SHORT COMMUNICATION

Notes on fauna associated with an opportunistic artificial reef near cold-water corals

JOSÉ NUNO GOMES-PEREIRA, F. TEMPERA, P.A. RIBEIRO & F.M. PORTEIRO

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José Nuno Gomes-Pereira (josenunopereira@uac.pt), F. Tempera, P.A. Ribeiro & F.M. Porteiro, Department of Oceanography and Fisheries, Centre of IMAR of the University of the Azores, Rua Prof. Frederico Machado nº4, 9901-862 Horta, Faial, Açores, Portugal.

INTRODUCTION

Artificial reefs (AR) of many different designs and materials have been widely used for various purposes, from habitat protection and enhancement to recreational diving (Polovina 1991; Bortone et al. 2011). With more than 250 ARs covered by scientific literature world-wide (Baine 2001), very few studies concern areas deeper than 60 metres, reflecting the majority of deployment and vertical depth limits for SCUBA operations. Concurrently, with the deepening of fisheries (Morato et al. 2006) and the advent of optical and submersible technology, the ecological importance of cold water coral (CWC) habitats has become the focus of many recent large research programs. These deep-water "habitat-building species" alter sediment deposition and provide complex structural habitat (Roberts et al. 2006), considered essential for diverse fish and invertebrate communities (e.g. Reed 2002).

Opportunistic fish behaviour towards habitat is a relatively well known response from habitat complexity studies on shallow natural (Harding & Mann 2001), and artificial reefs (Gratwicke & Speight 2005). Observations of deep-water AR have demonstrated that local fish populations tend to utilise artificial structures similarly to other biological or geological reefs available (e.g. Koening et al. 2004; Husebø et al. 2002), even though differences may be found in comparison with natural reef fish communities (Clark & Edwards 1994). Thus, ARs can contribute to a better understanding on the use and importance of available habitats (Hixon & Beets 1989), while simplified structures can facilitate the observation of juvenile fish (Gorham & Alevizon 1989), usually hampered by the presence of larger fish (Ross & Quattrini 2007). This short communication provides a sporadic insight on the importance of a hard three-dimensional structure for deep-water fish near CWC. Fish size and behaviour inside the structure and in the surrounding area are described. Additionally, a list of biofouling macroorganisms found on the structure after one year of deployment is presented.

MATERIAL AND METHODS

Our observations were concentrated on a stainless steel framework, deployed for 375 days (29 July 2009 to 08 August 2010) on the Condor Seamount summit at 230 m depth (38º31.878'N, 029º01.944'W) (Figs. 1 and 2; see Tempera et al. 2012 for details on Condor seamount). The area was in close proximity (~2 m) to a coral garden growing on mixed unconsolidated-consolidated hardground dominated by the plexaurid gorgonian cf. *Dentomuricea*, together with sparse

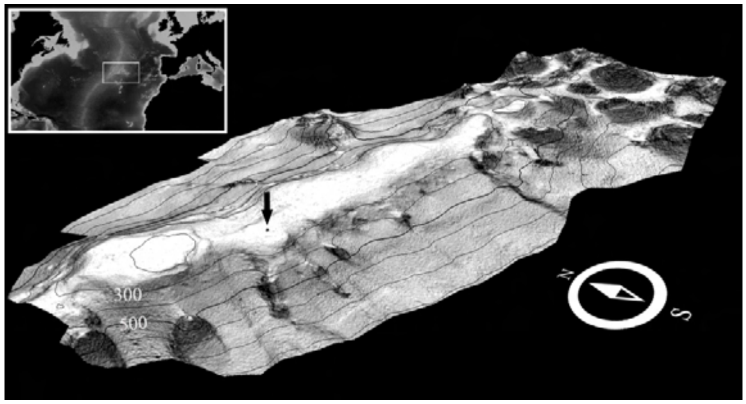

Fig. 1. Location of the opportunistic artificial reef on Condor seamount.

Viminella flagellum and hydroids cf. *Polyplumaria* forming canopy up to 1 m high (Tempera et al. 2012).

The one metre high structure was pyramidal in shape, and attached to a square cement base with a leveled top holding an Acoustic Doppler Current Profiler (ADCP). The structure varied in width between 170 cm at the base and 113 cm at the top, while at mid-height it was 176 cm wide due to four extruding floaters (Fig. 2a). In view of the divergence between this structure and the most common definition of artificial reef - a submerged structure deliberately placed on the substratum (seabed) to mimic some characteristics of a natural reef (Jensen 1998) - this was therefore considered an “opportunistic Artificial Reef”. The structure and associated fish fauna were inspected for 38:08 minutes by the remotely-operated vehicle (ROV) “Luso”, recording full HD digital video. Removal of the top component occurred 17:01 minutes after the beginning of inspection, by mechanically releasing the metal framework and ADCP from the cement base.

Fish presence and relation to the opportunistic AR were analysed from video images using the video annotation software COVER ©Ifremer. A transition zone including 3 m outwards from the sand-reef interface was considered. All visible species were identified to the lowest possible taxon, counted and measured when possible. Each fish was considered a separate event, except for juvenile *Anthias anthias* due to size and schooling behaviour. Behaviour was annotated conservatively (Stoner et al. 2008), including ‘response to ROV’ (*escape*/*hide*/*no reaction*) and ‘response timming’ (*before detection*/*far from ROV*/*close to ROV*/*no reaction*). All fish that reacted ‘before detection’ or ‘not clear’ were excluded from subsequent analysis. Other behaviour recorded included ‘locomotion’ (*no locomotion*/*slow forward movements*/*station holding*), ‘position in the water’ (*sitting on bottom*/*less than one body length*/*< 0.5m*/*0.5-1m off bottom*) and ‘position to AR’ (*below*/*next to*/*sitting on*/*within*), ‘distance to AR’ (*in contact*/*<1 body length*/*<1 AR length* (1.20m)). Fish size estimations and distances from the AR were calculated using known measures from the AR with “ImageJ” (Abramoff et al. 2004). Twelve measurements were made per individual to minimise errors and average sizes are presented.

After retrieval of the structure onboard, the invertebrate fouling fauna was measured and the largest sizes of main taxa were recorded. Samples of representative taxa were preserved in 96% ethanol and kept in the reference collection “COLETA” at the Department of Oceanography and Fisheries, from the University of the Azores.

RESULTS AND DISCUSSION

The opportunistic AR was utilised by seven benthic fish species (N=18), observed in contact or swimming in the vicinity of the AR. Fish size and behaviour are presented in Table 1.

Table 1. Fish number, size and behavior: position in the water and relation to the artificial reef; **Callanthias ruber* position is not indicated once it was not identifiable at distance.

Lower taxon	Nº	TL (cm)	Position in the water	Position rel to AR	Distance to AR	Locomotion	Response timming	Response to ROV
A. anthias	1	11.52	Less than 0.5 m off bottom	next to AR	<1 body length	Station holding	Far from ROV	Slow escape
A. anthias	1	3.29	0.5-1 m off bottom	within AR	-	No locomotion	Far from ROV	Hide
A. anthias	7	3.53 - 4.49	1 body length to 1 meter off bottom	next to AR	<50 cm	Slow forward mov.	Far from ROV	Hide
A. anthias	2	3.27 - 3.58	Sitting on AR	below AR	In contact	No locomotion	Far from ROV	Slow escape
*C. ruber**	1	4.23	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
C. conger	1	135 - 160	Sitting on bottom	within AR	in contact	No locomotion	Close to ROV	Escape
H. dactylopterus	1	n.a.	Sitting on bottom	next to AR	<120 cm	No locomotion	No reaction	No reaction
Moridae	1	9.58	Less than 1 body length off bottom	within AR	Not clear	Not clear	After AR removal	No reaction
P. kuhlii	1	22.05	Sitting on bottom	sitting on	in contact	No locomotion	Close to ROV	Slow escape
Undetermined	1	n.a.	Sitting on bottom	next to AR	<120 cm	No locomotion	No reaction	No reaction

Table 2. List of sessile invertebrate fauna from the artificial reef; Maximum size in cm from visual inspection, ^{h} for height, ^{w} for width (in *C. longispinus* concerns the shell); measures are from *in situ* data, and do not correspond to the repository samples indicated (repository COLETA, from the Department of Oceanography and Fisheries, University of the Azores)

PHYLUM	CLASS	ORDER	FAMILY	Lower taxa	Nº	Size max (cm)	Average (cm)	Repository Code
BRYOZOA	Stenolaemata	Cyclostomatida	Tubuliporidae	cf. *Idmidronea*	>10	3.85^{w}	1.77	DOP-7440
BRYOZOA	Stenolaemata	Cyclostomatida	Tubuliporidae	Tubuliporidae	?	-	-	-
CNIDARIA	Hydrozoa	Leptothecata	Aglaopheniidae	*Aglaophenia* sp.	>10	2.90^{h}	-	DOP-7441
CNIDARIA	Hydrozoa	Leptothecata	Lafoeidae	*Acryptolaria* sp.	>10	6.25^{h}	-	DOP-7442
CNIDARIA	Hydrozoa	Leptothecata	Campanulariidae	*Obelia* sp.	>10	1.85^{h}	-	-
MOLLUSCA	Gastropoda	Trochoidea	Calliostomatidae	*Calliostoma* sp.	1	0.91^{h}/ 0.84^{w}	-	DOP-7443
MOLLUSCA	Gastropoda	Trochoidea	Trochidae	*Clelandella azorica*	1	0.77^{h} / 0.58^{w}	-	DOP-7444
ECHINODERMATA	Echinoidea	Diadematoida	Diadematidae	*Centrostephanus longispinus*	1	0.91^{w}	-	-
ANNELIDA	Polychaeta	Sabellida	Serpulidae	Filograninae undet.	>10	-	-	-

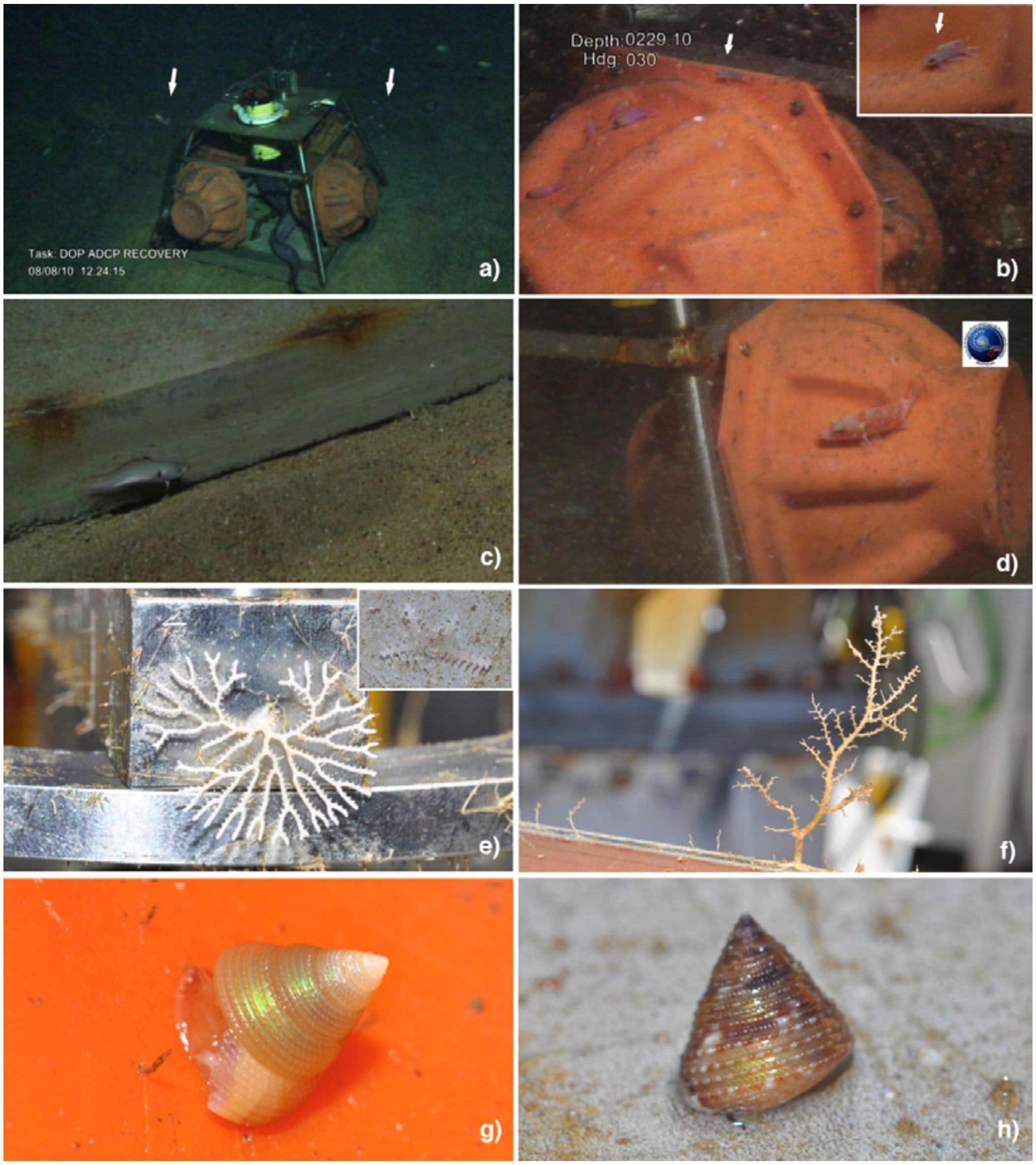

Fig. 2. Fauna associated with the artificial structure: a) general view of opportunistic AR with indication of adult *A. anthias* (left arrow) and school of juveniles (right arrow); b) juvenile *A. anthias* and *C. ruber* (indicated with arrows); c) undetermined Moridae circling the cement base; d) young *P. kuhlii* sitting on floaters; e) cf. *Idmidronea* (with top right insert of undet. Tubuliporidae), f) *Acryptolaria* sp., g) *Clelandella azorica*, h) *Calliostoma* sp.

All fish maintained their behaviour in relation to the artificial habitat throughout the 17 minutes of observations. Exceptions were adult *A. anthias* and *C. conger* that left the area during this period, as well as most juvenile *A. anthias* that swam towards the artificial structure (Fig. 2b). Besides the first two, the specimens observed near the AR were all juveniles (Fig. 2a). The juvenile *A. anthias* and one *Callanthias ruber* were within similar size ranges (*A. anthias* averaged 3.8, STD=0.53; Table 1). These were differentiated based on the purple body and a stocky yellow head of *A. anthias*, in contrast to a pallid and elongated *C. ruber*, with a straight dorsal fin profile (Fig. 2b). The undetermined Moridae was also a young stage, and *Pontinus kuhlii* was estimated to be between 7-8 years old (Isidro 1996; Krug et al. 1998; Fig. 2c,d), which is also likely an immature individual (Estácio et al. 2001).

The role of reefs in mediating processes of predation and competition by providing refuge for settling recruits is a concept known both from tropical natural and artificial reefs (Hixon & Beets 1989; Hixon 1991). The number of juvenile *A. anthias* was smaller than the hundreds of *Hemanthias vivanus* observed over *Oculina* reefs in Florida waters, using the coral branches for protection and feeding (Reed 2002). In this study the juvenile *A. anthias* reacted to the ROV "Luso" by hiding and placing themselves on the floater depressions, remaining in contact with the synthetic surface and reducing their exposure to the strong currents generated by the ROV thrusters (Fig. 2b).

The solitary macro-carnivorous *Conger conger* and *P. kuhlii* were using the structure, while *H. dactylopterus* and one undetermined species occupied the surrounding area, sitting on unconsolidated sediments. Species occurring near the artificial structure with reactions *before detection* or *not clear*, were the highly mobile *Pagellus bogaraveo* and *Trachurus picturatus*, together with one benthic *Helicolenus dactylopterus*, and three adult *A. anthias* (not in Table 1).

The invertebrate biofouling fauna attached to the AR comprised organisms from five different phyla, including rapidly growing sessile bryozoa and hydrozoa, one juvenile echinoderm and juvenile gastropods. No exact quantification was accomplished and species with a large number of individuals are indicated (Table 2, Fig. 2e-h). This data aims solely to provide clues on the growth rates of these species. Settlement of sessile invertebrate occurred from August onwards, hence maximum sizes should consider at least 12 months of growth. Even though AR may develop fouling assemblages different from epibioses on natural substrata (Carr & Hixon 1997), the relevance of these observations derives from the lack of taxonomic and ecological information on most of the species recruiting to CWC habitats. Samples are available for future studies.

The opportunistic AR proved useful in providing preliminary insights on the behaviour and habitat association of some bottom fish from CWC areas. Higher diversities of juvenile fish are often associated with increased habitat complexity (Gorham & Alevizon 1989; Hixon 1991). In comparison, the structure provided a more complex habitat than the CWC area in the vicinity, if only the living component is considered. Neither the fan shaped cf. *Dentomuricea*, nor the whip coral *V. flagellum*, can provide the number of cavities for sheltering *C. conger*, or juvenile *A. anthias* as the opportunistic AR in this study. Future research should include (non-opportunistic) reef design, orientated to study the importance of CWC 3D structures versus coral and rocky reefs (Carr & Hixon 1997; Auster 2005; Tissot et al. 2006), including temporal observation from visual inspection and/or automatic releases.

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