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# A COMPARATIVE STUDY ON THE DOMINANCE OF *Alcyonaceans* (Anthozoa: Octocorallia) IN THE REEF AREAS IN GULF OF MANNAR, INDIA

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**AUTHORS' CONTRIBUTIONS**

This work was carried out in collaboration between both authors. Author MB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author JKPE provided guidance, logistics, funding and the timely support to carry out the research work and reviewed the manuscript raised several critical reviews to improve the manuscript. Both authors read and approved the final manuscript

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## ABSTRACT

Corals constitute a dominant benthic community in the reef areas of the Gulf of Mannar. The decline of hard corals provides space for the dominance of other coral taxa, which helps in stabilizing the degraded reef ecosystems. We documented one such degraded patch reef area with abundant octocoral distribution. This site is located near Periyasamipuram, a coastal village on the mainland (outside Marine National Park). We made a comparative study to assess the significant difference in the distribution of octocorals between the patch reef and the main reef in Kariyachalli Island (inside Marine National Park). The study was conducted from January to March in 2017 and from January to March 2018. This study's underwater visual estimations reveal that the increase in the octocoral cover is significantly different in the patch reef and the island reef. A total of 19 species of octocorals were recorded, representing the families Alcyoniidae, Subergorgiidae, and Ellisellidae. Based on the external morphology and the presence of sclerites (calcareous structures), identification was done down to the possible level. Our preliminary study recorded a maximum of 15.53% of octocoral coverage in the patch reef area and total coverage of 1.51% in the reefs of Kariyachalli Island. Statistical analysis and non-parametric multivariate and univariate scaling reveal the difference in the octocoral distribution between the study sites. Long-term monitoring is required to assess their ecological role and formulate effective conservative reef ecosystem measures.

**Keywords:** Benthic communities; distribution; *Octocorals*; *Octocorallia*; Southeast coast.

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## 1. INTRODUCTION

Coral reefs are an integral part of the marine ecosystem. Referred to as the tropical rainforests, they provide food and shelter and act as nursery grounds for many marine organisms. Though they occupy less than 0.1% of the ocean floor, they harbor at least 25% of the known marine species [1]. However, there has been a global decline in reef habitats due to several factors such as an increase in sea surface temperature and ocean chemistry, leading to drastic reductions in the distribution, abundance, and survival of reef ecosystems [2,3]. The degradation of coral reefs, the habitats that provide space and substrate for the thriving of many organisms, causes gradual changes in the benthic ecosystem [4,5]. These alterations can impair the energy flow, affect the diversity of organisms and reduce the services to the human community [6]. Octocorals offer three-dimensional networks, providing critical habitat, food, and shelter to a great many marine organisms [7,8]. Unlike corals, octocorals are non-calcifying organisms that provide less ecological service to other associated reef dwellers [9,10].

Gulf of Mannar (GoM) is one of the four major reef areas in India with about 35% of healthy reefs [11] with 4,223 identified flora and fauna [12]. GoM is rich in biodiversity and rightly called 'Biologist's paradise' [13,14]. Lying off the south-eastern coast of India, GoM comprises a chain of 21 uninhabited islands surrounded by coral reefs. The reefs are dominated by fringing types of reefs [15]. Due to its ecological importance, the region between Rameswaram and Tuticorin covering an area of 560 sq km was declared as Gulf of Mannar Marine National Park by the Government of Tamil Nadu in 1986. Several vast patch reefs are also distributed outside this park area [16]. Generally, fringing reefs are mostly distributed at a distance of 100 to 350 m and patchy reef extends up to 1-2 km at a depth of 2-9 meters [17]. Corals are the dominant structures in the reef areas of GoM. However, there has been a drastic decline in live coral cover due to anthropogenic and natural factors especially destructive fishing practices and climate change [18,19]. This decline of reefs resulted in the flourishing of other sessile or particular animal taxa, mainly sea anemones, octocorals, corallimorpharians [20], and sponges [21].

Octocorals (Octocorallia: Alcyonacea) are sessile marine invertebrates with a broad range of distribution in the tropical, sub-tropical, and temperate oceans [22]. Despite their global distribution, there remains a large knowledge gap in the basic ecology of many species [23]. This is due to the scarce availability of information, difficulty in species identification, and lack of regional expertise in octocoral taxonomy [24]. But continuous monitoring [25] and studies on spatial variation could be the best way to assess the dominance of octocoral assemblages. However, these studies are based on the assumption that species composition drives the population turnover [26] over a period of time.

A few notable works have been conducted on octocorals mostly on their taxonomy. Studies on their distributional status are relatively scarce or the area remains largely untouched in the Indian context. Studies on the Indian Ocean octocorals date back to [27-29]. However, reports on the octocorals from India remain scarce, except for the collections made by Royal Indian Survey Ship "Investigator" from Andamans, Ceylon, Ganjam Coast, and Coromandel Coast [30,31] and two reports from the Laccadive Archipelago [32,33]; and these remain as preliminary records on the octocoral fauna from India. Apart from the above, only a few stray reports are available notably those of [34-37]. Studies on the diversity of octocorals in the Gulf of Mannar are rare with sporadic information on their distribution status. During a routine coral health monitoring, we observed rich diversity of octocorals in a degraded patch reef area at a distance of 4 km from Periyasamipuram (mainland) a coastal village. Kariyachalli Island is located within the Marine National Park at 4 km to the south of Sippikulam a mainland coastal village. It is an ellipsoidal island stretching out from southeast to northwest with an elevation of 1.5 m above mean sea level and an area of 5.97 ha. Fringing reefs are seen on the windward side from a depth of 0.5 to 3.5 m below the mean sea level. Branching coral dominates the reef crest, whereas massive coral dominates the reef front. The present study compares the octocoral abundance recorded in the degraded patch reef area near Periyasamipuram on the mainland and the octocoral abundance recorded on the main reefs of Kariyachalli Island. We also provide baseline data on the octocorals of this area, details about the abundance of octocorals, and the dissimilarity in species distribution.

## 2. MATERIALS AND METHODS

### 2.1 Study Sites

Four sites were selected for the study of octocoral distribution. The study was conducted from January to March in 2017 and from January to March 2018. Two sites were located near the main reef of Kariyachalli Island (Site – 1: 8°57'40.15" N, 78°15'44.66" E; Site – 2: 8°56'57.02" N, 78°16'00.58" E) within the Marine National Park and two locations in the patch reef near Periyasamipuram of the mainland (Site – 3: 9° 02" 32.68' N, 78° 22" 05.74' E; Site – 4: 9° 1"

58.71' N, 78° 22" 45.21' E) outside the Marine National Park. (Fig. 1). The depth range in the study sites is between 3-6 meters.

The benthic surveys followed the Line Intercept Transect (LIT) method [38] to evaluate coral and octocoral cover and the other associated benthos within the transect. Percentages of benthic and octocoral cover were estimated by using the formula:

Percentage cover = (Length of category / Length of Transect) x 100

Transects were laid on the bottom parallel to the coast. The diver swam along the transect and recorded objects incepted below the tape. In each of the 4 study sites, four belt transects were laid, each of 20 x 1 m with a 5 m interval between adjacent transects. During the survey, the octocoral colonies in each transect were counted and colony lengths were also recorded. Octocorals were photographed underwater and samples were collected for species identification. The collected specimen were fixed in 4% formalin and then preserved in 70% ethanol. Identification was done to the lowest possible taxon based on the external morphology and sclerites. Sclerites were extracted using 10% sodium hypochlorite solution (Fabricius and Alderslade, 2001). Wet mounts were prepared, photographed, and measured under CosLab (model No. HL-9A) light microscope. Further, images of sclerites and colony structures were compared with the available literature.

## 2.2 Statistical Analysis

Statistical analyses were performed using the software PRIMER 6 Corp.2013 [39]. Raw data were square root transformed and similarity among the species was computed using Bray and Curtis similarity coefficient. Data were represented as points in multidimensional space using the Non-Multidimensional Scale plot (MDS). The analysis was based on the distributional data of octocorals in the study sites and the groups obtained from cluster analysis show the species responsible for the distribution. Species with more than 40% similarity threshold was considered to be the determining factor for the community structure. The percentage dissimilarity of the species distribution was computed using SIMPER test. Diversity indices namely Total species (S), Total individuals (N), Margalef's index (d) for species richness, Pielou's evenness index (J'), Shannon (H'(log e) and Simpson index (1-Lamda') were performed. These indices are used to reflect the

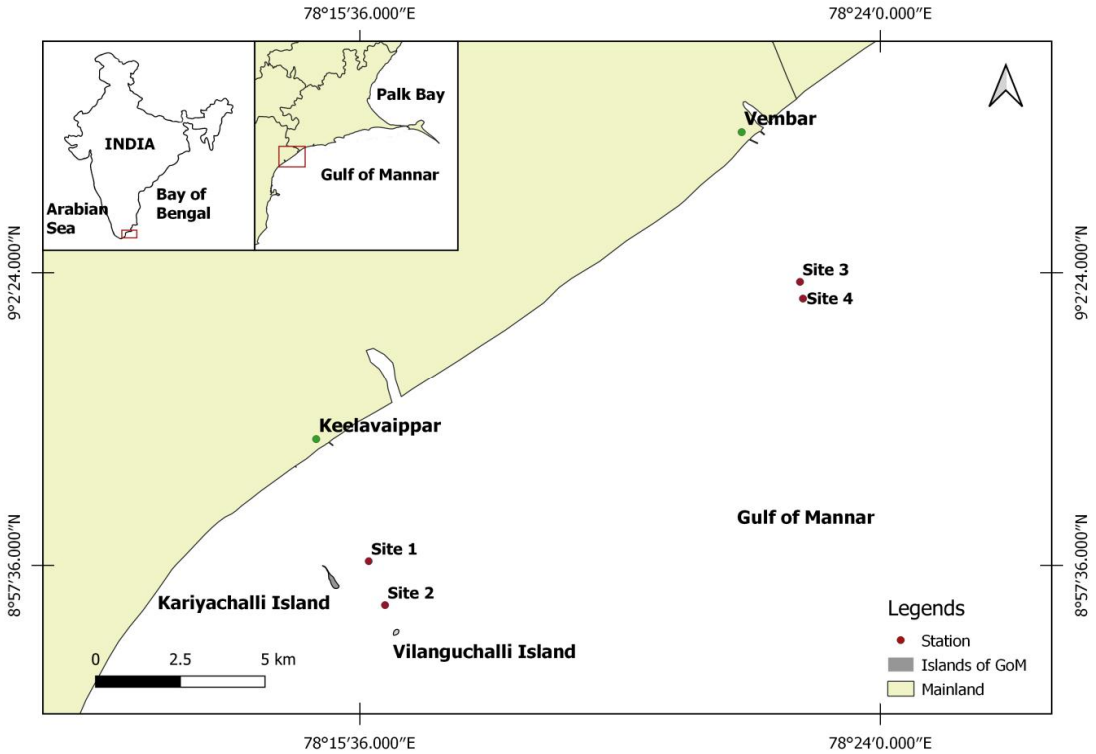


**Fig. 1. Study map with arrows indicating enlargement of study sites in the Gulf of Mannar, India. (Site 1 & 2 located nearby Kariyachalli Island within the park region and Site 3&4 at the patch reef area outside the park region), The triangle at the top right corner indicates direction**

homogeneity of the distribution pattern of the octocorals and provide more information about the community composition than the species richness, and they also provide information about rare and most common species distribution in the community structure. Lower values indicate the higher dominance of certain octocoral species and higher values indicate the even abundance of particular species.

## 3. RESULTS

The benthic communities are categorised into 7 components namely, Hard Corals, Octocorals, Algae, Dead Corals, Crustose Coralline Algae (CCA), Abiotic and Others which includes Echinoderms, Molluscs, etc. Coral reefs in Kariyachalli Island are of fringing type and encountered in the shallow depth of 3 m. In the main reef area, hard corals are the most dominant category with 38.05 to 40.52% cover. In the same reef the octocoral cover was low and varied from 1.02 to 1.51%, while algal cover varied from 33.36 to 22.58%, dead coral from 8.03 to 12.36%, CCA from 5.35 to 8.78%, the collective other coral-associated forms varied from 2.03 to 5.97% and abiotic from 9.69 to 10.76% during the year 2017 and 2018. Octocorals were distributed sparsely and mostly adjacent to the hard corals.

In the patch reef area unremitting spread of octocorals is seen, whereas hard coral distribution is discrete and random. The decrease in hard coral cover from 24.40 to 22.69% was followed by increase in octocoral distribution from 12.9 to 15.53%. The flat spread of patchy reef has facilitated the spread of octocoral communities. The runner form of growth is seen, which is the typical character of soft corals to monopolize the substrate. The algal cover ranged between 6.83 to 11.69% and the dead coral increased from 12.39 to 14.45%. Increase in dead coral cover facilitated the spread of octocoral communities. CCA varied from 8.57 to 9.69%, others from 10.92 to 13.01 % and abiotic from 23.99 to 12.95% respectively during the consecutive year 2017 and 2018 (Fig. 2).

This study recorded a total of 19 species of octocorals belonging to six genera and three families namely Alcyoniidae, Subergorgiidae, and Ellisellidae (Table 1).

In the patch reef, *Sinularia manaarensis* Verseveldt 1980 is the most abundant octocoral species (Fig. 3) with the percentages ranging between 5.39% (2017) and 7.03% (2018), and the species *Sinularia c.f triangula* Tixier-Durivault 1960 is recorded for the first time in Indian waters.

The species *S. triangula* (Fig. 4b) has a rugged surface and is distributed in the Indo-pacific region [40]. This is the first record from India and this species is characterised by the presence of triangular sclerites. Underwater images of a few species recorded during the study are given in Fig. 4a, b, c, and d.

An MDS plot (Fig. 5) was constructed to show the similarity between the octocoral distributions based on the square root transformed data, with a stress value of 0.15. The MDS cluster separates study sites into 3 clusters with 40% similarity.

The sites in the patch reef area are grouped together and a distinct distribution is seen in the study sites of main reefs of Kariyachalli Islands. These remain responsible for the dissimilarities between study sites (Table 2).

The distribution of the octocorals is wide and species rich in the patch reef area (Table 3) with a maximum of 14 species. SIMPER analysis reveals the dissimilarity in the octocoral distributions between the study sites: *S. manaarensis* (22.89%), *Sinularia* sp.3(10.33%), *Sinularia* sp.4 (9.95%) and *S. suberosa* (8.07%), *S. manaarensis* being the most dominant group in the octocoral community.

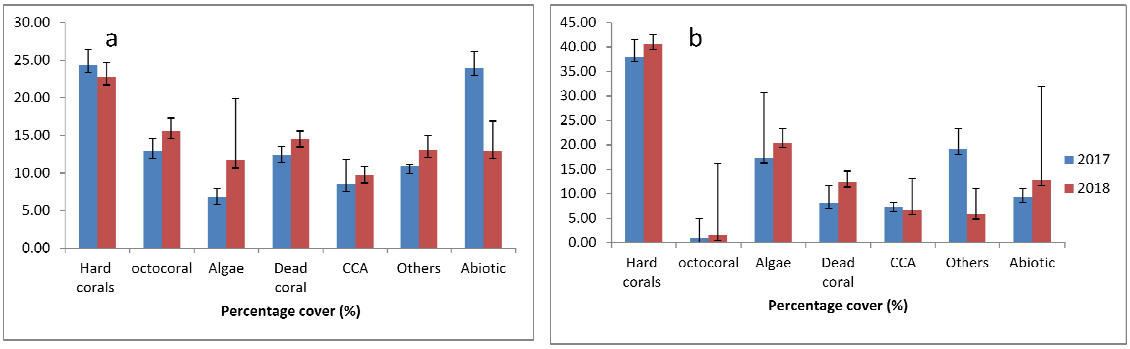


**Fig. 2. Percentage benthic cover (Mean) a, patch reef area b. main reef area of Kariyachalli Island, Gulf of Mannar**

**Table 1. List of octocorals recorded during the study. More than 20 colonies are abundant; less than 15 were counted as common; less than 10 colonies are few; less than 5 colonies are considered as rare**

| Species list | Colony form | Patch reef | Main reef |
|---|---|---|---|
| *Sinularia brassica* May, 1898 | Encrusting | few | common |
| *Sinularia erecta* Tixier-Durivault, 1945 | Encrusting | common | common |
| *Sinularia leptoclados* Ehrenberg, 1834 | Encrusting with lobes branches off into lobules | rare | common |
| *Sinularia manaarensis* Verseveldt, 1980 | Encrusting with lobes branches off into lobules | abudant | rare |
| *Sinularia c.f triangula* Tixier-Durivault, 1970 | Encrusting | few | - |
| *Sinularia* spp. 1 | Encrusting | - | few |
| *Sinularia* spp. 2 | Encrusting | common | - |
| *Cladiella laciniosa* Tixier-Durivault, 1944 | Encrusting | - | few |
| *Sarcophyton ehrenbergi* von Marenzeller, 1886 | Mushroom like | common | common |
| *Sarcophyton glaucum* Quoy & Gaimard, 1833 | Mushroom like | common | few |
| *Sarcophyton* spp. | Mushroom like | common | - |
| *Lobophytum* crassum von Marenzeller, 1886 | Wall like lobes | few | common |
| *Lobophytum pauciflorum* Ehrenberg, 1834 | Finger like lobes | few | - |
| *Lobophytum* spp. | Finger like lobes | common | - |
| *Subergorgia suberosa* Pallas, 1766 | Branching | common | common |
| *Junceella juncea* Pallas, 1766 | Whip like | few | common |

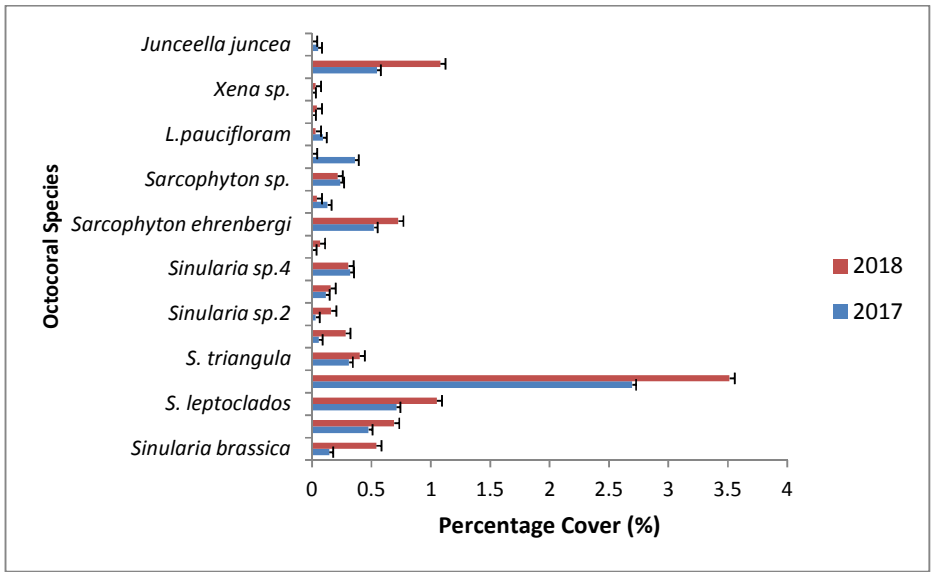


**Fig. 3. The percentage octocoral cover in the patch reef area and main reef area of Kariyachalli Island**

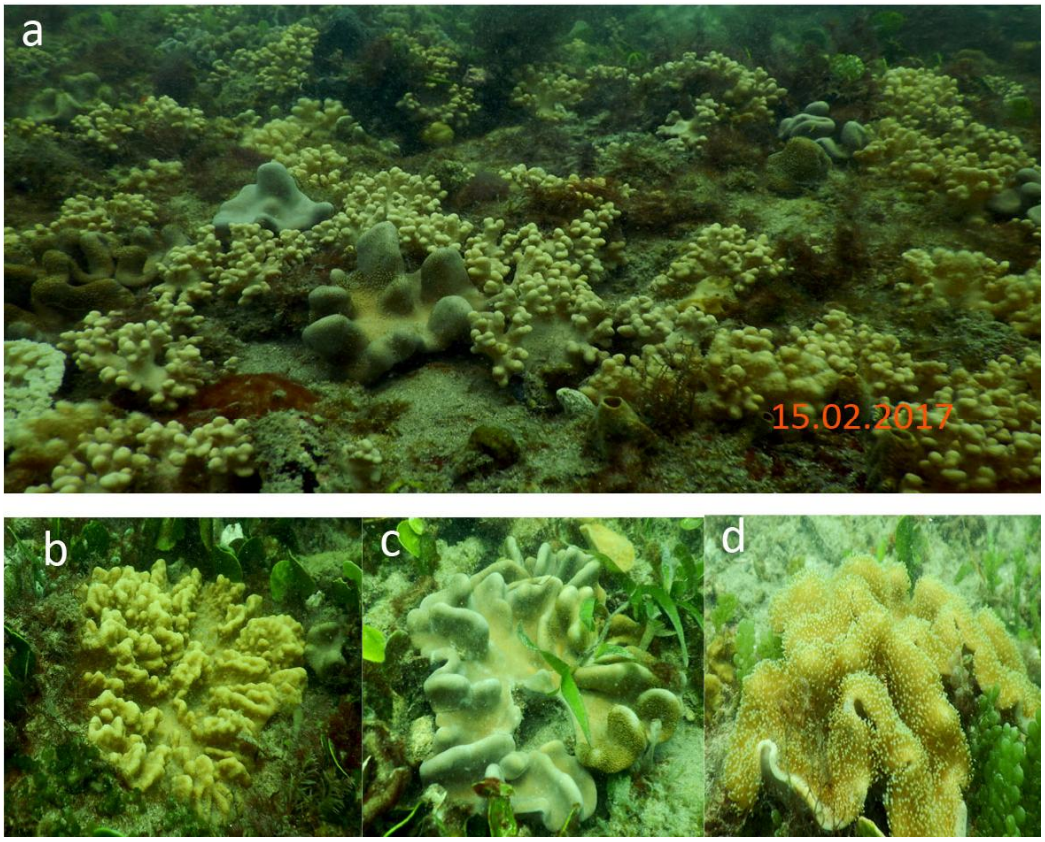


**Fig. 4. Octocoral species distribution in the shallow patch reef area a. runner formation seen in *Sinularia manaarensis* species b. *Sinularia c.f triangular* c. *Lobophytum* sp. d. *Sarcophyton glaucum***

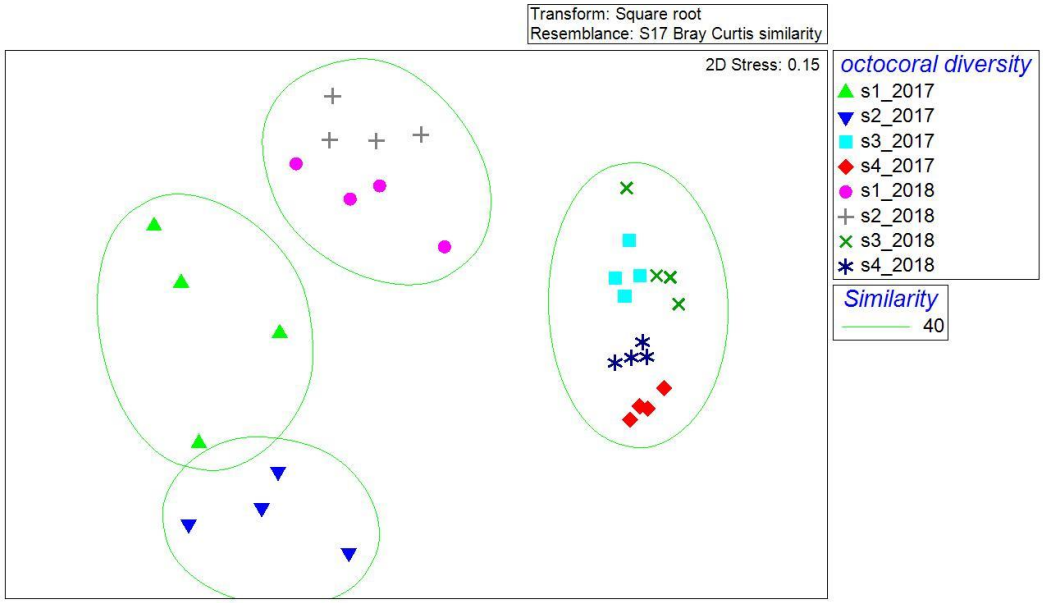


**Fig. 5. Non-metric Multidimensional (MDS) plot of Bray-Curtis similarities of square root transformed data with similarity in distribution among the study sites (Site1and 2 in Main reef area of Kariyachalli Island and Site 3 and 4 in Patch reef area)**

**Table 2. Species dissimilarity between the main reef and patch reef areas**

| Species (Average dissimilarity 77.10) | Contribution % | Cum.% |
|---|---|---|
| *S. manaarensis* | 22.89 | 22.89 |
| *Sinularia* sp.3 | 10.33 | 33.21 |
| *Sinularia* sp.4 | 9.95 | 43.16 |
| *Subergorgia suberosa* | 8.07 | 51.23 |
| *Sarcophyton ehrenbergi* | 7.25 | 58.48 |
| *S. erecta* | 6.73 | 65.22 |
| *S. triangula* | 6.58 | 71.79 |
| *S. leptoclados* | 5.8 | 77.59 |
| *Sinularia brassica* | 4.79 | 82.39 |
| *Sarcophyton sp.* | 4.75 | 87.14 |
| *Sinularia* sp.1 | 2.21 | 89.35 |
| *Sinularia* sp.2 | 1.75 | 91.11 |

**Table 3. Diversity index listed for patch reef and main reef area of Kariyachalli Island with S (species richness), N (number of species), d (Margalef's richness index), J' (Pielou' evenness index), H'loge (Shanon-Wiener diversity index), 1-Lambda' (Simpson diversity index)**

| Sample | S | N | d | J' | H'(loge) | 1-Lambda' |
|---|---|---|---|---|---|---|
| Main reef | 10 | 1 | 454.5 | 0.84 | 1.934 | 41.52 |
| Patch reef | 14 | 13 | 5.083 | 0.7429 | 1.961 | 0.8548 |

## 4. DISCUSSION

There are several factors that cause a negative impact on a sensitive reef ecosystem. Many hypotheses have been put forward to understand their ecological significance. One is coral phase shifts [41], the decline of coral cover associated with the increase in the persistent states of macro algae [42-44], octocorals, sponges, coralline algae, etc. [45]. The present study compares the distribution patterns of the benthic community structure encountered in the patch and main reef areas in Gulf of Mannar. There was a gradual decrease in hard coral cover followed by increase in octocoral cover during the study. Generally, hard corals are the dominant structures in the reef areas of Gulf of Manner, while octocorals are the least dominant [46]. However, during our survey we found unusual assemblages of octocorals carpeting the entire benthic surface leaving little space for hard corals. The dominance of octocorals is due to their fast colonising ability [47,48], competitive overgrowth [49,50], and toxic and allelopathic features [51]. These capabilities have made them more successful in the degraded reef areas. Apart from these two, macroalgae is of great concern in Gulf of Mannar, especially in the degraded reef area, when the corals are overgrown by Macroalgae. Macroalgae such as *Halimeda*, *Gracilaria*, and *Padina* species shows local dominance in reef areas of Gulf of Mannar [52]. As mentioned above, a total of 19 species of octocorals were identified, of which the species belonging to the genus *Sinularia* sp. are the most abundant (Fig. 5) and *Sinularia manaarensis* Verseveldt, 1980 is the most dominant species. It is known that the species belonging to this genus show a local dominance in the Indo-Pacific reefs [53-55] because of their ability to saturate [56] the substrate through reproductive strategies.

Statistical analysis is very useful in determining the community structures [57] and in predicting the conservation status of the reefs [58]. We adopted similar statistical methods for assessing the octocoral distribution in the main reef of Kariyachalli Island and the patch reef areas. MDS plots constructed for the distribution of octocorals show there is variation in the clusters with respect to their presence in the patch and main reef areas of Kariyachalli Island. The results from the MDS plots show that octocoral distribution is clustered in the patch reef area which indicates similar distribution of octocoral community, and distinct clustering shows dissimilar distribution of octocorals. The increase in octocorals in the patch reef area is likely due to the decline in the hard coral cover. Hard corals are declining because they are in close proximity to the mainland and hence subject to the impact of various anthropogenic factors [24,59]. It is well known that the Tuticorin coastal region suffers from many stressors [60]. Octocorals quickly take advantage of a disturbed environment and rapidly occupy the available space, and sometimes are considered to invade the shallow areas [61]. There are several factors that facilitate diversity such as larval settlement [62], availability of substrate, depth, current flow, etc. which are essential for the mega faunal distribution [63]. However, the present study

did not assess the factors influencing the octocoral diversity and their response to the changing environmental conditions.

## 5. CONCLUSION

This study shows the gradual increase in the percentage cover of octocorals in the reef areas of Gulf of Mannar, and its distribution outside the Park area. It provides baseline information on octocoral assemblage with new distributional status of the species *S.triangula*. Hence, potential octocoral grounds should be identified and monitored regularly for conservation of these ecologically and economically important communities. Further studies are required to assess the role of environmental variables, i.e. the effects of suspended particulate matter and water currents on the distribution and community structure of octocorals. More comprehensive and systematic underwater surveys should be carried out to gather information on the status of the benthic assemblages, which can help in the conservation of coral reef ecosystem in the Gulf of Mannar.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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