Animal- vs. plant-based bait: does the bait type affect census of fish assemblages and trophic groups by baited remote underwater video (BRUV) systems?[1]

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Running headline: bait type and BRUV deployments

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Coral reef fish communities were sampled at the Nayband Marine Park-Iran, using baited remote underwater video stations (BRUVSs) which incorporated animal- (i.e. frigate tuna, beef liver), or plant-based baits (i.e. raw dough, raw dough-turmeric powder mix). The frigate tuna was found to record significantly ($p< 0.05$) higher species richness and number of carnivorous fish than plant-based baits, while variations in abundance of herbivores was maximum in raw dough-turmeric powder mix trials. There was also a significant difference in trophic composition of fish assemblages surveyed by animal- and plant-based baits which seemed to be due to variations in attraction patterns of carnivores and herbivores occurring at the earlier phases of each BRUV deployments. Meanwhile, the species composition was comparable among fish assemblages sampled by different bait treatments, indicating that species-level responses to each bait type may be more complicated. In essence, the efficiency of mixed baits should also be examined in future studies.

Keywords: animal-based bait; plant-based bait; remote underwater video; coral reef fish

INTRODUCTION

The baited Remote Underwater Video (BRUV) sampling technique is now being applied to survey fish communities in marine protected areas (e.g. Willis & Babcock, 2000), deep sea habitats (e.g. Marouchos *et al.*, 2011), and/or topographically complex marine environments (e.g. Stewart & Beukers, 2000). It is a non-destructive and non-extractive technique, providing an inexpensive sampling tool for studying temporal and spatial trends in fish communities (Cappo *et al.*, 2007). The advantages and disadvantages of BRUV have been well demonstrated in the literature (e.g. Cappo *et al.*, 2006; Cappo *et al.*, 2010; Mallet & Pelletier, 2014). The main disadvantage of the BRUV technique lies in its potential selectivity towards those species that respond positively to the presence of bait (Cappo *et al.*, 2010). In this case, the BRUV may be originally viewed as an appropriate tool for sampling carnivores and scavengers, given that an animal-based bait (AB) (e.g. sardines) is commonly used for sampling (Cappo, 2007). However, comparative studies have demonstrated that the AB do not necessarily deter herbivores or omnivores from being recorded in the field of view, when compared to unbaited deployments (e.g. Watson *et al.*, 2005; Harvey *et al.*, 2007). Meanwhile, previous works on other baited sampling gears (e.g. traps and hooks) have shown that some species might attract more readily to certain types of bait, thereby resulting in biased representation of natural communities (Wirsing *et al.*, 2006; Alós *et al.*, 2009; Götz *et al.*, 2007). In essence, the type of bait should be standardized for large-scale temporal and spatial comparisons of fish communities sampled by BRUV surveys (Harvey *et al.*, 2007). While previous studies have mainly focused on comparison of BRUV and other sampling methods (e.g. unbaited remote underwater video (Harvey *et al.*, 2007; Watson *et al.*, 2005), trawls (Cappo *et al.* 2004), hook and line (Brooks *et al.*, 2011), underwater visual census (Colton & Swearer, 2010)), to our knowledge few studies have examined the efficiency of different bait types for BRUV sampling (e.g. Wraith *et al.*, 2007; Dorman *et al.*, 2012) and only a recent study (Dorman *et al.*, 2012) compared ABs and plant-based baits (PBs).

The present study was designed to investigate the effects of ABs and PBs on the performance of BRUV on a subtropical marine protected area (MPA). The experimental AB was consisted of a terrestrial or marine material, whereas the PBs were predominantly of terrestrial origin. The major question addressed here was whether estimates of species and trophic group (TG) assemblage metrics differ between ABs and PBs.

The following null hypotheses were tested:

(1) Species richness, total abundance, relative abundance of main TGs, and species/ TG composition would not significantly differ between unbaited and baited deployments, bait categories (animal/plant), and bait types.

(2) The proportion of TGs represented by different bait treatments would not differ from the theoretical proportions of trophic levels for reef fishes in the Persian Gulf

(3) The attraction patterns of TGs would not differ between unbaited and baited deployments, bait categories, and bait types.

(4) There would be no inter-correlation among different TGs attracted to the field of view.

MATERIALS AND METHODS

STUDY AREA

Sampling was carried out in March 2014 on a natural coral patch reef located (27°18' N, 52°40' E) in the Nayband marine park, a subtropical marine protected area in the northern Persian Gulf (Fig. 1). The area is dominated by *Platygyra* and *Porites* corals at ca. 5m depth and the mean percentage cover of live hard corals was 65% at the time of sampling.

SAMPLING APPARATUS

The BRUVS sampling apparatus included a GoPro® HERO3 Black Edition HD camera, fixed 0.30 m above the base of a stainless steel frame, and a plastic bait bag 1.2 m from the camera (Langlois *et al.*, 2012). A mechanical flowmeter was mounted on the frame (i.e. at perpendicular direction to the bait arm) to record the unidirectional water current velocity (Fig. 1).

EXPERIMENTAL PROCEDURE AND DATA COLLECTION

Prior to data collection, percentage cover of live hard corals was quantified along 12 randomly selected transects by the point intercept transect method (Hill & Wilkinson, 2004). This was done to confirm that coral cover is homogenous across the study area, since differences in hard coral cover can influence natural reef fish communities (Bell & Galzin, 1984). A Kruskal-Wallis test confirmed that mean hard coral cover did not significantly differ within study area ($H = 6.92$, $P=0.14$). This was followed by a pilot study during of which an optimum soak time (30 min) and sample replicate numbers (n=4 deployments) were determined (Appendix I).

Experimental remote underwater vide surveys (i.e. 35 min video recording sessions) were conducted at 4 randomly chosen sites within the study area using five bait treatments, i.e. two types of PB, two types of AB, and a control (unbaited) treatment. The PB was consisted of raw dough or raw dough-turmeric powder mix (common baits used by local anglers on fishing lines). The raw dough was prepared by adding 500 ml freshwater to 1200 g white flour plus three teaspoons salt and six tablespoons olive oil. The raw dough-turmeric powder mix (hereafter called spicy raw dough) was prepared by adding 250 g of turmeric powder to 1000 g of fresh raw dough. The AB was consisted of chopped frigate tuna *Auxis thazard thazard* (Lacepède, 1800) or beef liver (an appetizers substance for fish; McBnrop et al. 1962). Approximately 200 g of fresh bait was used for each baited deployment (Hardinge *et al.*, 2014). A single replicate treatment was randomly deployed at each site (n=4 replicates per treatment). Successive deployments were separated by 20 min (Harvey *et al.*, 2007). The fieldwork was conducted over two days during daylight hours (0830 to 1600 hours) to avoid contributions of the crepuscular or nocturnal species to the sampling. Water current velocities and vertical visibility were monitored during the sampling period to ensure constant dispersion rates of odour plume as well as equal chances of visual reinforcement of fish to the apparatus during sampling periods.

Recorded videos were observed on computer screen by a single observer using the GoPro Studio 2.0.0.285 player software. Analysis of each video started 5 min after settlement of the gear and continued for 30 min. For each casting, fish species richness was estimated by counting all fish species occurring in between the camera lens and the end of the bait arm (2 m distance at 170° viewing angle). Fish species were identified from illustrated fish catalogues (i.e. Blegvad & Loppenthin, 1944; Al-abdessalaam, 1995). The maximum number of each species (MaxN; Willis & Babcock, 2000) and the time of first arrival (t1st; Priede & Merrett, 1996) of each species were recorded as well. Fish species were then classified into three broad category TGs according to their trophic levels (Froese & Pauly, 2014): TG2 (herbivores): 2≤ trophic level ≤2.19; TG3 (omnivores): 2.20≤ trophic level ≤2.79; TG4 (carnivores): 2.80≤ trophic level.

DATA ANALYSIS

A one-way analysis of variance (ANOVA) followed by Tukey's HSD test was performed to test for differences in mean number of species, mean total MaxN, mean MaxN for TGs, or mean MaxN for the most frequently occurring species (i.e. Yellowbar angelfish *Pomacanthus* *maculosus* (Forsskål, 1775), Dory snapper *Lutjanus fulviflamma* (Forsskål, 1775), Moon wrasse *Thalassoma lunare* (Linnaeus, 1758), and Black-spotted butterflyfish *Chaetodon nigropunctatus* Sauvage, 1880) with the factor bait treatment. Assumptions of normality and homogeneity of variance were evaluated for each variable using Kolmogorov–Smirnov and Levene's tests, respectively (Zar, 1999).

A one-factor permutational non-parametric multivariate analysis of variance (PERMANOVA) (Anderson, 2001) was performed on Bray-Curtis distances of untransformed data to test for differences in species and TG composition with the factor bait treatment. Abundance data for each species/TG was priorly standardized by the total MaxN in each replicate to account for variations in the extent of active space area among replicate deployments (Colton & Swearer, 2010). Significant differences were tested by 9999 permutations. In the case of significant difference, permutational analysis of multivariate dispersions (PERMDISP) was used to evaluate homogeneity of multivariate variances among treatment groups. The PERMANOVA was then followed by posteriori pairwise comparisons to investigate pairwise differences. A SIMPER analysis (Clarke & Warwick, 2001) was performed to identify the contribution of each fish species/TG to the observed pairwise differences between bait treatments. Values of $\delta_i/SD(\delta_i) > 1$ and $\delta i \geq 3\%$ (where δ_i is the mean contribution of the i^{th} species to the observed pairwise dissimilarity and SD is standard deviation of the calculated mean) were considered as an indicator of strong contribution (Malcolm *et al.*, 2007). A nonmetric multidimensional scaling (nMDS) ordination was used to visualize the differences species/TG composition. Multivariate dispersion (MVDISP) was calculated to check for consistency of replicate samples in representing assemblages.

A chi-square goodness of fit test was used to compare the proportions of TGs represented by each treatment with a theoretical TG contribution profile for the Persian Gulf reef fish fauna (444 species). Proportion of each TG was calculated for each treatment as follows:

$$\mathrm{P}_{\mathrm{TGx}} = \frac{\text{species richness for TGx}}{\text{total number of sighted species}}$$

The theoretical TG profile for the Persian Gulf reef fishes was constructed using FishBase trophic level database.

In order to compare attraction patterns of TGs among different treatments, each video was processed by splitting in to two equal parts of 15 min length (i.e. early phase: 5-20 minutes, late phase: 20-35 minutes). Species were then assigned to one of the two phases according to the time of their first arrival. TG composition matrix was then constructed for each phase by summing up the number of species with each trophic group. Further comparison of the TG assemblages was performed in a similar fashion to the species composition.

In order to test the possible intercorrelation among different trophic groups being attracted to the different bait types, a RELATE (an analogues to Mantel test) procedure was performed using weighted Spearman's rank correlations.

RESULTS

SPECIES RICHNESS AND TOTAL MAXN

Total of 15 fish species belonging to 13 families were sighted during the study (Table I). Maximum number of species (n=10) were observed in a single case when tuna was used as bait and minimum number of species (n=5) were recorded in 75% (3 out of 4 replicates) of unbaited sampling trials as well as 25% of deployments with PB (both raw dough and spicy raw dough). The results of one-way ANOVA showed that the species richness was significantly influenced by bait treatment (ANOVA: $F_{4,15}= 5.16$, $P< 0.01$). Further pairwise comparisons indicated that tuna sampled significantly greater species richness than PBs or control treatment (Fig 2).

ANOVA was also significant for mean total MaxN (ANOVA: $F_{4,15}=4.32$, $P<0.01$). Results of post-hoc tests revealed no significant differences in total maxN pairwise differences between ABs and PBs, while both bait types sampled greater number of fish than unbaited treatments (Fig. 2).

MAXN OF TROPHIC GROUPS AND FREQUENTLY OCCURRING SPECIES

Mean MaxN of herbivores and carnivores differed significantly (ANOVA$_{(herbivores)}$: $F_{4,15}=11.86$, $P<.0.01$; ANOVA$_{(carnivores)}$: $F_{4,15}=5.98$, $P<0.01$) among treatments groups. The use of tuna as bait resulted in significantly greater mean $\text{MaxN}_{(\text{carnivores})}$ than PBs or unbaited treatments (Fig. 2). Meanwhile, the observed differences in mean $\text{MaxN}_{(\text{herbivores})}$ was mainly driven by absence of this group from beef liver trials (Fig. 2).

There was no significant difference in mean MaxN of omnivores (ANOVA: $F_{4,15}=0.64$, $P>0.05$), *P. maculosus* (ANOVA: $F_{4,15}=0.47$, $P>0.1$), *T. lunare* (ANOVA: $F_{4,15}=0.32$, $P>0.1$), *L. fulviflamma* (ANOVA: $F_{4,15}=1.13$, $P>0.1$), and *C. nigropunctatus* (ANOVA: $F_{4,15}=1.23$, $P>0.1$)

SPECIES AND TROPHIC GROUP COMPOSITION

Of 15 fish species recorded during the study, the *P. maculosus* was the most frequently occurring species being present in all videos. In contrast, three species (*Valenciennea persica* Hoese & Larson, 1994, *Carcharhinus melanopterus* (Quoy & Gaimard, 1824) and Pearly goatfish *Parupeneus margaritatus* Randall & Guézé, 1984) were observed only once during the sampling period. The Gulf parrotfish *Scarus persicus* Randall & Bruce, 1983 and *Epinephelus spp.* appeared to be absent from samples taken with ABs and PBs, respectively. The results of PERMANOVA analysis indicated no significant differences (PERMANOVA: $Pseudo\text{-}F_{4,15}=1.33$, $P_{(\text{perm})}> 0.05$) in species composition with the factor bait treatment.

In terms of trophic group composition, a large proportion (ca. 80%) of the observed fish species fitted to the TG4 (carnivores), whereas only single omnivorous species (TG3), and two herbivorous species (TG2) were sighted during the study. Composition of TGs differed significantly among treatments (PERMANOVA: $Pseudo\text{-}F_{4,\,15}=4.79$, $P_{(\mathrm{perm})}< 0.01$). Further pairwise comparisons revealed significant differences between samples taken with animal baits and spicy raw dough as well as between liver and unbaited treatments (Table II). This was also shown by the nMDS analysis (Fig. 3). The TG4 was identified by SIMPER as the strongest contributor to the observed pairwise differences. Meanwhile, replicate samples taken with raw dough recorded a higher variability (MVDISP=1.36) than spicy raw dough (MVDISP=1.10), liver (MVDISP=0.92), unbaited treatments (MVDISP=0.90) or tuna (MVDISP=0.70).

When the TG profile of fish species sampled with different treatments were compared to the theoretical proportions of TGs for reef fish in the Persian Gulf, no significant differences was found between samples taken with fish and the theoretical proportions (Fig. 4).

TROUPHIC GROUP ATTRACTION PATTERNS

Comparison of attraction patterns of TGs indicated significant differences among treatments during the early phase (PERMANOVA: $Pseudo\text{-}F_{4,\,15}=7.31$, $P_{(\mathrm{perm})}< 0.01$). Further pairwise comparisons indicated significant differences between animal baits and unbaited treatments or spicy raw dough as well as between liver and raw dough (Table III). The TG2 and TG4 were identified by SIMPER as the TG2 as the weightiest group contributing to the observed pairwise dissimilarities (Table III). No significant differences was found among treatments during the late phase (PERMANOVA: $Pseudo\text{-}F_{4,\ 15}$=2.31, $P_{(\mathrm{perm})}$> 0.05).

Results of the RELATE procedure demonstrated that, the overall multivariate similarity matrices of TG2 and TG4 abundances were significantly correlated (r= 0.95, P<0.05).

DISCUSSION

SPECIES RICHNESS

Ou findings indicated that tuna bait sampled significantly greater number of species than PB or unbaited treatments. In general, the BRUV has been found to record greater species richness than traps (e.g. Wakefield *et al.,* 2013), daytime trawls (Cappo *et al.,* 2004), video transects (e.g. Langlois *et al.,* 2010), or unbaited video (e.g. Bernard & Götz, 2012; Harvey *et al.,* 2007; Hardinge *et al.,* 2013 but see Dorman *et al.,* 2012), but may record fewer number of species when compared to UVC (e.g. Colton & Swearer 2010; Lowry *et al.*, 2011; Lowry *et al.*, 2012). Yet, Wraith (2007) concluded that using different types of bait (i.e. urchin, abalone and pilchards) would results in variations in mean number of sighted species, though theses variations are not always significant. On the other hand, Dorman *et al.* (2012) compared species richness data recoded by using pilchards (an AB), falafel (a PB mixed with tuna oil), cat food (an AB) as bait and found no significant differences between bait treatments. They falling particles of falafel (a PB) would attract cryptic small species to the sampling area, thereby resulting in comparable species richness with ABs. It is unlikely that this phenomenon happened in our study since bait bags with fine sized mesh were used. As such, the observed differences in species richness estimates for Abs and PBs might be due to the differences in odour properties of plant and animal baits rather than differences in the accessibility of each bait to fishes.

In the current study, the observed differences between AB and PB seemed to be mainly driven by attraction of nocturnal species (e.g. *C. melanopterus* and *Epinephelus spp.*) to tuna. Detectability of nocturnal species in daytime BRUV samples has been found to depend on the concentration of the bait plume rather than its spread (Wraith *et al.*, 2007). Given that lipids can improve retention of the bait plume concentration in water (Wraith *et al.*, 2007), observation of nocturnal species in samples taken with tuna may be partially explained by higher lipid content in tuna muscle (ca. 7% of wet weight; Medina *et al.*, 1995) compared to the wheat flour (1.5% of wet weight; McCormack *et al.*, 1991). However, calculated CV for estimates of mean species richness was considerably large for samples taken with fish, indicating that responses of the species to tuna bait might be inconsistent. This inconsistency may also be due to varied size of the sampling area among replicate deployments (Heagney *et al.*, 2007) but this effects might argued to be local, given that the course of active attraction to the bait occurs rapidly (Merritt et al., 2011).

ABUNDANCE

Unlike species richness, the two bait types were comparable in terms of mean total MaxN, a finding somewhat consistent with an earlier study (Dorman *et al.*, 2012) where no significant difference was found between falafel (a PB) and pilchard samples (an AB). However, MaxNs for carnivorous and herbivorus fish were influenced by the type of bait used, with highest number of carnivores or herbivores obtained from samples taken with spicy raw dough and tuna, respectively. Yet, responses of herbivorous fish to animal based-baits seemed to be species-specific, given that only *S. persicus* appeared absent from samples taken with both tuna and liver but specimens of Sohal surgeonfish *Acanthurus sohal* (Forsskål, 1775) were observed in samples taken with tuna bait. Species specific responses of fish to the bait has also been documented in previous studies. For example, Bernard & Götz (2012) found no significant effects of baiting (i.e. pilchard baiting) on maxN of bony carnivores, whereas the same effect was significant for cartilaginous carnivores. As such, factors other simply attraction to chemical cues may contribute to appearance of specimens in the field of view. These factors may include but are not limited to causal attraction of passing individual, attraction to the physical structure of the filming Apparatus, settlement of the apparatus with the territory of a territorial fish, attraction to the feeding aggregation, attraction to conspecifics, and agonistic and competitive repellence (Cappo *et al.* 2004).

SPECIES AND TROPHIC GROUP COMPOSITION

Consistent with previous studies (Dorman *et al.*, 2012, Wraith *et al.*, 2007) the bait type had no significant effect species composition, while there was also no significant difference in assemblage composition between baited and unbaited treatments. This may to be due to the identical responses of frequently occurring species (i.e. *P. maculosus, T. lunare*) to different bait treatments. The attraction of *P. maculosus* and *T. lunare* to the field of seemed be driven by acoustic and visual cues rather than the chemical cues released from the bait. Both were priority species, arriving within seconds of the filming apparatus landing on the seabed. The *Pomacanthus maculosus* is a diurnal omnivorous species that feeds on plants, sponges and tunicates and but is also highly curious towards unusual objects (Allen, 1998). In this case, auditory and visual cues associated with the settlement of the filming apparatus and its structure may be responsible for attraction of the species to the field of view. *Thalassoma lunare* is an opportunistic visual predator exhibiting a preference for red colour stimuli (Cheney *et al.,* 2013). During the experiment, specimens of *T. lunare* were observed approaching the bait bag (whether baited or unbaited) but not biting, suggesting that the appearance of this species in the field of view might be due to the attraction of fish to the red coloured bait bags.

On the other hand there was an apparent difference in trophic composition of fish assemblages sampled by ABs and PBs which was more evident between Abs and raw dough. These differences was found to be attributed to increased abundances of carnivores in AB trials. Carnivorous fish has been found to readily react to the bait (an AB) (Harvey *et al.,* 2007).

As expected from Merritt *et al.* (2011) the course of attraction seemed to occur at earlier phases of BRUV deployments. Yet, the observed differences in between ABs and PBs seemed to be attributed to varied responses of both carnivores and herbivores, suggesting that there might be a dietary preference by both trophic groups.

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Table I. Fish counts ±meaNmax±SD) for BRUV samples taken with different bait treatments.

Family	Species	TG	Treatment				
			Unbaited	Fish	Liver	Raw dough	Spicy raw dough
Acanthuridae	*Acanthurus sohal*	2	1.00±0.81	2.25±0.95	0.00±0.00	1.25±0.95	2.75±1.70
Carangidae	*Carangoides bajad*	4	0.25±0.50	3.00±4.69	0.50±1.00	0.50±1.00	0.00±0.00
Carcharhinidae	*Carcharhinus melanopterus*	4	0.00±0.00	0.25±0.50	0.00±0.00	0.00±0.00	0.00±0.00
Chaetodontidae	*Chaetodon nigropunctatus*	4	2.00±1.41	3.00±0.81	3.75±2.06	1.00±1.29	1.00±1.15
Gobiidae	*Amblyeleotris sp.*	4	0.00±0.00	0.50±1.00	1.25±0.95	0.25±0.5)0	0.00±0.00
Gobiidae	*Valenciennea persica*	4	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.50±1.00
Labridae	*Thalassoma lunare*	4	2.50±2.65	3.75±3.86	3.00±2.45	1.50±2.29	1.75±1.50
Lethrinidae	*Lethrinus borbonicus*	4	0.50±0.57	1.00± 1.41	0.25±0.50	1.00±1.15	0.00±0.00
Lutjanidae	*Lutjanus fulviflamma*	4	0.50±0.57	4.75±4.11	2.75±2.75	4.00±4.24	1.75±1.25
Mullidae	*Parupeneus margaritatus*	4	0.00±0.00	0.25±0.50	0.00±0.00	0.00±0.00	0.00±0.00
Nemipteridae	*Scolopsis ghanam*	4	0.00±0.00	0.25±0.50	0.00±0.00	0.50±0.57	0.00±0.00
Pomacanthidae	*Pomacanthus maculosus*	3	2.25±0.50	4.50±2.65	3.00±2.00	2.75±3.50	3.25±1.50
Scaridae	*Scarus persicus*	2	1.00±1.15	0.00±0.00	0.00±0.00	1.00±1.41	1.25±1.25
Serranidae	*Cephalopholis hemistiktos*	4	0.50±0.57	2.25±0.50	2.25±0.95	0.00±0.00	1.75±0.50
Serranidae	*Epinephelus spp.**	4	0.00±0.00	0.50±0.57	0.75±0.50	0.00±0.00	0.00±0.00

*identification was performed to the genus level since the species *Epinephelus coioides*, *Epinephelus malabaricus*, *Epinephelus tauvina* could not be distinguished on video footages.

TG, trophic group

Table II. Differences in assemblage structure of fishes sampled by different BRUVS treatments.

	Pseudo-t	P(perm) *	Avg dissimilarity	Most important species	δi/SD(δi)	SD(δi) (%)
No bait Vs. Fish	1.20	0.28	-	-	-	
No bait Vs. Liver	1.51	0.19	-	-	-	
No bait Vs. Raw dough	0.80	0.56	-	-	-	
No bait Vs. Spicy raw dough	0.92	0.60	-	-	-	
Fish Vs. Liver	1.39	0.11	-	-	-	
Fish Vs. Raw dough	1.34	0.19	-	-	-	
Fish Vs. Spicy raw dough	1.84	0.02	43.61	*Carangoides bajad*	7.37	8.08
Liver Vs. Raw dough	1.89	0.02	48.66	*Cephalopholis hemistiktos*	6.96	7.86
Liver Vs. Spicy raw dough	2.47	0.02	43.61	*Acanthurus sohal*	7.37	8.08
Raw dough Vs. Spicy raw dough	1.58	0.02	42.81	*Cephalopholis hemistiktos*	7.36	8.01

* multivariate dispersions were not significantly different (P=0.27) among different bait types

Fig 1

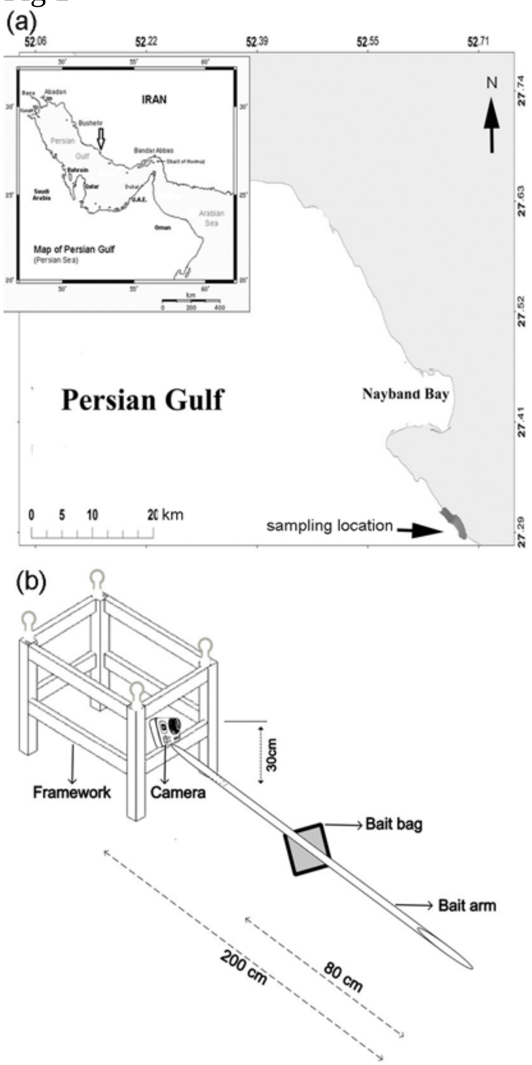
(a)
52.06
52.22
52.39
52.55
52.71
27.74
27.63
27.52
27.41
27.29
N
IRAN
Persian Gulf
Bushehr
Bandar Abbas
Bahrain
Qatar
Dubai
U.A.E.
Saudi Arabia
Oman
Arabian Sea
Map of Persian Gulf
(Persian Sea)
Persian Gulf
Nayband Bay
0 5 10 20 km
sampling location
(b)
Framework
Camera
30cm
Bait bag
Bait arm
200 cm
80 cm

Fig 2

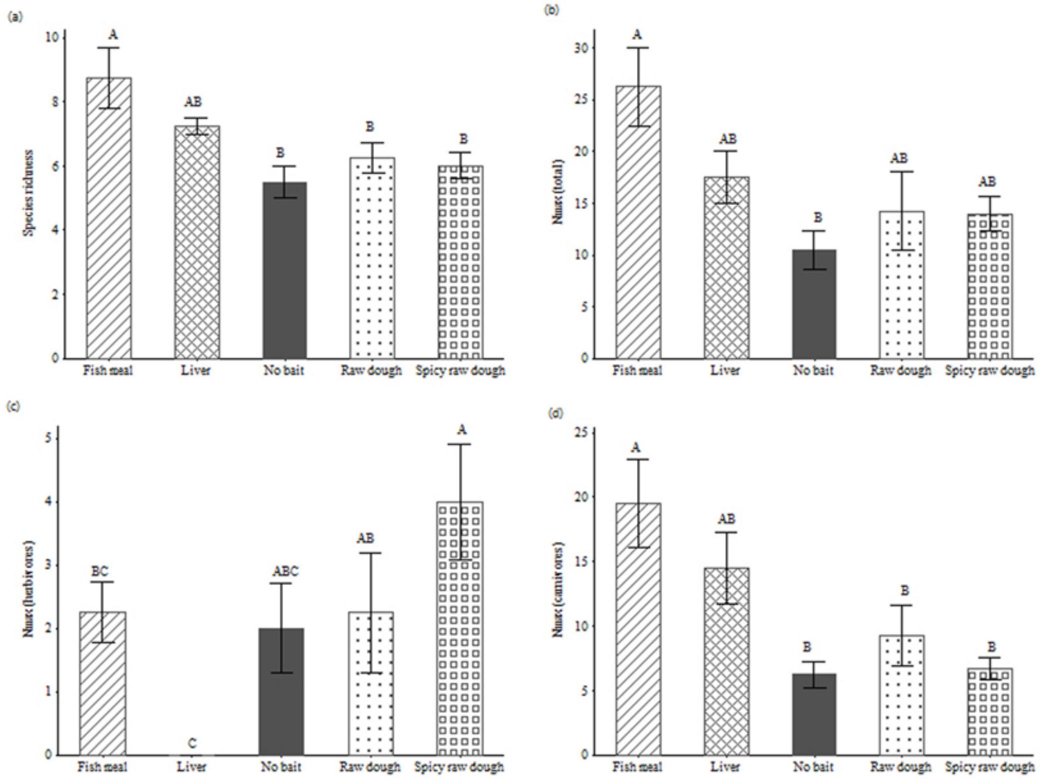
(a)
Species richness
0
2
4
6
8
10
A
AB
B
B
B
Fish meal
Liver
No bait
Raw dough
Spicy raw dough
(b)
Nmax (total)
0
5
10
15
20
25
30
A
AB
B
AB
AB
Fish meal
Liver
No bait
Raw dough
Spicy raw dough
(c)
Nmax (herbivores)
0
1
2
3
4
5
BC
C
ABC
AB
A
Fish meal
Liver
No bait
Raw dough
Spicy raw dough
(d)
Nmax (carnivores)
0
5
10
15
20
25
A
AB
B
B
B
Fish meal
Liver
No bait
Raw dough
Spicy raw dough

Fig 3

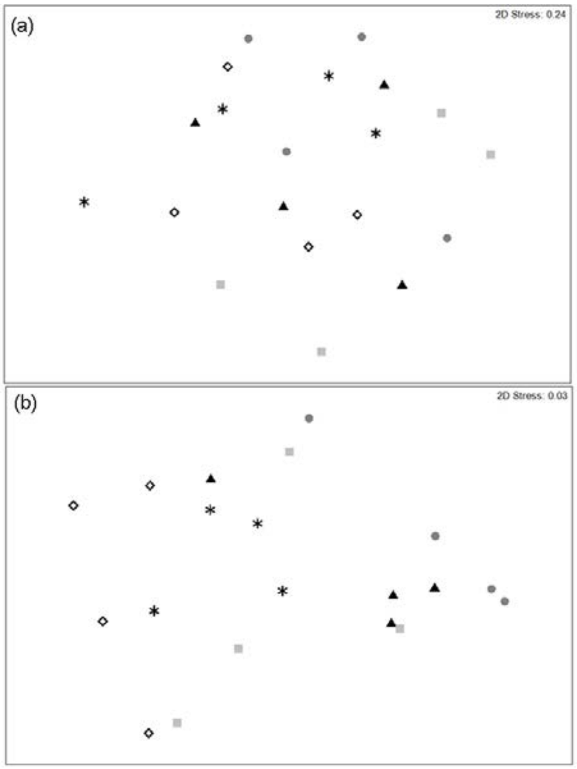

Figure legends

Figure 1. (a) Sampling location at Nayband Marine Park, Iran (b) illustration of the baited underwater video Apparatus

Figure 2. Mean (a) species richness, (b) total N_{max}, (c) N_{max} of herbivores, and (d) N_{max} of carnivores compared across different bait types. Note: different uppercase letters indicate significant difference between bait treatments. Error bars are ± SE

Figure 3. The nMDS plots of (a) composition, and (b) trophic structure of fish assemblages sampled by different bait treatments (✱ No-bait, ▲ Fish meal, ● Liver, ■ Raw dough, ◇ Spicy raw dough)