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Fish assemblages associated with natural and artificial habitats in Palk Bay, southeast coast of India: Comparison using Baited Remote Underwater Video

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Original Article

Abstract

In the present study, demersal fishes associated with natural habitats (seagrass and algal beds) and artificial habitat (artificial reef) were assessed between October 2012 and September 2013 using Baited Remote Underwater Video (BRUV) in Palk Bay, south-east India. This study is the first of its kind in India. High definition video recording was done for 1.5 hours with baits (crushed shrimp and fishes) placed in the study area every month. A total of 1,038 individuals from 24 fish species belonging to 21 families and 23 genera were recorded. The results reveal that the diversity and abundance of fish assemblages were significantly higher in artificial reefs than in natural seagrass and algal beds. Results indicate that artificial reefs provide better sheltering ground for fishes along the northern Palk Bay. Further, we suggest that BRUV is advantageous in assessing and monitoring demersal fishes owing to its non-destructive and cost effective nature.

***Keywords**: Underwater, fish, Palk Bay, artificial reef, seagrass*

Introduction

It is important to know that the habitat loss and habitat restoration will affect the fishery resource (Marasco *et al.,* 2007). Artificial reef has been used to improve marine biodiversity and to enhance the fishery resources in nearby waters (Adams *et al.,* 2006). Monitoring and assessment of artificial reefs to evaluate their effectiveness is gaining importance in recent years (Seaman and Jensen, 2000). Accurate description and regular monitoring of fish fauna may provide better understanding on ecological and biological processes occurring in artificial reefs. An artificial reef consists of one or more natural objects or man-made structures deployed purposefully on the sea-floor to support living marine organisms (Seaman and Jensen, 2000). It can be submerged for the purposes of increasing fishing resources (Brickhill *et al.,* 2005), and mitigating environmental impacts (Reed *et al.,* 2006), providing physical protection against trawling. Understanding the effectiveness of artificial reefs in increasing fishery resources requires a regular monitoring of fish assemblages living in and around artificial reefs. Fish assemblage census can be undertaken using destructive methods such as trawling (Bombace *et al.,* 1994), or non-destructive methods such as the underwater visual census (Santos and Monteiro, 2007). Artificial Reefs are assumed to function in combination of two mechanisms: aggregation of scattered specimens and secondary biomass production through increased survival and growth of juveniles (Seaman and Jensen, 2000; Osenberg *et al*., 2002). Fish and invertebrates use both natural and artificial structures for shelter, feeding, spawning, energy economy and orientation. Their accumulation around artificial reef is a stupendous outcome of behavioural ecology. Nevertheless, a great portion of the enhanced biomass comes from materials consumed in forage areas outside the artificial reef complex. Depending on each species, association with the artificial reef, its foraging range and behavioural patterns, feeding halos are formed around the artificial reef (Carr and Hixon, 1995). The income of fishery from artificial reef (AR) and non-artificial reef (NAR) sites by gillnet and hook and line was studied during 2007-08 from 11 fishing villages in 6 coastal districts of Tamil Nadu (Kasim *et al.,* 2013). However, there are no *in-situ* underwater experimental studies available in India to understand the difference in fish assemblages between artificial reefs and adjacent natural habitats. So, this study is aimed to find the difference in fish assemblages by using an underwater bait camera video system across artificial reefs, seagrass and algal beds in Palk Bay region.

Material and methods

Study area

The artificial reefs were made up of concrete and steel in different shapes and sizes. They were placed randomly in 2000 square meter area. The reefs were installed by the Department of Fisheries (DoF), Government of Tamil Nadu, 7.6 km from Sethubhavachattiram, a fish landing centre in northern Palk Bay (Fig. 1) (N 10 ° 10'46; E 79 ° 26'37). The sites were identified and georeferenced with the help of DoF. The boundary of the artificial reefs, adjacent seagrass and algal beds were also marked with a GPS (Garmin etrex). The study was carried out during lowest low tide periods for better visibility.

Study Design

This study is the first of its kind in India, which used advanced digital bait video system. Bait underwater camera system is a modified design from Langlois *et al.* (2006). The experimental iron frame was designed at OMCAR Palk Bay Centre to hold a camera in its middle, and bait in front of the camera view (Fig. 2a). A GoPro underwater camera was fixed at the middle of the frame (Fig. 2b & c). The camera has a capacity to record HD video for 1.30 hours continuously. The bait was fixed at a height of 75 cm from sea floor in iron frame (Fig. 2d). The bait camera system was deployed once in every month in each site between October 2012 and September 2013 in all the three sites namely artificial reefs (AR), seagrass beds (SB) and algal beds (AB). About one kg of crushed shrimps and fishes were packed in a fishing bag and used as bait. Total number of fishes were counted from the video and individual screen shots were

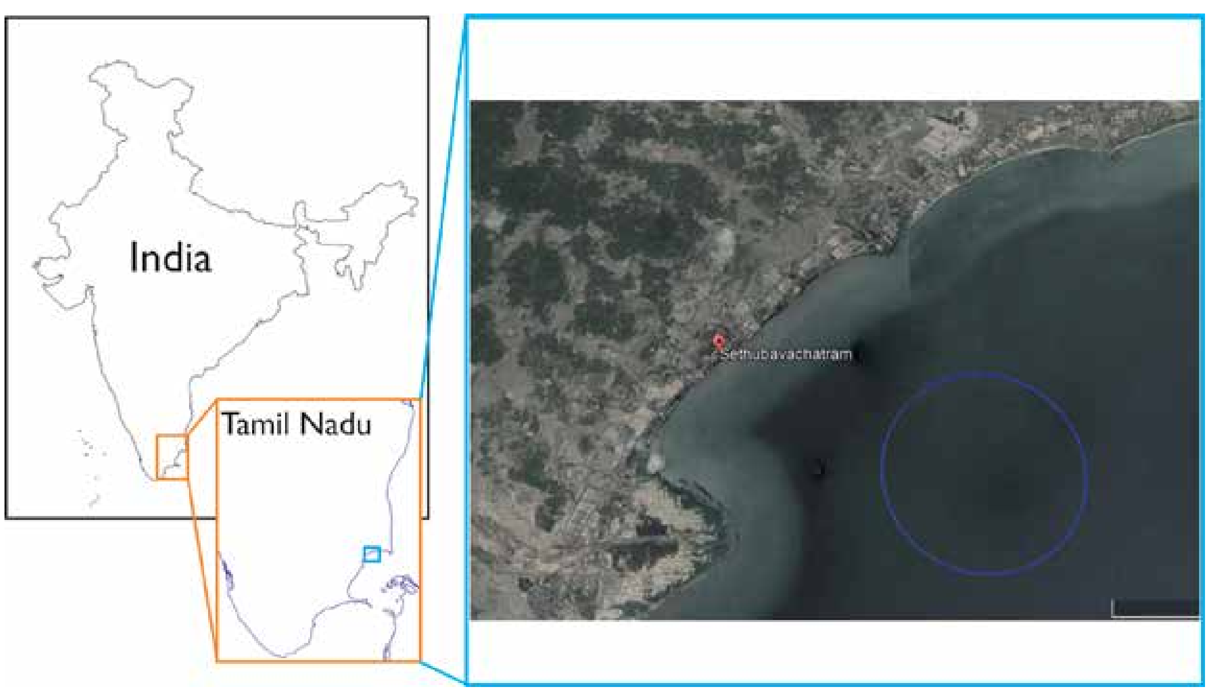

Fig. 1. Map of the study site, showing the location of the artificial reef sites in the Palk Bay

Fig. 2. Experimental setup of comparison of baited remote underwater video

taken to convert into image files for measuring total length using digimizer image analysis software.

Data analysis

Basic environmental parameters were collected from all the three habitats (AR, SB and AB) for one year. Temperature was measured by centigrade thermometer, salinity by refractometer

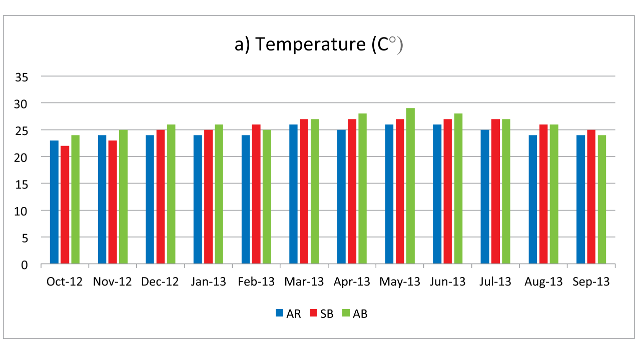

Fig. 3. Environmental parameters of seawater a) Temperature b) pH c) Salinity

(Atago) and pH was measured with pH pen (Eco test pH1). Identification of fishes, their abundance, and species diversity were determined from the recorded videos. The diversity index was calculated using the statistical software package PRIMER7 (Clarke and Gorley, 2006).

Results

During the study period, the water temperature was minimum (24.2°C± 0.31) in artificial reefs, whereas maximum temperature (31.76°C± 0.61) was recorded in seagrass beds (Fig. 3). pH ranged between 6.4 ±0.05 and 7.1±0.05. Minimum pH was recorded in artificial reefs and maximum in algal beds (Fig. 3) between 29 and 32 ppt. Maximum salinity (32 ppt) was observed in artificial reefs and minimum was recorded (29 ppt) in seagrass beds (Fig. 5).

Two-way ANOVA test was performed to correlate the interaction between environmental parameters and fish abundance in artificial reefs, seagrass beds and algal beds. The coefficient of determination (R^2 = 0.89 in AR, 0.99 in SB and 0.72 in AB) showed that the variability of the fish count is not necessarily correlated directly with the environmental parameters as the abundance of fish species here is highly related to the habitats (Table 1).

A total of 1038 individuals from 24 fish species belonging to 21 families and 23 genera were recorded. The artificial reef harbours 20 species belonging to 17 families, whereas seagrass beds harbour 13 species representing 12 families and only four species belonging to four families were supported by algal beds (Table 2). Fish species abundance was significantly higher in artificial reef (38.17% ± 5.30) compared to seagrass (24.75% ± 4.90) and algal beds (23.58% ± 4.82) (Table 4). *Terapon jarbua* was the most abundant fish in all the three habitats, which was 25.52% in algal bed, 17.72% in seagrass bed and 15.60% in artificial reefs. *T. jarbua* is not a commercially important fish species but is commonly used by small scale fishers as a bait fish. The size of *T. jarbua* is also comparatively small in all the three sites in relation to other species found in the assemblages. In the present study, another important observation is that the Bamboo shark (*Chiloscyllium plagiosum*) was recorded only in seagrass beds. In all the three habitats, *Siganus javus* and *T. jarbua* were found to be present throughout the study period.

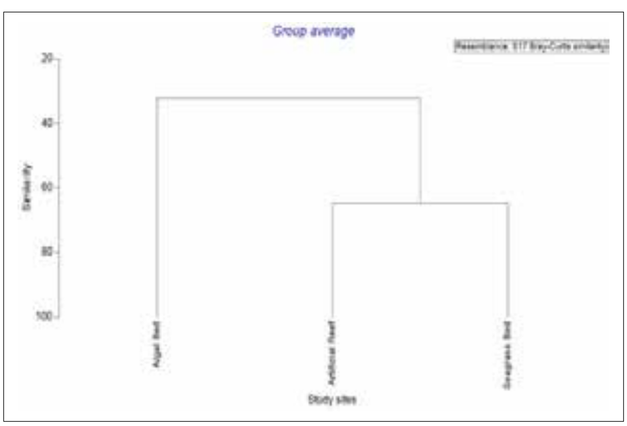

Fig. 4. Hierarchical clustering analysis of the fish species showing assemblage along three sites

Table 1. Showing Goodness of fit coefficients for all the three sites

	Artificial Reefs	Seagrass Beds	Algal Beds
R (coefficient of correlation)	0.946	1	0.847
R^2 (coefficient of determination)	0.896	0.999	0.718
R^2adj. (adjusted coefficient of determination)	0.166	0.993	-1.258
SSR	0.951	0.036	38.281

Table 2. Fish assemblages in artificial and natural habitats (AR- artificial reef, SB- seagrass bed, AB- algal bed)

Family	Species	AR	SB	AB
Ariidae	*Arius maculatus*	-	+	+
Balistidae	*Odonus niger*	+	-	-
Belonidae	*Ablennes hians*	-	+	-
Engraulidae	*Stolephorus indicus*	+	+	-
Gerreidae	*Gerres filamentosus*	+	+	-
Lactariidae	*Lactarius lactarius*	+	-	-
Latidae	*Lates calcarifer*	+	+	-
Latidae	*Psammoperca waigiensis*	+	+	-
Lethrinidae	*Lethrinus nebulosus*	+	+	-
Loliginidae	*Uroteuthis (Photololigo) duvaucelii*	-	+	-
Lutjanidae	*Lutjanusjohnii*	+	-	-
Lutjanidae	*Lutjanus lutjanus*	+	+	-
Polynemidae	*Eleutheronema tetradactylum*	+	-	-
Scaridae	*Scarus ghobban*	+	-	-
Sciaenidae	*Johnius dussumieri*	+	-	-
Sciaenidae	*Protonibea diacanthus*	+	-	-
Scombridae	*Rastrelliger faughni*	+	-	-
Sepiidae	*Sepia* sp.	-	+	+
Serranidae	*Epinephelus diacanthus*	+	-	-
Siganidae	*Siganus javus*	+	+	+
Sillaginidae	*Sillago sihama*	+	-	-
Sphyraenidae	*Sphyraena barracuda*	+	+	-
Stromateidae	*Pampus argenteus*	+	-	-
Terapontidae	*Terapon jarbua*	+	+	+

Table 3. Family wise percentage composition of fish assemblage in the three habitats

Common name S	Scientific name	AR	SB	AB
	ACTINOPTERYGII			
Whipfin silver biddy	Gerreidae *Gerres filamentosus* (Cuvier, 1829)	3.3	4.4	0
Great barracuda	Sphyraenidae *Sphyraena barracuda* (Edwards, 1771)	2.2	1.3	0
Red-tooth trigger fish	Tetraodontoidei *Odonus niger* (Rüppell, 1836)	1.5	0	0
Streaked spinefoot	Siganidae *Siganus javus* (Linnaeus, 1766)	3.1	2.7	2.1
Bigeye snapper	Lutjanidae *Lutjanus lutjanus* (Walbaum, 1792)	3.7	3	0
John's snapper	*Lutjanus johnii* (Bloch, 1792)	3.1	0	0
Sea bass	Centropomidae *Lates calcarifer* (Bloch, 1790)	3.5	2.4	0
Indian anchovy	Engraulidae *Stolephorus indicus* (van Hasselt, 1823)	6.3	12	0
Spangled emperor	Lethrinidae *Lethrinus nebulosus* (Forsskål, 1775)	4.4	4.4	0
Parrot fish	Scaridae *Scarus ghobban* (Forsskål, 1775)	4.6	0	0
Tiger Bass	Terapontidae *Terapon jarbua* (Forsskål, 1775)	35.4	62	94
Waigieu sea perch	Centropomidae *Psammoperca waigiensis* (Cuvier, 1828)	2.8	2	0
Thorny cheek grouper	Serranidae *Epinephelus diacanthus* (Valenciennes, 1828)	5.9	0	0
Threadfin	Polynemidae *Polynemus tetradactylus* (Shaw, 1804)	3.3	0	0
Sin croaker	Sciaenidae *Johnius dussumieri* (Cuvier, 1830)	2	0	0
Black spotted croaker	*Protonibea diacanthus* (Lacepède, 1802)	2.2	0	0
False trevally	Lactariidae *Lactarius lactarius,* (Bloch & Schneider, 1801)	3.9	0	0
Silver whiting	Sillaginidae *Sillago sihama,* (Forsskål, 1775)	3.1	0	0
White pomfret	Stromateidae *Pampus argenteus* (Euphrasen, 1788)	3.9	0	0
Faughn's mackerel	Scombridae *Rastrelliger faughni* (Matsui, 1967)	1.3	0	0
Spotted catfish	Ariidae *Arius maculatus* (Thunberg, 1792)	0.2	2.4	4.2
Flat needlefish	Belonidae *Ablennes hians* (Valenciennes, 1846)	0.4	3.4	0
Bamboo shark	ELASMOBRANCHII Hemiscylliidae *Chiloscyllium plagiosum* (Bennett, 1830)	0	0.3	0

Discussion

Palk Bay is a unique ecosystem in respect of marine biological process and species diversity. Generally, it receives large quantities of fresh water from the surrounding rivers (Madhupratap *et al.,* 2003). The faunal assemblage and diversity are influenced by the physico-chemical parameters of both sediment and water. (Thilagavathi *et al*., 2013). Environmental parameters are very important for the biological productivity in all ecosystems (Das *et al*., 2007), especially salinity, dissolved oxygen and organic matter play an important role in the biological processes of marine ecosystem. In the present study, the atmospheric temperature was high during the summer month (April) with the peak at 35ºC and lower values in November, which confirms the established trends along southeast coast as observed by Vijayalakshmi (1999) and Sridhar *et al*., (2006). No profound variation was evident in surface water temperature between the three sites (Fig. 2a) due to their shallow depths. The gradual increase in water temperature from monsoon to summer may perhaps be due to the direct result of atmospheric condition and radiation. Similar findings have been reported from the southeast coast of India by previous workers (Nair and Ganapathy, 1983; Vijayalakshmi, 1999). In the present study maximum pH of 7.2 was recorded in the algal bed site during summer and low pH level (6.5) in the artificial reef during monsoon. However, there was no drastic fluctuation in pH. The low values of pH noticed during monsoon season was due to dilution and mixing of coastal waters by rain floods which led to a reduction in salinity and temperature. The present findings are in agreement with that of Anandhan (1995). Salinity is considered to be the prime factor among the environmental variables influencing the dynamic nature of the coastal waters. It is one of the most fluctuating parameters, typified with wide range of variations in coastal environment. Hence, among the three sites, the salinity values ranged from 22 to 33 ppt during the study period. Maximum salinity was recorded at the artificial reef site during summer and minimum salinity recorded at algal bed site during monsoon. This may be due to the fact that the artificial reef is located far away from the shore and algal beds located close to shore receive more fresh water from the rivers.

Marine biodiversity has significantly declined throughout the world and many commercially valuable fish species are overexploited. Palk Bay serves as a breeding and feeding ground for many shell and finfishes. Present results specify the significance of the artificial reefs compared to the natural ecosystem like seagrass beds and algal beds. Artificial reefs tremendously support marine fishes and other organisms and also mitigate the environmental impacts (Reed *et al*., 2006). Based on the available records, artificial reefs seems to be good habitat supporting the diversity of fishes. (Rooker *et al*., 1997). In the present study using underwater video observation

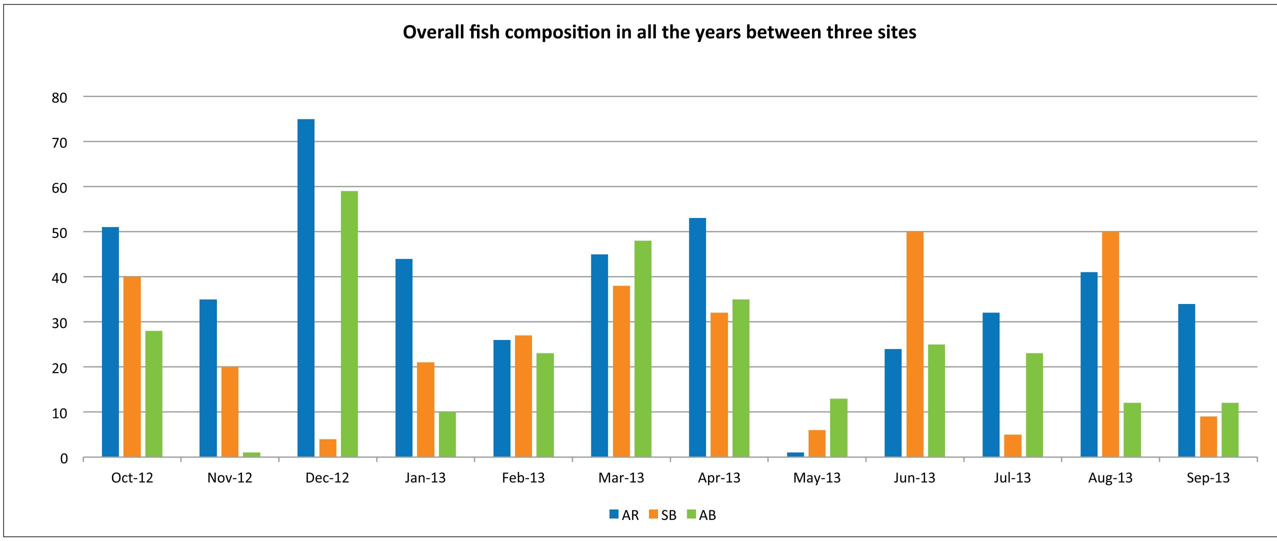

Fig. 5. Overall fish composition in three sites during October 2012 to September 2013

confirmed that the fish population has been increasing in the artificial reef areas and most abundant species in all the three habitats was *T. jarbua*, whereas the following fish species *Protonibea diacanthus*, *Johnius dussumieri*, *Lethrinus nebulous* and *Lates calcarifer* were rare *i.e.*, only one individual was recorded throughout the study period.

Overall, species composition was high in the artificial reef even though the Shannon diversity (H'), were relatively similar in both natural ecosystems (Table 2). The artificial reef fish assemblage was dominated by shallow water fishes of Terapontidae and Anchovies. The artificial reefs had more abundance (38.17% ± 5.30) compared to the natural seagrass (24.75% ± 4.90) and algal beds (23.58% ± 4.82). Species abundance and diversity was maximum in artificial reef areas, followed by fish diversity was maximum (1.84 ± 0.21) in artificial beds and minimum in algal beds 0.27 ± 0.07 (Table .4). One third of the fish species was recorded in artificial reefs followed by seagrass bed and algal beds. Generally, artificial reef habitats provide a platform to a diverse ichthyofaunal assemblage comprising both mobile fishes as well as site attached fishes (Rooker *et al.,* 1997). It is likely that this may be due to the lack of proper foraging grounds. The maximum percentage composition of Terrapontidae family represented the highest proportion of fish across all the three habitats, which may be due to their frequent presence and huge diversity. Based on the field observations *T. jarbua* diversity was high in trash landings of Sehtuvabachathiram fishing harbour. In the bait video system large numbers of bamboo shark was observed incidentally in seagrass beds.

The cluster diagram shows (Fig. 4) one main clade combined 2 sub clusters indicating the similarity between the artificial reefs and seagrass and algal beds. In general, seagrass ecosystem is the best nursery and feeding grounds for many fishes and invertebrates (Gartside *et al.*, 1999) but here in the artificial reef more number of species are reported than in natural seagrass beds. Artificial reefs have been used for protecting juvenile fish populations from predators and creating fishing grounds (Jenson, 2002). Artificial reefs can improve the fish assemblages in Palk Bay (Fig. 5).

Palk Bay is one of the rich biodiversity hotspots in Tamil Nadu, where more than 8907 motorized and 12,727 non-motorized fishing vessels are operated daily. Various methods of fishing are practised in Palk Bay, most of which benefit directly or indirectly the small scale fishery. Due to overfishing and habitat destruction, fish population and diversity has gradually declined and lead to less income. Our results highlight the importance of artificial reef establishments. Artificial reef promotes fish production and it can be used as an enhancement tool for the development of sustainable and small-scale fisheries for coastal communities. Overall purpose of this study is to recommend to the Tamil Nadu fisheries and Forest officials to implement more artificial reef blocks, fish aggregating devices for better fish assemblage and diversity in Palk Bay areas.

Table 4. Species composition of fish assemblage in the three habitats

Index	Artificial Reef	Seagrass bed	Algal bed
Abundance	38.17 ± 5.30	24.75 ± 4.90	23.58 ± 4.82
Diversity	1.84 ± 0.21	1.1 ± 0.15	0.27 ± 0.07

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