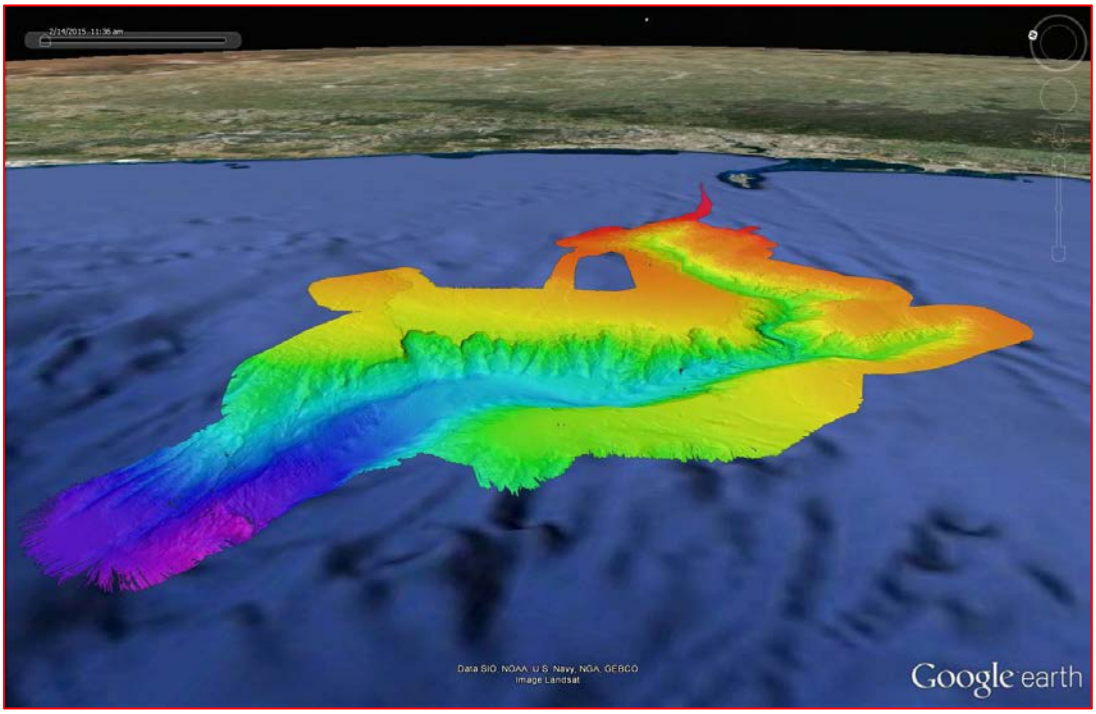
UV-B logger and PAR loggers

2 20-L carboys of de-ionized water

Manta net

14. Station Plots.

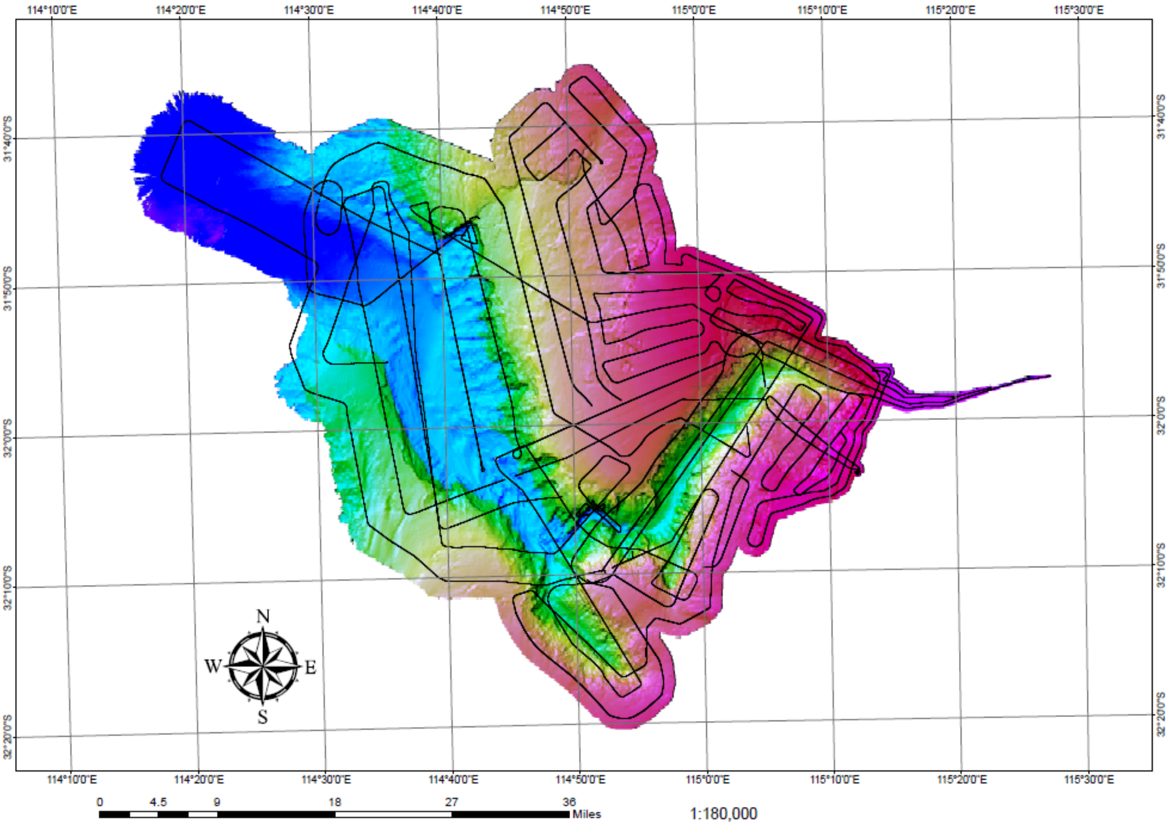




Ship tracks for multi-beam.

The area mapped was about 3950 Square Kilometers (1107 SQNM).

A total of 1692.1 kilometers of ships track were run.



15. Other

Include any additional information that should be documented in an annual Schmidt Ocean Institute Operations Report.

Media out-reach – this was unprecedented and is still ongoing (see attachments 3 and 4). Generated huge interest both locally (Perth) as well as nationally and internationally. It was an outstanding success made possible by the combination of the RV Falkor capabilities, online steaming of the ROV's high quality videos/stills and foremost the truly 'discovery' character of the Perth Canyon expedition. The infamous star trek phase: *"To boldly go where no man has gone before"* is an apt description.