

Notes on a remotely operated vehicle survey to describe reef ichthyofauna and habitats – Agulhas Bank, South Africa



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Background: Despite their ecological and economic importance, reef habitats on the central Agulhas Bank, off the southern tip of Africa, remain poorly studied. The ichthyofauna of these habitats cannot be surveyed using trawl gear.

Objective: Preliminary assessment of the use of a remotely operated vehicle (ROV) to investigate the ichthyofauna associated with deep reef habitats on the central Agulhas Bank.

Method: Underwater visual surveys were carried out during ROV dives (maximum duration 60 minutes; area covered approximately 800 m²; maximum dive depth 100 m).

Results & discussion: The number of detected fish species (36) compares well with that reported from fishing surveys and commercial fisher data. Most (68%) fishes appeared to be undisturbed by the ROV. Species saturation was reached after a maximum of 135 minutes survey time, but species numbers increased and saturation times shortened (34 minutes minimum) with the introduction of bait.

Conclusion: ROV surveys may represent a non-extractive alternative to assess demersal ichthyofaunal diversity in relation to habitat structure and benthic cover on temperate reefs around South Africa.

Introduction

Surveys of the marine ichthyofauna associated with temperate reefs are challenging because, unlike soft sediment, these habitats cannot be surveyed with trawl gear (Sink *et al.* 2012). Reefs often harbour complex species assemblages, stratified according to physical and biological gradients (Ross & Quattrini 2007; Söfker, Sloman & Hall-Spencer 2011). Survey methods for such habitats have mostly been confined to diver-based underwater visual census (UVC) for shallow depths (<30 m) (Assis *et al.* 2013) and traps, hooks and line fishing for deeper depths (>30 m) (Söfker *et al.* 2011). Recently developed remote video-based methods have produced promising results (Cappo, Speare & De'ath 2004; Stoner *et al.* 2008). Unlike stationary video sampling methods such as baited remote underwater video (BRUV) surveys (Cappo, Speare & De'ath 2007), remotely operated vehicle (ROV) surveys, like diver-based UVC, allow for a comprehensive inspection of the sampling area and can also be used within a standardised sampling design in the form of transects or fixed, baited stationary deployments. Here we report on the first ROV dives to investigate the deep reef ichthyofauna and its associated habitats on the central Agulhas Bank. In addition to general habitat observations, we were interested in (1) fish behaviour towards a ROV, (2) deployment times sufficient to detect representative species assemblages and (3) the number of fish species detected relative to other surveys.

Methods

Study area

The Agulhas Bank is the centre of abundance for a number of southern African warm temperate demersal reef species, many of which are endemic (Sink *et al.* 2012). Most of the hard substrate habitats of the Agulhas Bank remain poorly researched (Götz *et al.* 2014; Smale *et al.* 1993).

Dates: Received: 07 June 2016; Accepted: 19 Oct. 2016; Published: 03 Dec. 2016

How to cite this article: Makwela, M.S., Kerwath, S.E., Götz, A., Sink, K., Samaai, T. & Wilke, C.G., 2016, 'Notes on a remotely operated vehicle survey to describe reef ichthyofauna and habitats – Agulhas Bank, South Africa', *Bothalia* 46(1), a2108. <http://dx.doi.org/10.4102/abc.v46i1.2108>

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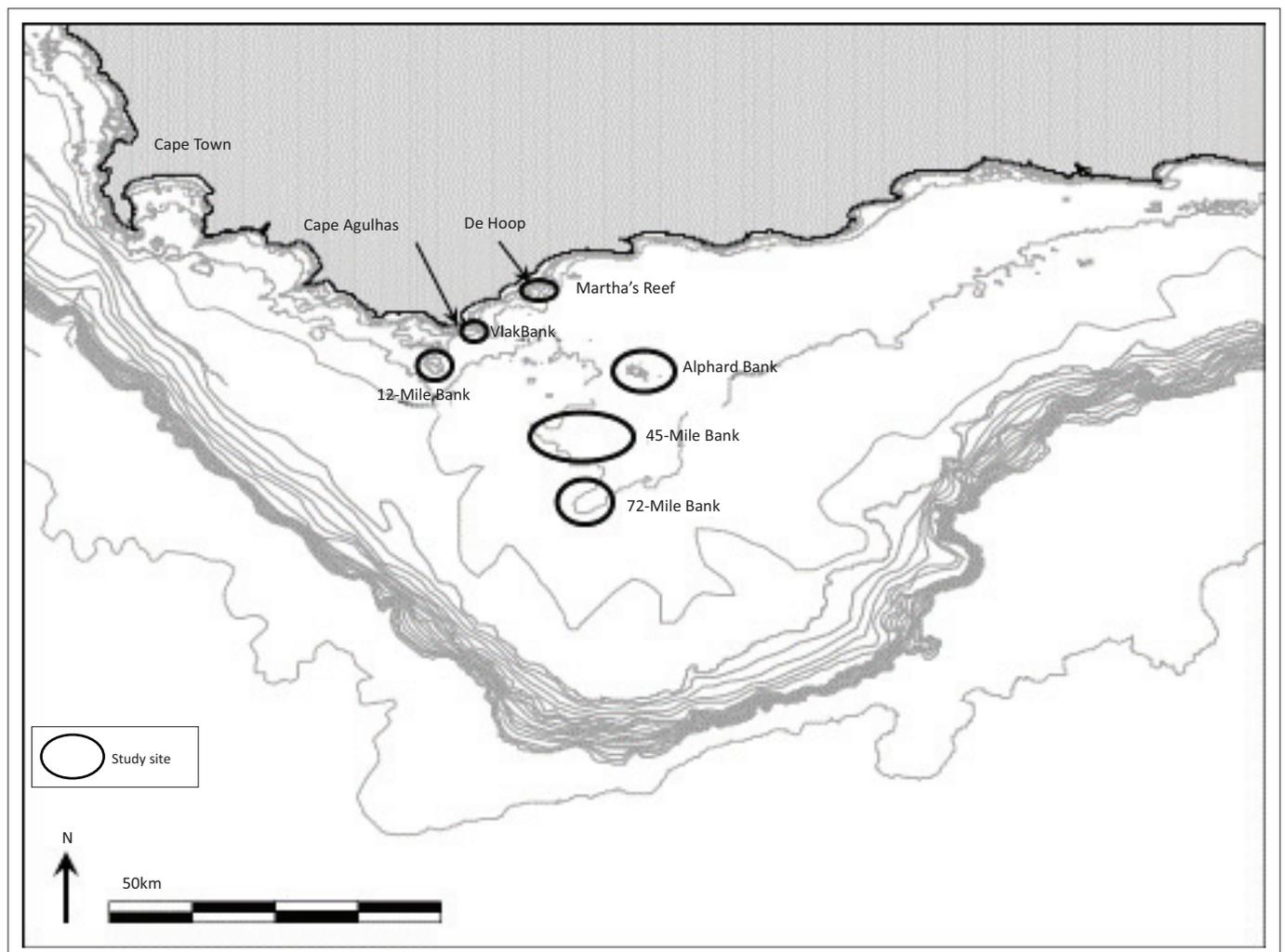
Six sites were surveyed on the central Agulhas Bank during summer 2009 to 2010, namely Vlak Bank, Martha's Reef, 12-Mile Bank, Alphard Bank, 45-Mile Bank and 72-Mile Bank. The former four were surveyed during dedicated research voyages with the *RV Ellen Khuzwayo*; the latter two during a 2009 survey with the *Seacor Achiever* dedicated to assessing the impact of petroleum infrastructure on the area (Sink *et al.* 2010) (Figure 1).

Survey dives

A Seaeye Falcon ROV (SAAB, system 12177) was used to carry out the surveys. The ROV dives from the *RV Ellen Khuzwayo* were carried out on anchor, and the *Seacor Achiever* was able to maintain position above the dive stations. At each of the six sites, four ROV dives of between 45 and 60 minutes each were conducted consecutively at adjacent locations 0.5 km apart. Cumulative dive times per site amounted to between 180 and 240 minutes, and dives usually covered an area of approximately 800 m². Although the pilot attempted to fly the device close (~2 m) to the seafloor to allow for recognition of the sessile marine life, the difficulty of maintaining a constant distance to the seafloor over diverse,

high-profile reef in considerable currents precluded standardised transects. The general habitat characteristics for each site were assessed following the methodology of Götz *et al.* (2009), in terms of substrate composition, reef profile (low, medium and high), rugosity (low and high) and benthic cover.

At the site with the highest ichthyofauna diversity (Martha's Reef), species behaviour towards the ROV was recorded as follows: positive, if the fishes were attracted and swam towards the vehicle; negative, if the fishes were visibly disturbed and altered their behaviour to avoid the vehicle; neutral, if no behavioural reaction was evident. In addition, ROV motion at the time of observation was noted as 'stationary' or 'moving'. At four of the six sites, species saturation was determined by noting individual video times when new species were detected. At two sites, after an initial reconnaissance period, a weighted bait bag with pilchard (*Sardinops sagax*) was lowered down at the end of a 10-mm rope to the sea floor in the vicinity of the ROV to attract more fishes to the survey area. Overall ichthyofaunal diversity was compared to fishing survey reports and commercial fishing data from the same sites



Source: DAFF, DEA & SAEON unpublished data

FIGURE 1: Bathymetric map of the South African south coast with locations of ROV dive sites on prominent reefs on the central Agulhas Bank.

(Table 3, Götz *et al.* 2014, Department of Agriculture, Forestry and Fisheries [DAFF], unpublished data).

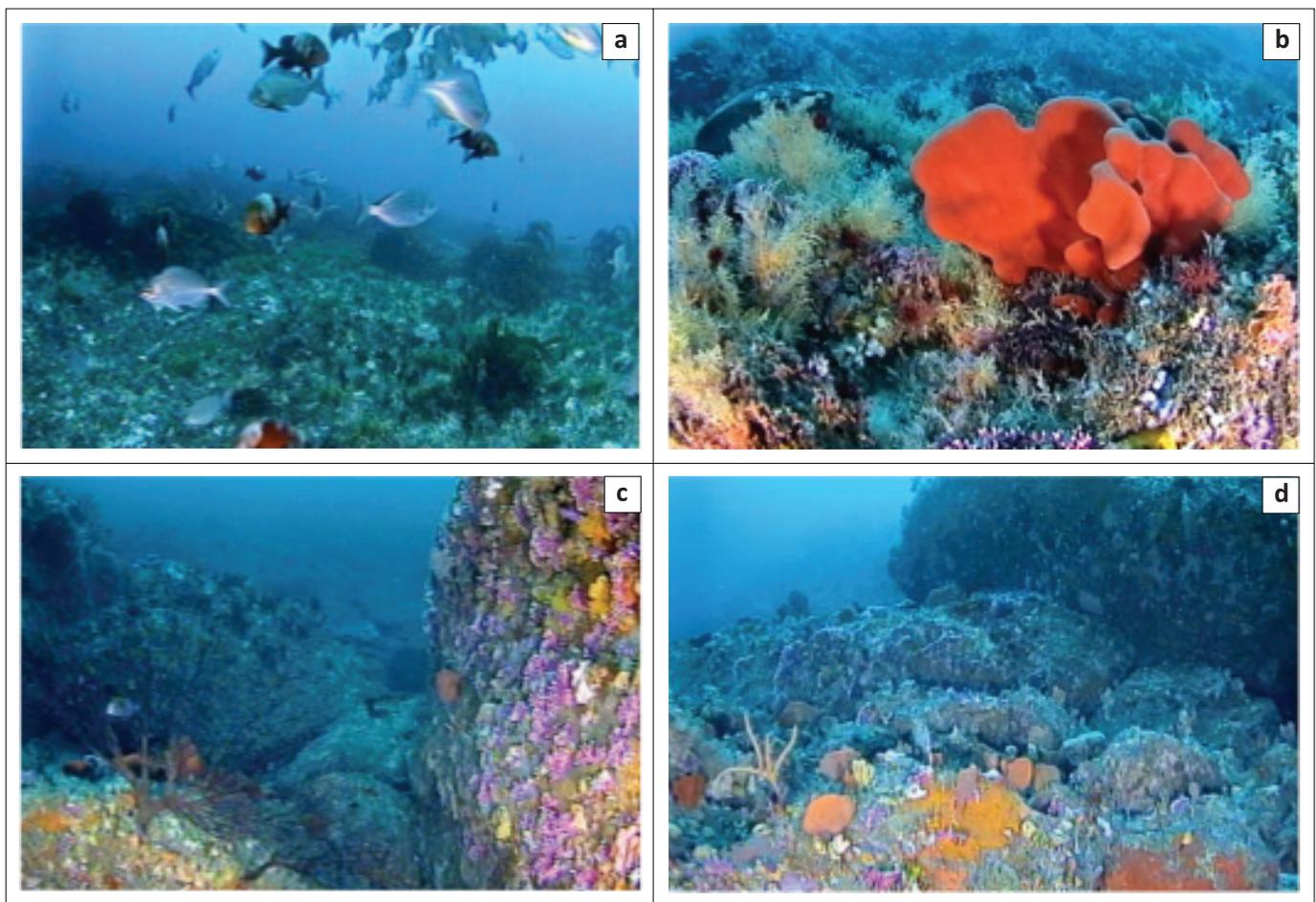
(Japp, Sims & Smale 1994) and dredging (Götz *et al.* 2014; Samaai, Janson & Kelly 2012).

Results and discussion

Although ROVs have been used to study abundance and behaviour of fish communities beyond SCUBA diving depth since the early 2000s (Harvey *et al.* 2007; Widder *et al.* 2005), their use in South Africa has been limited (Roberts *et al.* 2006). Although our findings should be regarded as preliminary because of the small sample size and the exploratory nature of the observations, they represent the first ichthyofaunal (and habitat) ROV survey on the Agulhas Bank mesophotic reefs. Previously, these habitats were assessed only with indirect methods like fishing

General description of study sites

The ROV surveys in this study revealed complex, diverse reef habitats (Figure 2), which differed considerably in profile, rugosity, sand inundation and benthic invertebrate cover (Table 1). The survey at the Vlak Bank between 20- and 30-m water depths revealed patchy, low-profile reef habitat interspersed with sandy areas. The reef itself was of low rugosity and heavily inundated with sand. Massive (up to 50-cm height) wall sponges (*Spirastrella* spp), gorgonians (*Eunicella* spp) and red algae dominated the benthic biota. Martha's Reef was surveyed in an area with rocky ridges of



Source: DAFF, DEA & SAEON unpublished data

FIGURE 2: ROV video footage illustrating the diverse habitats found on the mesophotic reefs on the Agulhas Bank and associated ichthyofauna.

TABLE 1: Description of habitat characteristics of the six study sites evaluated from remotely operated vehicle footage.

Study site	Substrate	Reef profile	Rugosity	Benthic cover
Vlak Bank	Variable	Low	Low	<i>Spirastrella</i> spp and <i>Eunicella</i> spp dominated
Martha's Reef	Rocky reef with few sandy patches	Medium	High	Bryozoan, red algae and sponge dominated sponges mostly small, erect, spherical or encrusting
12-Mile Bank	Rocky reef	High	Low	Covered by <i>Ecklonia radiata</i> to a depth of 35 m below dominated by <i>Stylaster</i> spp, small sponges and ascidians
Alphard Bank	Rocky reef with few sandy grooves	High	Low	Covered by <i>Ecklonia radiata</i> in the 15–35 m depth zone abruptly giving way to <i>Eunicella</i> , <i>Stylaster</i> and sponges
45-Mile Bank	Rocky reef partly inundated by sand	Low	Low	Sparsely covered, dominated by small morphotypes of sponges, octocorals and <i>Stylaster</i>
72-Mile Bank	Rocky reef partly inundated by fine dark sediment	Low	Low	Dominated by sponges particularly the tubular sponge <i>Biemna anisotoxa</i> , octocorals, <i>Stylaster</i> spp. and black corals

Source: DAFF, DEA & SAEON unpublished data

medium profile at 30-m depth, with high rugosity and dense benthic growth dominated by bryozoans, red algae and sponges. Sponges were mostly small (>10 cm), erect or spherical but included some encrusting forms.

The survey on the 45-Mile Bank was carried out on extensive, sparsely populated, low-profile reef at 70-m depth, with low rugosity, partly inundated with sand. The benthic fauna comprised morphotypes dominated by *Stylaster nobilis* species (noble coral). The 12-Mile Bank was covered by kelp (*Ecklonia radiata*) at the ROV dive site to a depth below 35 m. The reef was high in profile but low in rugosity. *Stylaster nobilis* and small to massive forms of sponges and ascidians dominated the deeper areas. The steep, conical pinnacles of the Alphard Bank were covered by kelp in the 15- to 35-m depth zone where kelp cover ends abruptly and gives way to gorgonians (*Eunicella* sp.), hydrocorals (*S. nobilis*) and sponges. The site on the 72-Mile Bank was of low profile and low rugosity, and the reef was partly inundated by fine, dark sediment. Benthic growth was sparse, as was expected considering the reduced light penetration at the diving depth of 70 m, and was mostly restricted to delicate gorgonians (*Eunicella* spp), whip corals (possibly *Ctenocella*) and sponges.

Fish behaviour towards ROV

Few studies have evaluated fish behaviour towards ROVs (Ross & Quattrini 2007). Stoner *et al.* (2008) reviewed behavioural responses to ROVs, which they broadly classified as attraction or avoidance. Responses may not be only species and size specific, but also depend on size, illumination, sound emission and speed of the vehicle. Our findings suggest that most species (68%) behaved neutrally towards the vehicle (Table 2). Positive reaction mostly occurred when sediment and benthic growth were stirred up by down-thrusting, attracting omnivorous and herbivorous small

TABLE 2: Behavioural response (*O* = neutral, *N* = negative and *P* = positive) to mobile (M) and stationary (S) ROV encountered at Martha's Reef. Number denotes individuals per species encountered during the dives.

Species	Behaviour			ROV mode
	<i>O</i>	<i>N</i>	<i>P</i>	
Bank steenbras	2	0	0	M
Blacktail	2	0	0	M, S
Blue hottentot	0	0	5	M
Cape knifejaw	2	0	0	M, S
Fransmadam	0	0	2	M, S
Giant yellowtail	>30	0	0	M
Hottentot	0	0	7	M, S
Janbruin	2	0	0	M, S
Striped catshark	1	0	0	M
Redfingers	3	0	0	M, S
Red stumpnose	0	0	1	M
Roman	0	0	3	M, S
Strepie	>30	0	0	M
Steentjie	>30	0	0	M
Twotone fingerfin	5	0	0	M, S
White sea catfish	1	0	0	M
Windtoy	1	0	0	M
Yellowbelly rockcod	0	1	0	M
Zebra	4	0	0	M, S

Source: DAFF, DEA & SAEON unpublished data

shoaling species such as fransmadam (*Boopsoidea inornata*) and hottentot seabream (*Pachymetopon blochii*). Only yellowbelly rockcod (*Epinephelus marginatus*) were repelled by the ROV and hid in holes in the reef. These effects need to be taken into account in future surveys, but alternative survey methods have their own inherent bias (Bernard *et al.* 2014; Watson *et al.* 2005).

Species detection

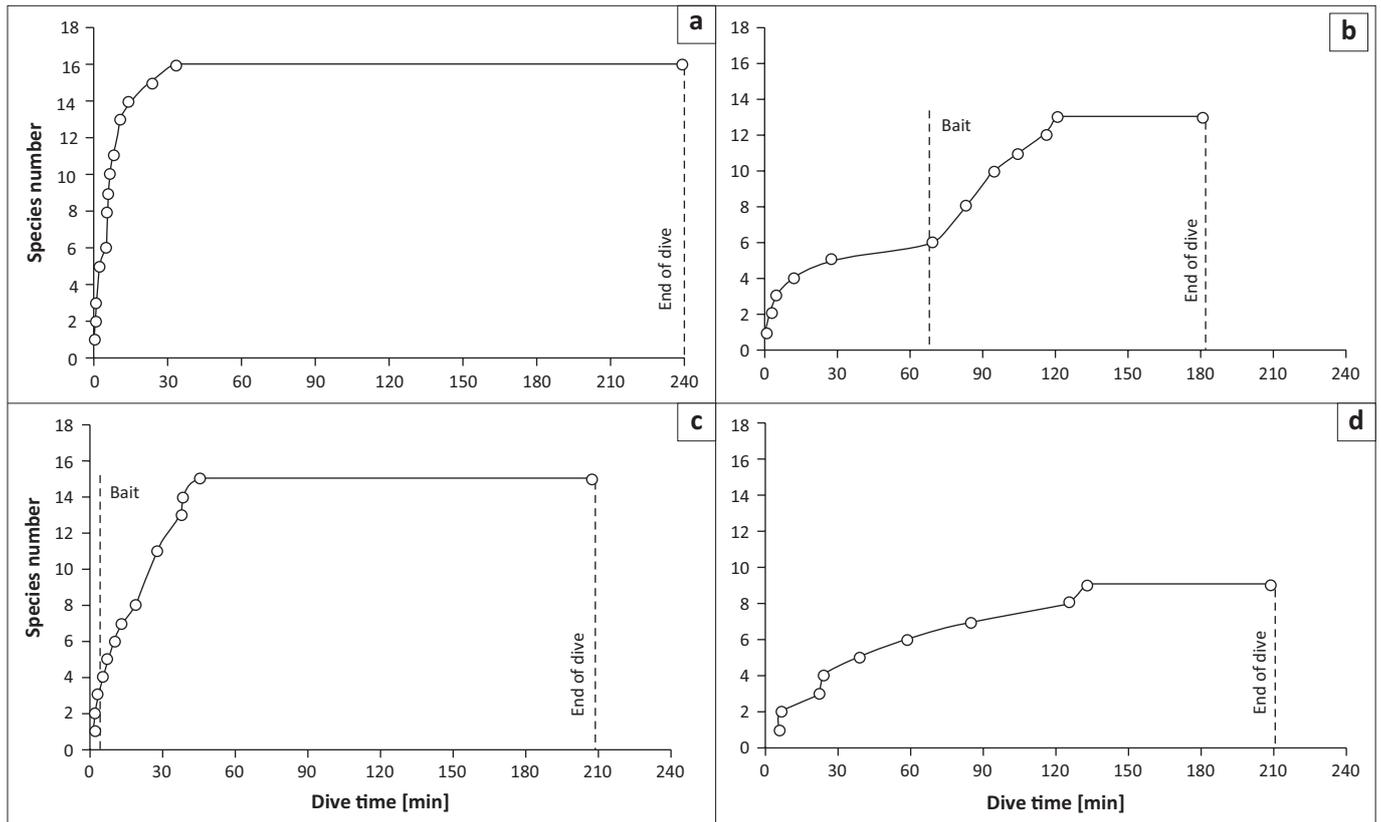
Species richness and saturation varied considerably among dives (Figure 3). Minimum and maximum time of species saturation was reached at 34 and 133 minutes, respectively, depending on location (Figure 3). Additional deployment of bait tested during two dives shortened the species saturation time (Figure 3b and c). A total of 35 species were detected, with the number per individual site ranging between 9 and 19 species. Overall detection numbers are similar to those of research fishing surveys (Götz *et al.* 2014) and to those reported by the commercial line fishery (30 species reported over 10 years) (Table 3, DAFF unpublished data). Five species were detected solely by ROV, but two could only be identified to genus and family level. Most of the common, resident species were detected (Table 3), and omissions of shoaling species such as horse mackerel (*Trachurus capensis*) and large, solitary chondrichthyans might be ascribed to the short survey time. Although the deployment of bait accelerated species detection (Sink *et al.* 2010), ROV surveys have the added advantage of direct exploration of the seascape and the capability of detecting cryptic species and species that are not attracted to bait.

Conclusions

This survey has shown that ROV-based assessments of the ichthyofauna associated with temperate reefs in South Africa may present an alternative to existing methods and the only one that can directly relate ichthyofaunal observations to the surrounding seafloor environment. Unlike stationary video sampling methods such as BRUV surveys (Cappo *et al.* 2007), ROV surveys allow for a comprehensive inspection of the sampling area. Considering that ROV surveys yielded similar species numbers compared to previous survey methods based on fishing and species accumulation curves compare well with those of BRUV surveys (Cappo *et al.* 2007), this approach is potentially useful where rapid assessments of species diversity within a complex habitat are required.

Acknowledgements

Funding was provided by the Department of Agriculture, Forestry and Fisheries (DAFF), the Department of Environmental Affairs – Oceans and Coasts (DEA–O&C) and the National Research Foundation (Grant Number 80970). The Elwandle Node of the South African Environmental Observation Network (SAEON) also provided assistance. The ROVs were provided by the South African Institute for Aquatic Biodiversity (SAIAB) and through a co-operative research partnership with PetroSA. The officers and crew of



Source: DAFF, DEA & SAEON unpublished data

FIGURE 3: Species accumulation curves for four ROV dives at (a) Martha's Reef, (b) Vlak Bank, (c) Alphard Bank and (d) 12-Mile Bank. Introduction of bait and termination of the dive are indicated by stippled lines.

TABLE 3: Presence-absence data for fish reported from research angling (RA), fish traps (FT), underwater visual census (UVC), demersal long lines (LL), remotely operated vehicle (ROV) and commercial catch data from the National Marine Linefish System (NMLS) between 2000 and 2013.

Species	RA	FT	UVC	LL	ROV	NMLS
Baardman (<i>Umbrina robinsoni</i>)	-	-	*	-	-	-
Bank steenbras (<i>Chirodactylus grandis</i>)	-	-	*	-	*	-
Barred fingerfin (<i>Cheilodactylus pixi</i>)	-	-	*	-	-	-
Black musselcracker (<i>Cymatoceps nasutus</i>)	*	-	-	-	-	*
Blacktail (<i>Diplodus capensis</i>)	*	*	*	-	*	*
Blue hottentot (<i>Pachymetopon aeneum</i>)	*	*	*	-	*	-
Bluefin gurnard (<i>Chelidonichthys kumu</i>)	*	-	-	-	-	-
Cape gurnard (<i>Chelidonichthys capensis</i>)	*	-	-	-	-	*
Cape knifejaw (<i>Oplegnathus conwayi</i>)	-	-	*	-	*	-
Cape stumpnose (<i>Rhabdosargus holubi</i>)	-	-	*	-	-	-
Carpenter (<i>Argyrozona argyrozona</i>)	*	*	*	*	*	*
Clinid (<i>Clinus sp</i>)	*	-	-	-	-	-
Congiopodus sp 1	-	-	-	-	*	-
Copper shark (<i>Carcharhinus brachyurus</i>)	-	-	-	-	-	*
Dageraad (<i>Chrysoblephus cristiceps</i>)	-	-	-	-	-	*
Dark shyshark (<i>Haploblepharus pictus</i>)	-	*	-	-	-	-
Dogfish sp (<i>Squalus sp</i>)	*	*	-	-	-	-
Doublesash butterflyfish (<i>Chaetodon marleyi</i>)	-	-	*	-	-	-
Eagle ray (<i>Myliobatis aquila</i>)	-	-	*	-	-	-
Elephantfish (<i>Callorhynchus capensis</i>)	*	-	-	-	-	-
Elf (<i>Pomatomus saltatrix</i>)	-	-	-	-	*	*
Evileye pufferfish (<i>Amblyrhynchotes honckenii</i>)	*	-	*	-	-	-
Fransmadam (<i>Boopsoidea inornata</i>)	*	*	*	-	*	*
Galjoen (<i>Dichistius capensis</i>)	-	-	*	-	-	*
Geelbek (<i>Atractoscion aequidens</i>)	-	-	-	-	-	*
Goldi (<i>Callanthias legras</i>)	-	-	-	-	*	-
Hakes (<i>Merluccius spp</i>)	-	-	-	-	-	*
Hottentot (<i>Pachymetopon blochii</i>)	*	*	*	-	*	*

Table 3 continues on the next page →

TABLE 3: (Continues...) Presence–absence data for fish reported from research angling (RA), fish traps (FT), underwater visual census (UVC), demersal long lines (LL), remotely operated vehicle (ROV) and commercial catch data from the National Marine Linefish System (NMLS) between 2000 and 2013.

Species	RA	FT	UVC	LL	ROV	NMLS
Jacopever (<i>Helicolenus dactylopterus</i>)	-	*	-	-	*	-
Janbruin (<i>Gymnocrotaphus curvidens</i>)	-	-	*	-	*	-
Kob (<i>Argyrosomus spp</i>)	-	-	-	-	-	*
Koester (<i>Acanthistius sebastoides</i>)	*	-	*	-	-	-
Leopard catshark (<i>Poroderma pantherinum</i>)	*	*	-	*	*	-
Maasbanker (<i>Trachurus capensis</i>)	*	*	-	-	-	-
Mackerel (<i>Scomber japonicus</i>)	*	-	-	-	-	-
Moustache rockcod (<i>Epinephelus chabaudi</i>)	*	*	-	-	-	-
Olive grunter (<i>Pomadasys olivaceus</i>)	*	*	-	-	-	-
Panga (<i>Pterogymnus laniarius</i>)	*	*	-	-	*	*
Puffadder shyshark (<i>Haploblepharus edwardsii</i>)	*	*	-	-	*	-
Ragged-tooth shark (<i>Carcharias taurus</i>)	-	-	-	-	-	*
Red steenbras (<i>Petrus rupestris</i>)	*	*	*	-	*	*
Red stumpnose (<i>Chrysolephus gibbiceps</i>)	*	*	*	-	*	*
Redfingers (<i>Cheilodactylus fasciatus</i>)	-	-	*	-	*	-
Roman (<i>Chrysolephus laticeps</i>)	*	*	*	-	*	*
Sandsoldier (<i>Pagellus belottii natalensis</i>)	*	-	-	-	-	-
Santer (<i>Cheimerius nufar</i>)	*	*	*	-	-	*
Scorpionidae sp 1	-	-	-	-	*	-
Seventy-four seabream (<i>Polysteganus undulosus</i>)	*	-	-	-	-	-
Shortnose spiny dogfish (<i>Squalus megalops</i>)	*	*	-	*	-	*
Short-tail stingray (<i>Dasyatis brevicaudata</i>)	-	-	*	-	*	-
Sixgill shark (<i>Hexanchus griseus</i>)	-	-	-	*	-	-
Slinger (<i>Chrysolephus puniceus</i>)	-	-	-	-	-	*
Smooth-hound (<i>Mustelus mustelus</i>)	*	*	*	*	*	*
Snoek (<i>Thyrsites atun</i>)	*	-	-	-	-	-
Soupin shark (<i>Galeorhinus galeus</i>)	*	-	*	*	*	*
Spearnose skate (<i>Rostroraja alba</i>)	-	-	-	*	-	-
Spotted gullyshark (<i>Triakis megalopterus</i>)	*	*	*	-	-	*
Spotted sevensgill shark (<i>Notorynchus cepedianus</i>)	-	-	-	-	*	*
Spotted skate (<i>Raja straeleni</i>)	-	-	-	*	-	-
Steentjie (<i>Spondylisoma emarginatum</i>)	*	*	*	-	*	*
Strepie (<i>Sarpa salpa</i>)	-	*	*	-	*	-
Striped catshark (<i>Poroderma africanum</i>)	*	*	*	*	*	-
Twotone fingerfin (<i>Chirodactylus brachydactylus</i>)	-	-	*	-	*	-
White seacatfish (<i>Galeichthys feliceps</i>)	*	*	*	-	*	-
White stumpnose (<i>Rhabdosargus globiceps</i>)	*	*	*	-	*	*
Whitespotted smooth-hound (<i>Mustelus palumbes</i>)	*	*	-	*	-	-
Windtoy (<i>Spicara axillaris</i>)	-	-	-	-	*	-
Wreck fish (<i>Polyprion americanus</i>)	-	-	-	-	*	-
Yellowbelly rockcod (<i>Epinephelus marginatus</i>)	-	-	*	-	*	-
Yellowspotted catshark (<i>Scyliorhinus capensis</i>)	*	*	-	-	-	-
Yellowtail (<i>Seriola lalandi</i>)	*	-	*	-	*	*
Zebra (<i>Diplodus hottentotus</i>)	*	-	*	-	*	*
Total	40	29	35	11	36	30

Source: comparative data – DAFF, unpublished data

the Seacor Achiever and RV Ellen Khuzwayo are thanked for their cooperation, support and patience despite bad weather.

Competing interests

The authors declare that they have no financial or personal relationships, which may have inappropriately influenced them in writing this article.

Authors' contributions

S.K. was the project leader; A.G. was responsible for project design. S.K., A.G., T.S. and C.W. participated on the survey.

S.K., A.G. and T.S. were the ROV pilots. T.S. and K.S. made conceptual contributions and M.M. viewed, collated and analysed the data from all the video footage. M.M. also identified all the fish species and drafted the manuscript. A.G. and S.K. performed all the calculations.

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