Ophiopsila pantherina beds on subaqueous dunes off the Great Barrier Reef

Conference Paper · January 2009

DOI: 10.1201/b13769-24

9 authors, including:

Erika Woolsey
James Cook University
18 PUBLICATIONS **199** CITATIONS
SEE PROFILE

Maria Byrne
University of Sydney
316 PUBLICATIONS **5,916** CITATIONS
SEE PROFILE

Stefan B. Williams
University of Sydney
151 PUBLICATIONS **2,892** CITATIONS
SEE PROFILE

Oscar Pizarro
University of Sydney
129 PUBLICATIONS **1,994** CITATIONS
SEE PROFILE

Ophiopsila pantherina beds on subaqueous dunes off the Great Barrier Reef

E. Woolsey, M. Byrne, J. M. Webster, S. Williams, O. Pizarro, K. Thornborough & P. Davies
University of Sydney, Sydney, Australia

R. Beaman
James Cook University, Cairns, Australia

T. Bridge
James Cook University, Townsville, Australia

ABSTRACT: An autonomous underwater vehicle (AUV) was used to generate images of an *Ophiopsila pantherina* population on subaquous dunes at Hydrographers Passage, 200 km off the Australian mainland. High-resolution stereo images captured by the AUV were used to determine population structure of the aggregations, which consisted of adults at a mean density of 418 animals m^{-2} at depths of 65-70 m. *Ophiopsila pantherina* (8-15 mm dd) takes advantage of their elevated position on the lee side of the dunes for suspension feeding. On contact stimulation, the arms emit visible light as a bright green flash that travels down the arm. These aggregated ophiuroid communities in dune fields may be a specialized natural feature for consideration in managing common inter-reefal sandy habitats within the Great Barrier Reef Marine Park.

1 INTRODUCTION

Ophiuroids are well known to form dense aggregations in most of the world's marine zones from intertidal to deep-sea habitats in tropical, temperate, and polar regions (Brooks et al., 2007; Kingston, 1980; Metaxas and Giffin, 2004; Oak and Scheibling, 2006; Summers and Nybakken, 2000). These dense brittlestar aggregations show their effectiveness as suspension feeders and are important as conduits between the benthic and pelagic environments (Brooks et al., 2007; Warner and Woodley, 1975). Suspension-feeding ophiuroids exhibit a preference for current-dominated habitats where they are supported by high nutrient flow (Broom, 1975; Warner, 1979). Because cycling and re-suspension of food particles increases the odds of successful capture, suspension feeders are often found on the leeward side of structures, where the eddying and low velocity aids in food capture (Warner, 1977).

Here we present data on a recently discovered population of *Ophiopsila pantherina* (Koehler, 1898) that form dense aggregations on underwater dunes in the central Great Barrier Reef (GBR) (Byrne, 2009). This work was undertaken in association with surveys of the relict drowned or submerged reefs along the GBR margin (Webster et al., 2008; Byrne 2009). The brittlestar genus *Ophiopsila* (Forbes, 1843) is widespread throughout temperate and tropical environments and is known to form aggregations on soft sediments (Basch, 1988; Kingston, 1980). This genus is also known to be bioluminescent (Basch, 1988; Grober, 1988a; Grober, 1988b; Vanderlinden and Mallefet, 2004) and this phenomenon is observed here. This species is reported to occur in benthic inshore habitats of the GBR at 0-40 meters depth (Clark and Rowe, 1971; Kingston, 1980; Rowe and Gates, 1995). The distribution of *Ophiopsila* in the inter-reefal areas of the GBR Marine Park was obtained from the Seabed Biodiversity Survey (Pitcher et al., 2007).

2 MATERIALS & METHODS

The research was conducted at Hydrographers Passage (20.0º S, 150.4º E), 200 km off the coast of Queensland (Figure 1) in October 2007 and August 2008 using the *RV Southern Surveyor* (Marine National Facility, voyages SS07/2007 and SS09/2008). An autonomous underwater vehicle (AUV) was used to survey and image the seafloor. The AUV remained at a constant altitude of 2 m and captured time-stamped images every half-second. A Wetlabs EcoPuck Fluorometer mounted on the AUV collected data on chlorophyll and turbidity. Bathymetry data of the dunes was documented by multibeam swath mapping using a Simrad EM300 multibeam system.

Samples of ophiuroids and sediments were collected at 65-70 metre depths with a Smith-Macintyre grab at five locations along the dune system. In the 2007 survey, one grab (19.8704833º S, 150.4507500º E) was deployed near the aggregation. In the 2008 survey, four grabs were deployed- two

on lee dune slopes (19.866500º S, 150.447883º E; 19.867500º S, 150.449483º E) and two on stoss dune slopes (19.867216º S, 150.448033º E; 19.867900º S, 150.450083º E). The Smith-Macintyre grab deployed was a half cylinder with a radius of 18 cm and a width of 30 cm. Although the ophiuroids were likely to have been collected from surface sediments, the total volume of sediment collected was approximately 20 L.

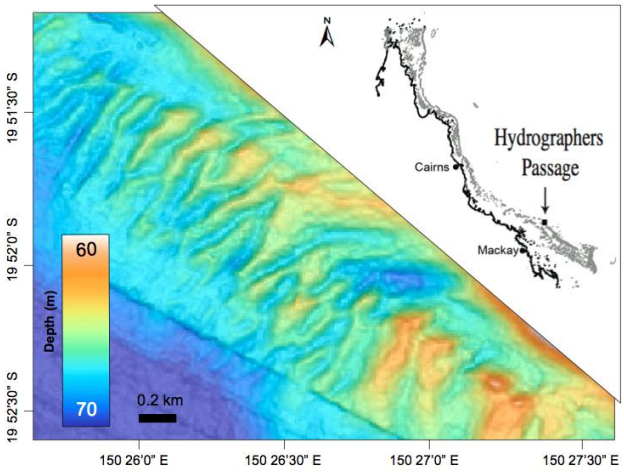

Figure 1. Multibeam bathymetry showing the subaqueous dunes at Hydrographers Passage, a narrow channel in the outer reef matrix of the central GBR, 200 km northeast of Mackay, Queensland.

Bioluminescence of live *O. pantherina* collected by grab samples was documented with video on board the *Southern Surveyor*. Images of bioluminescence were collected from 5 specimens. The brittle stars from each grab were preserved in 70% ethanol. Disc diameter and arm length were measured and the incidence of regenerating arms was recorded. Still images taken by the AUV were used to count feeding arms and estimate the population density of the aggregations.

3 RESULTS

The populations of *Ophiopsila pantherina* on dunes at Hydrographers Passage occupy a dynamic dune system on the outer shelf in the central GBR- at depths of about 65-70 m depth. The dune habitat covered approximately 3.4 km^2 of sea floor in the surveyed area. The dunes were 2-6 m in height and consisted of well-sorted medium-sized carbonate sand. Each AUV image represented approximately 1.5 m^2 of the seafloor (Figure 2).

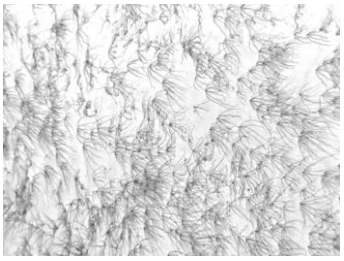

Figure 2. Example image from the AUV. Dimensions are approximately 1.5 x 1.0 metres

The track compiled from AUV imagery over the dunes showed three separate aggregations of *O. pantherina* (Figure 3) each of which were 50-70 m long. Examination of the images indicated that the ophiuroids on the seafloor each had four arms extended with the fifth arm buried and out of view. Analysis of randomly selected images indicated that the population of ophiuroids had a mean density of 418 animals m $^{-2}$.

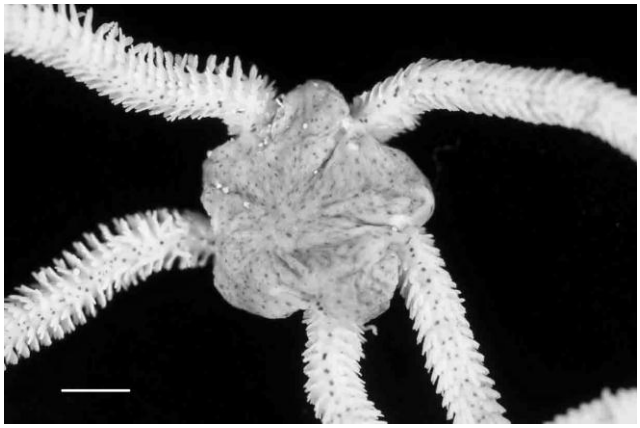

Figure 3. *Ophiopsila pantherina* (3mm scale bar)

The AUV survey indicated that the ophiuroids exhibited a preference for the leeward side of the dunes and this was examined in four grabs, two from a lee slope and two from stoss dune slopes of the dunes. Ophiuroids were only present in the lee slope grabs, confirming the AUV observations.

The AUV images show that the population is dominated by large ophiuroids and this is also indicated by the size frequency of the animals collected. These had disc diameters between 8 and 15 mm (mean 10.17 mm). In the 2007 grabs the mean diameter was 9.17 mm (n=6, range=7-10mm) and in the 2008 grabs the diameter was 10.43 (n=23, range=5-15mm). For specimens from 2007 and 2008 that had all arms intact, the longest arm had a mean arm length of 149.07 mm (n=27, range=80-220 mm). In total, 18 specimens (3 from 2007 and 15 from 2008) were recovered intact in the grab samples. Ten of these individuals exhibited regeneration (56%). In respect to the total number of arms in these specimens 22% exhibited evidence of regeneration. Juveniles were not present in any grab samples.

Ophiopsila pantherina is bioluminescent and exhibited visible light in a bright green flash that traveled down the arm from proximal to distal.

At 70 metres depth, the EcoPuck Fluorometer mounted on the AUV measured chlorophyll content as approximately 0.8 µg/L. At the sea surface, the AUV collected a reading of approximately 0.45 µg/L.

The Seabed Biodiversity Survey (Pitcher et al. 2007) indicates the sediment type where *Ophiopsila pantherina* were found along the GBR (Figure 4).

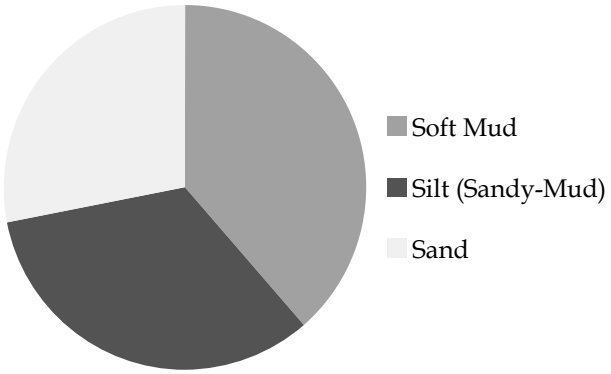

Figure 4. Sediment types where *O.pantherina* specimens were collected by the Seabed Biodiversity Survey (Pitcher et al., 2007). Biomass was larger in soft mud (38%) habitats, followed by silt (33%), and sand (28%) habitats. Less than 1% of specimens were discovered in coarse sand and rocky habitats. No specimens were found in habitats described as sand-waves/dunes, rubble, stones, or bedrock/reefs.

4 DISCUSSION

This survey of subaqueous dune systems at Hydrographers Passage assimilated data from multibeam, seismic profiles, oceanographic instruments, and AUV imagery to understand the seabed environment of the sea floor and generate a visual reconstruction of the *O. pantherina* aggregations.

These ophiuroids extend four arms into the water column to feed while one arm is anchored into the sand. This activity was recorded during the day and contrasts with previous observations of cryptic day time behaviour, which was considered to be an avoidance of predators during the day and extension of arms to feed with at night (Aronson, 1998; Sides, 1987). However the Hydrographers Passage ophiuroids did show evidence of sublethal predation as indicated by the presence of regenerating arms in 56% of the specimens examined. In this case the benefits of day and night time feeding by *O. pantherina* in a high nutrient habitat, as illustrated by the density and extent of the beds, may outweigh the risks from predators. Dense aggregations of ophiuroids appear in Ordovician fossil record and low regeneration rates (< 2%) of these ancient communities suggest that predation pressures were low (Aronson, 1992). The change in modern ophiuroid lifestyle from dense beds to cryptic living in previously observed aggregations has been attributed to the evolution of predators such as teleosts and decapod crustaceans (Aronson, 1989; Aronson, 1992).

Ophiuroids are known to aggregate in large numbers, with hundreds to thousands occurring in one location (Brooks et al., 2007; Grange, 1991; Jensen and Frederiksen, 1992; Metaxas and Giffin, 2004; Metaxas and Griffin, 2004; Pipenburg and Schmid, 1996; Summers and Nybakken, 2000). The *O. pantherina* beds at Hydrographers Passage showed a mean density of approximately 400 animals m^{-2}. Such dense aggregations require high food delivery rates that at Hydrographers Passage are likely to come from high tidal current flow over the dunes and increased nutrient richness at the seafloor (Uthicke et al., 2009; Warner, 1979).

Benthic animals are important for energy cycling within pelagic environments, as most ophiuroids feed on suspended organic material (Brooks et al., 2007; Canuel et al., 2007). The discovery of *O. pantherina* on the leeward sides of the dunes reflects commonly observed behaviour in suspension feeders (Warner 1977). It has been suggested that leeward positioning on topographic high features among eddying reduces current velocities and resuspension of fine material provides a clear feeding advantage (Warner 1977). In addition, by actively seeking conspecifics in highly dynamic areas, ophiuroids accomplish both optimum feeding locations and ensure reproductive success (Broom, 1975; Warner, 1979).

Upwelling is an important mechanism that supports marine life in the oligotrophic waters of the Great Barrier Reef shelf system (Andrews and Gentien, 1982). There is strong upwelling at Hydrographers Passage, resulting in a nutrient-rich environment where flood tides flow through gaps in the relict reef matrix at the shelf break and deliver nutrients to the dune system (Coutis, 2000). The chlorophyll levels at 70 metre depth, 0.8 $\mu g\ L^{-1}$, was higher than at the sea surface, 0.45 $\mu g\ L^{-1}$. The sea surface chlorophyll reading is consistent with the modeled mean surface data over the whole GBR (0.46 $\mu g\ L^{-1}$) as well as offshore areas off of Mackay (0.5 $\mu g\ L^{-1}$) (De'ath and Fabricius, 2008).

A feature of *Ophiopsila pantherina*, as documented here, is its luminescence. This is considered to serve as a defensive mechanism by visually stunning any predatory fishes and invertebrates (Basch, 1988; Grober, 1988a; Grober, 1988b; Vanderlinden and Mallefet, 2004). Although the feeding biology of *O. pantherina* remains to be documented, it seems likely that this species uses bioluminescence as a defensive response to startle predators, thereby reducing predation on exposed arms. In the northeast Pacific *O. californica* uses the startling effect of bioluminescence for defense, utilizing a luminescent range from dim glows to intense proximal-distal flashes (Basch, 1988).

The ability to autotomize and regenerate arms allows recovery from non-lethal predation (Pomoroy and Lawrence, 2001). While arm loss in brittlestars has been attributed to environmental stressors, the

primary cause of autotomy is likely predation (Woodley, 1980; Woodley et al., 1981; Bowmer and Keegan, 1983; Makra and Keegan, 1999; Sides, 1987). Such is likely to be the case in the Hydrographers Passage ophiuroids.

The consistency of disc diameters in the studied populations suggests that the beds were comprised of adults. In the 2007 Seabed Biodiversity Survey report, *O. pantherina* was described as living in soft mud to sandy habitats off the north Queensland coastline, with a particular high biomass occurring in offshore and mid-shelf areas near Rockhampton (23.28º S) (Pitcher et al., 2007). A high biomass from this study occurs in areas described as soft mud and silt, while our study finds high biomass on the medium-grained san dunes occurring at the limit of the outer shelf.

The dense brittlestar beds found at Hydrographers Passage suggests that similar aggregations of ophiuroids may occur in a broader range of seabed habitats than is currently recorded in the waters of tropical Australia. The *O. pantherina* beds represent a new biotic community associated with active dune systems in the Great Barrier Reef Marine Park. Other dune systems, particularly in areas of upwelling, may support other dense aggregations of suspension-feeding ophiuroids. These aggregated ophiuroid communities in dune systems may be a specialized natural feature for consideration in managing inter-reefal habitats within the Marine Park.

5 ACKNOWLEDGEMENTS

Thanks to the captain and crew of RV Southern Surveyor (SS07/2007, SS09/2008). Dr. B. Tilbrook (CSIRO) provided support for SS09/2008. Funded by the Marine National Facility Integrated Marine Ocean Observing System and a grant from National Geographic. Thanks to Niel Bruce and the Museum of Tropical Queensland and Tom Savage of The University of Sydney. Thanks to reviewers for helpful comments.

6 REFERENCES

Andrews, J.C. & Gentien, P. 1982. Upwelling as a source of nutrients for the Great Barrier Reef ecosystem: a solution of Darwin's question? *Marine Ecology Progress Series* 8: 257-269.

Aronson, R.B. 1989. Brittlestar beds: low predation anachronisms in the British Isles. *Ecology* 70: 856-865.

Aronson, R.B. 1992. Biology of scale- independent predator-prey interaction. *Marine Ecology Progress Series* 89: 1-13.

Aronson, R.B. 1998. Decadel-scale persistance of predation potential in coral reef communities. *Marine Ecology Progress Series* 172: 53-60.

Basch, L.C., 1988. Bioluminescent anti-predator defense in subtidal ophiuroid. In: B.e. al (Editor), *Echinoderm Biology*, Rotterdam, Balkema pp. 503-515.

Bowmer, T. & Keegan, B. 1983. Field survey of the occurrence and significance of regeneration in *Amphiura filiformis* (Echinodermata: Ophiuroidea) from Galway Bay, west coast of Ireland. *Marine Biology* 74: 65-71.

Brooks, R.A., Nizinski, M.S., Ross, S.W. & Sulak, K.J. 2007. Frequency of sublethal injury in a deepwater ophiuroid, *Ophiacantha bidenta*, an important component of western Atlantic *Lophelia* reef communities. *Marine Biology* 152: 307-314.

Broom, D.M. 1975. Aggregation behaviour of the brittle-star *Ophiothrix fragilis*. *J. Mar. Biol. Ass. U.K.* 55: 191-197.

Byrne, M. 2009. Flashing stars light of the Reef's shelf. *ECOS* 150: 28-29.

Canuel, E.A., Spivak, A.C., Waterson, E.J. & Duffy, J.E. 2007. Biodiversity and food web structure influence short-term accumulation of sediment organic matter in an experimental seagrass system. *Limnology & Oceanography* 52: 590-602.

Clark, A. & Rowe, F. 1971. Monograph of shallow-water Indo-west Pacific Echinoderms. Trustees of the British Museum (Natural History): 238 pp.

Coutis, P.F. 2000. Currents, coasts and cays: a study of tidal upwelling and island wakes, University of New South Wales, Sydney.

De'ath, G. & Fabricius, K. 2008. Water quality of the Great Barrier Reef: distribution, effects on reef biota and trigger values for the protection of ecosystem health. Final Report to the Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science (Editor), pp. 104.

Forbes, E. 1843. On the radiata of the Ophiuridae of the eastern Mediterranean. Part I: Ophiuridae. *Trans. Linn. Soc. Lond.* 19: 143-153.

Grange, K. 1991. Mutualism between the antipatharian *Antipathes fiordensis* and the ophiuroid *Astrobrachion constrictum* in New Zealand fjords. *Hydrobiologica* 216/217: 297-303.

Grober, M.S. 1988a. Brittle-star bioluminescence as a aposematic signal to deter crustacean predators. *Animal Behaviour* 36: 493-501.

Grober, M.S. 1988b. Responses of tropical reef fauna to brittle-star luminescence (Echinodermata: Ophiuroidea). *Journal of Experimental Marine Biology and Ecology*, 115: 157-168.

Jensen, A. & Frederiksen, R. 1992. The fauna associated with the bank-forming deepwater coral *Lophelia pertusa* (Scleractinaria) on the Faroe Shelf. *Sarsia*, 77: 53-69.

Kingston, S. 1980. The Swain Reefs expedition: Ophiuroidea. *Rec. Aust. Mus.* 33: 123-147.

Koehler, R. 1898. Echinodermes, receuillis par *l'Investigator* dans l'Ocean Indien. II Les ophiures littorales. *Bull. Scient. Fr. Belg.* 31: 55-124.

Makra, A. & Keegan, B. 1999. The Population Dynamics of the Brittlestar *Ophioderma brevispinum* in Near and Farshore Seagrass Habitats of Port Saint Joseph Bay, Florida. *Gulf of Mexico Science* 1999 (2): 87-94.

Metaxas, A. & Griffin, B. 2004. Dense beds of the ophiuroid *Ophiacoantha abyssicola* on the continental slope off Nova Scotia, Canada. *Deep-Sea Research Part I* 51: 1307-1317.

Oak, T. & Scheibling, R.E. 2006. Tidal activity pattern and feeding behaviour of the ophiuroid Ophiocoma scolopendrina on a Kenyan reef flat. *Coral Reefs* 25: 213-222.

Pipenburg, D. & Schmid, M. 1996. Brittle star fauna (Echinodermata: Ophiuroidea) of the Arctic northwestern Barents Sea: composition, abundance, biomass and spatial distribution. *Polar Biology* 16: 383-392.

Pitcher, C.R., Doherty, P., Arnold, P., Hooper, J. & Gribble, N. 2007. Seabed Biodiversity on the Continental Shelf of the Great Barrier Reef World Heritage Area, AIMS/CSIRO/QM/QDPI CRC Reef Research Task Final Report. 320pp.

Pomoroy, C. & Lawrence, J. 2001. Arm regeneration in the field in *Ophiocoma echinata* (Echinodermata: Ophiuroidea): effects on body composition and its potential role in a reef food web. *Marine Biology* 135: 57-63.

Rowe, F. & Gates, J. 1995. Echinodermata. In: A. Wells (Editor), Zoological Catalogue of Australia. CSIRO Australia, Melbourne.

Sides, E. 1987. An experimental study of the use of arm regeneration in estimating rates of sublethal injury on brittlestars. *Journal of Experimental Marine Biology and Ecology* 106: 1-16.

Summers, A. & Nybakken, J. 2000. Brittlestar distribution patterns and population densities on the continental slope off central California (Echinodermata: Ophiuroidea). *Deep-Sea Research Part I* 47: 1107-1137.

Uthicke, S., Schaffelke, B. & Byrne, M. 2009. A boom and bust phylum? Ecological and evolutionary consequences of density variations in echinoderms. *Ecological Monographs* 79: 3-24.

Vanderlinden, C. & Mallefet, J. 2004. Synergic effects of tryptamine and octopamine on ophiuroid luminescence (Echinodermata). *The Journal of Experimental Biology* 207: 3749-3756.

Warner, G. 1979. Aggregation in Echinoderms. In: G. Larwood and B.R. Rosen (Editors), Biology and Systematics of Colonial Organisms. Academic Press, London.

Warner, G.F. 1977. On the shapes of passive suspension feeders. Proceedings of the eleventh European symposium on marine biology. University College, Galway. Pergamon Press, Oxford, 567-576 pp.

Warner, G.F. & Woodley, J.D. 1975. Suspension-feeding in the brittle-star *Ophiothrix fragilis*. *J. Mar. Biol. Ass. U.K.* 55: 199-210.

Webster, J.M. Beaman, R.J., Bridge, T., Davies, P.J., Byrne, M., Williams, S., Manning, P., Pizarro, O., Thornborough, K., Woolsey, E., Thomas, A. & Tudhope, S. 2008. From corals to canyons: the Great Barrier Reef Margin. *Eos* 89: 217-218.

Woodley, J.D. 1980. Hurricane Allen destroys Jamaican coral reefs. *Nature* 287: 387.

Woodley, J.D., Chornesky, E.A., Clifford, P.A., Jackson, J.B.C., Kaufman, L.S., Knowlton, N. et al. 1981. Hurricane Allen's impact on Jamaican coral reefs. *Science*, 60: 35-45.