The status and distribution of Corals and other Marine Flora and Fauna- Malvan Marine Sanctuary

Co guide: Mr. N Vasudevan

Mangrove Foundation

Guide: Dr. Kranti Yardi

Study conducted by: Noah Shinde

Malvan Marine Sanctuary: Pre-monsoon Survey Report

CONTENTS

1. Introduction

About 70% of our planet is covered by oceans and seas. Although, fishing first emerged in the 15th century, it really took off after the arrival of steam boats in the 19th century. This marked the beginning of the commercial fishing industry as we know it now. However, our understanding and exploration of life under water is very recent (1). Until the introduction of scuba diving our interactions with marine was restricted to intertidal area (2). These advances have opened up new possibilities for exploration of our seas and the life forms found in their depths. Recreational diving is a growing industry driven by sheer inquisitiveness and curiosity of the unknown.

Marine life generally occurs in 3 oceanic zones, viz. benthic (of the sea bed), pelagic (of the open sea) and littoral (along the shore). The predominance of species in an area is mostly dependent on the feeding ground, temperature and water quality. Depending upon the substratum, the various habitats where marine biodiversity occurs can be classified as sandy beaches, rocky shores, mudflats, mangroves, coral reefs and seagrass beds, inland brackish water wetlands and coastal lagoons (2).

Coral reefs are the most unique and most productive among the various marine habitats. The most diverse marine life occurs in coral reefs. Corals are tiny marine animals that belong to phylum Coelenterata. This phylum has 9200 species of which corals constitute about 1000; the known reef building corals among them number 793 (2). Reefs occupy less than 0.2% of the seabed. Yet they run along more than 150 000 km of coastline in more than 100 countries and territories. By their massive formation between the surface and the first few tens of meters deep, coral reefs are a very effective for absorbing elements coming from the ocean. They absorb waves energy and contribute to environmental protection through the reduction of coastal erosion. They reduce the damage in case of storms, hurricanes, and in some way, the energy of tsunamis. In doing so, they protect both ecosystems located between the reefs and coasts, such as seagrass and lagoon for example, and human settlements located by the sea. Their impact is so effective that the man mimics immersing concrete structures along some of our fragile coasts (3).

Worldwide decline in coral cover has serious implications for the health of coral reefs. Many ecologists have expressed concern over the worldwide decline in coral cover due to global warming and associated coral bleaching, overfishing, and coastal pollution. Coral reefs support a high diversity of fishes that may ultimately depend on corals for their survival; however, the impact of long-term reef degradation on fish populations is unknown. Most attention to the protection of marine fish populations has focused on the benefits of controlling exploitation by establishing ‘‘no-take’’ marine reserves (4).

People and governments have to come together if we are to stop the damage caused to our seas. Protection and sustainable development of the oceans and their resources are critical for the future of our planet, its people and myriad life forms (2).

2. Literature Review

For the purpose of the project, national and international journals were reviewed to gain a better understanding of the causes of damage to coral reefs and other marine life forms. These causes were broadly divided into natural and anthropogenic causes. Human activities, directly and indirectly, are now the primary cause of changes to marine biodiversity. Natural perturbations have always occurred in the oceans—ranging from seasonal climatic events (such as hurricanes, typhoons, and storm tides) leading to local habitat destruction, to El Niño-Southern Oscillation events, to natural oil seeps—but the resulting changes in biodiversity were frequently reversible or have been long integrated into the larger spatial and temporal patterns of ecosystem structure and function. Effects of many human activities, however, are frequently irreversible, at least over the span of a human life (5). These activities can be broadly termed as stressors to marine life forms. Changes in the ability to respond to environmental change can have a negative effect on growth and development, as demonstrated by marine invertebrates exposed to lowered salinity, increased UV radiation, and/or increases in CO2 levels in the seawater (6).

The stressors can be further categorized as extractive stressors and non-extractive stressors. Non-extractive stressors can be defined as the (mostly unintended) effects of mainly (but not exclusively) recreational activities on coral reef. These activities include snorkeling, diving, trampling, boating etc. SCUBA (Self-Contained Underwater Breathing Apparatus) a means for scientists to study corals and their importance to the ecosystem more closely. With advancements in technology, SCUBA has also become a leisurely venture by which tourists could see firsthand the majesty of coral reef communities. According to the Professional Association of Diving Instructors (PADI), almost one million people are certified every year for recreational diving. (7). Unregulated scuba diving is a major cause for the loss of coral cover. Amateur divers are likely to have an impact on marine organisms by kicking them with diving fins. In reefs all over the world, divers kicked, grabbed, and broke corals, along with accidentally hitting marine life with high technology consoles that hung below divers as they swam. Poor diver etiquette, lacking buoyancy control, improperly secured gear, photography flashes, and blasts from fin kicks were the main causes of damage to corals (8).

Extractive stressors include commercial and local fishing practices, coral harvesting etc. Fishing also plays a central social and cultural role in many island and coastal communities, where it is often a critical source of food and income. The impacts from unsustainable fishing on coral reef areas can lead to the depletion of key reef species in many locations. Such losses often have a ripple effect, not just on the coral reef ecosystems themselves, but also on the local economies that depend on them. Additionally, certain types of fishing gear can inflict serious physical damage to coral reefs, seagrass beds, and other important marine habitats (9). Towing a heavy trawl net through a cold water coral reef is a bit like driving a bulldozer though a nature reserve. The only practical way of protecting these reefs is therefore to find out where they are and then prevent boats from trawling over them (10). A devastating decline in coral cover caused a

parallel decline in fish biodiversity, both in marine reserves and in areas open to fishing. Over 75% of reef fish species declined in abundance, and 50% declined to less than half of their original numbers. The greater the dependence species have on living coral as juvenile recruitment sites, the greater the observed decline in abundance. Several rare coral-specialists became locally extinct (4).

For the collection of data of the marine flora and fauna present in the area, various methodologies were reviewed. Manta tow and timed swims, are the best methods for obtaining a broad scale, general description of a reef site and involve either towing a diver behind a boat around a reef or a diver swimming for a set time or distance (11). However, due to low visibility and large number of fishing boats present in the study area, it is not the recommended course of action. Point intercept transects (PIT) measure objects at specific intervals either below the transect tape, or below and to the side of the transect tape (11) helps estimate the benthic substrate cover in the area. Fish belt transect method(11) aim to count (quantify) the abundance and community composition of fish on a transect, however due to low fish aggregation visual estimation method is recommended.

Quadrats can be used to estimate the percent cover of each species or other reef components and obtain information about density, abundance, diversity and colony size (12).

3. Methodology:

3.1 Study Area:

The state of Maharashtra is located on the western side of the Indian Peninsula. The state has 720 kilometers coastline. Sindhudurg is southern-most district of Maharashtra state which is bordered by Sahyadri mountain range on east and 122 km of coastline west, it is harboring critical habitats and rich biodiversity. The coastal and marine habitat includes creeks, tidal flats, marshes, mudflats, mangroves, coral reefs, rocky islets which harbors rich marine biodiversity. These waters are also known to be migrant routes for whales, whale sharks etc. Thus placing Maharashtra State in top 5 states in India as rich in coastal and marine biodiversity. However, these habitats and biodiversity is threatened by unsustainable fishing. It is not only threatening biodiversity but also livelihood of traditional fishermen in long term.

Sindhudurg is an emerald district in Maharashtra with natural scenic beauty, abundant greenery, attractive beaches and temples and with distinctive style of architecture, colorful and lively feasts and festival and above all, hospitable people with a rich cultural milieu. Considering, tourism as a potential driver of regional economy of Sindhudurg, Government of Maharashtra declared the district as a Tourism District in 1997 emphasizing that the economic growth of the district can be achieved through tourism ensuring sustainable development in the district. The marine biodiversity in Malvan has been reported to be relatively rich and hence the government of Maharashtra declared port of Malvan coastal waters as a Marine Sanctuary in 1987. The total area of the Marine Sanctuary is 29.12 sq.km. The buffer zone is approximately 25.95 sq.km. The core zone covering the area of Sindhudurg fort, Padamagad Island along submerged exposed rocks extends to about 3.2 sq.km (13).

3.2 Data Collection:

Data collection was conducted in the entire marine sanctuary area. The sanctuary area was divided into grids of 500meter square each. The hot spots identified in the previous work conducted in the region in 2016 will be used to identify the baseline data of the area.

Work Plan: The following methods was used to survey the study area. The belt width is taken 1m due to low visibility in the region. Once placed the same meter tape is used for the different methods so that the survey can be done efficiently and time is saved and maximum number of transects can be done.

Belt transect (11):

1. Set out 25m tape on the base

2. Set camera such that the meter tape is visible
3. Start video and turn 360, document surrounding area
4. Diver swims at a slow pace along the meter tape with video cam recording coral species.

Point Intercept transect (11):

1. Along the same meter tape identify the base substrate
2. Identify at every 1m
3. Begin from 0m- end at 25m

Photo quadrat (12):

1. Along the same meter tape
2. Place quadrate at 5m intervals
3. Begin from 0m- end at 25m
4. Photographs of the quadrate will be captured

Water sample collection:

1. Diver carries a glass sampling bottle(closed) to the bottom of the surveyed site
2. Open the bottle underwater
3. Close it and carry it up to be sealed and analyzed for chemical constituents

3.2.1 Physical and chemical parameters:

1. Temperature
2. Visibility
3. Nitrite
4. Nitrate
5. Ammonia
6. pH

3.2.2 Biological Parameters:

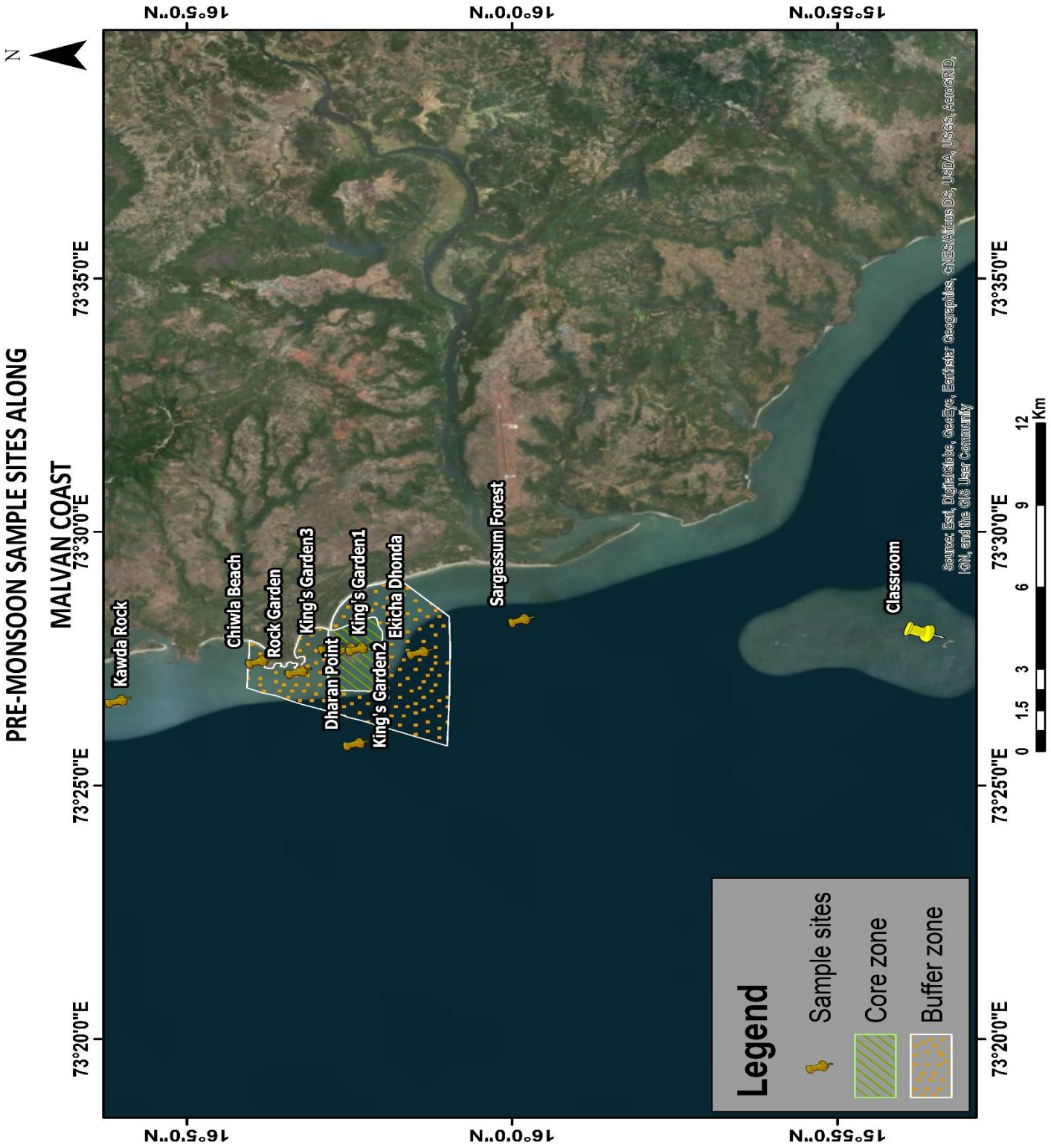
1. Benthic cover
2. Fishes diversity

3.3.1 Sample sites:

Pre-identified biodiverse hotspots were selected for sampling. The GPS locations of these sites were recorded and then mapped out to see the distribution of marine biodiversity along the Malvan coast.

Sr. no.	Dive site name	GPS location	
		Latitude	Longitude
1.	Kawda Rock	16°06'03.2" N	073°26'40.7" E
2.	Chiwla Beach	16°03'53.8" N	073°27'27.4" E
3.	Rock Garden	16°03'17.0" N	073°27'15.3" E
4.	Dharan Point	16°02'23.9" N	073°28'14.4" E
5.	Kings' Garden 1	16°02'21.6" N	073°27'42.74" E
6.	Kings' Garden 2	16°02'31.2" N	073°27'42.3" E
7.	Kings' Garden 3	16°02'46.9" N	073°27'44.0" E
8.	Ekicha Dhonda	16°01'25.0" N	073°27'38.2" E
9.	Sargassum Forest	15°59'51.5" N	073°28'16.5" E
10.	Classroom Point	15°53'38.7" N	073°28'02.3" E

3.3.2 Map of sample sites and the current boundary of Malvan Marine sanctuary:



4 Observations:

4.1 Diversity of Corals:

Sr. no	Family	Genus	Species	Common names	IUCN
1.	Arcoporidae	*Montipora*	*Montipora foliosa*	Cabbage coral	Near threatened
2.			*Montipora venosa*	Table coral	Near threatened
3.	Poritidae	*Goniopora*	*Goniopora stokesi*	Flower coral	Near threatened
4.		*Porites*	*Porites lichen*	Yellow finger coral	Least concern
5.			*Porites solida*	Boulder coral	Least concern
6.	Faviidae	*Goniastrea*	*Goniastrea edwardsi*	Brain coral	Least concern
7.			*Goniastrea pectinata*	Lesser star coral	Least concern
8.		*Favites*	*Favites abdita*	Larger star coral	Near threatened
9.			*Favites complanata*	Stony coral	Near threatened
10.		*Plesiastrea*	*Plesiastrea versipora*	Small knob coral	Least concern
11.		*Favia*	*Favia speciosa*	Elliptical star coral	Least concern
12.	Dendrophylliidae	*Tubastrea*	*Tubastrea aurea*	Orange tube coral	-
13.		*Turbinaria*	*Turbinaria mesentriana*	Pakoda scroll coral	-
14.	Lobophylliidae	*Lobophyllia*	*Lobophyllia corymbosa*	Brain root coral	Least concern
15.	Ellisellidae	*Ellisella*	*Ellisella barbadensis*	Devil's sea whip	-
16.	Discosomidae	*Amplexidiscus*	*Amplexidiscus sp.*	-	-
17.	Siderastreidae	*Sideratsrea*	*Sideratsrea sp.*	Starlet coral	Least concern

4.2 Diversity of Algae:

Sr. no	Family	Genus	Species	IUCN
1.	Caulerpaceae	*Caulerpa*	*Caulerpa sertularioides*	Not evaluated
2.			*Caulerpa lentillifera*	Not evaluated
3.			*Caulerpa scalpelliformis*	Near threatened
4.			*Caulerpa taxifolia*	-
5.	Sargassaceae	*Sargassum*	*Sargassum cinereum*	Near threatened
6.	Corallinaceae	*Amphiroa*	*Amphiroa fragillissima*	Not evaluated
7.	Ulvaceae	*Ulva*	*Ulva reticulata*	Endangered
8.	Gelidiellaceae	*Gelidiella*	*Gelidiella acerosa*	Not evaluated
9.	Ulvaceae	*Enteromorpha*	*Enteromorpha compressa*	-
10.	Cladophoraceae	*Chaetomorpha*	*Chaetomorpha linum*	-
11.	Sphacelariaceae	*Sphacelaria*	*Sphacelaria furcigera*	Not evaluated
12.	Dictyotaceae	*Padina*	*Padina tetrastromatica*	Near threatened
13.			*Padina gymnospora*	-
14.		*Dictyopteris*	*Dictyopteris australis*	Not evaluated
15.	Lomentariaceae	*Gelidiopsis*	*Gelidiopsis intricata*	Not evaluated

4.3 Diversity of Reef Fish:

Sr. no	Family	Genus	Species	Common names	IUCN
1.	Pomacanthidae	*Pomacanthus*	*Pomacanthus annularis*	Blue ring angelfish	Least concern
2.	Pomacentridae	*Pomacentrus*	*Pomacentrus nigromanus*	Goldback damsel	Not evaluated
3.		*Pomacentrus*	*Pomacentrus coelestis*	Neon damselfish	Not evaluated
4.		*Neopomacentrus*	*Neopomacentrus sindensis*	Arabian demoiselle	Not evaluated
5.		*Amphiprion*	*Amphiprion melanopus*	Cinnamon clownfish	Least concern
6.		*Abudefduf*	*Abudefduf bengalensis*	Bengal sergeant	Least concern
7.		*Dascyllus*	*Dascyllus trimaculatus*	Threespot dascyllus	Vulnerable
8.		*Neopomacentrus*	*Neopomacentrus cyanomos*	Regal demoiselle	Not evaluated
9.		*Chrysiptera*	*Chrysiptera leucopoma*	Surge demoiselle	Not evaluated
10.	Acanthuridae	*Acanthurus*	*Acanthurus lineatus*	Lined surgeonfish	Least concern
11.			*Acanthurus gahhm*	Black surgeonfish	Least concern
11.	Mugilidae	*Mugil*	*Mugil cephalus*	Flathead grey mullet	Least concern
12.	Chaetodontidae	*Chaeodon*	*Chaetodon collare*	Redtail butterflyfish	Least concern
13.		*Heniochus*	*Heniochus acuminatus*	Longfin bannerfish	Least concern
14.	Kyphosidae	*Kyphosus*	*Kyphosus cinerascens*	Blue sea chub	Least concern
15.	Serranidae	*Epinephelus*	*Epinephelus coioides*	Orange-spotted grouper	Least concern
16.	Serranidae	*Cephalopholis*	*Cephalopholis formosa*	Bluelined hind	Least concern
17.	Balistidae	*Odonus*	*Odonus niger*	Red-toothed triggerfish	Not evaluated
18.	Diodontidae	*Diodon*	*Diodon hystrix*	Spot-fin porcupinefish	Least concern
19.	Carangidae	*Caranx*	*Caranx sexfasciatus*	Bigeye trevally	Least concern
20.	Haemulidae	*Plectorhinchus*	*Plectorhinchus chubbi*	Dusky rubberlip	Not evaluated
21.	Labridae	*Halichoeres*	*Halichoeres nigrescens*	Bubblefin wrasse	Least concern
22.	Siganidae	*Siganus*	*Siganus vermiculatus*	Vermiculated spinefoot	Least concern

23.	Sparidae	*Acanthopagrus*	*Acanthopagrus pacificus*	Pacific seabream	Least concern
24.	Mullidae	*Parupeneus*	*Parupeneus indicus*	Indian goatfish	Least concern
25.	Sphyraenidae	*Sphyraena*	*Sphyraena flavicauda*	Yellowtail barracuda	Least concern
26.	Muraenidae	*Gymnothorax*	*Gymnothorax polygonius*	Reticulated moray eel	Least concern
27.	Blenniidae	*Parablennius*	*Parablennius sanguinolentus*	Rusty blenny	Least concern
28.	Pempheridae	*Pempheris*	*Pempheris adusta*	Dusky sweeper	Not evaluated
29.	Gobiidae	*Amblyeleotris*	*Amblyeleotris guttata*	Spotted prawn-goby	Not evaluated
30.		*Favonigobius*	*Favonigobius reichei*	Indopacific tropical sand goby	Least concern
31.	Lutjanidae	*Lutjanus*	*Lutjanus griseus*	Grey snapper	Least concern
32.	Nemipteridae	*Scolopsis*	*Scolopsis aurata*	Yellowstripe monocle bream	Not evaluated
33.	Delphinidae	*Sousa*	*Sousa plumbea*	Humpback dolphin	Endangered
34.	Synanceiidae	*Synacenia*	*Synacenia sp.*	Stone fish	-
35.	Leiognathidae	*Karalla*	*Karalla daura*	Goldstripe ponyfish	Not evaluated

4.4 Crustaceans:

Sr. no	Family	Genus	Species	Common names	IUCN
1.	Portunidae	*Portunus*	*Portunus sanguinolentus*	Three spotted crab	-
2.	Alpheidae	*Alpheus*	*Alpheus bellulus*	Tiger pistol shrimp	-

4.5 Other associated marine life:

Sr. no	Family	Genus	Species	Common names	IUCN
1.	Aglaopheniidae	*Macrorhynchia*	*Macrorhynchia sp*	White stinging hydroid	-
2.	Actiniidae	*Bunodosoma*	*Bunodosoma goanense*	Sea anemone	-
3.	Pelagiidae	*Chrysaora*	*Chrysaora sp.*	Jelly fish	-
4.	Gorgoniidae	*Gorgonia*	*Gorgonia sp.*	Sea fan	-
5.	Sphenopidae	*Palythoa*	*Palythoa sp.*	Zooanthids	

4.6 Abundance of Coral species in Malvan:

Abundant	Common	Uncommon	Rare
-	*Favites complanata*	*Ellisella barbadensis*	*Amplexidiscus sp*
	Montipora foliosa	*Favites abdita*	*Favia speciosa*
	Porites solida	*Goniastrea edwardsi*	*Lobophyllia corymbosa*
		Goniastrea pectinata	*Turbinaria mesentriana*
		Goniopora stokesi	
		Montipora venosa	
		Plesiastrea versipora	
		Porites lichen	
		Tubastrea aurea	

4.7 Abundance of Reef fish species in Malvan:

Abundant	Common	Uncommon	Rare
-	*Abudefduf bengalensis*	*Acanthurus gahhm*	*Acanthurus lineatus*
	Cephalopholis formosa	*Amblyeleotris guttata*	*Caranx sexfasciatus*
		Amphiprion melanopus	*Dascyllus trimaculatus*
		Chaetodon collare	*Diodon hystrix*
		Chrysiptera leucopoma	*Epinephelus coioides*
		Halichoeres nigrescens	*Gymnothorax polygonius*
		Neopomacentrus cyanomos	*Kyphosus cinerascens*
		Pomacanthus annularis	*Odonus niger*
		Acanthopagrus pacificus	*Pempheris adusta*
		Aurelia sp.	*Plectorhinchus chubbi*
		Mugil cephalus	*Pomacentrus nigromanus*
		Lutjanus griseus	*Scatophagus argus*
		Sphyraena flavicauda	*Siganus vermiculatus*
			Zanclus cornutus

4.8 Sample sites showing percentage cover of Hard corals, number of coral species, algal percentage cover and species and reef fish species at all the 10 sample sites:

Sr. no.	Sample sites	Hard coral %	No. of Hard corals	Algal %	No. of algal species	No. of Reef fish species
1.	Dharan Point	55%	9	31%	10	7
2.	Chiwla beach	54%	10	15%	10	5
3.	Classroom point	27%	9	33%	5	18
4.	Saragassum forest	23%	6	49%	5	7
5.	Kawda rock	23%	3	12%	7	4
6.	Kings' garden 3	19%	11	27%	6	5
7.	Kings' garden 2	19%	6	11%	5	6
8.	Kings' garden 1	13%	10	31%	6	4
9.	Rock garden	0%	0	40%	3	2
10.	Ekicha dhonda	0%	0	19%	5	5

4.9 Sample sites in descending order of the number of species of Hard corals:

Sr. no.	Sample sites	No. of Hard coral species	Hard coral %	No. of algal species	Algal %	No. of reef fish species
1.	Kings' garden 3	11	19%	6	27%	5
2.	Chiwla beach	10	54%	10	15%	5
3.	Kings' garden1	10	13%	6	31%	4
4.	Dharan point	9	55%	10	31%	7
5.	Classroom point	9	27%	5	33%	18
6.	Sargassum forest	6	23%	5	49%	7
7.	Kings' garden 2	6	19%	5	11%	6
8.	Kawda rock	3	23%	7	12%	4
9.	Rock garden	0	0%	3	40%	2
10.	Ekicha Dhonda	0	0%	5	19%	5

4.10 Key Findings:

- It is seen that Dharan point, Chiwla beach and Classroom point have the highest percentage cover of hard corals, and species diversity of corals and reef fish.
- Sargassum forest has the highest percentage cover of algae, which is a competition to the corals present in the area.
- Kings' garden 3, Chiwla beach, Kings garden 1, Dharan point and Classroom point can be termed as hotspects since these sites have the highest coral and fish diversity among all the sample sites.
- The sites Kings' garden 1, Kings' garden 2 and Kings' garden 3 that are present in the core zone of the sanctuary have high dead coral cover but are highly diverse in the number of species.
- Classroom point is a point far off from Malvan towards the south but has high soft coral cover and highest fish diversity observed in all the sample sites.

Threats:

- These sites are threatened by diving and need immediate protection to ensure survival and rejuvenation of the present coral cover.
- There are dead corals and solid waste observed at certain sites which have heavy inflow of scuba divers on a daily basis.
- Sites where active fish feeding by scuba divers was observed have higher algal percentage cover, which is competition for existing coral (Sargassum forest).
- Trawler fishing is also a major threat which has left some sites with scraped benthos.

4.11 Photographs showing coral species in Malvan:

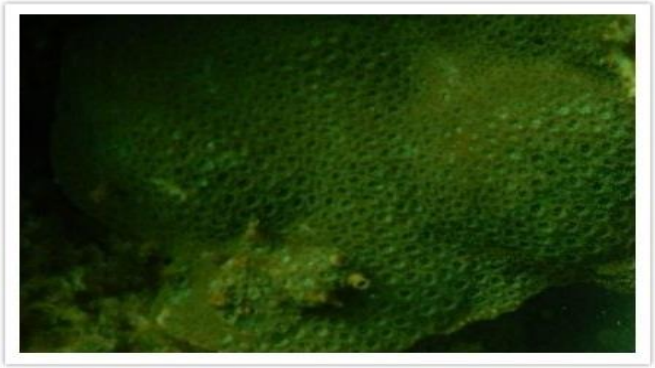
Favia speciosa ELLIPTICAL STAR CORAL

Ellisella barbadensis DEVIL'S SEA WHIP

Favites abdita LARGER STAR CORAL

Amplexidiscus sp.

Favites complanata STAR CORAL



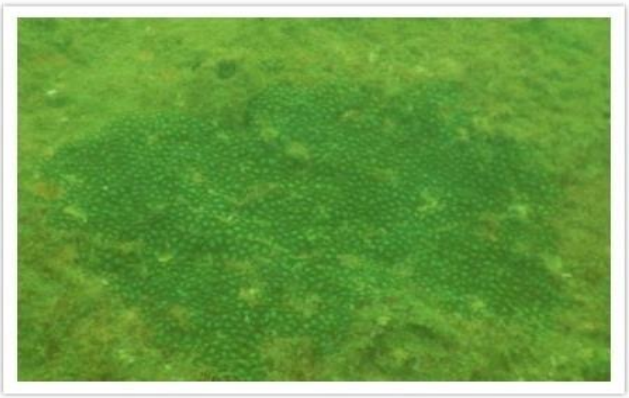
Goniopora minor FLOWER POT CORAL

Goniopora stokesi FLOWER CORAL

Lobophyllia corymbosa BRAIN ROOT CORAL

Montipora foliosa TABLE CORAL

Montipora venosa CABBAGE CORAL



Palythoa sp. ZOOANTHID

Plesiastrea versipora SMALL KNOB CORAL

Porites lichen SMALL POLYP STONY CORAL

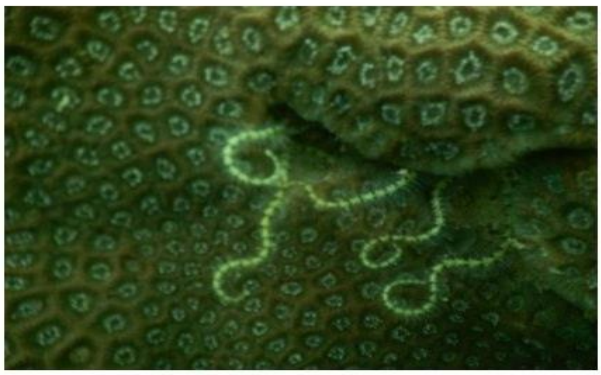
Porites solida BOULDER CORAL

Tubastrea aurea ORANGE TUBE CORAL

Turbinaria mesenterina CUP CORAL

4.12 Photographs showing fish species in Malvan:

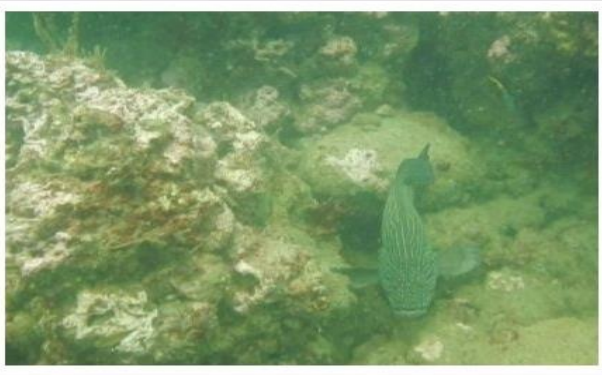
Abudefduf bengalensis BENGAL SERGEANT



BRITTLE STAR

Amblyeleotris guttata SPOTTED PRAWN GOBY and PISTOL SHRIMP

Acanthopagrus pacificus PACIFIC SEABREAM



Cephalopholis formosa BLUE LINED HIND

Chrysiptera leucopoma SURGE DEMOISLLE

Dascyllus trimaculatus THREE SPOT DASCYLLUS

Epinephelus coioides ORANGE SPOTTED GROUPER

Halichoeres nigrescens BUBBLE FIN WRASSE

Heniochus acuminatus LONGFIN BANNERFISH

Mugil cephalis FLATHEAD GREY MULLET

Muraena retifera RETICULATED MORAY EEL

Pomacentrus nigromanus GOLDBACK DAMSEL

Pomacanthus annularis BLUE RING ANGELFISH

Parupeneus indicus INDIAN GOAT FISH

4.13 Chemical parameters:

Water quality analysis was carried out on site. High levels of Nitrate, Nitrite and Ammonia can affect the growth and survival of marine life forms.

Ammonia:

Ammonia can block oxygen transfer in the gills of fish, thereby causing immediate and long term gill damage. Fish suffering from ammonia poisoning will appear sluggish and come to the surface, as if gasping for air (14).

Nitrites:

Nitrites occur in water as an intermediate product in the biological breakdown of organic nitrogen, being produced either through the oxidation of ammonia or the reduction of nitrate. The presence of large quantities of nitrites is indicative of waste water pollution (14).

Nitrates:

Nitrates occur in water as the end product in the biological breakdown of organic nitrogen, being produced through the oxidation of ammonia. Although not particularly toxic to fish, excess nitrates in the water is often used as an indicator of poor water quality (14).

pH:

By definition, pH is the negative logarithm of the hydrogen ion concentration. It is in effect an "Index" of the amount of hydrogen ion present in a substance and is used to categorize the latter as acid, neutral, or alkaline (basic) (14).

4.14.1 Water quality standards (14):

Nitrate(ppm)	Nitrite(ppm)	Ammonia(ppm)	pH
1 - 5	0 - 0.4	0.02-0.4	6.8-8.5

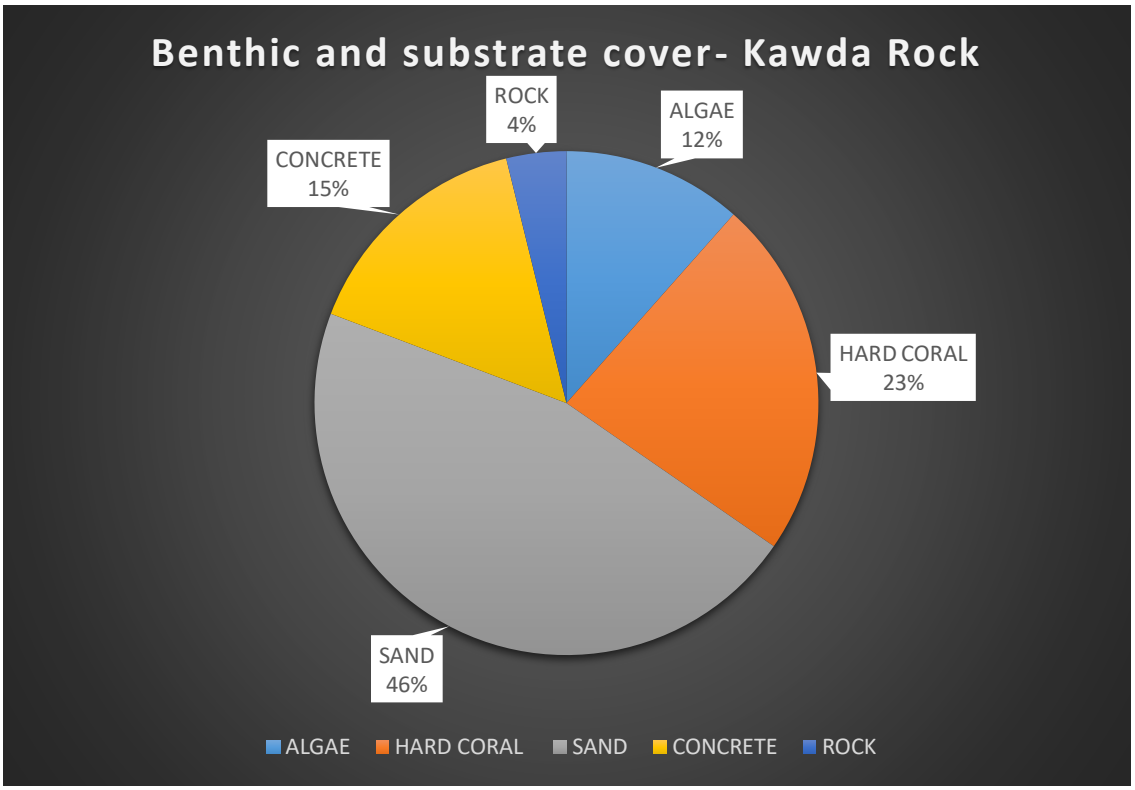
4.14.2 Water quality at the sample sites:

Sr. no.	Sample site name	Nitrate(ppm)	Nitrite(ppm)	Ammonia(pmm)	pH
1	Kawda Rock	5	0	0.25	8.2
2	Chiwla Beach	5	0	0.25	8
3	Rock Garden	5	0	0.5	8.4
4	Dharan Point	5	0	0.5	8.4
5	Kings' Garden 1	5	0	0.25	8.2
6	Kings' Garden 2	5	0	0.25	8.4
7	Kings' Garden 3	5	0	0.25	8.4
8	Ekicha Dhonda	5	0	0.25	8.4
9	Sargassum Forest	5	0	0.25	8.4
10	Classroom Point	5	0	0.25	8.2

4.15 Physical parameters:

Average Temperature	27.6℃
Average visibility	1.5meters

5.1 Kawda Rock:

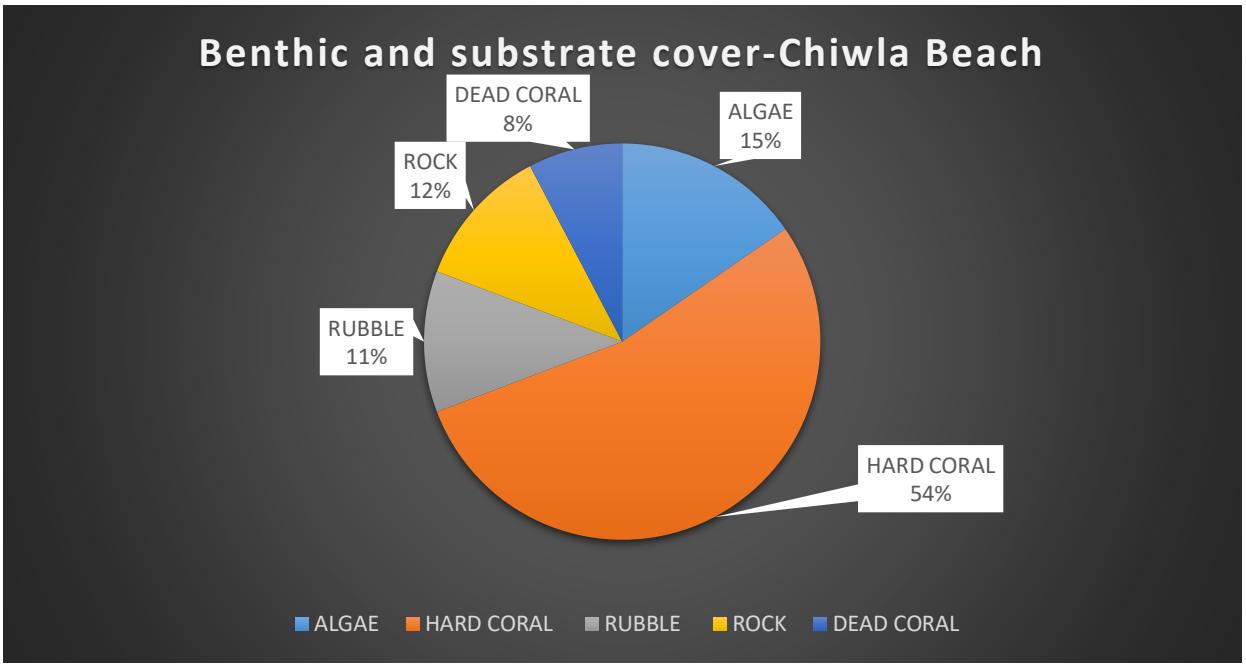


Fish	**Coral**	**Algae**
Abudefduf bengalensis	*Montipora foliosa*	*Sargassum cinereum*
Sphyraena flavicauda	*Ellisella barbadensis*	*Enteromorpha compressa*
Scatophagus argus	*Palythoa sp.*	*Chaetomorpha linum*
Aurelia sp.		*Padina gymnospora*
		Gelidiopsis intricata
		Ulva reticulata
		Gelidiella acerosa

Montipora foliosa is the dominant coral specie in this area. The site is a cove like structure with perfect rock cover for corals to thrive in, with the rock protecting it from strong winds and water current. Hereby providing a stable environment. But a lot of debris that is carried from the beach is being collected in this region. This has affected the growth of the transplanted corals.

Clean up initiatives and regular monitoring of the coral transplants should enhance their growth rate.

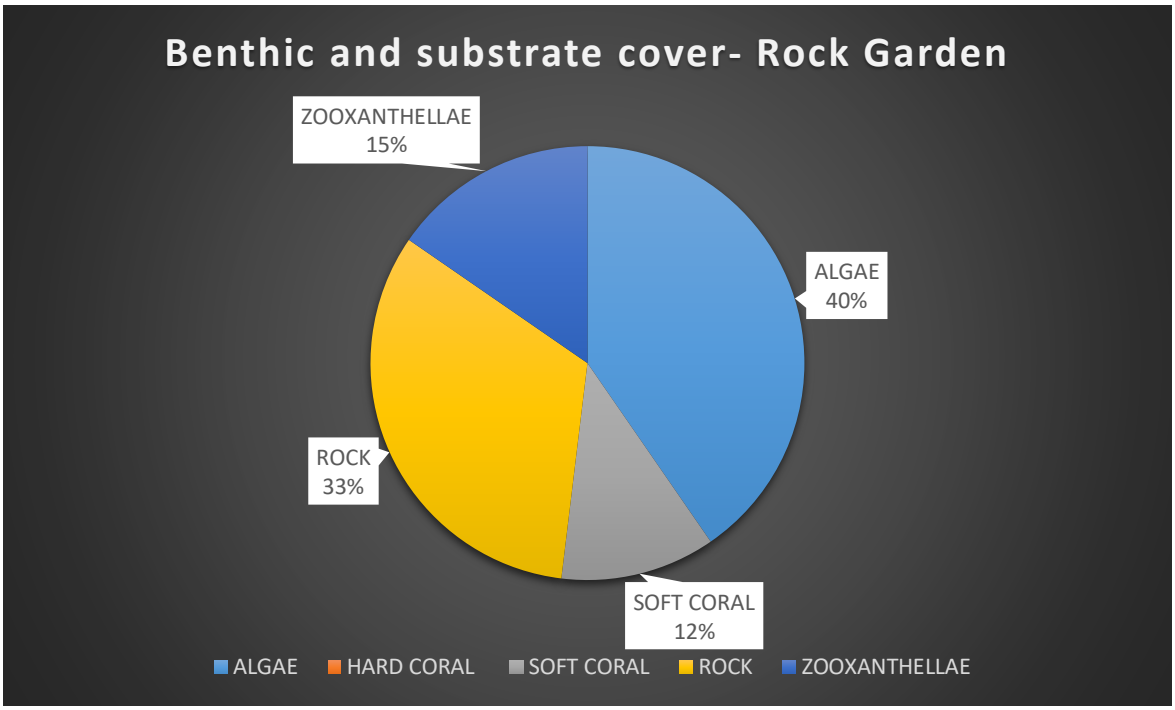
5.2 Chiwla Beach:



Fish	Coral	Algae
Cephalopholis formosa	*Plesiastrea versipora*	*Caulerpa taxifolia*
Pomacanthus annularis	*Montipora foliosa*	*Sargassum cinereum*
Abudefduf bengalensis	*Montipora venosa*	*Amphiroa fragillissima*
Pomacentrus nigromanus	*Goniopora stokesi*	*Ulva reticulata*
Neopomacentrus cyanomos	*Porites lichen*	*Gelidiella acerosa*
	Porites solida	*Enteromorpha compressa*
	Goniastrea edwardsi	*Chaetomorpha linum*
	Goniastrea pectinata	*Sphacelaria furcigera*
	Favites abdita	*Padina tetrastromatica*
	Favites complanata	*Padina gymnospora*

Plesiastrea versipora is the dominant coral specie at this site. Chiwla is a crowded beach in Malvan, flooded with tourists. It is a recreational diving spot for many amateur divers. There were quite a few fragmented and killed coral found at this site which was a result of fin kicking and grabbing of coral plates. A large aggregation of debris was found at this site (plastic bottles, wrappers etc. stuck in the cervices of coral plates).

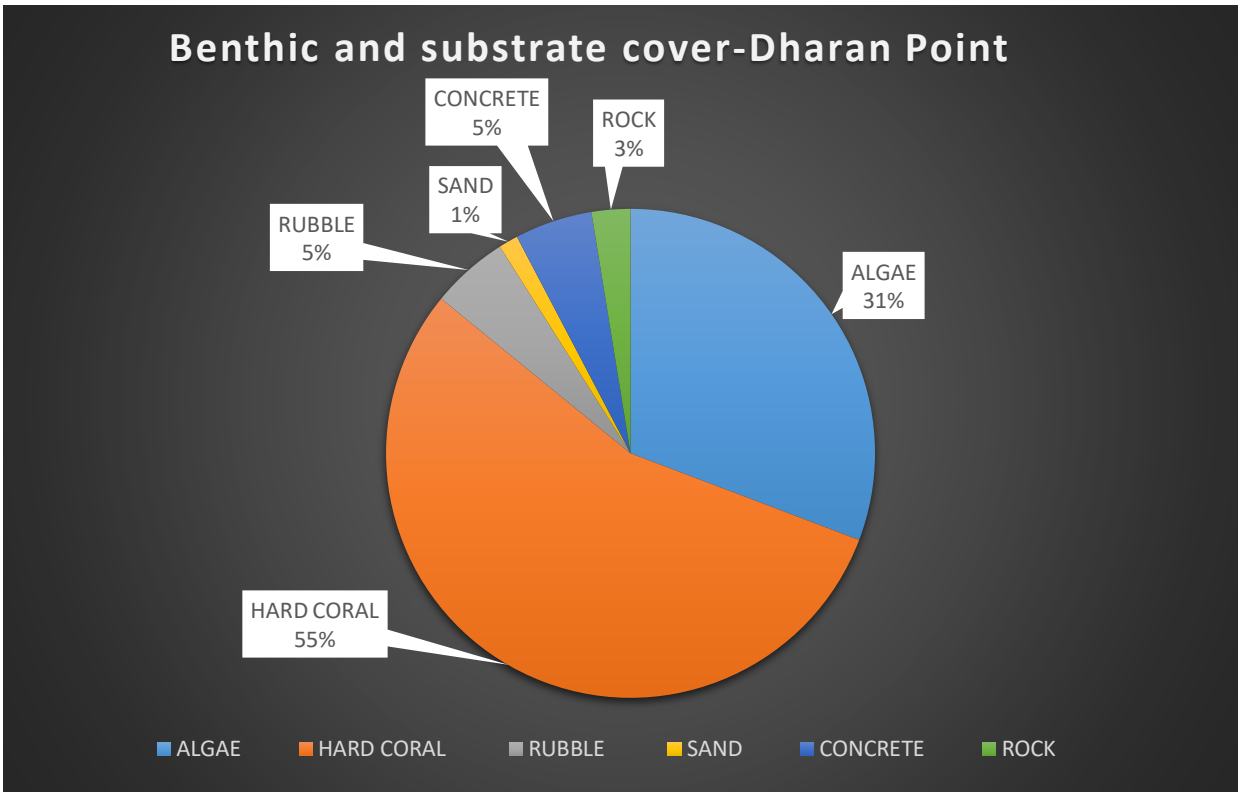
5.3 Rock Garden:



Fish	Coral	Algae
Acanthopagrus pacificus	*Goniastrea pectinata*	*Ulva reticulata*
Amphiprion melanopus	*Tubastrea aurea*	*Amphiroa fragillissima*
	Palythoa sp.	*Gelidiopsis intricata*
	Favites complanata	
	Ellisella barbadensis	

Favites complanata is the dominant coral specie at this site. *Tubastrea aurea* is also present in large aggregation but is scattered in small colonies. Feather stars have also been sighted in the region. The site majorly comprises of large boulders and it's difficult to navigate here due to strong currents and low visibility. Due to this there is minimal human disturbance here.

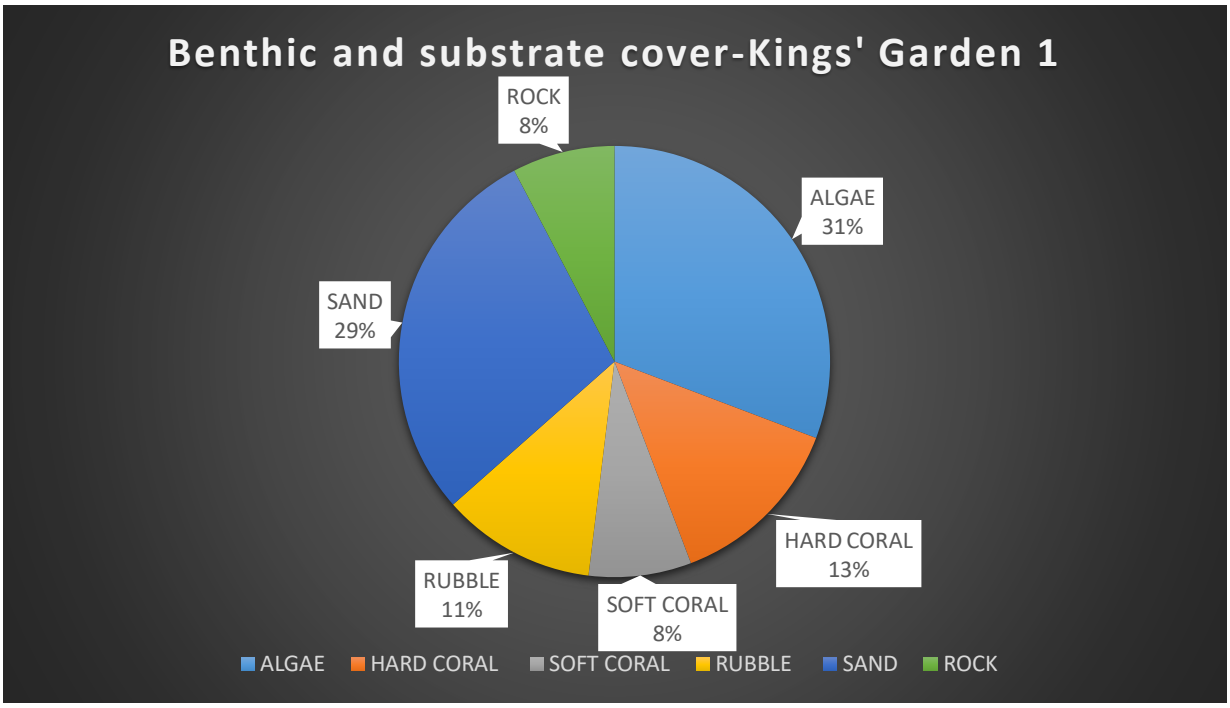
5.4 Dharan Point:



Fish	**Coral**	**Algae**
Chrysiptera leucopoma	*Montipora foliosa*	*Caulerpa sertularioides*
Zanclus cornutus	*Favites abdita*	*Caulerpa lentillifera*
Abudefduf bengalensis	*Favites complanata*	*Caulerpa scalpelliformis*
Pomacentrus nigromanus	*Plesiastrea versipora*	*Caulerpa taxifolia*
Cephalopholis formosa	*Favia speciosa*	*Sargassum cinereum*
Chaetodon collare	*Porites lichen*	*Amphiroa fragillissima*
Diodon hystrix	*Porites solida*	*Gelidiella acerosa*
	Goniopora stokesi	*Padina tetrastromatica*
	Goniastrea pectinata	*Padina gymnospora*
		Gelidiopsis intricata

Favites complanata is the dominant coral specie at Dharan Point. This site is located outside the buffer zone boundary of Malvan marine sanctuary. It has naturally occurring corals and coral transplants present. The coral transplants have shown a good survival rate and the triangular artificial reefs have succeeded in protecting the transplants and providing a habitat of fish life in the area. This site has minimum human disturbance although ghost nets have been retrieved here.

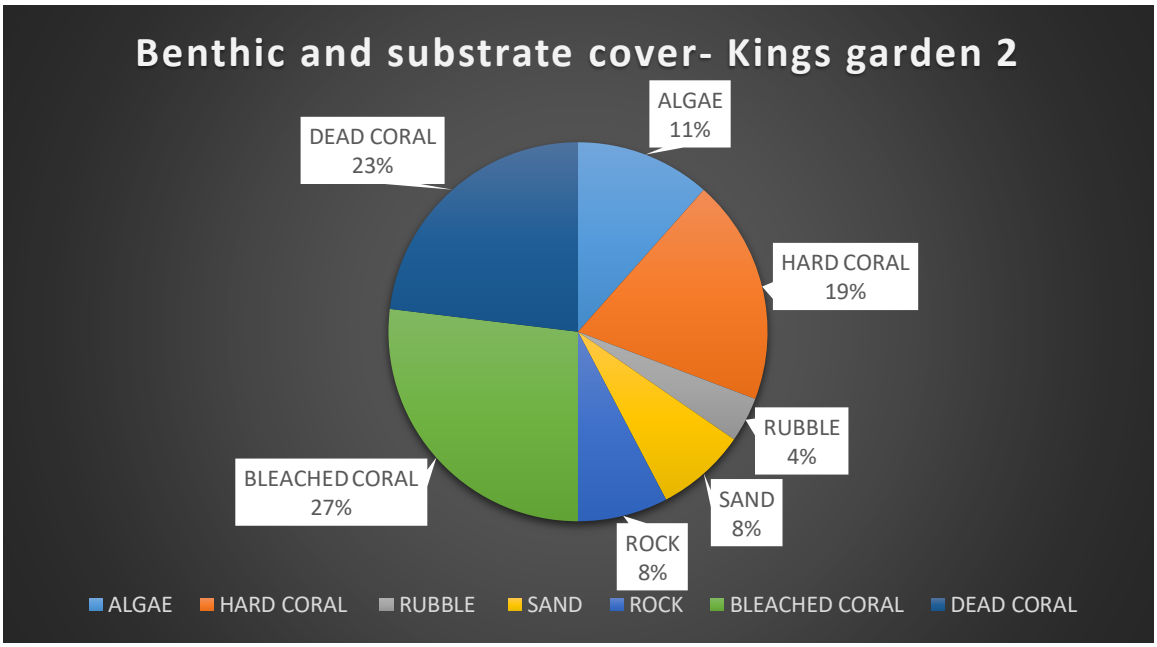
5.5 Kings' Garden 1:



Fish	**Coral**	**Algae**
Halichoeres nigrescens	*Montipora foliosa*	*Caulerpa lentillifera*
Amblyeleotris guttata	*Porites solida*	*Caulerpa scalpelliformis*
Acanthurus gahhm	*Plesiastrea versipora*	*Caulerpa taxifolia*
Lutjanus griseus	*Montipora venosa*	*Amphiroa fragillissima*
	Goniopora stokesi	*Ulva reticulata*
	Goniastrea edwardsi	*Gelidiopsis intricata*
	Favites abdita	
	Tubastrea aurea	
	Turbinaria mesentriana	
	Lobophyllia corymbosa	

Montipora foliosa is the dominant coral specie at this site. This site is located in the core zone of Malvan marine sanctuary. The Sindhudurg fort shelters this site from strong wind and water currents. It is a known spot for diving in Malvan. Although, diving is not the recommended practice because firstly, it's within the core zone of the sanctuary and secondly, the depth is 3-4meters. SCUBA does more damage than help in exploration of the site at such shallow depths.

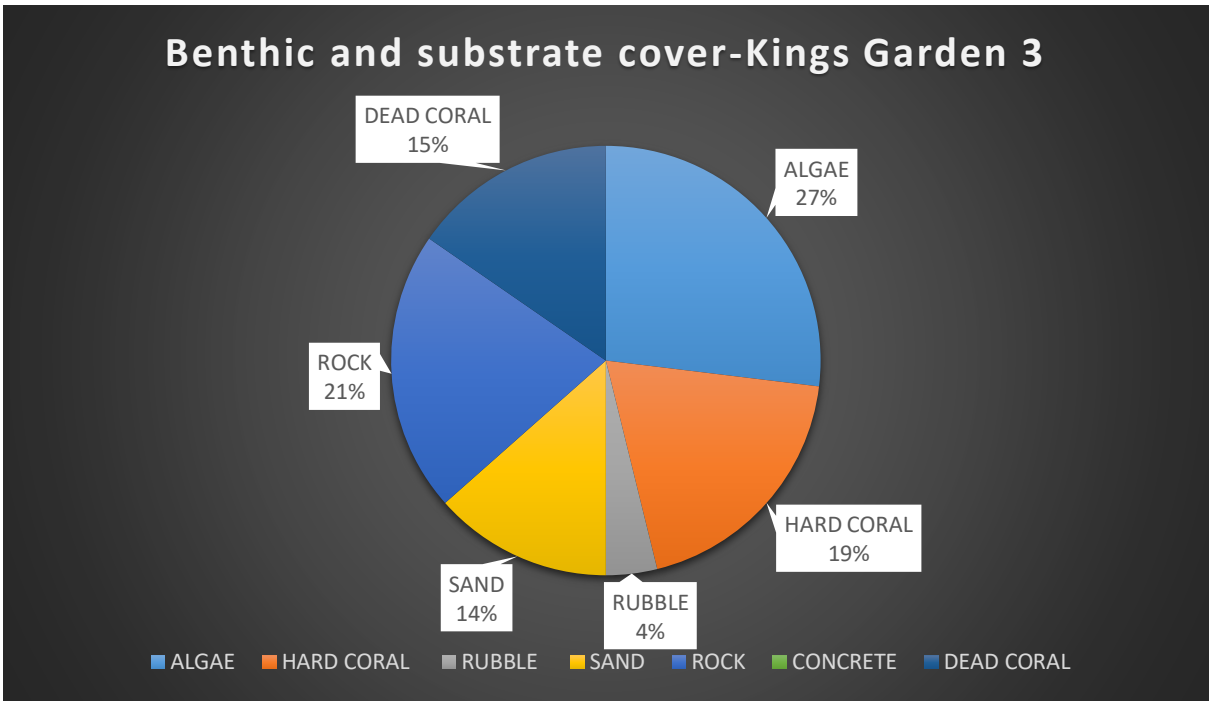
5.6 Kings' garden 2:



Fish	**Coral**	**Algae**
Amblyeleotris guttata	*Montipora foliosa*	*Caulerpa sertularioides*
Siganus vermiculatus	*Montipora venosa*	*Caulerpa scalpelliformis*
Dascyllus trimaculatus	*Porites lichen*	*Caulerpa taxifolia*
Halichoeres nigrescens	*Favites complanata*	*Padina gymnospora*
Acanthopagrus pacificus	*Plesiastrea versipora*	*Gelidiopsis intricata*
Abudefduf bengalensis	*Goniastrea edwardsi*	

Favites complanata and *Porites lichen* are the dominant coral species at this site. This site is located on the south-eastern flank of the Sindhudurg fort and lies within the core zone of Malvan marine sanctuary. It is a known dive spot. A large number dead and bleached corals were found here, caused by rampant unregulated diving. Large aggregation of debris was found eg. Rings, wrappers, bottles, nets etc.

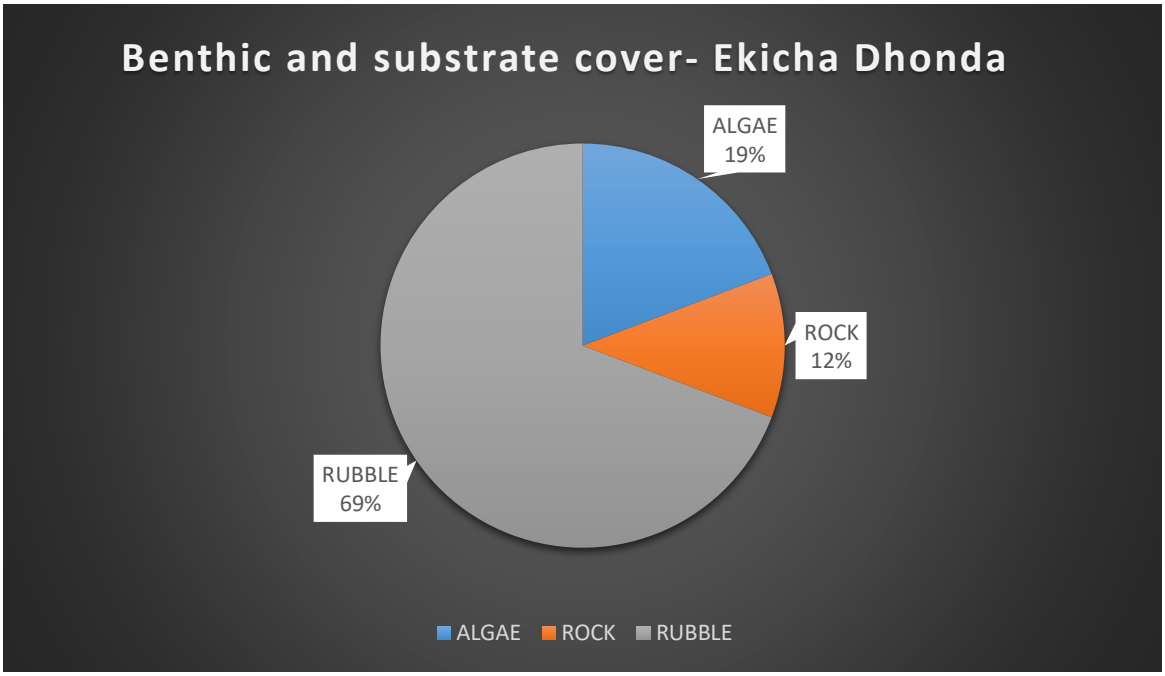
5.7 Kings' Garden 3:



Fish	Coral	Algae
Dascyllus trimaculatus	*Montipora foliosa*	*Caulerpa lentillifera*
Chrysiptera leucopoma	*Montipora venosa*	*Caulerpa scalpelliformis*
Cephalopholis formosa	*Goniopora stokesi*	*Caulerpa taxifolia*
Halichoeres nigrescens	*Porites solida*	*Amphiroa fragillissima*
Amblyeleotris guttata	*Goniastrea edwardsi*	*Ulva reticulata*
	Favites abdita	*Gelidiopsis intricata*
	Favites complanata	
	Tubastrea aurea	
	Turbinaria mesentriana	
	Lobophyllia corymbosa	
	Palythoa sp.	

Montipora venosa and *Favites complanata* are the dominant coral species at this site. The site is located on the eastern flank of the Sindhudurg fort. A large percentage of dead coral was found in the area. It is highly contaminated with debris from tourist activities.

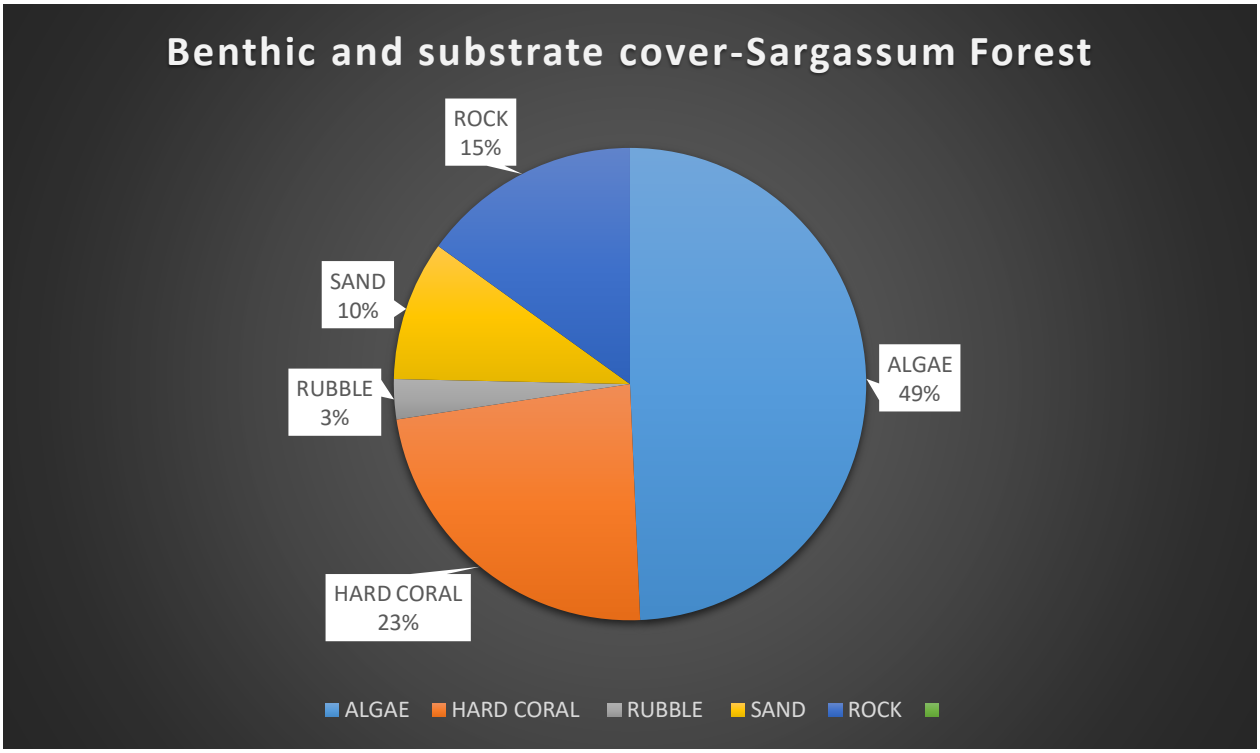
5.8 Ekicha Dhonda:



Fish	Coral	Algae
Zanclus cornutus	*Ellisella barbadensis*	*Gelidiopsis intricata*
Cephalopholis Formosa		*Sphacelaria furcigera*
Chaetodon collare		*Dictyopteris australis*
Acanthurus gahhm		*Gelidiella acerosa*
Abudefduf bengalensis		*Ulva reticulata*

Ellisella barbadensis was the only coral specie found at this site, which was sparsely distributed. There was good fish aggregation. The site has large boulders and has a large rubble cover. Large aggregation of jelly fish was observed at this site.

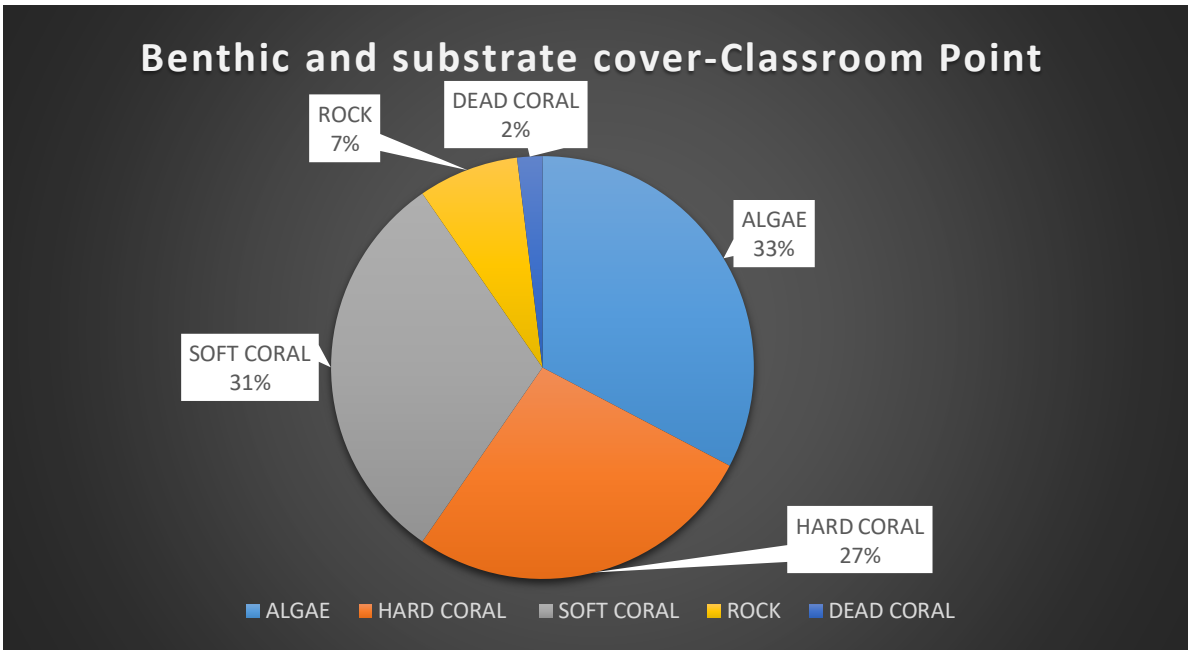
5.9 Sargassum Forest:



Fish	Coral	Algae
Gymnothorax polygonius	*Montipora foliosa*	*Ulva reticulata*
Plectorhinchus chubbi	*Goniopora stokesi*	*Sphacelaria furcigera*
Pomacanthus annularis	*Porites lichen*	*Amphiroa fragillissima*
Abudefduf bengalensis	*Porites solida*	*Gelidiella acerosa*
Cephalopholis formosa	*Favites complanata*	*Gelidiopsis intricata*
Odonus niger	*Goniastrea pectinata*	
Amphiprion melanopus		

Favites complanata is the dominant coral specie at this site. Large algal percent cover has been observed at this site. This may be due to the fish feeding practices by dive schools in order to attract fish. This is done for the tourists get a good photograph with the fish. This practice may have changed the natural balance at this site and the algae cover has increased with can in turn increase the competition for coral survival.

5.10 Classroom Point:



Fish	Coral	Algae
Amphiprion melanopus	*Montipora foliosa*	*Amphiroa fragillissima*
Neopomacentrus cyanomos	*Porites solida*	*Ulva reticulata*
Acanthurus lineatus	*Favites complanata*	*Gelidiella acerosa*
Acanthurus gahhm	*Amplexidiscus sp*	*Sphacelaria furcigera*
Mugil cephalus	*Porites lichen*	*Gelidiopsis intricata*
Chaetodon collare	*Favites abdita*	
Pempheris adusta	*Plesiastrea versipora*	
Kyphosus cinerascens	*Tubastrea aurea*	
Epinephelus coioides	*Ellisella barbadensis*	
Cephalopholis formosa		
Odonus niger		
Diodon hystrix		
Caranx sexfasciatus		
Plectorhinchus chubbi		
Pomacanthus annularis		
Neopomacentrus cyanomos		
Abudefduf bengalensis		
Chrysiptera leucopoma		

Montipora foliosa and *Amplexidiscus sp.* were the dominant coral species at the Classroom point. This was the most biodiverse site of all sample sites. It is located near Vengurla lighthouse and is far from Malvan marine sanctuary.

4. Conclusion:

1. 17 species of corals, 15 species of algae and 35 species of reef fish were identified during the pre-monsoon survey of the project.
2. There is good aggregation of hard coral present in the area.
3. The coral transplants are thriving but need to be regularly monitored as some have become loose from the supporting concrete table and are being washed away.
4. The artificial reefs have successfully formed a suitable habitat for fish and other marine fauna.
5. Comparatively, low fish aggregation was observed at sites within the sanctuary boundary than the sites outside the sanctuary.
6. The results of chemical analysis of water were within the accepted standards of water quality for marine life.
7. Malvan has rich marine biodiversity, but it is rapidly degrading by the day.
8. Unregulated diving and overfishing are the two major contributors to the degrading habitat in the area.
9. Practices such as fish feeding during DSD/fun dives have increased the dependency of fish on food provided by the recreational divers. This has resulted in increased coralline algal growth which competes with existing coral species.
10. Amateur divers have left certain sites ransacked and completely broken. Sites within the core zone of the sanctuary have very low live coral percent cover. These sites are laden with broken, dead and diseased corals, and seemingly look like a “coral graveyard”.
11. In addition, these sites are treated as dump yards by visiting tourists. Plastic bottles, wrappers, rings, keys, clothing, nets etc. have been retrieved from the sample sites during data collection.
12. The beaches too are being littered on by visiting tourist, and this debris is carried out to the open sea. Solid waste can have detrimental effect on the marine ecosystem and needs to be managed properly.
13. Fishing trawlers and nets too have led to fragmentation of corals and deterioration of the benthic zone.
14. Such progressive damage will eventually lead to the complete loss of marine biodiversity in the area.

5. Suggestions:

1. Ecological sensitization of the locals and tourists must be done via educational programs.
2. Diving within the sanctuary boundary should be completely stopped to allow the corals to regenerate.
3. Diving at other sites must be regulated. Only dive masters or higher certified divers should be allowed to guide tourist. This ensures good diving practices and the safety of the tourist.
4. Regular checks and patrolling should be done to ensure this.
5. The area can be divided into zones, while some are periodically open for divers the others are closed for such activities. Thereby allowing regeneration and promoting growth.
6. Permanent transect sites should be set up for the monitoring of the reef health. Regular monitoring of these sites should be conducted. This would give a trend in the health of the coral, regular monitoring would help in understanding whether coral areas are improving or deteriorating.
7. Coral aquaculuture or coral transplants can be done in these areas to increase the coral cover.
8. Coral gardens can be created with viewing galleries in an interpretation centre, that will minimize the number of tourist divers and thereby minimizing the damage too.

6. References:

1. The history of fishing [Internet]. [cited 2019 May 4]. Available from: https://www.alimentarium.org/en/knowledge/history-fishing

2. Apte D. Field Guide to the Marine Life of India. Deepak Apte and co-published and distributed by Animesh Apte, 2012; 502 pages.

3. Why are coral reefs so important? [Internet]. Coral Guardian. [cited 2019 May 4]. Available from: https://www.coralguardian.org/en/coral-reef-important/

4. Jones GP, McCormick MI, Srinivasan M, Eagle JV. Coral decline threatens fish biodiversity in marine reserves. Proc Natl Acad Sci. 2004 May 25;101(21):8251–3.

5. Read "Understanding Marine Biodiversity" at NAP.edu [Internet]. [cited 2019 May 5]. Available from: https://www.nap.edu/read/4923/chapter/5

6. Stressors on the marine environment [Internet]. OUPblog. 2016 [cited 2019 May 5]. Available from: https://blog.oup.com/2016/06/stressors-marine-environment/

7. raychellemarsman_ofj2015.pdf [Internet]. [cited 2019 May 4]. Available from: https://oceansfirstjournal.files.wordpress.com/2015/05/raychellemarsman_ofj2015.pdf

8. Ecotourism the boon or bane for a marine sanctuary by Ruth S. Guzman.

9. Overfishing and Coral Reefs [Internet]. ReefCI. [cited 2019 May 5]. Available from: https://reefci.com/2018/01/19/overfishing-and-coral-reefs/

10. Commercial Bottom Trawling and Deep Sea Coral - Final [Internet]. [cited 2019 May 5]. Available from: http://jrscience.wcp.muohio.edu/fieldcourses06/PapersMarineEcologyArticles/CommercialBottomTrawlinga.html

11. Hill J, Wilkinson C. Methods for Ecological Monitoring of Coral Reefs: Version 1. Townsville: Australian Institute of Marine Science; 2004. 117 p.

12. Rogers DC. Coral Reef Monitoring Manual. :114.

13. Critical habitat information system of Malvan by Dr. B.R. Subramanian and Dr. V.Sampath (2001).

14. Interpreting Water Analysis Test Results [Internet]. [cited 2019 May 6]. Available from: http://www.alken-murray.com/TESTS01.htm