



MONTSERRAT

CORAL CAY CONSERVATION ANNUAL MARINE SURVEY REPORT

YEAR 2013-2014

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**CORAL CAY
CONSERVATION**



EXECUTIVE SUMMARY

For nearly three decades, Coral Cay Conservation has been providing environmental and capacity building services to countries through our pioneering and award winning citizen-science programme. In 2013, Montserrat became the 16th country (and the 6th in the Caribbean) to benefit from our expertise.

Despite numerous setbacks in the first year of the programme – especially mechanical and boat issues, both the marine and the terrestrial survey programmes have gained momentum and are starting to yield encouraging results. This yearly report covers the marine programme from mid-2013 until the end of 2014.

Highlights of 2013-14 include:

- Surveys were conducted by trained CCC teams at 14 sites along the Western coast of Montserrat, between July 2013 and August 2014 inclusive.
- Surveys were conducted using a modified Reef Check survey protocol at two survey depths; 6 m and 12 m.
- Hard coral cover was limited to a few sites (M007-M012) around Lime Kiln Bay.
- There are extensive seagrass meadows in the area between Bransby Point and Old Road Bluff.
- Overall fish abundance and diversity was greatest at sites with diverse substrate composition; namely M007-M010.
- Overall invertebrate abundance and diversity was greatest at sites with diverse substrate composition; namely M007-M010.
- Few commercially important fish from families including Grouper, Grunt and Parrotfish were recorded. Recorded individuals were all small (< 40 cm) in size.
- Gorgonians were the most abundant target invertebrate recorded on the surveys. They were located in areas with hard substrate.
- Anthropogenic and environmental impacts including trash and coral disease were generally low across the survey area.
- This report recommends investigating the potential of a zoned Locally Managed Marine Area (LMMA) in the region of sites M005-M010. This process will involve thorough stakeholder engagement and consultation.

Alistair Cole

Alistair Cole FRGS FLS
Chief Executive

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CORAL CAY CONSERVATION

Founded in 1986, Coral Cay Conservation is dedicated to:

“Providing resources to help sustain livelihoods and alleviate poverty through the protection, restoration and management of coral reefs and tropical forests”

Coral Cay Conservation (CCC) works in collaboration with both government and non-governmental organisations within a host country without charging that country for the services provided (Figure 1). CCC is primarily self-financed through an innovative volunteer participatory scheme whereby international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs. Upon arrival at a project site, volunteers undergo a training programme in marine and terrestrial species identification and survey techniques under the guidance of qualified scientists prior to assisting in the acquisition of data. Finances generated from the volunteer programme allow CCC to provide a range of services including; data acquisition, assimilation and synthesis, conservation education, technical skills training and other capacity building programmes.

For nearly three decades, CCC has been successfully operating volunteer based conservation programmes in developing world countries with several internationally notable accomplishments, including the establishment of multiple Marine Protected Areas around the world. Examples of CCC action include the creation of the UNESCO World Heritage Site in Belize, the Danjungan Marine Reserve and Wildlife Sanctuary in Negros and the development of several no-take marine parks around Sogod Bay in the Philippines.

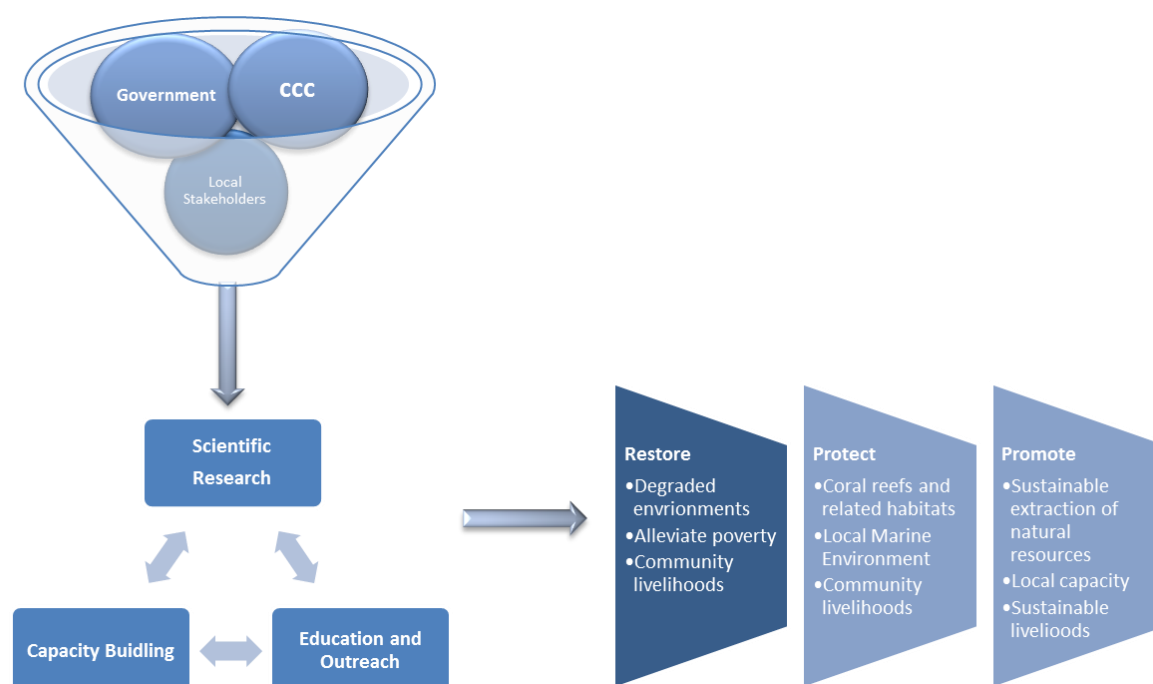


Figure 1: Schematic representation of CCC approach to community based conservation.

1 INTRODUCTION

1.1 Montserrat – The Emerald Isle of the Caribbean

Montserrat, part of the Leeward Isles in the Lesser Antilles, is a small Caribbean island with an area of approximately 102 km² located at 16° 45' 0" N, 062° 12' 0" W. The island, like most in the region, is volcanic in nature which is evident when studying its topography which shows three distinct volcanic ranges.

The majority of the island's natural vegetation is tropical forest with five forest types present: dry forest, coastal littoral forest, mesic forest, wet forest and elfin woodland. The type of vegetation present at different parts of the island is determined mainly by the amount of rainfall. Elfin woodland for example occupies a very small area and is found only in the highest points of the Centre Hills. Historically there were areas of saline lagoons and mangroves in Fox's Bay in the South West of the island but these were destroyed by volcanic ash flows during the eruptions of the 1990's (Hilton, Martin & Daley, 2006). There is now virtually no remaining wetland on the island, with the last substantial area of mangrove wetland in the North of the island having been reduced in recent times. Areas such as these were formerly important habitats for numerous water birds and wetland birds.

There is a wide array of spectacular marine life in the waters around Montserrat. The island has approximately 40 km of coastline with numerous reefs easily accessible from the shore. The main coral reefs are patch reefs, with many reefs extending off the western and north western shores of the island.

Over the last two and a half decades, Montserrat has experienced a number of catastrophic natural disasters which have had a severe and prolonged impact on the country's population, environment and economy. Hurricane Hugo struck the island in 1989, leading to widespread defoliation, destruction of property and loss of livestock. In 1995, the Soufrière Hills volcano became active and subsequently erupted three times, having a drastic impact on the island's marine and terrestrial ecosystems. As a result, more than 60% of the island's forest has now been destroyed.

1.2 Marine and Terrestrial Biodiversity of Montserrat

Despite its relatively small area, Montserrat has a very high level of endemic fauna and flora, similar to many of the other islands in the Lesser Antilles. Recent natural disasters, however, have adversely affected both the marine and terrestrial biodiversity of the island.

Terrestrial biodiversity on the island is particularly well studied and the island boasts a number of globally threatened and endemic species. Three species of plant found on the island are endemic to Montserrat only (Montserrat Orchid (*Epidendrum montserratense*), Pribby (*Rondeletia buxifolia*), and *Xylosma serratum*), while one bird species, one mammal sub-species, two reptile species and four reptile sub-species, are also endemic to Montserrat. The Montserrat Oriole (*Icterus oberi*) is the

national bird of Montserrat, and is both critically endangered and endemic to the island. The critically endangered Mountain Chicken (*Leptodactylus fallax*) is now only found on Montserrat and one other island.

In the marine environment, there are a number of colonies of Pillar Coral (*Dendrogyrus cylindrus*) and Elliptical Star Coral (*Dichocoenia stokesii*) – two vulnerable species, and several endangered Star Corals (*Montastraea spp.*) found on the island's reefs (Myers, 2013). Less commonly seen but also present are Staghorn Coral (*Acropora cervicornis*) and Elkhorn Coral (*Acropora palmata*) – both critically endangered, and found predominantly in the north western reefs on the island.

1.3 The Montserrat Ridge to Reef Conservation Project

In 2013 CCC, in partnership with the Royal Society for the Protection of Birds (RSPB) and the Montserrat Ministry of Agriculture, Trade, Lands, Housing and the Environment (MALHE), established the Montserrat Ridge to Reef Conservation Project (MRRCP). The project is funded in part by a grant from the Darwin Initiative and in part by contributions from volunteers who join the project to assist with survey work. The project has four main objectives:

1. Assessment and monitoring of marine resources
2. Assessment and monitoring of terrestrial resources
3. Community engagement, education and awareness raising
4. Capacity building training programmes for members of the local community interested in or already working within the field of conservation

Working with both local and UK based project partners, CCC's work aims to provide a more thorough understanding of the marine and terrestrial ecosystems on Montserrat to help the local community better utilise these natural resources and conserve threatened biodiversity. The project also aims to raise awareness on the island about the importance of conservation through education and outreach work in schools, libraries and public events. CCC also offers young Montserratians the chance to volunteer at no cost with the organisation as part of a 'Local Scholars Programme' to build capacity and further raise awareness about the importance of conservation.

Since the project's inception, marine surveys have so far been focussed on the western coast of the island. Through data collection and analysis, consultations with local stakeholders such as fishermen and representatives of the fisheries department, one of the project's long term aims is the establishment of a Locally Managed Marine Area (LMMA) to be managed by these local stakeholders and the Montserratian authorities.



Figure 2 – Map of Montserrat indicating the exclusion zones and the location of the CCC project base.

Terrestrial survey work aims to build on and augment existing efforts by both the RSPB and the Montserrat Department of Environment to monitor biodiversity and conserve resources across the island's forests and beaches, particularly the Centre Hills. The Centre Hills forest is the single most important remaining forest ecosystem on the island. Despite a management plan being proposed for this area in recent years, its paramount importance to the island's terrestrial biodiversity means that there are still

areas of conservation which will benefit from further collection and analysis of survey data.

At the start of the MRRCP, CCC developed both marine and terrestrial survey methodologies to provide broad scale environmental data on the health of biodiversity on Montserrat. These methods focus on selected target species and families which are used as a proxy for estimating the state of environmental resources in the area. Species and families were chosen based on their ecological and economic importance.

2 MARINE SURVEY PROGRAMME

At the inception of the marine survey programme, 44 proposed baseline survey sites were identified at 500 m intervals along the coast, around the northern half of the island. These ran from Bransby Point on the west coast, to Statue Rock on the east (Figure 3). Due to the proximity of sites to the CCC project base, marine surveys have initially focused on the western and north-western coast of the island. At each survey site two transects were completed; one at a depth of 6 m and one at 12 m. Between July 2013 and August 2014 marine surveys were conducted and completed at 14 sites (M001-M014). To be considered as complete, each proposed site must be surveyed at both depths. This equates to over 56 individual survey dives completed by CCC dive teams. Over the course of the year the rate of marine surveying has increased steadily, with the exception of December 2013 to February 2014 when the prevailing weather and swell conditions made surveying logistically difficult. During this time the marine survey programme was placed on hold and all efforts were focussed on the terrestrial project in the interim (See Coral Cay Conservation Montserrat Annual Terrestrial Report 2013-14).



Figure 3 – Map of Montserrat indicating the marine survey sites. Each site comprises of a survey at depths of 6 m and 12 m.

In addition to the baseline survey sites, a permanent transect site was established towards the end of the first year in Fox's Bay (Figure 3). This site will be surveyed monthly (weather permitting) throughout 2015 in order to provide temporal datasets relating to the health and status of the reefs. A further transect was established in October 2014 in Lime Kiln Bay and two more are planned to be established in 2015 at Rendezvous and Woodlands Bay. The preliminary data from these permanent transects will be published in the subsequent marine report for 2014-2015

2.1 Marine Survey Methodology

Baseline surveys are conducted using a modified Reef Check Methodology (Hodgson, 1999) which incorporates additional target species of fish to give a more comprehensive picture of the ecology and health of coral reefs (see Appendix A). Trained volunteer surveyors work in four-man teams, surveying along 100 m transect lines parallel to the shore. Surveys are carried out at 2 depths: 6 m and 12 m. Survey points are predetermined using GPS coordinates and navigated to by boat, or accessed from the shore if already marked by a buoy (Figure 4)

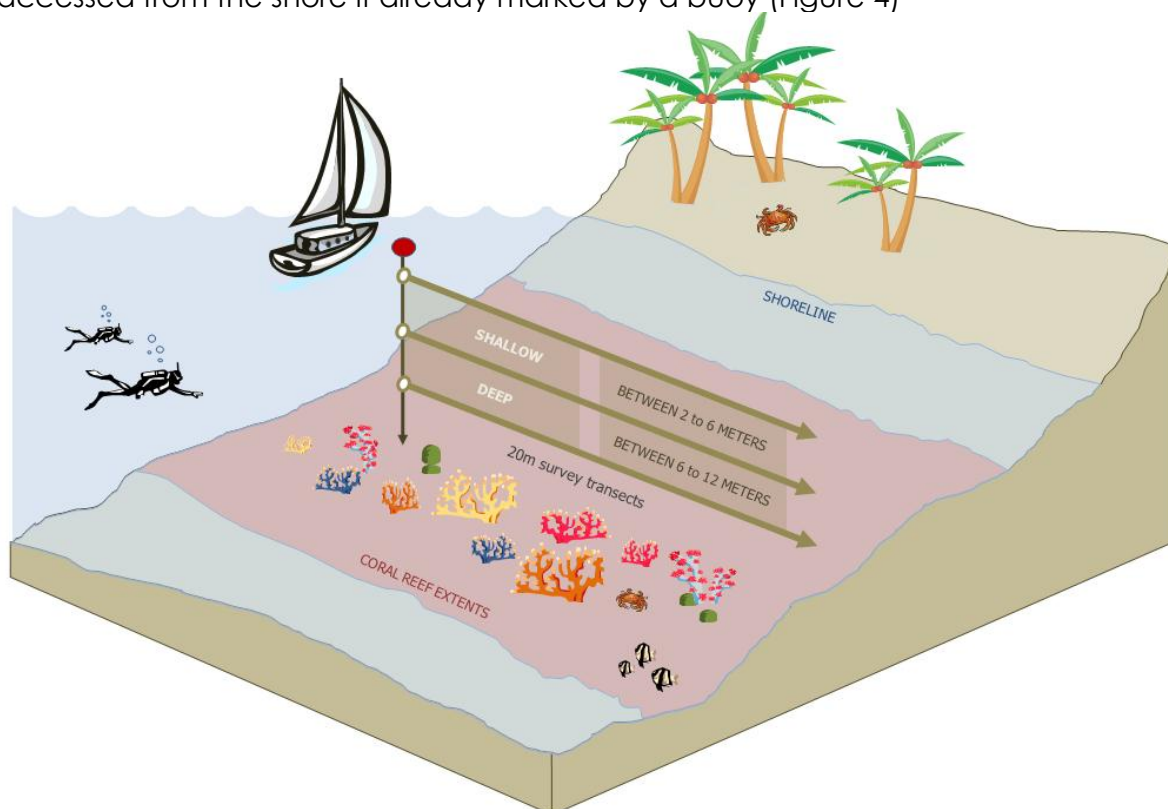


Figure 4 - Schematic diagram of survey depths, conducted parallel to the shoreline.

Along each depth contour, four 20 m transect replicates are marked out and surveyed to make up one complete transect (Figure 5). Each consecutive replicate's start and end point is separated by a minimum gap of 5 m. These gaps are necessary to ensure independence between the samples which is imperative for reliable statistical testing. Therefore, the distance between the start point of the transect's first replicate and the end point of the last replicate is 95 m.

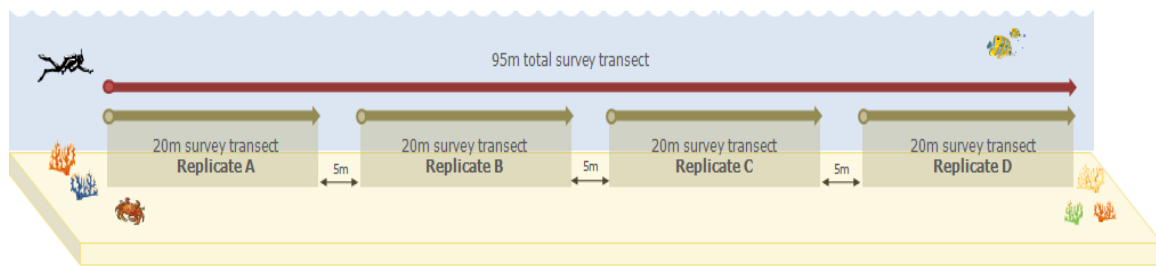


Figure 5 - Schematic diagram of transect setup

2.1.1. Fish

Fish diversity and abundance data is collected using an Underwater Visual Census. Selected fish families and species recognised as being suitable indicators of fishing pressure, aquarium collection and reef health are recorded. Two families are also recorded by size: Groupers (Serranidae) and Parrotfish (Scaridae).

Fish data is recorded along a 'belt' transect, where fish are counted within an imaginary 5x5x5 m box along the four 20 m replicates (Figure 6). Surveying is carried out by two divers swimming slowly side by side along the transect and counting the indicator fish. The divers stop every 5 metres and wait 1 minute for the indicator fish to come out of hiding before proceeding to the next 5 metre stop-point.

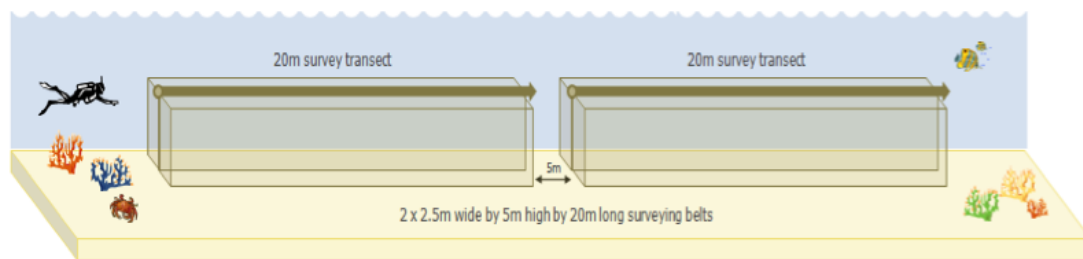


Figure 6 - Survey method for recording fish. The diagram shows two of the four replicates in a 100 m transect.

2.1.2. Invertebrates

The same areas used for the fish belt transect are used to record the diversity and abundance of selected invertebrate species typically targeted as food species, collected as curios or important to the ecological balance of the reef. Divers record invertebrates 2.5 m either side of the transect line (Figure 7), looking in holes and under overhangs to look for organisms such as lobsters, sea urchins or other cryptic species.

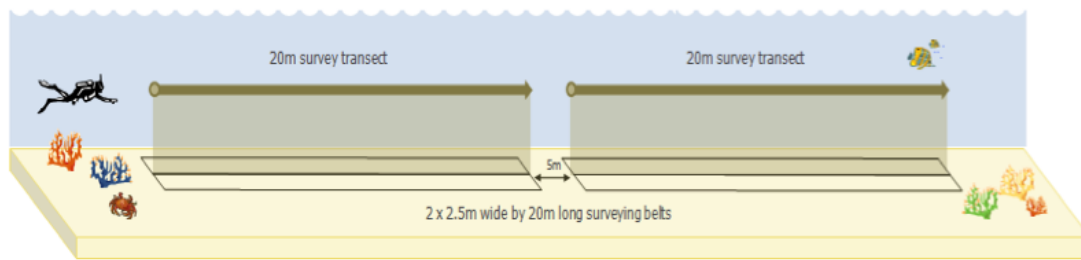


Figure 7 - Survey method for recording invertebrates. The diagram shows two of the four replicates in a 100 m transect

2.1.3. Substrate

Benthic diversity is measured by recording living and non-living benthic categories along a point intercept transect. Along the transect line, benthic organisms and substrate types are recorded at 50 cm intervals (Figure 8). To minimize bias, a plumb line is dropped at each designated 50 cm point and the substrate type underneath is recorded. Every 20 m replicate therefore contains 40 benthic points.

Benthic categories are: sand, rock, rubble, silt/mud, nutrient indicator algae, sponge, recently killed coral, soft coral, hard coral and any other biotic lifeforms (see Appendix A).

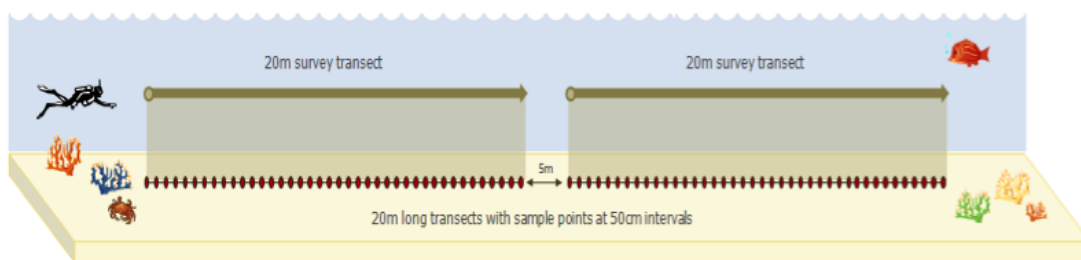


Figure 8 - Survey method for recording substrate data. The diagram shows two of the four replicates in a 100 m transect

2.1.4. Impacts

Within the same area assessed for invertebrates, divers record a number of impacts on the reef; estimating the total percentage of the coral population effected by bleaching, as well as the estimated percentage of each individual coral colony that is bleached. Coral diseases are recorded as a percentage of the population infected and, where possible, the disease is identified. Damage is recorded in three categories: 'boat/anchor', 'dynamite' and 'other' (which includes predation), on a categorical scale from 0 to 3 (0 = none, 1 = low, 2 = medium, 3 = high). The impact of trash on the site is recorded on the same scale and separated into 'general' and 'fishing nets/traps'.

2.2 Marine Survey Results

Over the course of the survey period the weather was predominantly sunny (54%), with some cloudy weather (41%) and occasional rain showers (5%). The average air temperature over the year was 30°C. The water temperature was, on average, 29°C (25 - 33°C range) at the surface, and 28°C at both 3 m and 10 m depth. Estimated underwater horizontal visibility was 14 m on average with a maximum of 25 m and a minimum of 2 m.

2.2.1 Fish

Overall total fish abundance was greatest at site M010 (303.8 ± 92.7 individuals per 500 m³ replicate, (mean $\pm$ Standard Error of the Mean (SEM)) (Figure 9). This was followed by site M006 (152 ± 82.4 individuals per 500 m³ replicate) and M008 (118 ± 45 individuals per 500 m³ replicate). When considering the depth contours separately, site M008 had the greatest abundance of fish at 6 m (228 ± 66.5 per 500 m³) (Figure 10) and site M010 had the highest abundance at 12 m (448 ± 177.4 per 500m³) (Figure 10). Sites M001 and M002 consistently had the lowest abundance figures. The high abundance levels at sites M008 and M010 can be mostly attributed to large abundances of Damselfish and Wrasse observed at these sites. Wrasse was the most commonly recorded fish family across the survey area with the greatest abundance at sites M010, M014 and M008 (Figure 11).

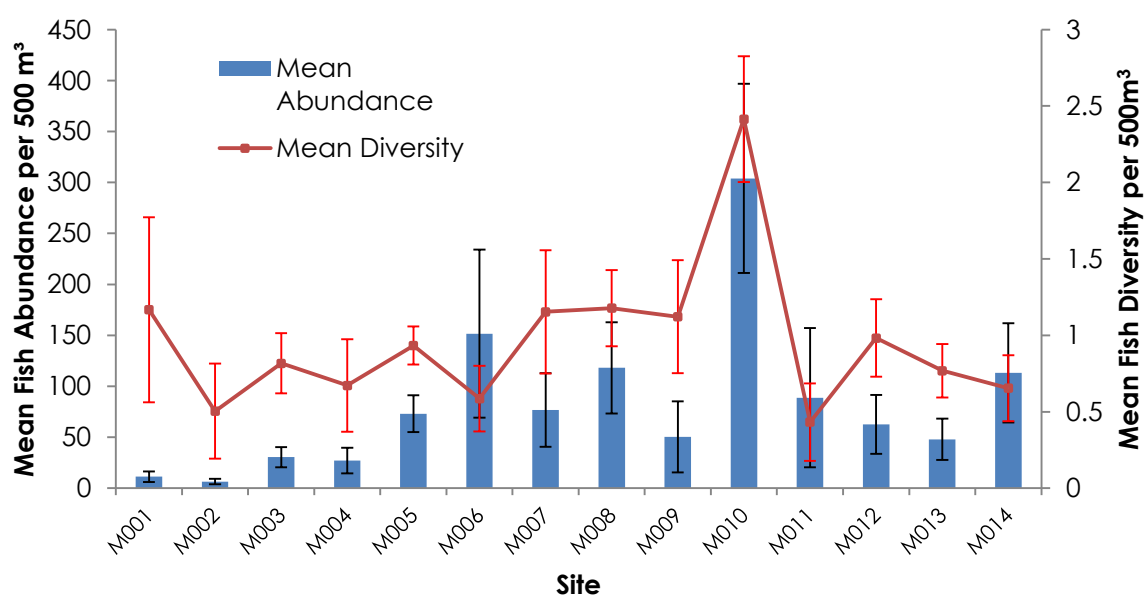


Figure 9. Mean fish abundance and diversity per site. Blue bars represent mean fish abundance per 500 m³, with black error bars denoting standard error of the mean (SEM). The red graph shows mean fish diversity per 500 m³ using the Fisher's α diversity index, with the red error bars representing SEM.

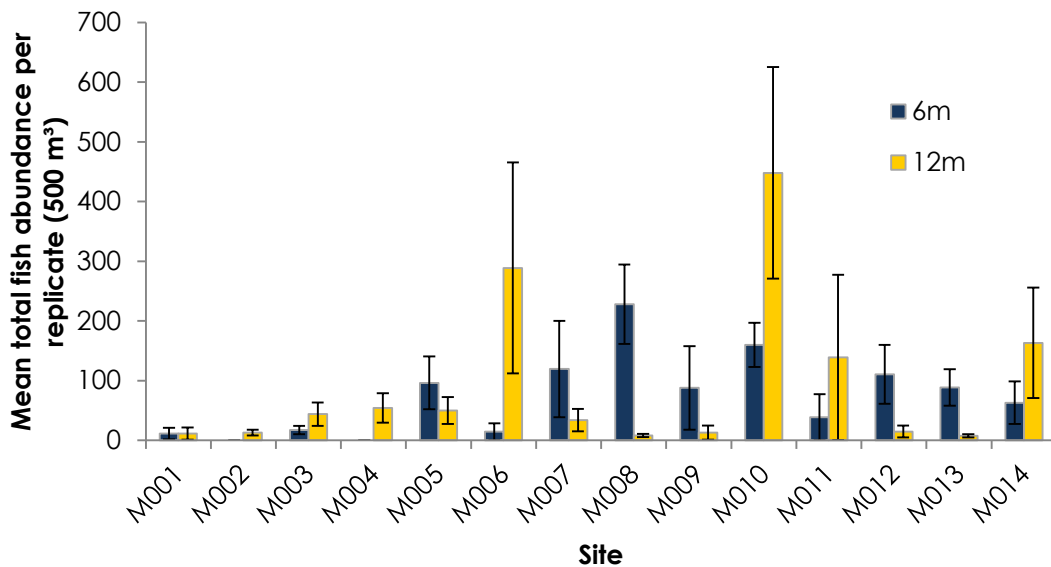


Figure 10. Comparison of mean fish abundance at depths of 6 m and 12 m at each site. Blue bars represent mean abundance per 500 m³ at 6 m. Yellow bars denote mean abundance at 12 m. Error bars denote SEM

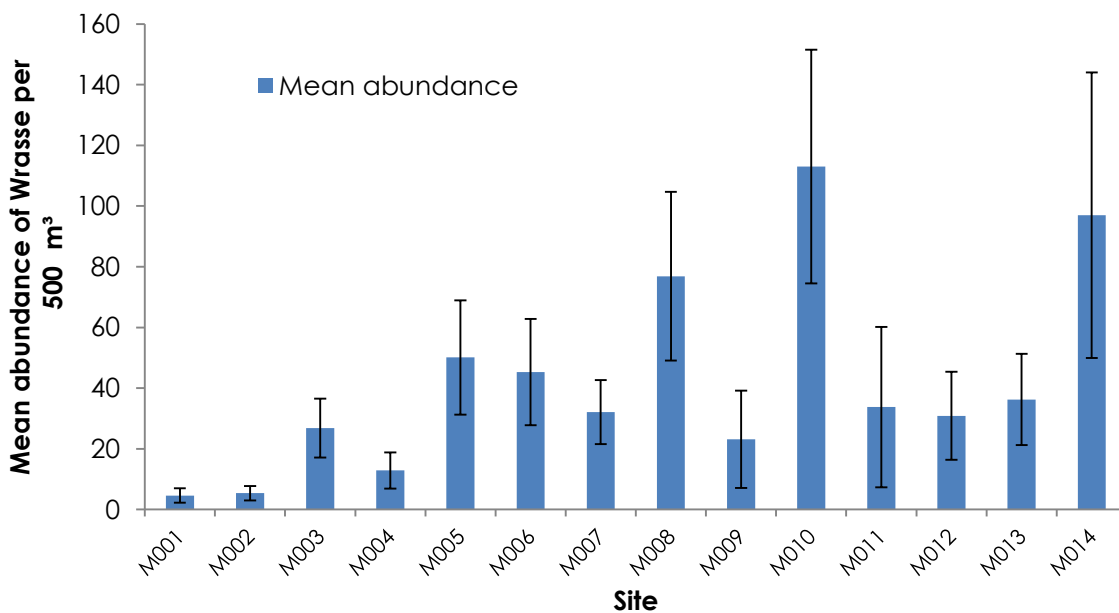


Figure 11. Mean abundance of Wrasse per site. Blue Bars represent mean abundance per 500 m³, error bars denote SEM

The difference in abundance between 6 m and 12 m, was significant at sites M006 (6 m; 14.5 ± 14.2 per 500 m³ and 12 m; 289 ± 176.7 , $p = <0.05$) and M008 (6 m; 228 ± 66.5 per 500 m³ and 12 m; 8.3 ± 2.7 per 500 m³, $p = <0.05$).

Overall fish diversity was greatest at site M010 (Figure 9). A total of 19 target fish species and families were recorded at this site. Diversity was lowest at sites M002 and M011. Diversity of species was not significantly different between 6 m and 12 m at any site (Figure 12). Across the survey area no individuals of target grouper or

parrotfish species were recorded greater than 40 cm in length. Of those that were recorded, 70% of parrotfish were less than 10 cm, 81% of hinds were less than 20 cm and 100% of Nassau grouper (*Epinephelus striatus*) were less than 10 cm. No sharks, turtles or rays were recorded on any survey. One lionfish (*Pterois* spp.) was recorded across the entire survey area, at M003.

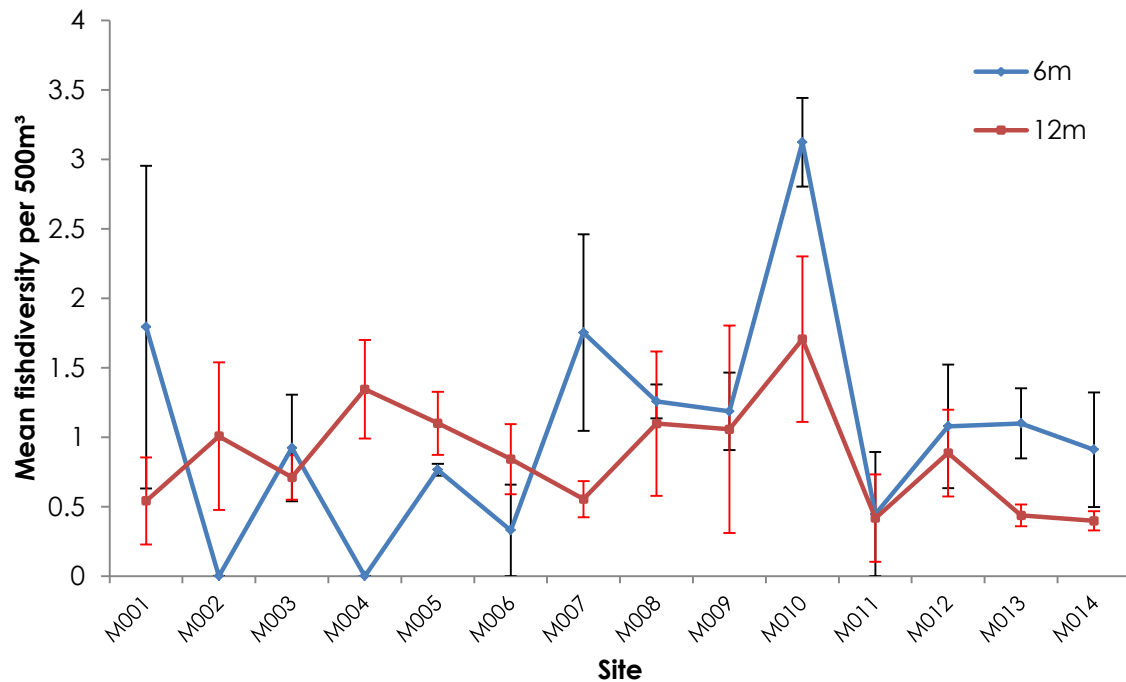


Figure 12. Mean fish diversity at 6 m and 12 m depths. Points represent mean abundance per 500 m³, error bars denote SEM

2.2.2 Invertebrates

Invertebrate abundance varied considerably between survey sites (Figure 13). Sites M002, M003, M004, M005 and M006 had consistently low abundance figures across both survey depths. Overall site M010 had the greatest total abundance (95.5 ± 37.03 individuals per 500 m³ (mean $\pm$ SEM)). Surveys at 6 m showed a higher abundance than those at 12 m (Figure 14). The difference between the depths was significant at 3 sites; M001 (6 m: 186.5 ± 29.6 , 12 m: 5.5 ± 4.5 , $p < 0.05$), M008 (6 m: 173 ± 32.5 , 12 m: 0 ± 0 , $p < 0.05$) and M010 (6 m: 174.25 ± 50.7 , 12 m: 24.75 ± 10.3 , $p < 0.05$). The greater abundance of invertebrates at 6 m at these sites can be principally attributed to the high occurrence of Gorgonians.

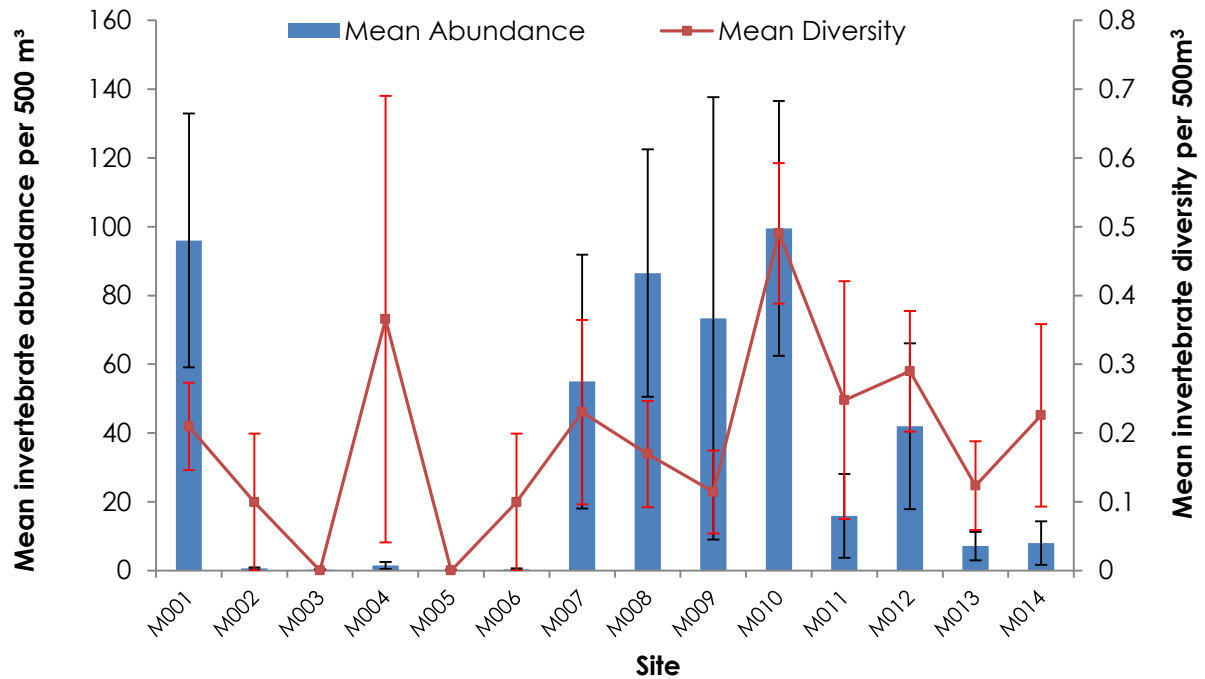


Figure 13. Mean invertebrate abundance and diversity per site. Blue bars represent mean invertebrate abundance per 500 m³, while black error bars denote SEM. Red graph portrays mean invertebrate diversity per 500 m³ using the Fisher's α index, with red error bars denoting SEM.

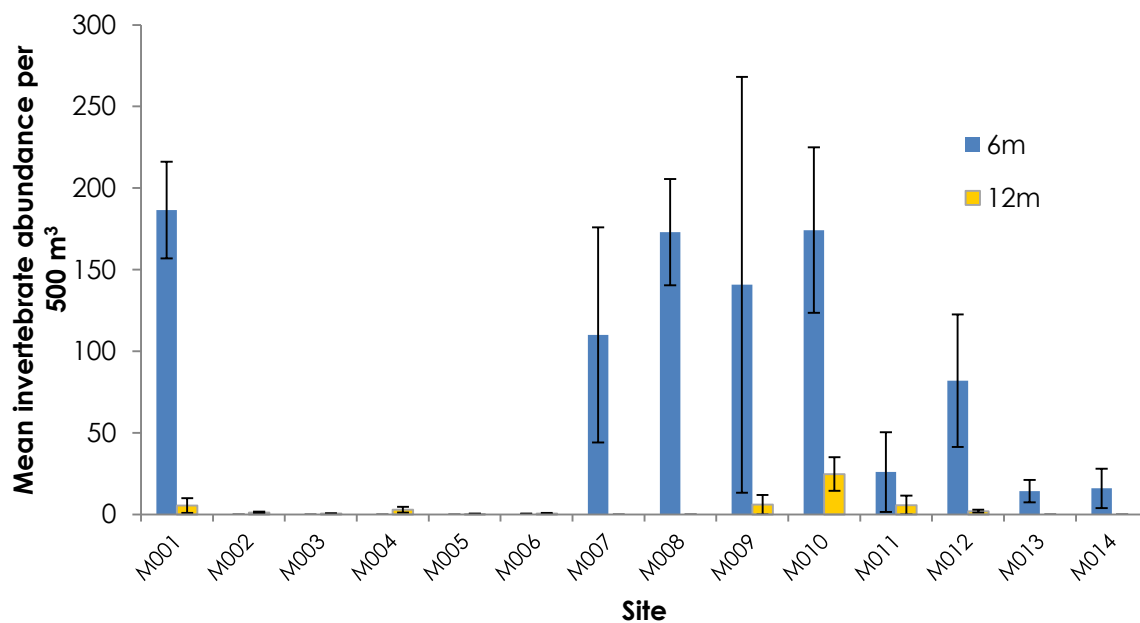


Figure 14. Mean invertebrate abundance at 6 m and 12 m depths. Blue bars represent mean invertebrate abundance per 500 m³ at 6 m. Yellow bars represent mean invertebrate abundance per 500 m³ at 12 m. Error bars denote SEM.

Diversity of invertebrate species was low across all sites (Figure 13). Site M010 had the greatest overall species diversity. Gorgonians were by far the most commonly encountered invertebrate on surveys accounting for over 95% of the total invertebrates recorded. No Gorgonians were recorded on sites M002 – M006 (Figure

15) Urchins (*Diadema*, Pencil and Collector) were the second most commonly recorded invertebrates.

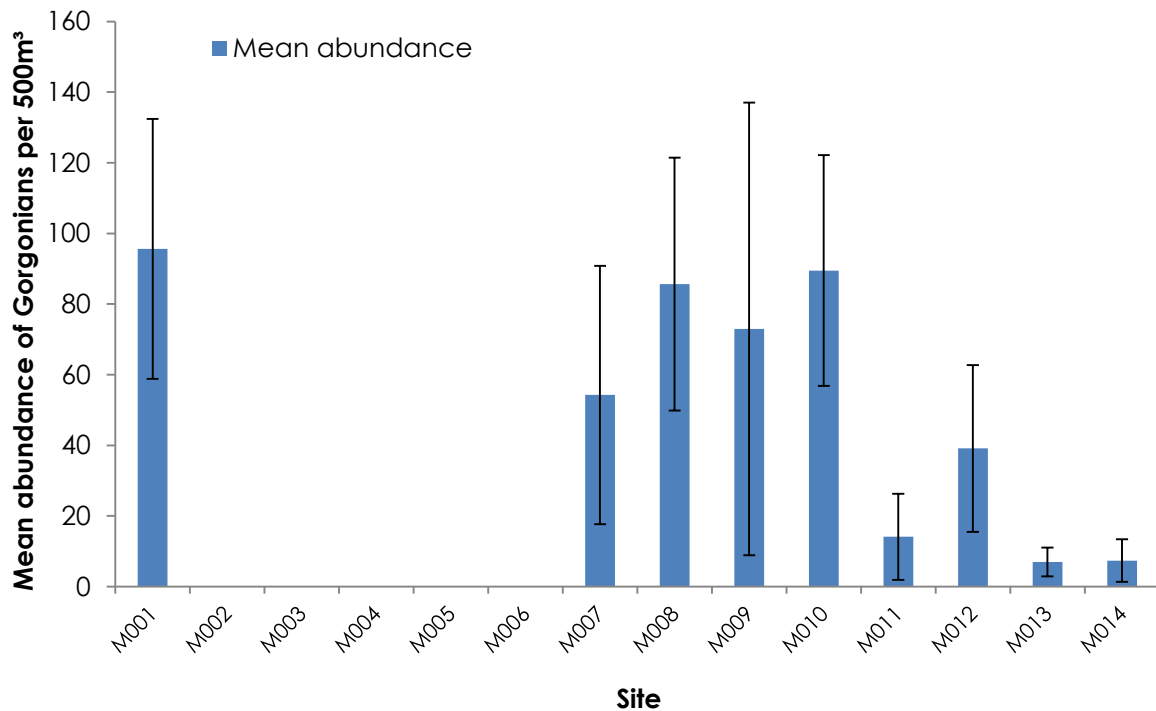


Figure 15. Mean abundance of Gorgonians per 500 m³ at each site. Blue bars represent mean abundance per 500 m³, error bars denote SEM.

2.2.3 Substrates

The most commonly observed substrate on surveys was sand (SD), accounting for 66% of all substrate points. Other (OT) which includes seagrass and other biotic substrates was the next most common followed by rock (RC) and silt (SI).

Site M010 had the highest mean hard coral cover of any site at 7.8%. It also had the greatest range of substrates with 9 out of the 10 categories observed. Hard coral was also recorded on site M001, M007, M008, M009, M011 and M012 (Figure 16).

There are considerable differences between substrates across the two depth ranges. Twelve meter transects were largely dominated by a single substrate. Sites M002, M003, M004, M005 and M006 were dominated by OT (sea-grass) with the remainder, (except M010), dominated by sand (SD) (Figure 17). Six meter transects were more varied and contained a greater diversity of substrates (Figure 18). Nutrient Indicator Algae (NIA) was low across all sites with the greatest occurrence at M010 (Figure 16). Rock (RC) was predominantly recorded on the sites from M007 – M012. M010 had the highest amount of rock (Figure 16).

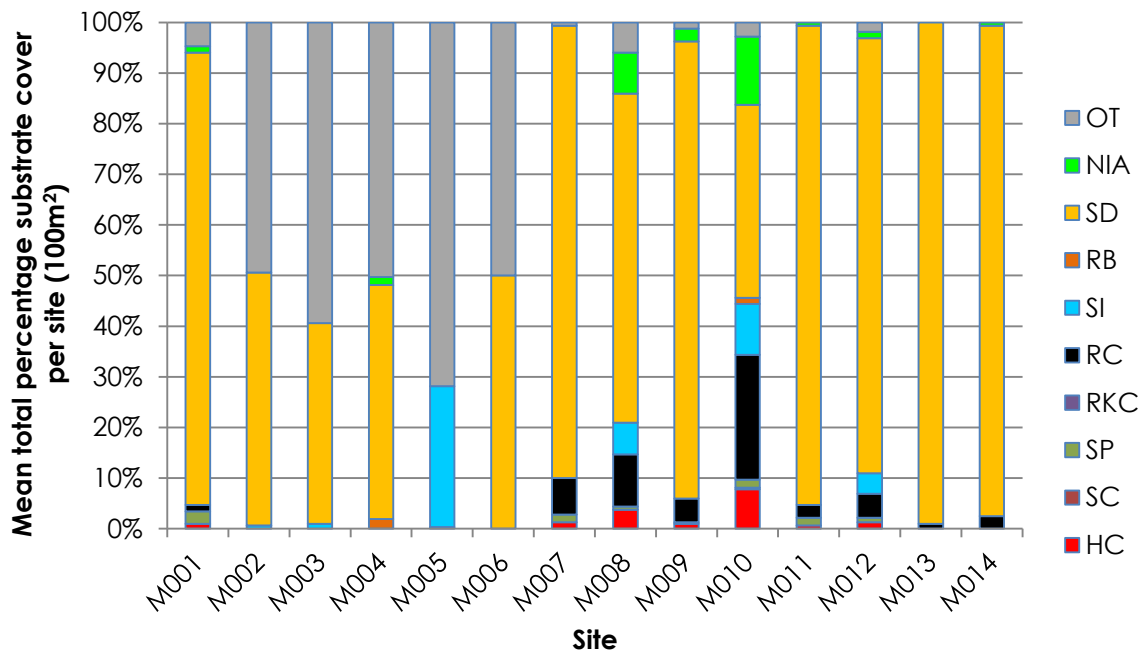


Figure 16 - Mean substrate percentage cover per 100 m³ at each site for depths of both 6 m and 12 m. HC – Hard coral; SC – Soft coral; SP – Sponge; RKC – Recently killed coral; RC – Rock; RB – Rubble; SD – Sand; SI – Silt/mud; NIA – Nutrient Indicator Algae; OT – Other living organisms

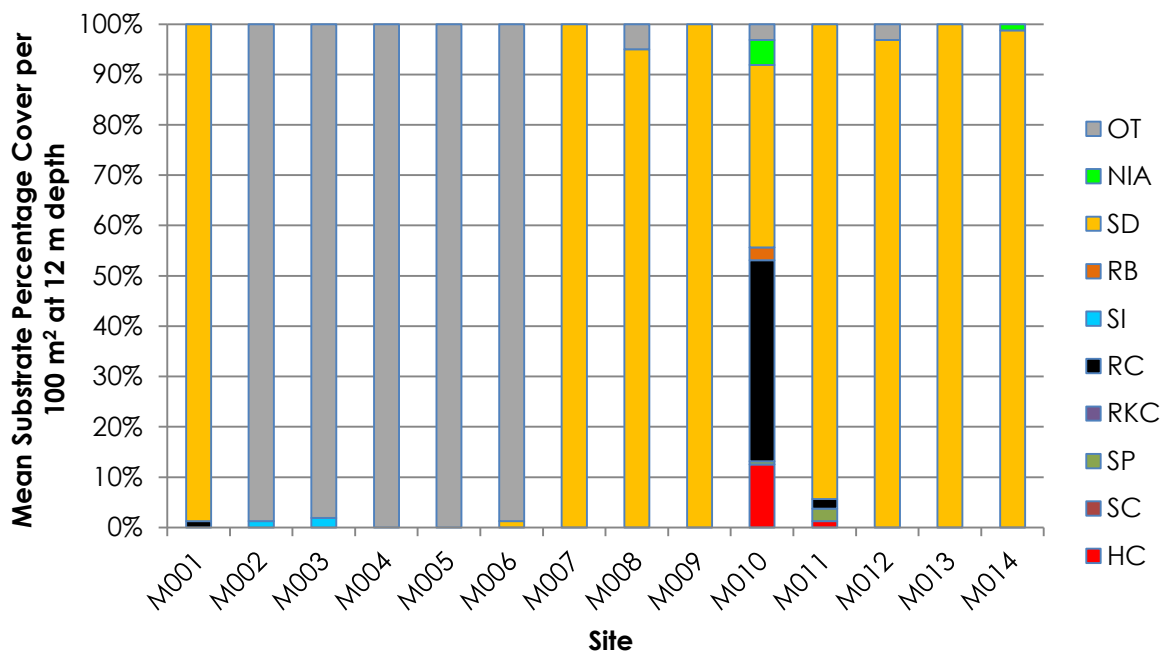


Figure 17 - Mean substrate percentage cover per 100 m² at 12 m depth. HC – Hard coral; SC – Soft coral; SP – Sponge; RKC – Recently killed coral; RC – Rock; RB – Rubble; SD – Sand; SI – Silt/mud; NIA – Nutrient Indicator Algae; OT – Other living organisms

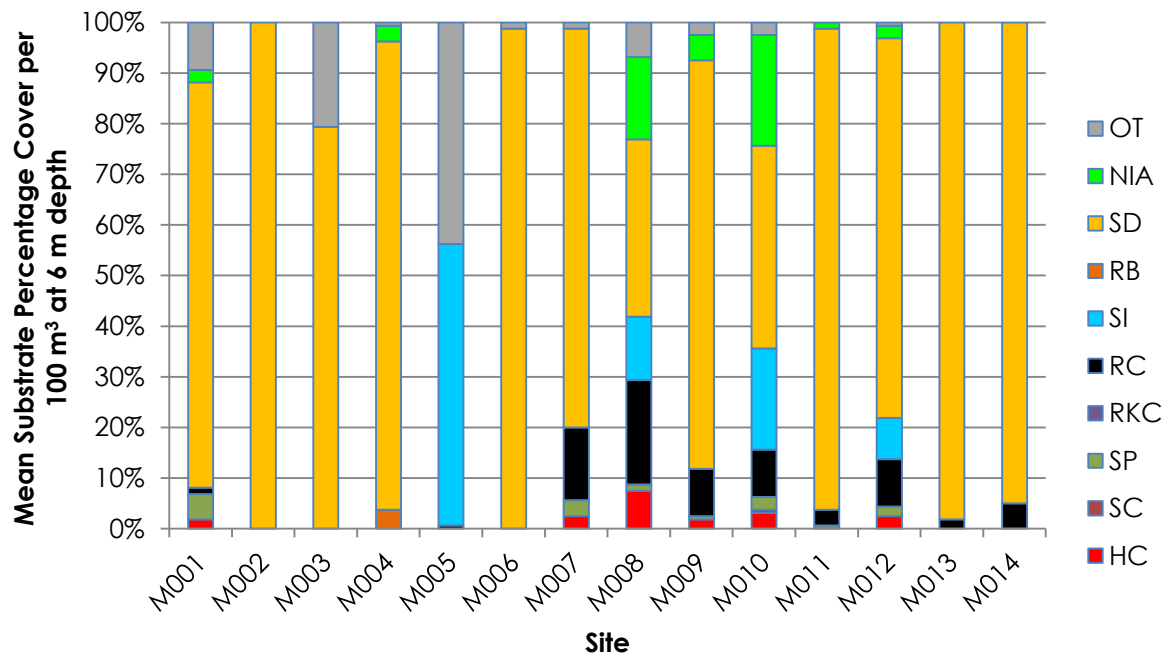


Figure 18 - Mean substrate percentage cover per 100 m² at 6 m depth. . HC – Hard coral; SC – Soft coral; SP – Sponge; RKC – Recently killed coral; RC – Rock; RB – Rubble; SD – Sand; SI – Silt/mud; NIA – Nutrient Indicator Algae; OT – Other living organisms

2.2.4 Impacts

Across all of the surveyed area the level of anthropogenic and environmental impacts was low. No damage to corals caused by anchors or fishing practices was recorded on any of the sites; however damage from other sources was occasionally recorded at 6 m at sites M007, M008, M009, M010 and M012. Only site M010 had damage recorded at 12 m. General trash levels were low across the survey area with no individual sites having greater than 2 incidences of trash. Of the sites which contained hard coral bleaching (recorded at M008, M009, M010 and M011), bleaching was less than 1% of the total hard coral population.

3 DISCUSSION

The initial marine surveys reveal that there are a variety of habitats, located in the near shore waters around Montserrat. Overall anthropogenic and environmental impacts appear low and at certain sites fish and invertebrate populations are good. Trends observed in the data are discussed in relation to potential management options in the following sections.

3.1 Fish

The results indicate that sites M006 through to M010 have the greatest abundance and diversity of fish species. Site M010 in particular has the greatest abundance of fish. This is largely attributed to the high abundances of both Damsel fish (Pomacentridae) and Wrasse (Labridae). Both of these fish families associate closely with reef habitat and require a high level of reef rugosity (Booth & Beretta, 1994; DeMartini *et al.*, 2010) (the diversity of substrates is discussed further in section 3.3). Wrasse are an ecologically important family of fish because they are one of the most abundant herbivorous fish found on coral reefs. They graze on large quantities of algae, which would otherwise compete with coral for space. Thus they help regulate the balance between algal and reef dominated ecosystems.

Commercially important species such as Grouper (Serranidae), Grunts (Haemulidae) and Parrotfish (Scaridae) were observed in low numbers across the entire survey area and those that were observed were small in size. In many regions around the world a lack of these species is indicative of unsustainable fishing pressure (Coleman & Williams, 2002; Sadovy & Domeier, 2005). However, anecdotal evidence from Montserrat suggests these species are not commonly targeted by fishermen. The resulting low numbers are therefore probably due to limited suitable habitat, as species from these families often associate closely with reef and rocky areas for both feeding opportunities and predator avoidance. What is slightly worrying is the lack of large sexually mature individuals. Families such as Snappers (Lutjanidae) and Groupers take many years to increase in size, reach sexual maturity and typically change sex. Snappers have been shown not to reach sexual maturity until they are approximately 55 cm in length, suggesting that a population with no individuals larger than 40 cm will not be able to replenish itself (Froese & Pauly, 2001). The fecundity (or reproductive output) of these families also exponentially increases with size. One 12.5 kg female Snapper can produce the same number of eggs as 212 1.1kg Snappers (Bohnsack, 1990). Therefore increasing the adult population of these important species should be a priority for conservation initiatives.

The impact of invasive Lionfish throughout the Caribbean has been widely documented over the last decade (Albins & Hixon, 2011; Darling *et al.*, 2011). Across all the surveyed sites only one Lionfish was observed within the transect area. Whilst this appears promising with regards to the health of the reefs around Montserrat, it should be viewed with caution. Anecdotal observations

of Lionfish are much more common than the data would suggest and the low abundance on surveys is likely a factor of the survey methodology. A review of the methodology to include Lionfish observed outside of the transect area should improve the accuracy of lionfish observations.

The diversity of fish species is largely similar across all the surveyed sites, with the exception of M010. The greater diversity at this site is likely due to the greater diversity of substrate types in the area. A range of substrates provides an increase in potential ecological niches and facilitates co-habitation of an area by different species.

3.2 Invertebrates

The trend for invertebrate diversity and abundance closely follows that of fish with the greatest values recorded at sites M007 to M010. At sites M002-M006 virtually no invertebrates were recorded. This is likely due to the low diversity of substrates and the dominance of sand and seagrass in these areas. Substrate homogeneity results in fewer niche provisions for species and often in low levels of rugosity. As a result, areas dominated by a single substrate will be able to support fewer species. Furthermore, the target species recorded on the surveys largely associate with rocky and reef dominated habitats. Banded-coral Shrimp and Lobster in particular associate closely with rocky substrate which provides adequate crevices for protection from predators. In addition, Gorgonians, which contributed over 95% of the recorded invertebrates, require a hard substrate on which to anchor. Sites M002-M006 which are dominated by sand and seagrass are therefore less suitable for these species. However, it is important to note that this does not mean that these areas are of low biological or conservation value. Seagrass meadows support a variety of organisms including many species of echinoderm such as seastars and sea cucumbers (Perez-Ruzafa *et al.*, 2012). They are also important nursery grounds for many reef and pelagic fish families including Grunts, Snappers and Parrotfish (Heck, Hays & Orth, 2003; Nagelkerken *et al.*, 2000; Nagelkerken, 2009). Therefore these habitats should be considered as important elements of the near shore waters of Montserrat. Further study with focus on invertebrates that closely associate with these habitats would likely emphasise their importance.

At the sites with the greatest invertebrate abundance (M007-M010) there was a large disparity between the survey depths. The invertebrates recorded at 6 m constitute 95% of the invertebrates recorded across the entire survey area. The relative lack of invertebrates at 12 m is likely a result of the more homogenous nature of the substrates at this depth.

Lobsters (*Panulirus* spp.) are a highly prized food item throughout the world. They can be quickly removed from areas as they are easily caught in traps and nets. As with many fish species, larger lobsters sell for a higher price in the live food trade. The targeting of large individuals removes the most fecund (reproductively successful) females from the community, resulting in population decline. Across the survey area lobsters were conspicuous in their absence; only one individual was observed (at M011). As an important species for fisheries the lack of individuals would appear to be a concern.

However, this lack is likely due to the low occurrence of rocky reef habitat observed on the surveys. Anecdotal evidence from non-survey dives in the area report a greater abundance of individuals than suggested in the data and thus it is unlikely that high fishing pressure is to blame for the low recorded abundance. Like many other reef species juvenile lobsters are known to associate with seagrass meadows. Studies have shown that reef areas surrounded by seagrass habitat can have up to four times the immigration rates of juvenile lobsters than from areas surrounded by rubble (Acosta, 1998). This further highlights the importance of a diverse patchwork of marine habitats.

Gorgonians constitute an important component of Caribbean reef biota and are commonly more conspicuous than scleractinian corals (Jordan-Dahlgren, 2002). Whilst gorgonians contribute less to the structure of reef-scapes than corals, their relative importance in creating a spatially diverse and heterogeneous reefs-scape is high. Many species of fish and invertebrate associate with gorgonians and the range of habitat options they provide. The distribution of gorgonians across the survey sites is clearly not uniform and correlates directly with the availability of hard substrate. Sites M001 and M007-M010 have the greatest abundance of Gorgonians and thus increase the spatial and ecological heterogeneity in these areas.

3.3 Substrates

As previously discussed the results indicate that whilst there are a range of substrate types found in the near shore waters of Montserrat, the distribution of these substrates is not uniform, both between sites and between depths. Whilst it is sites M007-M010 that have the greatest diversity of substrates and thus would appear the most important, other areas, such as the seagrass meadows at sites M002-M005 are also potentially very significant as nursery grounds.

Hard coral is limited on the reefs that have been surveyed. This does not mean however that the reefs are necessarily in poor condition. Reefs in the Caribbean generally have lower coral cover than those in the Indo-Pacific and reef complexity is provided by other organisms such as Gorgonians (Jordan-Dahlgren, 2002). Where coral was recorded it was found to be in good overall health with little indication of coral disease and few cases of coral damage. Site M010 had both the greatest amount of hard coral and the highest occurrence of coral damage. This site is situated between Lime Kiln Bay and Woodlands Bay, which are both snorkelling beaches on Montserrat. The higher level of coral damage is potentially a factor of visitor use and accidental trampling. Alternatively, the damage could be as a result of predation from the greater abundance of fish and invertebrates found in this area.

The relatively low recorded occurrence of Nutrient Indicator Algae (NIA) is a positive sign for the reefs. Many species of NIA require a hard substrate with which to attach and so it is not surprising to find the highest levels of NIA at the same sites as the high occurrence of rock and hard coral (M007-M010). A high level of NIA is indicative of two things; (i) increased nutrient loading from

terrestrial sources (usually as a result of agricultural processes or poor waste management) and/or (ii) overfishing of herbivorous fish and other algal grazers. The low occurrence on the survey therefore suggests that these two factors are limited and balanced by natural processes.

Fine sediments such as silt can have a very damaging effect on reef systems and smother what would otherwise be a viable habitat for coral recruitment or productive reef habitats (Fabricius, 2005). The volcanic activity of Montserrat has the potential for releasing large quantities of such sediment into the marine environment. Fortunately silt was only recorded on a couple of sites with M005 containing the greatest quantity. Site M005 is adjacent to the mouth of the Belham River which has a catchment which will include areas of volcanic deposits. In recent times the river has ceased to flow due to the river bed becoming choked with sediment. The higher silt levels recorded at site M005 are therefore a factor of historical sediment loading from the Belham River. Future bad weather and storm events may see the river flow again which could lead to an increase in the quantity of fine sediments.

4 RECOMMENDATIONS

One of the major targets for the work that CCC is undertaking in Montserrat is to provide the scientific evidence to support the establishment of a Locally Managed Marine Area (LMMA). From this first year of surveys and the available data there are a number of trends which indicate where protection could be most beneficial. Sites M007-M010 contained the best areas of patch reef surveyed so far, with corresponding high abundances of fish and invertebrates. Adjacent areas of seagrass are also of importance as potential nursery grounds for many reef and pelagic species. The initial recommendation, based on the data thus far, will be to suggest that these areas should be considered as potential sites for protection, in order to preserve both of these important habitats. This should include the areas between sites M005 and M010. The physical extent of zonation and the level of protection in this area will require significant discussion. This report should act as a catalyst for engaging stakeholders in decision making regarding the potential establishment of a protected area. The collection of further baseline data along the North West of the island will undoubtedly yield other areas of important habitat. As and when this data becomes available it will feed into the discussion regarding location and zonation of an LMMA.

A recent study by Edgar *et al.* (2014) argues that the effectiveness of Marine Protected Areas (MPAs) such as LMMA, relies on five criteria: that they should be no-take zones and well enforced, that they should be both large and old (>10 years), and that they should be isolated by deep water or sand. This is an ideal, but something that should be considered in the process of setting up protected areas on Montserrat. It will be important from the outset when discussing the implementation of an LMMA to clearly define the purpose of the protection. Does the management area aim to increase fisheries potential and reduce the catch per unit effort of the local fishing community? Is there a desire to establish a protected area for the potential tourism

benefits and increased revenues this will bring? Is it purely for the sake of protecting the reef habitat for its own intrinsic value? Or is it likely a mixture of these factors and possibly many more? These questions will guide the development of the LMMA and ultimately define the limits of protection. Furthermore, that successful reserves should be old (Edgar *et al.*, 2014) is something that needs to be considered when setting up a protected area. Response times can be slow and it may be a number of years before stakeholders see the benefits of any protection, regardless of its level.

In the early stages of the project CCC hosted a consultation workshop with local fishers and other user stakeholders. The workshop was held to facilitate an exchange of scientific and local knowledge and aimed to bring together people who use the sea for their livelihood. Discussion was focussed around perceptions and concerns about marine conservation and the potential for future management of the marine environment. Some concerns were raised regarding the general management of fisheries and the lack of regulation to ensure their sustainability. Generally support for the establishment of an LMMA was good.

Following this, the consultation process needs to be continued as it is unreasonable to suggest any reduction of fishing grounds and recreational areas, without prior consultation. Planning meetings to include fishers, user stakeholders, government representatives and CCC will be crucial in the forthcoming discussion and implementation of an LMMA. The specific zonation of any proposed management area will allow some restricted level of fishing in buffer zones. This means that local fishers and other users will be able to continue to benefit from the area whilst allowing fishing on the reefs to be sustainable.

Beyond the establishment phase, perhaps the most important criteria ensuring the success of a protected area is that it is well enforced (Lundquist & Granek, 2005; Mascia, 2003). If a protected area is designated without the relevant parties being made fully aware of the process then the entire activity is rendered pointless and the goals of the LMMA become unachievable. The creation of a management committee to oversee the effective running of the LMMA will ultimately mitigate this. The committee should ideally be comprised of members from all stakeholder groups and will coordinate the collection of MPA fees for possible dive and snorkel sites, provide training and support to marine guards, oversee the enforcement of the area and be a link to the Government for matters concerning the regulation of the LMMA. It will be important for the management committee to establish goals and objectives for the MPA based on the criteria of species protection, fisheries and tourism. Reviewing these objectives will help inform management decisions.

5 ACTIVITIES FOR 2015

The target for 2015 is to complete the remaining surveys on the North Western side of the island, from M015-M027. This will continue the baseline assessment of the marine resources of Montserrat and help provide support for the establishment of a LMMA. In addition, the establishment of further permanent transect sites will assist in providing a greater range of temporal data for monitoring the health of Montserrat's reefs over time.

Due to a variety of safety and logistical constraints surveying of the sites on the North East side of the island is very difficult. Options for solving these issues are being looked into and it is hoped that a solution will be found to enable these surveys to be completed at a later date.

At the end of October 2014, CCC staff and volunteers were granted the opportunity to dive in the marine exclusion zone south of Bransby Point. Permission for these exploratory dives was provided by the Montserrat Volcano Observatory (MVO) and the Royal Montserrat Police Force (RMPF).

Little to no activity has been permitted in the area since the volcanic eruptions started in the mid-1990s. The dives therefore provided a first underwater visual assessment of the area in nearly two decades. Four dives were conducted by three-person teams swimming parallel to shore at a depth of roughly 10 m. The teams encountered a variety of habitats including patch reef, seagrass beds and sand. The dive teams that were deployed further North West, closer to Bransby Point, found reef habitat with a good diversity of species including the globally vulnerable Elliptical Star Coral (*Dichocoenia stokesii*). Those further South East found mostly seagrass. This is likely as a result of the closer proximity to the pyroclastic flows that destroyed Plymouth. Across all the dives a wide variety of fish and invertebrates were recorded including, Butterflyfish (Chaetodontidae), Barracuda (Sphyraenidae), Jacks (Carangidae), Diadema urchins and Queen Conch (*Strombus gigas*).

Over the next year further survey dives are planned for this area. Additional survey points within the area South of Bransby Point are to be calculated and included in the ongoing survey programme. This will provide a great opportunity to assess the extent of the damage and regeneration of habitats following the volcanic eruptions.

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8 APPENDIX A

Table 1 lists the target substrates which are recorded on CCC surveys. Hard corals also include fire coral and soft corals also include zoanthids.

Table 1- Target Substrates

SUBSTRATES		
Hard Coral (including fire coral)	Soft Coral (including zoanthids)	Recently Killed Coral
Sponge	Nutrient indicator algae	Rock
Rubble	Sand	Silt
Other		

Table 2 lists the target invertebrates recorded on CCC surveys.

Table 2 - Target Invertebrates

INVERTEBRATES	
Banded Coral Shrimp (<i>Stenopus hispidus</i>)	Long Spined Sea Urchin (<i>Diadema antillarum</i>)
Collector Urchin (<i>Tripneustes</i> spp.)	Pencil Urchin
Flamingo Tongue (<i>Cyphoma gibbosum</i>)	Triton's Trumpet (<i>Charonia variegata</i>)
Gorgonians (Gorgonacea)	Lobster (Palinuridae)

Table 3 lists the target fish families and species recorded on CCC surveys. Families are shown in **bold type** and all members of these families are recorded. Additional target species, shown in regular type, are also recorded for some families.

Table 3 - Target Fish Families and Species

Target Fish	
Angelfish (Pomacanthidae)	Lizardfish (Synodontidae)
Ballyhoo (Hemiramphidae)	Moray Eel (Muraenidae)
Basslet (Grammatidae)	Needlefish (Belonidae)
Butterflyfish (Chaetodontidae)	Parrotfish (Scaridae)
Chromis/Damselfish (Pomacentridae)	Porgy (Sparidae)
Chub (Kyphosidae)	Scorpionfish (Scorpionidae)
Filefish (Monacanthidae)	Snake eel (Ophichthidae)
Goatfish (Mulidae)	Snapper (Lutjanidae)
Grouper (Serranidae)	Squirrelfish/Soldierfish (Holocentridae)
Coney (<i>Cephalopholis fulva</i>)	Surgeonfish (Acanthuridae)
Hamlet (<i>Hypoplectrus</i> sp.)	Blue tang (<i>Acanthurus coeruleus</i>)
Hind (<i>Epinephelus guttatus</i> and <i>Epinephelus adscensionis</i>)	Triggerfish (Balistidae)
Nassau grouper (<i>Epinephelus striatus</i>)	Trumpetfish (Aulostomidae)
Grunt (Haemulidae)	Trunk/Box/Cowfish (Ostraciidae)
Jack (Carangidae)	Honeycomb cowfish (<i>Acanthostracion polygoia</i>)
Lionfish (<i>Pterois</i> spp.)	Wrasse (Labridae)

