SPONGE DIVERSITY IN CORAL FRAMEWORKS AND CORAL COMMUNITIES WITHIN THE LAS PERLAS ARCHIPELAGO, PANAMA.

by

JADE BERMAN

September 2004

Submitted as part assessment for the degree of

Master of Science
in
Marine Resource Development and Protection

School of Life Sciences

Heriot-Watt University, Edinburgh

Sponge diversity in coral framework and coral communities within the Las Perlas Archipelago, Panama.

Contents

Acknowledgments **i**

Abstract **ii**

1.0 Introduction 1

1.1 Study Area & the Physical Environment 1

1.2 What are Sponges? 2

1.3 How is this Research relevant to Marine Resource Development and Protection? 5

1.4 The Essential Role of Sponges in Coral Reefs 6

1.5 The Biochemical Benefits 8

1.6 Aims 10

1.7 Hypothesis 10

1.8 Null Hypothesis 10

2.0 Methods **11**

2.1 Fieldwork 11

2.1.1 Definitions for the Site Categories 11
2.1.2 Sponge Collection 14
2.1.3 Transect Methods 14

2.2 Sponge Preservation 15

2.2.1 Freezing 15
2.2.2 Formalin 15
2.2.3 Alcohol 15

2.3 Sponge Identification 16

2.3.1 Spicule Preparation 16
2.3.2 Tissue Sectioning 17
2.3.3 Identification 17

2.4 Data Analysis 18

3.0 Results 19

3.1 Sponge Diversity 19

3.2 Similarity of Species Abundance, Diversity and Distribution within and between Sites. 24

3.3 Sponge Abundance and Diversity in Relation to Coral Cover. 27

4.0 Discussion and Evaluation 30

5.0 References 35

6.0 Appendix 1 – *The Sponge* 45

7.0 Appendix 2 – *Raw Data* 46

Acknowledgements

I wish to thank Hector Guzman for helping me to formulate ideas for the development of my dissertation, inviting me back to Panama and the Smithsonian to join the 2004 Darwin Initiative cruise, helping me find somewhere to stay and a lab to work in as well as generally being there for me.

Thanks are also due to Hamish Mair for allowing me to delay my dissertation for a year and being a good supervisor,

Thanks to Carlos, Sarah Benfield, José-Miguel, Lina, Carmen, Susan and the crew of the *Urraca* for helping me with maps, locations and fieldwork.

Thanks to Colin Moore for his help with my statistics and Paul Kingston for the CD on North Atlantic Sponges and the lab space!

Finally I have really appreciated Claire Valentine's help, without her I would not have been able to find many of the old references and grey literature or developed my taxonomic skills.

Abstract

Sponge faunas are poorly described worldwide and the sponges of the Tropical Eastern Pacific are some of the least documented in the world. The Las Perlas Archipelagos, Panama is in an area affected by strong upwelling and yet there are coral reefs present in this area of high environmental stress. There is a paucity of sponge species in relation to both abundance and diversity within the waters of the archipelagos. There were 22 species in total recorded from 7 different orders. This paucity is likely to be due to the isolation of the region from the major oceanic currents, which facilitate larval dispersal. Also biological and physical factors such as inter- and intra-specific competition, water movement, substratum type, light penetration and stability of the habitat are likely to influence sponge distribution. The site off Isla San Telmo to the south east of the Archipelagos had the greatest sponge abundance and diversity and the lowest coral coverage. The variation both within and between sites was significant. There was no evidence of a significant relationship directly between coral coverage and sponge abundance and diversity in the area, however, the lilac *Callyspongia sp.* has an inversely proportional relationship with coral cover (P=0.05). The ecology of the sponges in the area is still little understood and further research is vital for monitoring and management of the whole reef systems.

Keywords: Porifera; Sponge Diversity; Panama; Tropical Eastern Pacific; Las Perlas Archipelagos.

Sponge diversity in coral framework and coral communities within the Las Perlas Archipelago, Panama.

1.0 Introduction

Sponge faunas are under-described worldwide (Kelly-Borges & Valentine, 1995; Hooper *et al.*, 2000). Furthermore, the sponge fauna of the eastern Pacific is one of the least known in the world (Carballo *et al.*, 2004). The main areas where sponge research in the eastern Pacific has been carried out are: the coast of North America and Canada (Lambe, 1893, 1894, 1895, 1900; de Laubenfels, 1926, 1932 & Dickinson, 1945); the coast of Mexico (de Laubenfels, 1935, Green & Gómez, 1986, Gómez & Bakus, 1992; Gómez, 1998, Gomez *et al.* 2002 & Carballo *et al.,* 2003, 2004) and the Galapagos Islands (van Wilson, 1904; de Laubenfels, 1939; Desqueyroux-Faúndez & van Soest, 1996, 1997).

Between the southern Mexico border and northern Chile there has been virtually no taxonomic study except for comparisons of a few sponge species at either end of the Panama Canal (de Laubenfels, 1936; Wulff, 1996, 1997 & Boury-Esnault *et al.,* 1999) and limited studies in the Panamanian Gulf of Chiriqui (Diaz, unpublished data, Maldonado *et al.,* 2001).

This study will try to expand of the knowledge of the sponges in the Tropical Eastern Pacific region (TEP) by investigating the patterns of sponge distribution within coral communities and frameworks of the Las Perlas Archipelago, Panama.

Firstly, it is important to set the research in context by describing the study area, the study organisms and why this research is relevant to marine resource development and protection.

1.1 Study Area & the Physical Environment

The TEP stretches from the Sea of Cortez off California to the northern Pacific coast of Peru. This region supported a continuous Pacific and Caribbean marine biota until about 3.5-3.1 million years ago when the Bolivar Seaway closed (Coates *et al*., 1992,

Coates & Obando, 1996). Closure of the isthmus resulted in radically different near-shore environments in the TEP and the Caribbean. The warm equatorial Atlantic current, which used to flow westwards through the seaway between North and South America, was blocked and deflected northwards by the Isthmus of Panama. Colder currents flowing towards the equator began to dominate in the TEP.

Due to the boundaries created by the cold-water currents to the north and south, and the eastern Pacific Barrier (a large expanse of deep water), to the west, the TEP is one of the most isolated regions of the world's oceans (Grigg & Hey, 1992; Cortés, 1997). Coral reefs form only a small component of coastal habitat in the TEP. In fact, until about thirty years ago (Glynn 1972, Glynn *et al.* 1972) it was assumed that structural coral reefs were absent from the coasts of the region (Darwin, 1842, Dana 1843, Crossland, 1927).

Reefs of the TEP are typically small in size (a few hectares or less), patchily distributed, low in species diversity and shallow (Glynn & Wellington, 1983; Guzmán & Cortéz, 1993). The largest reefs are found in the Gulf of Chiriquí under the relatively high and stable thermal conditions (Glynn & Stewart, 1973; Glynn & Maté, 1997; Maté, 2003). There are also smaller reefs within the Las Perlas Archipelago in Panama Bay.

The Las Perlas Archipelago consists of 53 basaltic rock islands, islets and shoals about 73km SE of Panama city and 31km SW from the closest Panamanian coast (Fig 1.).

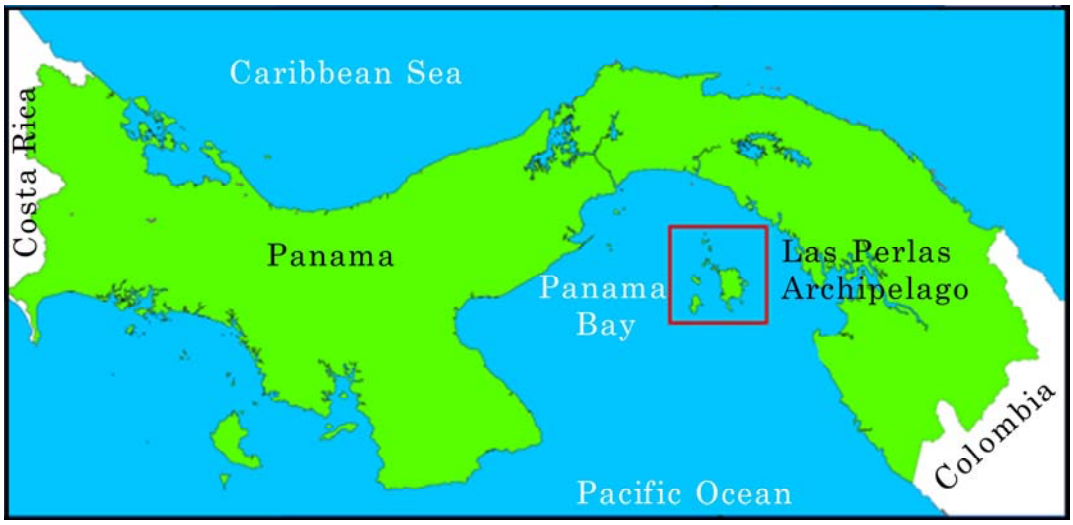


Figure 1. Las Perlas Archipelago and the surrounding area.

The framework coral reefs in this area are limestone formations of mainly *Pocillopora* coral species. They range in thickness from 1-6m and are shallower than the 6m isobath (Glynn & Stewart, 1973; Maté, 2003). The reefs tend to be more abundant and larger on the northern and eastern sides of the islands as they are protected from the coldest upwelling waters (Glynn & Stewart, 1973). There are also areas called coral communities, which do not form a continuous framework structure and consist of a variety of species including *Pocillopora, Pavona* and *Porites.* Coral reefs are normally restricted to warm relatively clear oligotrophic waters (Wells, 1957), therefore it is unusual to find coral reefs, albeit small ones in an area of strong upwelling.

Upwelling can cause the seawater surface temperature to drop as low as 14.7^{o}C, which it did in 2001 leading to rapid bleaching and mortality of corals in Panama Bay (Maté, 2003). The majority of seasonal upwellings occur in the dry season, which runs from January till April. There are many other factors, apart from seasonal upwelling, which affect the growth rates of corals in the area, for example;

- El Niño-Southern Oscillation;
- Sub-aerial Exposure;
- Dinoflagellate blooms;
- Terrestrial run-off and sedimentation;
- *Acanthaster planci* (starfish) plagues;
- Coral extraction (now stopped);
- Ship grounding and anchor damage;
- Herbicides;
- Over-fishing;
- Heavy metal contamination from ammunition dumping;
- Poor management and no enforcement strategies.

These factors are also likely to have affected the overall biodiversity in the area and not just coral species.

1.2 What are Sponges?

A sponge is:

"A sedentary, filter-feeding metazoan which utilizes a single layer of flagellated cells (choanocytes) to push a unidirectional water current through its body."

Bergquist, 1978

The sponges belong to the Porifera, which is evolutionarily the oldest, still extant, phylum (Müller *et al.,* 2001). They were already well established in the Lower Cambrian (> 550 million years ago), they were the major reef-builders in the Devonian (>370 million years ago) and most modern genera, including the reef building corals appeared at the beginning of the Cretaceous period (>150 million years ago)(Hooper & van Soest, 2002).

It has been established that the sponges share a common ancestor with the other phyla within the metazoans (Müller *et al*., 1994). In fact, it has been calculated (Gamulin *et al*., 2000) that among 42 phylo-genetically conserved proteins from marine sponges, *(S. domuncula, G. cydonium, S. raphanus* and *A. vastus*), the majority of the sponge proteins are significantly more similar to human proteins than those of a nematode worm (*C. elegans*).

The Porifera is also one of the most diverse and successful of the 28 aquatic invertebrate phyla, both in terms of number of species and range of morphology (Hooper & van Soest, 2002). There are about 7000 described extant species and certainly many more yet to be described (Hooper & van Soest, 2002). They can be found in all aquatic habitats from the abyssal depths of the oceans, to freshwater and even some ephemeral habitats. The basic characteristics of the phylum are:

- Metazoans at the cellular grade of construction, without true tissues;
- Adults can be asymmetrical or radially symmetrical;
- Cells tend to be totipotent (able to change functions as required);
- Choanocytes are flagellated cells unique to the phylum;
- Motile larval stage and sessile suspension feeders as adults;
- No basement membranes in outer and inner cell layers;
- The mesohyl (middle cell layer) varies, however normally has motile cells and some skeletal material;

- Individuals not colonies, as the epithelium (skin) is continuous.
- Most have a mineral skeleton made of calcium carbonate, silicon dioxide and/or collagen fibres;
- Diverse size and geometry of the skeletal elements (spicules);

The phylum is divided into four extant classes on the composition and structure of the skeleton:

- Calcarea; exclusively marine with calcium carbonate spicules;
- Hexactinella; majority in deep ocean habitats with six-rayed siliceous spicules;
- Sclerospongiae; marine and characterised by a massive calcareous skeleton;
- Demospongiae; 95% of sponges are in this class including all freshwater species. The skeleton consists of siliceous spicules, which, in some cases, is supplemented or replaced by collagenous spongin fibres.

There have been many significant modifications to sponge taxonomy even in recent years so different sponge species can be hard to distinguish and classify. Most taxonomic literature especially the older works describes sponge species using the characteristics of the skeleton and spicules present.

1.3 How is this Research relevant to Marine Resource Development & Protection?

Sponges are often ignored in coral reef monitoring programmes. The reasons for their oversight include:

- the difficulties in sponge identification in the field;
- sponge taxonomy at all levels is currently in flux;
- many species are cryptic;
- difficulties in adequate measurements due to their complex 3-D shapes within and around the coral framework matrix;
- many species fragment asexually or die partially leaving little trace as dead parts biodegrade quickly.

However, there are many good reasons for assessing and monitoring sponge abundance and diversity, these reasons can be encompassed in two main themes:

- the essential role sponges play in coral reef ecosystems;
- their value as a marine resource, especially related to possible new compounds and chemicals.

1.4 The Essential Role of Sponges in Coral Reefs.

Sponges are among the most prominent coral reef groups, usually with a greater diversity of species then corals and algae (Meesters *et al*., 1991; Alcolado, 1994 & Clifton *et al*., 1997). Often in marine surveys the number of sponge species is under-estimated as identification usually requires microscope preparations and correctly identified colour images. There are few reliable field guides or keys for sponges (Diaz & Rützler, 2001).

Diversity is promoted further through the associated infauna of sponges. They provide shelter, a food source and a place to reproduce for a wide diversity of macrofauna. 139 and 53 species respectively of fish, molluscs, crustaceans and ophiuroids were found inhabiting the interior cavities of *Aplysinia lacunosa* and *Aplysinia archeri* (Villamizar & Laughlin, 1991) and in just 19 specimens of *Mycale microsigmatosa* in Brazil over 2200 individuals of 75 different species were associated fauna (Ribeiro *et al.,* 2003).

As sessile organisms, sponges tend to have biological and chemical defences against predators in their normal environment. However, generalist herbivores, such as parrotfish, will eat cryptic reef sponges in the Eastern Pacific if the sponges are exposed (Wulff, 1997a,b). Sponge specialist feeders, for example Hawksbill turtles and Angelfish, have tolerances to the toxins in sponges by either only eating sponges within a certain order or eating small amounts of lots of different sponges respectively. (Meylan, 1990; Wulff, 1994).

In addition to relationships with associated macrofauna, sponges often have diverse symbiotic relationships with microbial endosymbionts. In the Caribbean up to 58% of sponge species carry photosynthetic microorganisms (Wilkinson & Chessire, 1990). Other microbial associations include:

- zooanthellae and boring sponges (Pang, 1973);

- cyanobacteria and other prokaryotes (Rützler, 1990);
- nitrifying bacteria (Diaz, 1997);
- methanotrophic bacteria (Vacelet *et al.,* 1995).

Many of these associations are not yet fully understood.

Sponges act as a sink and a source for different organic compounds and micro-organisms. As filter feeders, sponges pump large quantities through their chambers and this affects the nutrient fluxes and productivity of the surrounding waters. This was shown in two species of *Ircinia* in the Caribbean, which are a net source for nano- and pico-eukaryotic bacteria and a net sink for prokaryotes (Pile, 1997). Sponges, with their large biomass, high water filtering rates and little understood relationships with microbial fauna, are likely to play an important role in the balance and dynamics of carbon and nutrients in the water column.

As well as often having the largest biomass in reef communities, the percentage area cover of Caribbean reef sponge species can reach 24% on hard substrata in light exposed open reef habitats (Zea, 1994) and up to 54% in cryptic low-light sub rubble communities (Meesters *et al.,* 1991). The area covered by sponges tends to increase in lower light intensity, higher sediment exposure and even (mildly) organically polluted zones of the reef as other space competitors such as algae and hard corals are out-competed (Alcolado, 1994, Zea, 1994).

Some species of sponges can out-compete corals and other sessile invertebrates by over-growing them (Vicente, 1978; Aerts & van Soest, 1997). Generally it is thick-incrusting species such as *Aplysinia cauliformis* and *Desmapsamma anchorata,* which often overgrow corals in the Colombian Caribbean (Aerts & van Soest, 1997). Sponge capability to overgrow corals successfully is probably due to their ability to attach to corals without causing harm, diverse biochemistry and their plastic morphology (Rützler, 1970; Sarà, 1970; Faulkner, 1995).

Other than overgrowing the corals, sponges are known to both bio-erode and cement coral reefs together (Wulff & Buss, 1979; Diaz & Rützler, 2001). Sponges of the genus *Cliona* are some of the best-known bio-eroding sponges and can cause a net decrease in

coral reef biomass and destruction of parts of the reef (Holmes, 1997). However, the first step in the regeneration or formation of a reef is the stabilisation of the substrate. Sponges facilitate this regeneration as they can bind pieces of rubble together quickly so that that the carbonate secreting corals can fuse together without being separated by wave action and foraging (Wulff, 1984, 2001). According to Wulff, (2001) although sponge-seeding experiments have not been carried out in the Eastern Pacific, a positive correlation was found between rubble consolidation and the presence of cryptic sponges in the reef framework, which matches the pattern found in Caribbean reefs.

There is a need to study the sponge communities on coral reefs due to their 'species-specific' functionality which impacts reef health, community composition and the success of regeneration and restoration. There is also great potential waiting to be nurtured in relation to the active bio-metabolites sponges produce.

1.5 The Biochemical Benefits.

Sponges have far more economic potential then solely as commercial bath sponges. They are one of the most prolific sources of marine natural products for biomedical applications (Faulkner, 2000). Many sponges from varied localities have been screened for a variety of biological activities, for example: antimicrobial; hemagglutinating; ichthyotoxic; lethal properties and others (Green, 1977; Thompson *et al.,* 1985; Mebs *et al*., 1985, 1995; Green *et al*., 1990; Huysecom *et al*., 1990). Some 1000–1500 different natural products represented by terpenes, polyketides and amino-acid derivatives in sponges were already known over a decade ago (Faulkner, 1993). Some of the diverse range of compounds and their sources are listed in the table (Table 1.) below.

Table 1: Examples of biomedical compounds, their applications and source sponge species.

PRODUCT	APPLICATION	SOURCE SPONGE SPECIES	REFERENCE
Ara-A	Antiviral drug (Herpes)	*Cryptotethya crypta*	Tziveleka *et al.* 2003
Ara-C	Anticancer drug (Leukemia and Non-Hodgkins Lymphoma)	*Cryptotethya crypta*	Tziveleka *et al.* 2003
Manoalides	Molecular probes, phospholipase A2 inhibitor, Antibacterial agent against *Strep. aureus*.	*Luffariella sp.*	Namikoshi *et al.* 2004
Avarol and	Anti-tumour agents (Human	*Dysidea avara*	Shen *et al.* 2003

Avarone	hepatoma)		
Scalarane Sesterterpenes	Cytotoxins	*Hyatella intestinalis*	Karuso *et al.* 1989

The properties of different bio-metabolites extend beyond benefits for human health. For example, there is potential to use sponges in shrimp farming for their antibiotic properties, as a more economically viable alternative to antibiotics, with less chance of the bacterial resistance (Selvin & Lipton, 2004). There are new possibilities being developed all the time. However, in order to find new compounds, thorough taxonomic studies are vital to discover any biochemical potential.

1.6 Aims

- **To identify some of the sponge species found in the Las Perlas Archipelago to at least family level.**

- **To investigate the differences in sponge distribution and diversity in relation to coral frameworks and coral communities.**

1.7 Hypothesis

- **There will be a significant difference between the sponge diversity and abundance of framework coral reefs and the sponge diversity and abundance of coral communities.**

1.8 Null Hypothesis

- **There will be no significant difference between the sponge diversity and abundance of framework coral reefs and the sponge diversity and abundance of coral communities.**

The null hypothesis will be tested.

2.0 Methods

2.1 Fieldwork

The fieldwork was carried out during the Darwin Initiative mapping survey of the Las Perlas Archipelago, Panama, August 2004. Ten sites were chosen: five on coral frameworks and five on coral communities. Since the survey, two of the coral community sites have been reclassified as transition sites.

2.1.1 Definitions for the site categories

The definition of a framework site is: where live coral is growing on dead coral. The framework reefs in the Las Perlas Archipelago are limestone formations of rigid interlocking branches of mainly *Pocillopora* coral species, which range in thickness from 1-6m. They tend to be areas of high percentage coral cover (Fig. 2).

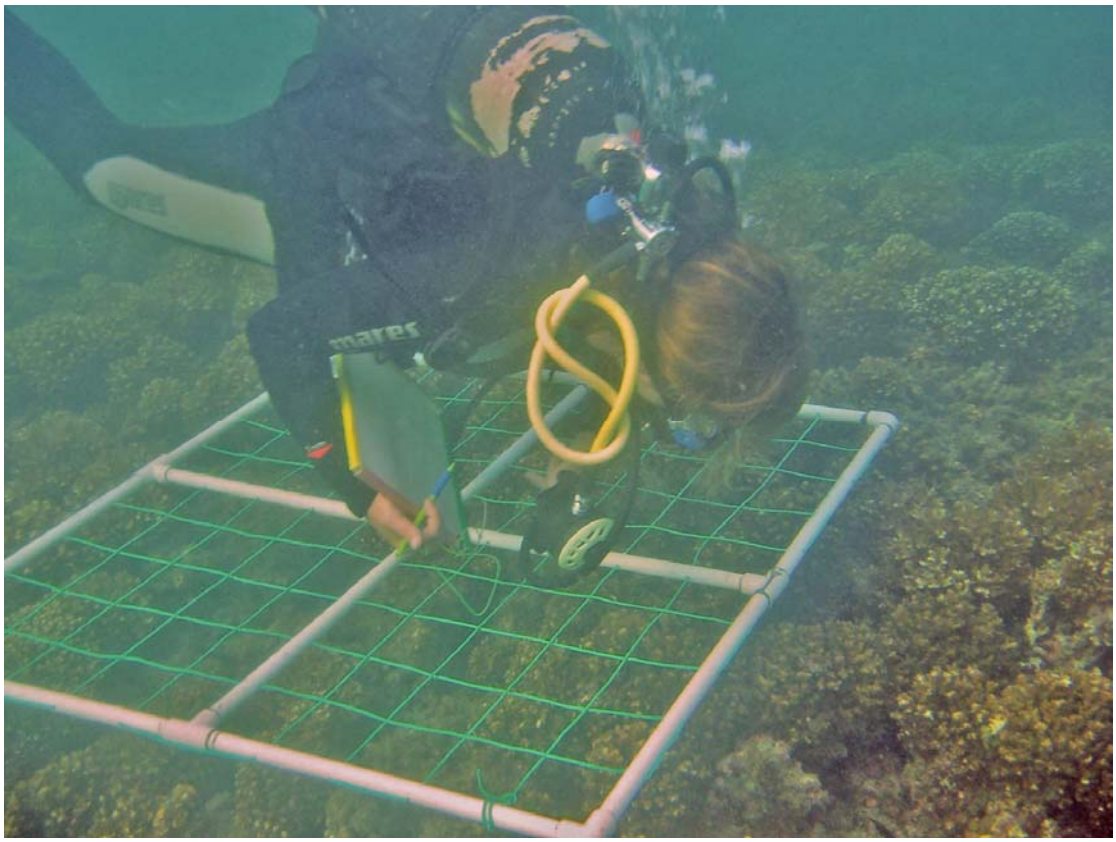


Figure 2. Transect survey in progress on a *Pocillopora* coral framework reef site.

The definition of a coral community site is: where live coral is growing on bare rock. There is no continuous framework and a variety of species form small colonies

including *Pocillopora, Pavona* and *Porites* species. These areas tend to have a low percentage coral cover (Fig. 3).

Figure 3. A typical coral community site with coral colonies growing directly on the bedrock.

The definition of transition sites is: a mixture of coral communities growing on bare rock and small patchy frameworks growing on dead coral.

The sites chosen had been surveyed for coral cover previously or were surveyed during the 2004 survey (See Fig. 4 and Table 2).

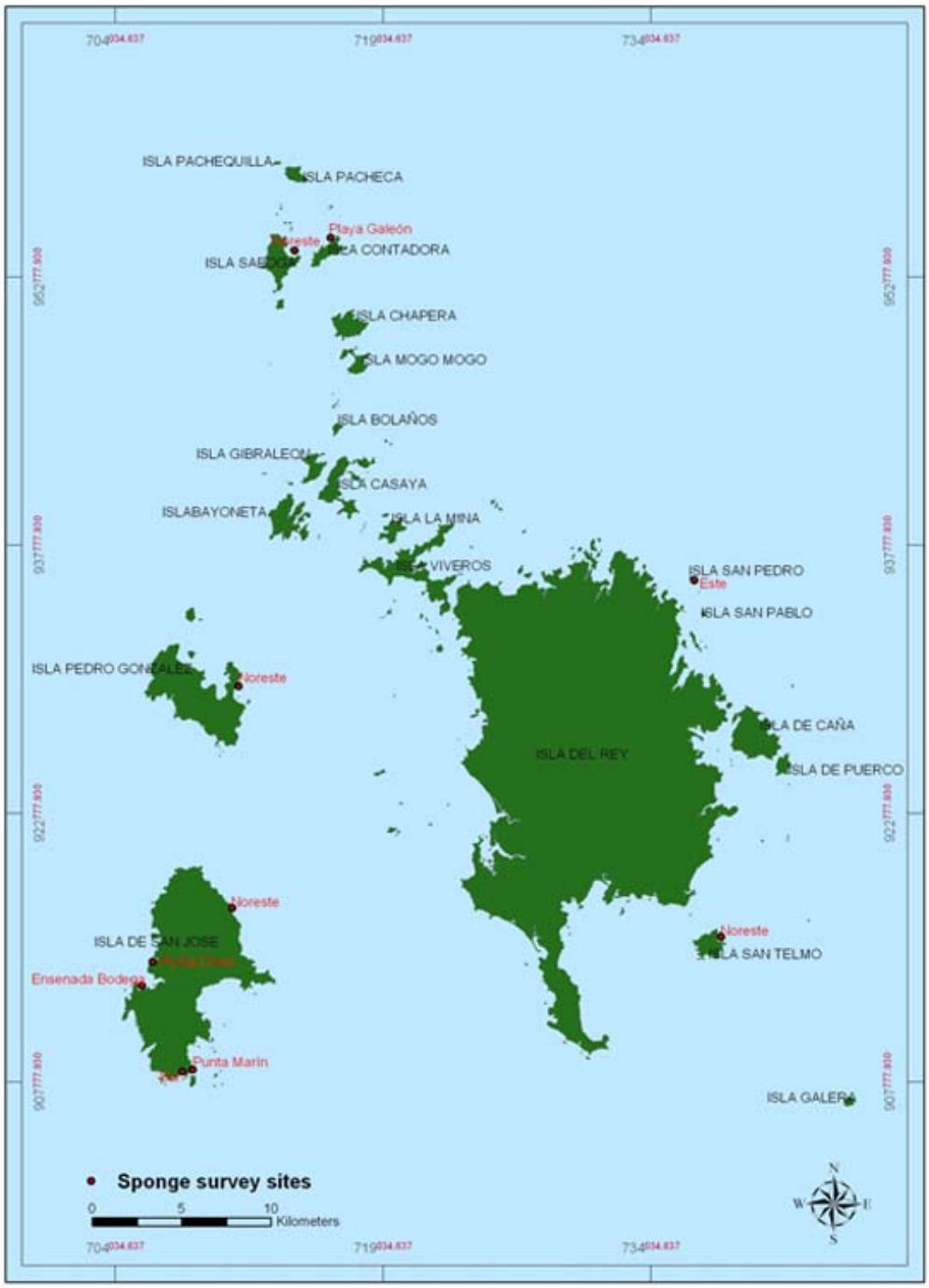


Figure 4. Sites of the sponge surveys (indicated in red text) within the Las Perlas Archipelagos (adapted from Benfield, unpubl. data)

Table 2. Information for relocation of the sites surveyed and their habitat type.

Sit	Location Name	Latitude/Longitude	Habitat Type

e			
F1	Isla Pedro González Noreste	8º24'28.10"/79º05'02.10"	Framework
C2	Isla San José Noreste	8º17'45.00"/79º05'16.00"	Coral Community
C3	Isla San José Sur	8º12’47.00”/79º06’48.80”	Coral Community
F4	Isla Saboga Noreste	8º37'40.00"/79º03'16.00"	Framework
T5	Isla San José (Punta del Chivo)	8º16’08.00”/79º07’42.00”	Transition
F6	Isla San José (Ensenada de Bodega)	8º15’24.00”/79º08’02.00”	Framework
T7	Isla San José (Punta Marín)	8º12’51.00”/79º06’30.00”	Transition
F8	Isla San Pedro Este	8º27’36.48”/78º51’08.29”	Framework
F9	I. Contadora (Playa Galeón)	8º38’02.60”/79º02’09.60”	Framework
C10	Isla San Telmo Noreste	8º16’47.20”/78º50’22.40”	Coral Community

2.1.2 Sponge Sample Collection

Sponge samples were collected using scuba diving on air from the Smithsonian Institution research vessel *Urraca.* HSE and Heriot-Watt diving regulations were adhered to for health and safety reasons. Most sponge samples were collected during a preliminary dive dedicated to familiarisation of the sampling techniques and species present. Further samples were collected at each of the other nine sites whenever a new species was found and also to reduce misidentification of morphologically similar species. A section large enough to review the sponge’s inner structure and some ostia and oscula was taken, however, some of the sponge was left behind in order that the remaining part could continue to survive. All samples were collected, labelled and stored in separate plastic bags to avoid cross-contamination of cells, metabolites and spicules.

2.1.3 Transect methods

Transect lines 50m long were laid parallel to the shore at about three to six metres depth. A one metre squared quadrate was used to sample the first ten metres, then from twenty to thirty metres and from forty to fifty metres. In total an area of $30m^2$ was sampled at each site. Percentage cover of each sponge colony was measured to the nearest 0.25%. Only visible sponges were counted as it would be destructive and time-consuming to try to sample the sponges deep within the framework lattice.

2.2 Sponge Preservation

Each specimen was photographed both in-situ and in the laboratory using an Olympus Mui 410 digital camera and underwater housing. Samples were preserved using three different techniques:

- Freezing
- Alcohol
- Formalin

2.2.1 Freezing

This technique was recommended in Hooper (2000), as the best preservation technique for sponges as it fixes the colour and halts biodegradation rapidly. Also it is very useful if genetic techniques were to be used on the samples in further research (Boury-Esnault *et al*., 1999). As soon as sponge samples were brought out of the seawater they were photographed and a label was inserted into the bag with the date, site and sample name information. Then the samples were put straight into a freezer.

2.2.2 Formalin

In this technique the samples were photographed and labelled as above and then put in individual jars of 5% buffered formalin for no more than 24 hours before being transferred to at least 70% alcohol (Maldonado et al., 2001). This technique should never be used on calcareous sponges as it dissolves the spicules.

2.2.3 Alcohol

The samples were photographed and labelled and then transferred to specimen jars of at least 70% alcohol as recommended and used in van Soest, (1986); Kelly-Borges (1994); Kelly *et al.* (2003).

After experimenting with all three of the above techniques in the first week of sampling it was decided to use the alcohol as the preferable method when the specimen was too small to create three sub-samples.

2.3 Sponge Identification

Most sponge identification is based on the spicules and structure of the tissue matrix. Notes were also taken on the habitat, colour, distinctive smell, texture, size and form. At least two slides of the tissue matrix and the spicules were prepared for each different sponge species. Techniques for spicule and tissue matrix side preparation were perfected by practising on the brown *Sigmadocia sp.* and the lilac *Callyspongia sp.*. These were the best samples to practice on as a reasonable amount of these samples were collected and they were larger then most other specimens.

2.3.1 Spicule Preparation

For spicule preparation the bleach method was initially used as it is less toxic than using nitric acid, quick and can be carried out directly on the slide. Adapted from Claire Valentine (pers. com.) and A simple fool's guide to Sponge Taxonomy (Kelly-Borges, 1994).

Small portions of ectosome and choanosome ($3mm^2$) were cut and placed in a labelled well. (utensils were cleaned in-between specimens). Each well was half filled with bleach and left for 30-60 minutes. Hard, dense or fleshy sponges needed longer than dry, spongy and crumbly ones. The bleach was pipetted off without disturbing spicules and tissue settled at the bottom of the well. Bleach must be removed from the solutions or it will crystallise and look like microseres. Water was added to carefully re-suspend spicules and then the solution was left to settle for 10-15 min. The water was pipetted off without disturbing tissue or spicules. The spicules and tissues were re-suspended with 100% ethanol. The spicule suspension was aspirated into a pipette. The solution was squirted onto a warm slide and spread around using the pipette tip. After the ethanol evaporated mounting medium was added and a cover slip.

The above method was used for the first few slide spicule preparations, however, it was found that there were not enough spicules present and too much debris on the final slides to perform any accurate taxonomic identification. Therefore $10mm^2$ of the tissue was used and the Nitric Acid digestion was repeated on all of the samples.

The nitric acid technique provides cleaner, more permanent preparations, however it involves dangerous chemicals and the appropriate health and safety precautions must be taken. These precautions involve using a fume cupboard, protective clothing, gloves

and safety goggles and working in a well ventilated laboratory. In this method the tissue samples are heated gently in a small flask of nitric acid. The heat must be low so that the acid is evaporated and not burnt. It is also suitable to heat the solutions directly on the slides as the spicules bond with the glass. When the slides were cool they were mounted without washing.

2.3.2 Tissue Sectioning

The 'simple clearing' technique was used to determine the structure of the mineral skeleton. This method is a reasonably quick and easier which is very important when the samples have to be processed to a high standard within a short time-frame. Using a very sharp razor, thin slices of each sample were taken (50-100µm thick), through the surface perpendicularly and also deeper skeletal sections. These tissue sections were placed in Xylene or a similar clearing agent for between 4-24 hours, longer times are needed for more collagenous sponges. The sections were then mounted using small glass slivers as support for the cover slips.

Spicule and tissue sections were both viewed under a magnification of 40-400x using a light microscope. Electron microscopy is a useful technique in sponge identification, however it was too expensive for this project.

2.3.3 Identification

There are no keys or species lists for sponge species in the Eastern Pacific. Therefore experts were contacted for further advice (Valentine, Wulff, Diaz & Guzmán pers. com.). Historical literature was also traced as well as unpublished and grey literature. As a non-expert with limited time it would be unfeasible to try and name all of the samples to species level therefore identification levels vary between samples.

2.4 Data Analysis

Sponge diversity was calculated for each site in terms of: total species recorded; species recorded on transect; total species per square metre and the variation in species distribution for individual sites, in comparison to all the sites and as coral community and coral framework sites. The distribution pattern (regular, random or clumped) was also calculated for each site.

The simple matching coefficient was used from the MVSP programme to calculate the similarity between the replicates within and between sites. This coefficient was used because it takes into account sites where no sponge species were recorded which is important especially in areas of low sponge abundance an diversity.

The correlation coefficient was used to test the relationship between coral cover and total sponge abundance, sponge diversity, and individual sponge species distribution.

3.0 Results

The results are divided into three sections:

- The diversity of sponge species found;
- The similarity between individual quadrates and the similarity between sites;
- The relationship between coral cover and sponge abundance and diversity.

The raw ecological data is in Appendix 1.

3.1 Sponge Diversity

29 different species were identified to at least Order level during the surveys in the Las Perlas Archipelagos (Table 3). Some of the species were found by scuba diving at the sponge sites and some were recovered during trawling.

Table 3. The species list for the Las Perlas Archipelagos. The "x*" means that a species was found at a site, however it was not present on the transect line. Trawl samples were brought up while sampling benthic communities in deeper areas of the Las Perlas. There are copies of the slides in the Smithsonian Tropical Research Institute and in Heriot-Watt University. Type samples are currently stored in the Smithsonian Tropical Research Institute for further work-up to species level.

	Site Locations Recorded "X"											Slide Numbers	Type Sample
Species	C 10	C 3	C 2	T 5	T 7	F 1	F 4	F 9	F 6	F 8	Trawl		
Beige *Halichondria sp.*								X	x*	x*		22,23,60, 69	AB
Beige Haplosclerid								x*				87,88	E
Black *Haliclonia sp.*			X									81,64	AA
Blue *Haliclonia sp.*	x*											36,37	N
Blue Homosclerid								X				45,46	
Blue-grey *Sigmadocia sp.*	X	X	X		X		X	X	X			18,32,53	P
Brown *Aplysina sp.*											X	93,94	D
Brown *Sigmadocia sp.*	X	X	X	X	X	X	X	X	X	X		4,5,6,11,12 ,13,24,25,	Q
Brown *Spirastrella sp.*	X											101,102	U
Clear/red dots Pocilosclerid	X		X		X				X			57,68	Z
Cream *Geodia sp.*	X											99,100	T
Dull Yellow *Aplysina sp.*											X	78,79	B
Lilac *Callyspongia sp.*	X	X	X		X	X	X	X	X			17,31,52	F
Lilac Haplosclerid	X	X	X		X		X	X	X	X		1,2,3,7,8,9, 10,20,21	R

Species	Site Locations Recorded "X"											Slide Numbers	Type Sample
	C 10	C 3	C 2	T 5	T 7	F 1	F 4	F 9	F 6	F 8	Trawl		
Orange *Chondrilla sp.*	X	X	X	X	X		X		X	X		16,30,35,56,67	G
Orange Haplosclerid	X		X									19,33,54	S
Orange *Sigmadocia sp.*	X	X			X		X	X				54,58,74	M
Orange *Spirastrella sp.*	X											105,106	V
Pink Haplosclerid	X											91,92	A
Purple *Aplysina sp.*		x*										95,96	J
Purple Haplosclerid	X												K
Red Asterophorid sp.	X				X		X		X	X		15,29	Y
Red Hadromerid	X												X
Red *Pseudoceraatina sp.*											X	42,75	C
Red *Spirastrella sp.*	X											103,104	W
Turquoise Haplosclerid	X		X									14,28	O
White *Clatherina sp.*	X		X		X	X						39,40,41,47	H
Xmas Tree Hadromerid											X	97,98	L
Yellow *Suberites sp.*	X				X		X	X				89,90	I

22 species in total were recorded during the transect surveys of the Las Perlas Archipelagos. There were 21 species recorded from the coral community sites, 10 species from the transition sites and 14 from the framework sites. The brown *Sigmadocia sp.* is the only species to have been recorded at all the sites. The beige *Halichondria sp.* was the only species present at the coral framework sites that was not recorded at any of the coral community sites.

The total number of sponge species at each site in relation to their geographical location can be seen in figure 5.

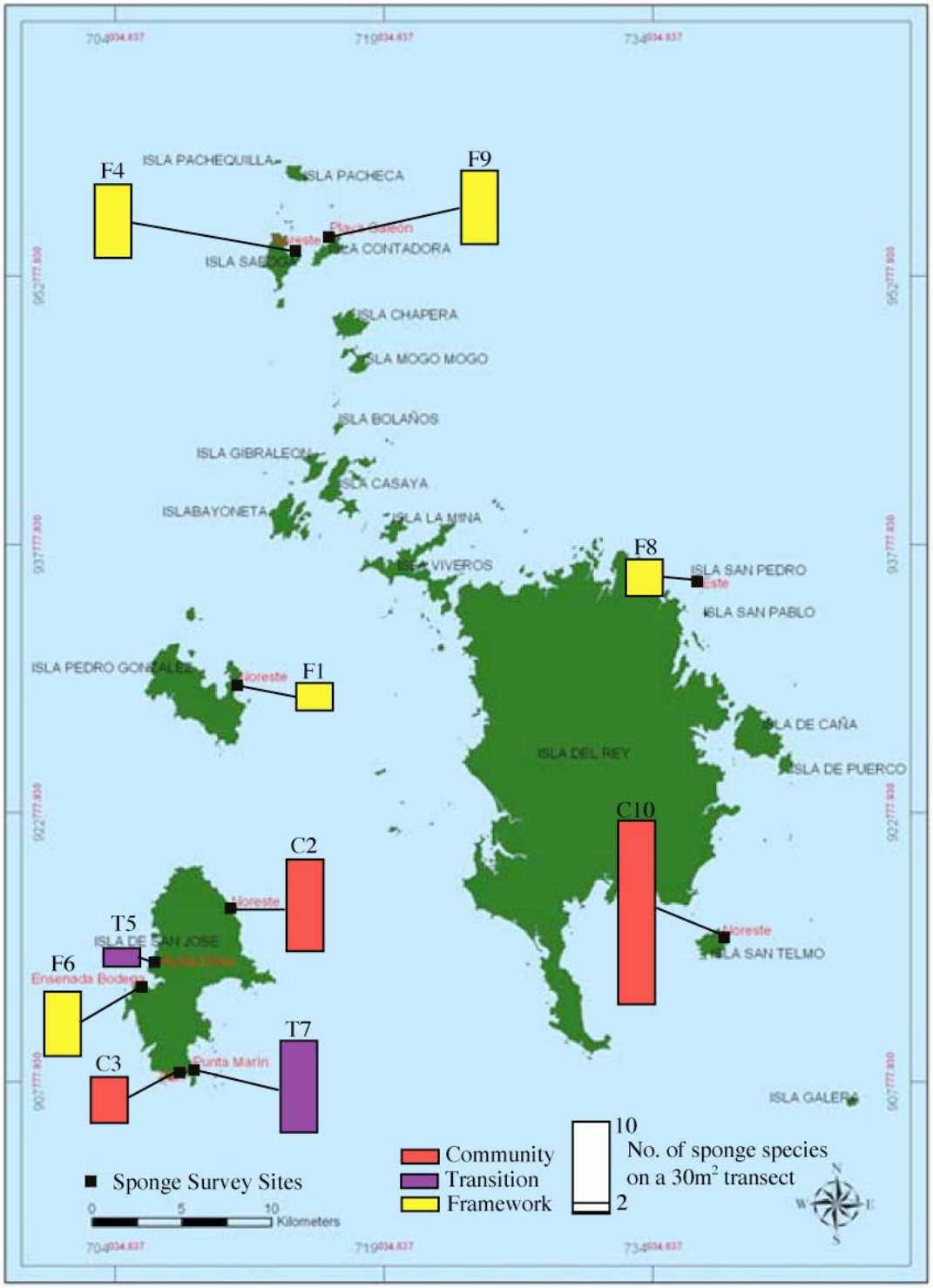


Figure 5. Number of sponge species recorded at each site shown at their geographical locations in the Las Perlas Archipelagos.

San Telmo had the highest number of species recorded on transect with 20 species in total and an average of 4.333±1.77 species per metre squared. Punta del Chivo on Isla San José had the lowest total number of species recorded, however, Este on Isla San Pedro had the lowest average species per metre squared (Table 4).

Table 4. Total number of species on each of the survey sites and average number per m^2.

Site name	Site No.	Total No. of sponge sp.	Average No. of sponge sp./m^2	Average sponge percentage cover /m^2
Isla San Telmo Noreste	C10	20	4.333±1.77	2.743±2.64
Isla San José Sur	C3	5	1.233±1.00	0.433±0.38
Isla San José Noreste	C2	10	2.167 ±0.98	2.842±2.34
Isla San José (Punta del Chivo)	T5	2	0.733±0.45	0.216±0.17
Isla San José (Punta Marín)	T7	10	1.533±1.17	1.275±2.25
Isla Pedro González Noreste	F1	3	1.067 ±0.52	0.783±0.77
Isla Saboga Noreste	F4	8	1.867±0.86	1.241±1.75
Isla Contadora (Playa Galeón)	F9	8	2.133±0.82	1.49±1.03
Isla San José (Ensenada de Bodega)	F6	7	1.967±0.67	1.733±1.32
Isla San Pedro Este	F8	4	0.567±0.73	0.325±0.57

The average percentage cover of sponges was highest at the coral community sites of Isla San José Noreste (C2) and Isla San Telmo Noreste (C10) (Fig. 6).

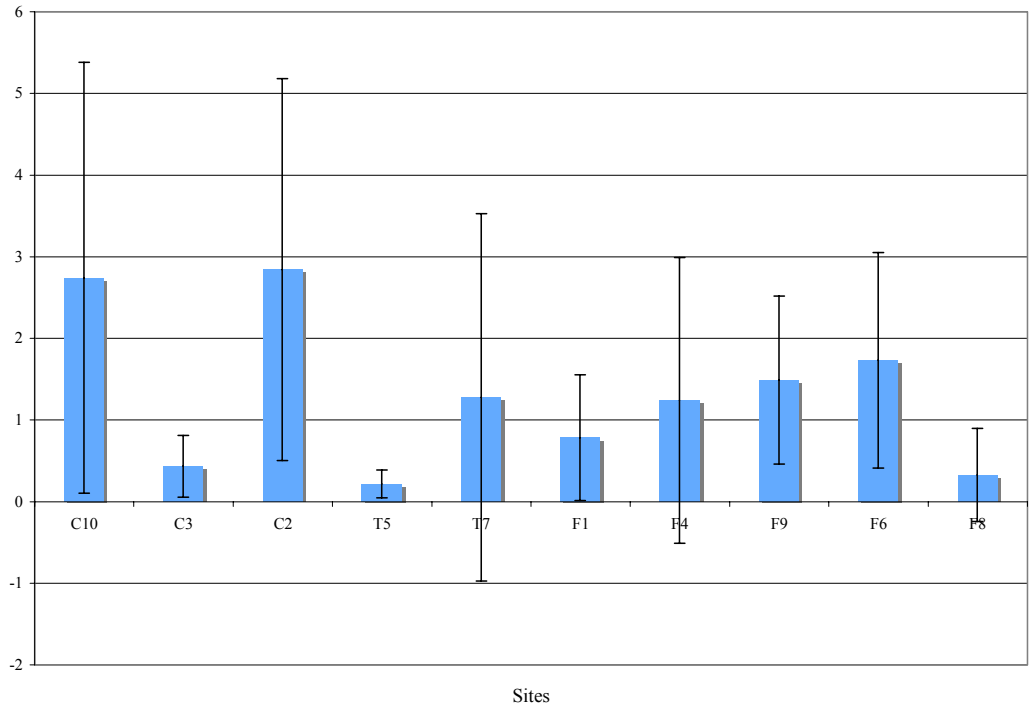


Figure 6. The average percentage cover of sponges in each of the survey sites with standard deviation error bars.

The standard deviation bars on figure 6 show that in relation to average sponge percentage cover the sites were very variable along the transects. Therefore, although Punta del Chivo (T5) on Isla San José has the lowest average percentage cover, the standard deviations of Punta Marín (T7) on Isla San José, Isla Saboga Noreste (F4) and Isla San Pedro Este (F8) are all greater in value then the mean and have theoretical negative values due to the high variability of the sites.

The percentage abundance of the individual sponge species recorded in relation to total sponge abundance varies between the coral community sites and the framework sites (Fig 7. and Fig. 8. respectively).

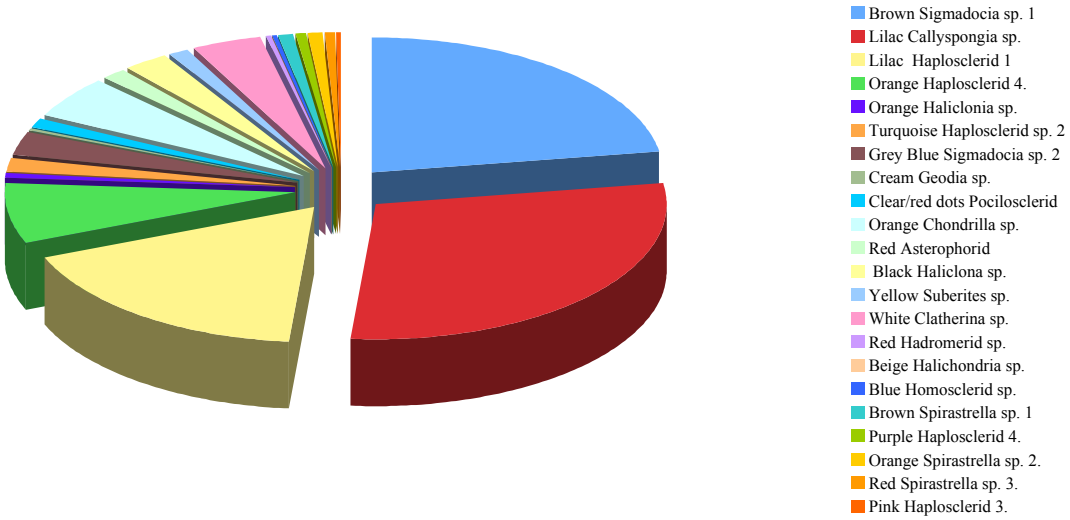


Figure 7. The relative abundance of the sponge species found along transects in coral community and transition sites.

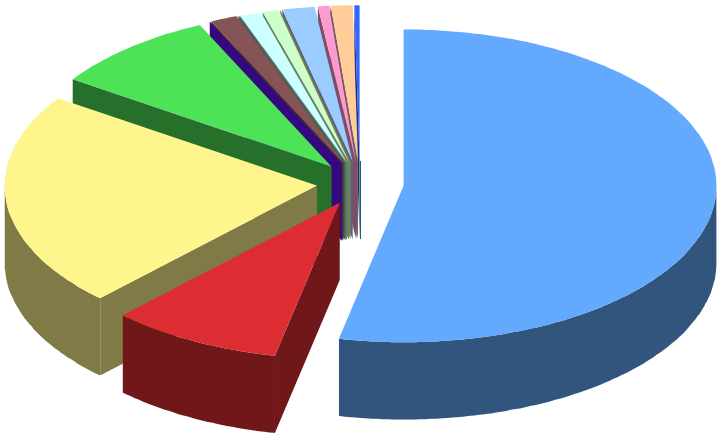


Figure 8. The relative abundance of the sponge species found along transects in framework sites. (Legend as in Fig. 7.)

The species with the greatest abundance was the brown *Sigmadocia sp.* with 53% of the total abundance at framework sites and the second largest abundance (23%) at coral community sites. The lilac *Callyspongia sp.* has the greatest abundance (29%) at the coral community sites and had the fourth largest abundance (9%) on framework sites. Other abundant species were a lilac and an orange haplosclerid species 19% and 10% respectfully on the coral community sites and 22% and 10% respectfully on the framework sites.

3.2 Similarity of Species Abundance, Diversity and Distribution within and between Sites.

The species are distributed randomly within the coral community sites of Isla San Telmo Noreste (C10) and Sur on Isla San José (C3), the transition site of Punta Marin on Isla San José (T5) and the framework site of Este on San Pedro (F8) (Table 5). The other sites all have a regular dispersal of the sponge diversity throughout the areas surveyed.

Table 5. The distribution patterns of sponge diversity in relation to number of species per square metre.in the Las Perlas Archipelagos.

Site name	Site No.	Average No. of sponge sp./m^2	Variance (s^2)	Dispersion Index	Degrees of freedom (29) x dispersion index	95% Confidence in the distribution pattern
Isla San Telmo Noreste	C10	4.333±1.77	3.13	0.72	20.88	Random
Isla San José Sur	C3	1.233±1.00	1	0.81	23.52	Random
Isla San José Noreste	C2	2.167 ±0.98	0.96	0.36	10.44	Regular
Isla San José (Punta del Chivo)	T5	0.733±0.45	0.20	0.27	7.83	Regular
Isla San José (Punta Marín)	T7	1.533±1.17	1.37	0.89	25.81	Random
Isla Pedro González Noreste	F1	1.067±0.52	0.27	0.25	7.25	Regular
Isla Saboga Noreste	F4	1.867±0.86	0.74	0.40	11.60	Regular
Isla Contadora (Playa Galeón)	F9	2.133±0.82	0.67	0.31	8.99	Regular
Isla San José (Ensenada de Bodega)	F6	1.967±0.67	0.45	0.23	6.67	Regular
Isla San Pedro Este	F8	0.567±0.73	0.53	0.93	26.97	Random

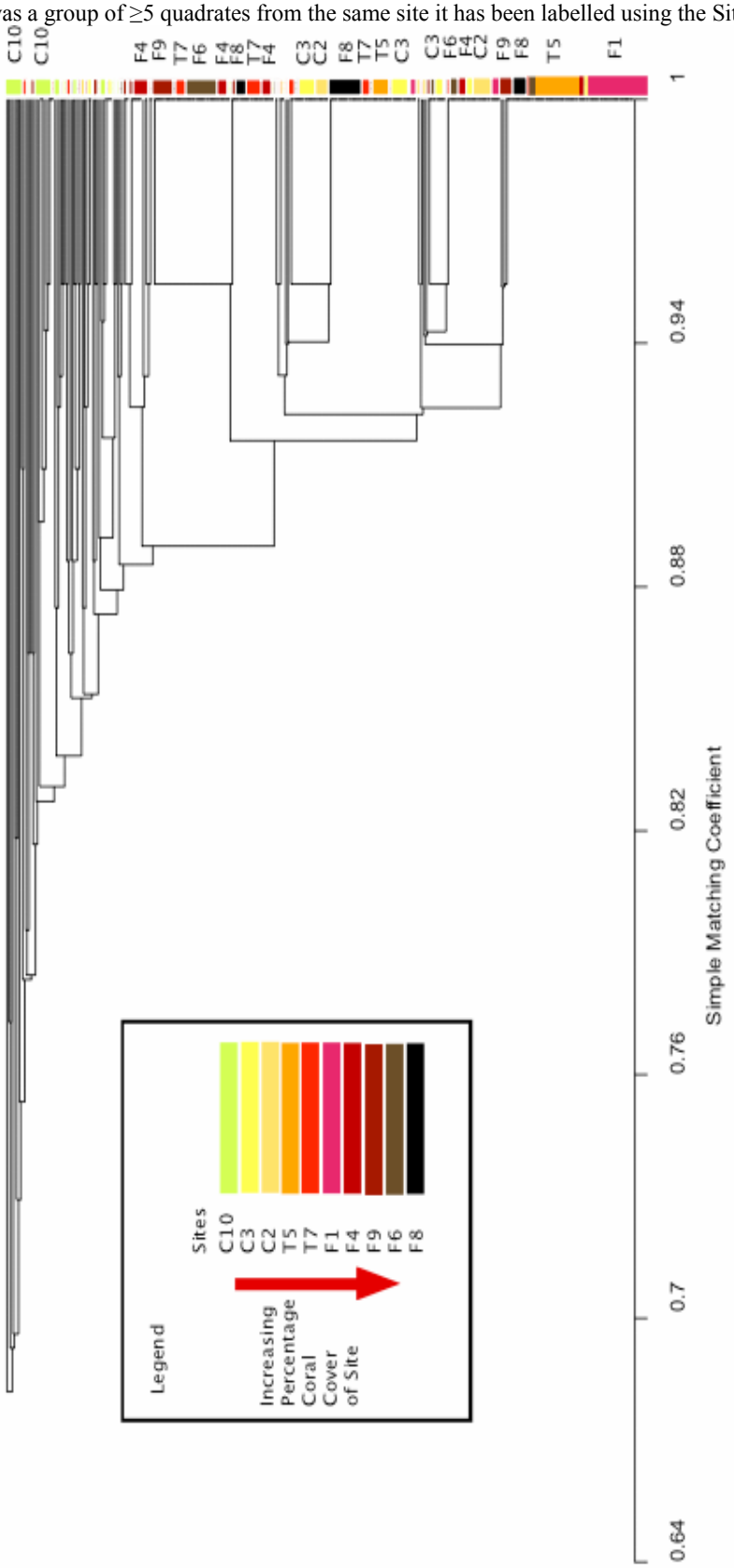
The abundance of sponges within the survey sites is distributed contagiously (clumped) at the coral community sites of Isla San Telmo Noreste (C10) and Isla San José Noreste (C2) and coral framework site of Isla Saboga Noreste (F4) (Table 6). The distribution is random at the transition site Isla San José Punta Marin (T7) and is regular at all other site surveyed.

Table 6. The distribution patterns of sponge abundance in terms of percentage cover in the Las Perlas Archipelagos.

Site name	Site No.	Average sponge percentage cover /m^2	Variance (s^2)	Dispersion Index	Degrees of freedom (29) x dispersion index	95% Confidence in the distribution pattern
Isla San Telmo Noreste	C10	2.743±2.64	6.97	4.23	122.67	Clumped
Isla San José Sur	C3	0.433±0.38	0.14	0.29	8.41	Regular
Isla San José Noreste	C2	2.842±2.34	5.48	2.64	76.56	Clumped
Isla San José (Punta del Chivo)	T5	0.216±0.17	0.029	0.19	5.51	Regular
Isla San José (Punta Marín)	T7	1.275±2.25	5.065	0.89	33.06	Random
Isla Pedro González Noreste	F1	0.783±0.77	0.59	0.25	7.25	Regular
Isla Saboga Noreste	F4	1.241±1.75	3.06	1.82	52.78	Clumped
Isla Contadora (Playa Galeón)	F9	1.49±1.03	1.06	0.43	12.47	Regular
Isla San José (Ensenada de Bodega)	F6	1.733±1.32	1.74	0.01	0.29	Regular
Isla San Pedro Este	F8	0.325±0.57	0.32	0.0001	0.003	Regular

The variability within and between sites in relation to sponge diversity and abundance was tested using the simple matching coefficient (Fig. 9). There are homo- and heterogeneous elements to all of the sites surveyed. The dendrogram shows that the majority of the quadrates Isla Pedro González Noreste (F1) and Punta del Chivo (T5) on Isla San José are very similar in relation to sponge species diversity and abundance. Isla San Pedro Este (F8) is quite homogenous and so is Ensenada de Bodega on Isla San José (F6), although they are different to each other. Isla San Telmo Noreste (C10) is the most diverse site both internally and in relation to the other sites surveyed.

Figure 9. This shows the similarity of the quadrates within each site and between sites in relation to the sponge species diversity and abundance using the simple matching co-efficient. This diagram originally showed every quadrate label. It has been simplified using colour coding for each site and where there was a group of ≥5 quadrates from the same site it has been labelled using the Site No.



3.3 Sponge Abundance & Diversity in Relation to Coral Cover.

Guzmán (unpubl. data), previously measured the average percentage coral cover, for each of the sponge survey sites. His coral cover values are listed along side the sponge percentage cover values (Table 7)

Table 7. Average coral and sponge percentage cover in the Las Perlas Archipelagos. (Coral data from Guzmán pers. com.)

Site name	Site No.	Average coral percentage cover /m^2	Average sponge percentage cover /m^2
Isla San Telmo Noreste	C10	12.4 ± 1.2	2.743±2.64
Isla San José Sur	C3	12.9 ± 1.2	0.433±0.38
Isla San José Noreste	C2	19.7 ± 1.6	2.842±2.34
Isla San José (Punta del Chivo)	T5	36.1 ± 2.8	0.216±0.17
Isla San José (Punta Marín)	T7	40.3 ± 2.4	1.275±2.25
Isla Pedro González Noreste	F1	44.7 ± 3.1	0.783±0.77
Isla Saboga Noreste	F4	76.0 ± 2.9	1.241±1.75
Isla Contadora (Playa Galeón)	F9	80.7 ± 2.8	1.49±1.03
Isla San José (Ensenada de Bodega)	F6	83.0 ± 2.1	1.733±1.32
Isla San Pedro Este	F8	93.7 ± 0.5	0.325±0.57

There is a weak correlation of 0.29 using the correlation coefficient and therefore it is unlikely there is a significant relationship between the percentage coral cover and the sponge abundance (Fig. 10).

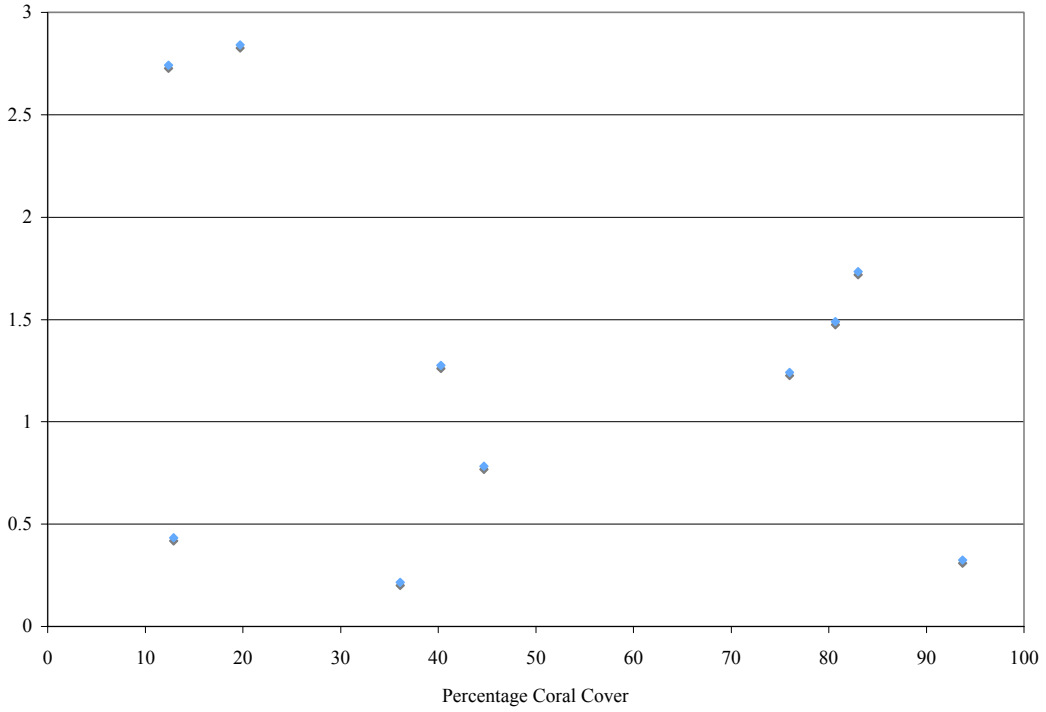


Figure 10. The relationship between percentage coral cover and sponge percentage cover.

There is a weak correlation of 0.36 between the total sponge species at each site and the percentage coral cover. Therefore there it is unlikely there is a significant relationship between the sponge diversity at a site and coral coverage (Fig. 11).

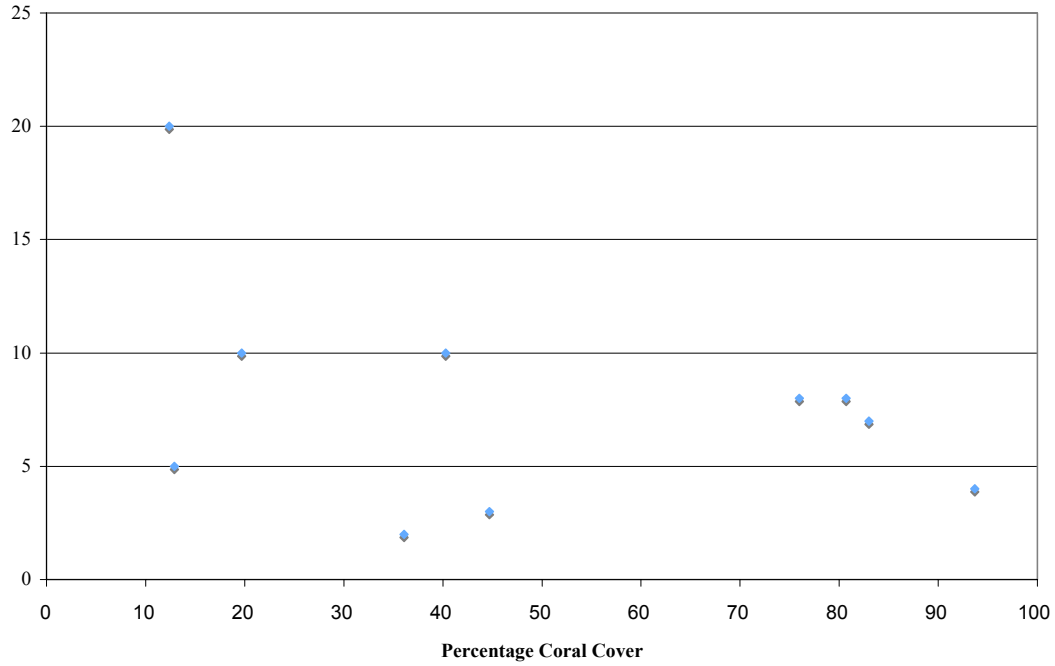


Figure 11. The relationship between percentage coral cover and the total number of sponge species found on transect at each survey site.

There is a weak correlation of 0.33 between the sponge species per square metre and the percentage coral cover. Therefore there is unlikely to be a significant relationship between these two variables.

The coefficient values were also calculated for every species recorded separately (Table 7). When n=10 (the number of sites) the degrees of freedom = 8 (n-2), therefore for the relationship between coral cover and to be statistically significant the coefficient value has to be ≥0.632 (Fowler *et al.,* 1998).

Table 7. The sponge species recorded on the sponge survey transects and their correlation with the coral coverage data.

Species	Speamans Rank Coefficient value	Correlation	Significant?
Beige *Halichondria sp.*	0.35	Weak	No
Black *Haliclonia sp.*	0.34	Weak	No
Blue Homosclerid	0.06	Very weak	No
Blue-grey *Sigmadocia sp*	0.40	Modest	No
Brown *Sigmadocia sp.*	0.29	Weak	No
Brown *Spirastrella sp*	0.42	Modest	No
Clear/red dots Pocilosclerid	0.46	Modest	No
Cream *Geodia sp.*	0.43	Modest	No
Lilac *Callyspongia sp.*	0.66	Modest	Yes P =0.05
Lilac Haplosclerid	0.28	Weak	No
Orange *Chondrilla sp*	0.46	Modest	No
Orange Haplosclerid	0.43	Modest	No
Orange *Sigmadocia sp*	0.10	Very weak	No
Orange *Spirastrella sp*	0.42	Modest	No
Pink Haplosclerid	0.42	Modest	No
Purple Haplosclerid	0.42	Modest	No
Red Asterophorid sp.	0.22	Weak	No
Red Hadromerid	0.42	Modest	No
Red *Spirastrella sp.*	0.42	Modest	No
Turquoise Haplosclerid	0.58	Modest	No
White *Clatherina sp.*	0.51	Modest	No
Yellow *Suberites sp.*	0.10	Very weak	No

Lilac *Callyspongia* was the only species to have a significant relationship (P= 0.05), which was inversely proportional to coral cover.

4.0 Discussion and Evaluation

A very low abundance and diversity of sponges within the Las Perlas Archipelagos was recorded in terms of percentage cover and species number in comparison to other coral reef areas in the Pacific and the Caribbean. Low values were expected, as they are typical of many phyla within the Tropical Eastern Pacific (TEP). The low abundance and diversity of sponge species might be related to the isolation of the TEP. Larvae carried in the oceanic currents are likely to be swept away to other areas as the currents bypass the region. Therefore there is little larval recruitment from outside populations and if a sponge species within the TEP has a bad year either through disease, El Niño damage, anthropogenic effects or other influences, the populations will struggle.

However, the percentage covers for all the sites were significantly higher during this survey then the previous overall sponge cover measurements included in the unpublished data on the same sites by Guzmán. There is unlikely to have been a temporal change in the data as they were collected within the last two years. The reason for this increase is likely to be because the emphasis of all previous work has been directly related to coral coverage. Most of the species found on the framework are cryptic or thinly incrusting and therefore not easy to spot when surveying a large area of framework coral quickly. The only obvious branching sponges on the surface of coral frameworks were a brown/black *Sigmadocia sp.,* a lilac *Callyspongia sp.* and another lilac haplosclerid sponge.

The other species recorded on coral frameworks tended to be where there was damage to or a gap in the framework structure. In these exposed areas it was possible to see some of the cryptic species within the interlocking branches of the corals. When cryptic species are exposed some are more vulnerable to predation (Fig. 12).

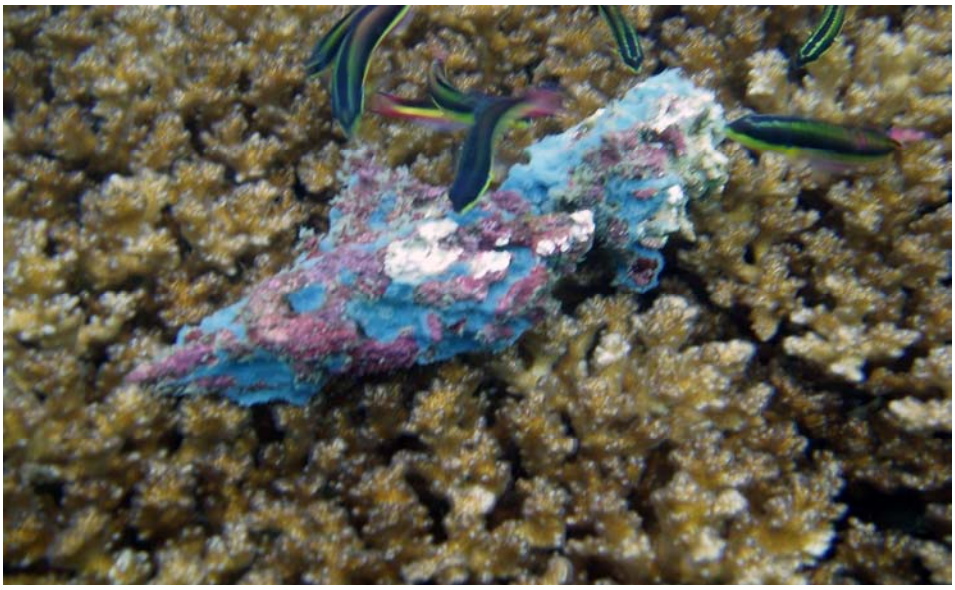


Figure 12. Wrasse devouring a normally cryptic turquoise haplosclerid species found on a coral framework site, Isla Pedro Gonzalez.

Sponge diversity and abundance within the archipelagos was highest at the coral community site San Telmo Noreste (C10). This site also had the lowest coral cover, which is likely to be due to strong wave and surge action and low in-water visibility, which led to the sponge survey of the sponges to be aborted twice before completion due to the weather conditions. The reasons for the higher sponge cover at San Telmo could be due to a variety of factors though it is predicted that the low light intensity and rough conditions mean that sponges probably out-compete corals and algae spatially. The large areas of bedrock, boulders and cobbles provide plenty of settlement sites and sponge lavae are know to be negatively phototaxic and can even move into more suitable positions such as crevices to avoid predation, burial and overcrowding and have better access to food availability and water flow (Maldonado & Uriz, 1998,1999).

The lowest species diversity was recorded at the transition site Punta del Chivo on the western side of Isla San José (T5). Five of the survey sites were around Isla San José, which included a framework, transitional and coral community sites. It is interesting to note that the framework site on the western side, Ensenada de Bodega (F6), had the highest average sponge cover and the second highest species per square metre of all the framework sites surveyed. Punta del Chivo (T5) is very close geographically to the framework at Ensenada de Bodega so theoretically if location was the only factor to take into consideration they should have a similar species complement. Ensenada de

Bodega is enclosed within a bay, which is likely to protect it from excessive exposure. The extra environmental stress from direct exposure to the cold nutrient rich upwelling waters is likely to have prevented coral forming a stable reef framework off the exposed headland of Punta del Chivo. Of all the sites surveyed the coralline algae cover was highest at Punta del Chivo so therefore there are fewer sites available for larval settlement. The algae may have a quicker growth rate and out-compete the sponges at this particular site.

Punta del Chivo has many replicates with exactly the same variation in sponge species and abundance as the framework site Noreste off Isla Pedro Gonzalez (F1). This similarity is due to both sites having large areas where no sponge species were recorded. The reasons for the lack of any sponge species on the framework at Pedro Gonzalez are likely to be related to the high percentage of coral in very good condition. There were very few areas of dead or damaged coral therefore it was very difficult to see if there were any cryptic species within the matrix of coral branches. Sponges growing over the coral appear to be attached to the framework at a site of damage or dead coral and then grow over the live coral without harming it. If there are no dead patches for initial larval settlement then there will also be no adult sponges. Other possible biological and physical factors include water movement, light penetration, stability, substratum, spatial-competition (Geister, 1977; Wilkinson & Trott, 1985; Wulff, 1985, Palumbi, 1986; Wilkinson & Cheshire, 1989, Wilkinson & Evans, 1989 and Zea, 1993).

The framework sites of Isla Saboga Noreste (F4) and Isla Contadora Playa Galeón (F9) are very similar to each other in terms of coral coverage and number of sponge species and abundance. This is not surprising since they are also very close geographically. They have the highest sponge diversity for framework sites. These sites are the closest surveyed to the mainland and there is a tourist resort on Contadora and many of the workers for the resort live on Saboga. These reefs were more disturbed, probably by fishing, diving tourism, scientific diving(!) and boats as the reefs are very close to where people live and work. The disturbance means that the reefs have small areas of damage where it is possible to see some of the cryptic species living within the reef framework (Fig 13).

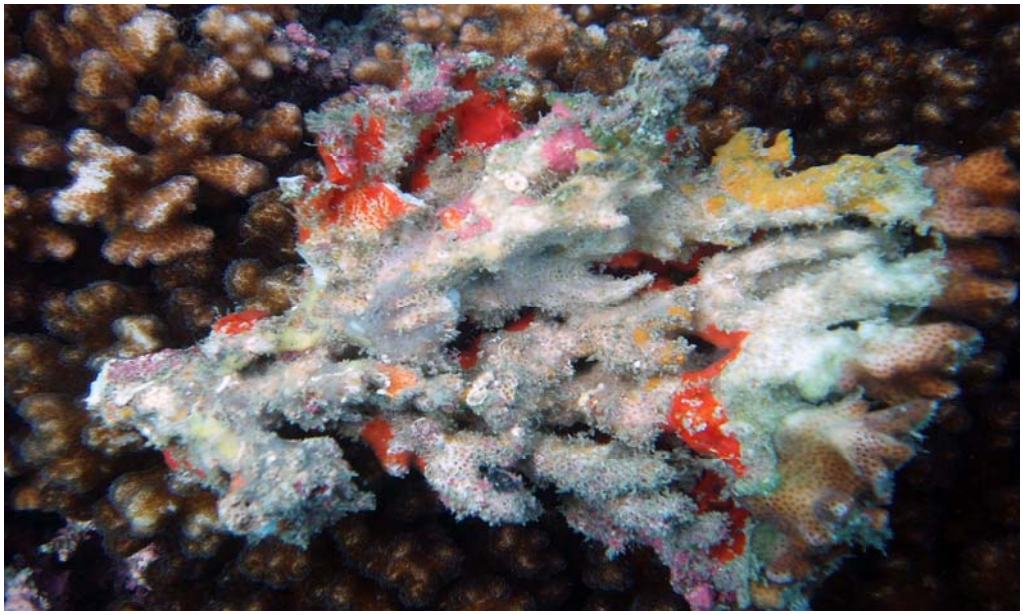


Figure 13. A recently broken part of the framework reef showing the diversity of species within the matrix of interlocking coral branches.

The original null hypothesis was:

"There will be no significant difference between the sponge diversity and abundance of framework coral reefs and the sponge diversity and abundance of coral communities."

The lilac *Callyspongia sp.* was the only sponge to have a significant (P=0.05) inversely proportional relationship with coral coverage. However, it was only found growing directly on and around coral branches whether within an area of coral frameworks or coral communities. Therefore I think that more sites need to be surveyed as l think that coral cover is probably not the only factor influencing the distribution of the lilac *Callyspongia sp.* As this species of sponge is quite visible on the reef and I have not observed any visible signs of predation this species is likely to be inedible and/or unpalatable to the spongivores of the TEP. The main factor involved in abundance is likely to be suitable larval settlement sites and spatial competition. There were no other significant relationships between coral cover and overall sponge diversity and abundance.

The body forms of Porifera are often extremely plastic and can be influenced by many physical and biological factors. Very little is known about the ecology of the sponges in the Las Perlas Archipelagos and the individual roles different species play. It is crucial

for any management plan and monitoring for the area to know which species it are important to record and monitor, for example; if a species is a boring sponge it breaks down the limestone framework of the reef; other sponges filter large quantities of nutrients out of the water preventing them becoming too eutrophic for corals. Also it is important to monitor for alien species which could easily be transported from the Pacific or the Caribbean to the Las Perlas Archipelagos with a tanker or other boat passing through the Panama Canal. 99.9% of alien species die or exist unobtrusively, however if a species finds an unoccupied niche and has no predators it could take over.

To record a fair species diversity and abundance at both coral community and coral framework sites the percentage surface cover probably does not in my opinion give an accurate description of a 3D community which is alive below the surface and within the substrate, like many sponge species. It would be useful to include some data on the sponge biomass comparisons between sites. An initial biomass survey (in conjunction with percentage cover measurements over larger areas) is vital to create a background species checklist and an idea of the relationship between sponge percentage cover and biomass beneath the surface. However, obtaining biomass measurements is time-consuming and very damaging to the reef structure. Therefore after the background survey, for any long-term monitoring programme, the destructive nature of biomass monitoring may outweigh any benefit, as the reefs of the TEP are small and patchy in comparison to the reefs in the Caribbean and other areas.

The biggest challenge of this research was trying to identify the sponge species. If more time were available it would be very useful to try and work-up the samples to species level as there so little is known about the sponges of the TEP it is certain there are new records for sponges in the area as well as undescribed species.

References

A.P.H., 1921. The Sponge. *Punch magazine.* Re-Published *in* M. Kelly-Borges ed. *A simple fool's guide to sponge taxonomy, Version 2.* Natural History Museum, London.

ALCOLADO, P.M., 1994. General trends in coral reef communities of Cuba. Pages 251-255 *in* R.W.M. van Soest, T.M.G. van Kempen & J.C. Braeckman, eds. *Sponges in time and space*. Balkema, Rotterdam.

AERTS, L.A.M. & SOEST, R.W.M. VAN, 1997. Quantification of sponge/coral interactions in a physically stressed community, NE Colombia. *Marine Ecology Progress Series,* **148,** 125-134.

BERGQUIST, P.R., 1978. Sponges. (Hutchinson:London) & (University of California Press: Berkeley & Los Angeles) 1-268.

BOURY-ESNAULT, N., KLAUTAU, M., BÉZAC, C., WULFF, J.L., & SOLÉ-CAVA, A.M., 1999. Comparative study of putative conspecific sponge populations from both sides of the Isthmus of Panama. *Journal of the Marine Biological Association of the United Kingdom.* **79,** 39-50.

CARBALLO, J.L., CRUZ-BARRAZA, J.A. & GÓMEZ, P., 2004. Taxonomy and description of clionaid sponges (Hadromerida, Clionadae) from the Pacific Ocean of Mexico. *Zoological Journal of the Linnean Society,* **141,** 353-397.

CARBALLO, J.L., GÓMEZ, P., CRUZ-BARRAZA, J.A. & FLORES-SÁNCHEZ, D.M., 2003. Sponges of the Family Chondrillidae (Porifera: Demospongiae) from the Pacific coast of Mexico, with the description of three new species. *Proceedings of the Biological Society of Washington,* **116(2),** 515-527.

CLIFTON, K.E., KIM, K., & WULFF, J.L., 1997. A field guide to the reefs of Caribbean Panama with an emphasis on Western San Blas. *Proceedings of the Eighth International Coral Reef Symposium,* **1,** 167-184.

COATES, A.G., JACKSON, J.B.C., COLLINS, L.S., CRONIN, T.M., DOWSETT, H.J., BYBELL, L.M., JUNG, P. & OBANDO, J.A., 1992. Closure of the Isthmus of Panama: The nearshore marine record in Costa Rica and western Panama. *Geological Society American Bulletin*, **104,** 814-828.

COATES, A.G. & OBANDO, J.A., 1996. The geological evolution of the Central American isthmus. Pages 21-56 *in* Jackson, J.B.C. & A.F. Budd, eds. *Evolution and environment in tropical America*. University Chicago Press, Chicago, IL.

CROSSLAND, C., 1927. Marine ecology and coral formations in the Panamá region, the Galápagos and Maquesas Islands, and the Atoll of Napuka. *Transcripts of the Royal Society of Edinburgh,* **55,** 531-554.

DANA, J.D., 1843. On the temperature limiting the distribution of corals. *American Journal of Science,* **45,** 130-131.

DARWIN, C., 1842. The structure and distribution of coral reefs. (Reprinted 1962), University of California Press, Berkley. 214pp.

DESQUEYROUX-FAÚNDEZ, R., & SOEST, R.W.M., VAN, 1996. A review of Iophonidae, Myxillidae and Tedaniidae occurring in the South East Pacific (Porifera, Poecilosclerida). *Revue Suisse de Zoologie,* **103(1),** 3-79.

DESQUEYROUX-FAÚNDEZ, R., & SOEST, R.W.M., VAN, 1997. Shallow-water Demosponges of the Galapagos Islands. *Revue Suisse de Zoologie,* **104(2),** 379-467.

DIAZ, M.C., 1997. Molecular detection and characterization of specific bacterial groups associated with tropical sponges. *Proceedings of the Eighth International Coral Reef Symposium,* **2,** 1399-1402.

DIAZ, M.C., & RÜTZLER, K., 2001. Sponges: an essential component of Caribbean coral reefs. *Bulletin of Marine Science,* **69(2),** 535-546.

DICKINSON, M.G., 1945. Sponges of the Gulf of California. *Allan Hancock Pacific Expedition,* **11(1),** 1-252.

FAULKNER, D.J., 1993. Marine natural products. *Natural Products Report,* **9,** 323–539.

FAULKNER, D.J., 1995. Marine natural products. *Natural Products Report,* **12,** 223-270.

FAULKNER, D.J., 2000. Marine natural products. *Natural Products Report,* **17,** 7-55.

GAMULIN, V., MÜLLER, I.M., MÜLLER, W.E.G., 2000. Sponge proteins are more similar to those of Homo sapiens than to *Caenorhabditis elegans***.** *Biological Journal of the Linnean Society*, **71,** 821–828.

GLYNN, P.W., 1972. Observations on the ecology of the Caribbean and Pacific coasts of Panamá. Pages 13-30 *in* Jones, M.L., ed*. The Panamic biota: some observations prior to a sea-level canal*. Bulletin of the Biological Society of Washington.

GLYNN, P.W., STEWART, R.H. & MCCOSKER, J.E., 1972. Pacific coral reefs of Panamá: structure distribution and predators. *Geologische Rundschau,* **61,** 483-519.

GLYNN, P.W. & WELLINGTON, G.M., 1983. Corals and coral reefs of the Galápagos Islands. University of California Press. Berkley.

GÓMEZ, P., 1998. First record and new species of *Gastrophanella* (Porifera: Demospongiae: Lithistida) from the central East Pacific. *Proceedings of the Biological Society of Washington,* **11(4),** 774-780.

GÓMEZ, P. & BAKUS, G.J., 1992. *Aplysina geradogreeni* and *Aplysina aztecus* (Porifera: Demospongiae) new species from the Mexican Pacific. *Annals del Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México,* **19(2),** 175-180.

GÓMEZ, P., CARBALLO, J.L., VÁQUEZ, L.E. & CRUZ, J.A. 2002. New records for the sponge fauna (Porifera: Demospongiae) of the Pacific coast of México (East Pacific Ocean). *Proceedings of the Biological Society of Washington,* **115(1),** 223-237.

GREEN, G., 1977. Ecology of toxicity in marine sponges. *Marine Biology,* **40,** 207–215.

GREEN, G., & GÓMEZ, P., 1986. Estudio taxonómico de las esponjas de la Bahía de Mazatlán. Sin., México. *Annals del Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México,* **13(3),** 273-300.

GREEN, G., GOMEZ, P., BAKUS, G.J., 1990. Antimicrobial and ichthyotoxic properties of marine sponges from Mexican waters. Pages 109-114 *in* Kutzler, K., ed. *New Perspectives in Sponge Biology.* Smithsonian Institution Press, Washington.

GUZMÁN, H.M. & CORTÉZ, J., 1993. Arrecifes coralinos del Pacífico oriental: revision y perspectivaes. *Revue Biology Tropical* **41,** 535-557.

HOLMES, K.E., 1997. Eutrophication and its effect on bioeroding sponge communities. *Proceedings of the Eighth International Coral Reef Symposium,* **2**, 1411-1416.

HOOPER, J.N.A., 2000. Sponguide: A guide to sponge collection and identification. http://www.qmuseum.qld.gov.au/organisation/sections/SessileMarineInvertebrates/index/asp [Download the "Guide to Sponge Collection and Identification."]. Queensland Museum, 129pp.

HOOPER, J.N.A., KENNEDY, J.A. & SOEST, R.W.M., VAN. 2000. Annotated checklist of sponges (Porifera) of the South China Sea Region. *The Raffles Bulletin of Zoology,* **Supl. 8.** 125-207.

HOOPER, J.N.A & SOEST, R.W.M., VAN. 2002. Systema Porifera: A guide to the classification of Sponges. Kluwer Academic/Plenium Publishers, New York.

HUYSECOM, J., VYVER, G., BRAEKMAN, J.C., DALOZE, D., 1990. Chemical defense in sponges from North Brittany. Pages 115-118 *in* Kutzler, K. ed. *New Perspectives in Sponge Biology*. Smithsonian Institution Press, Washington.

KARUSO, P., CAMBIE, C.R. & BOEDEN, B.F., 1989. Scalarane sesterterpenes from *Hyatella intestinalis*. *Journal of Natural Products,* **52(2),** 289-93.

KELLY-BORGES, M., 1994. A simple fool's guide to sponge taxonomy, version 2, *Natural History Museum,* London.

KELLY-BORGES, M., & VALENTINE, C., 1995. The sponges of the tropical island region of Oceania: a taxonomic review. Pages 83-120 *in* Maragos, J.E., Peterson, M.N.A., Eldredge, L.G., Bardach, J.E. & Takeuchi, H.F., eds. *Marine and coastal biodiversity in the tropical island Pacific region. Vol. 1. Species systematics and information management priorities*. East-West Center, University of Hawaii, Honolulu.

LAMBE, L.M., 1893. On some sponges from the Pacific coast of Canada and the Behring Sea. *Proceedings and Transactions of the Royal Society Canada,* **10(4),** 67-78.

LAMBE, L.M., 1894. Sponges of the Pacific coast of Canada. *Proceedings and Transactions of the Royal Society Canada,* **11(4),** 25-43.

LAMBE, L.M., 1895. Sponges from the western coast of North America. *Proceedings and Transactions of the Royal Society Canada,* **12(4),** 11-138.

LAMBE, L.M., 1900. Catalogue of the recent marine sponges of Canada and Alaska. *The Ottawa Naturalist,* **14(9),** 153-172.

LAUBENFELS, M.W. de, 1926. New Sponges of California. *Annals and Magazine of Natural History*, **17(9),** 567-573.

LAUBENFELS, M.W. de, 1932. The marine and fresh-water sponges of California. *Proceedings of the United States National Museum*, **81(4),** 1-140.

LAUBENFELS, M.W. de, 1935. Some sponges of lower California (Mexico). *American Museum Novitates,* **779,** 1-14.

LAUBENFELS, M.W. de, 1936. A comparison of the shallow-water sponges near the Pacific end of the Panama canal with those at the Caribbean end. *Proceedings of the United States National Museum*, **83,** 441-466.

LAUBENFELS, M.W. DE, 1939. Sponges collected on the presidential cruise of 1938. *Smithsonian Miscellaneous Collections,* **98(15),** 1-7.

MALDONADO, M., CARMONA, C.M., SOEST, R.W.M., & POMPONI, S.A., 2001. First record of the sponge genera *Crambe* and *Discorhabdella* for the eastern Pacific, with a description of three new species. *Journal of Natural History,* **35,** 1261-1276.

MEBS, D., WEILER, I., HEINKE, H.F., 1985. Bioactive proteins from marine sponges: screening of sponge extracts for hemagglutinating, haemolytic, ichthyotoxic and lethal properties and isolation and characterization of hemagglutinins. *Toxicon,* **23,** 955-962.

MEBS, D., MIESELER, S., RIMPAU, U., VOSSIUS, C., KONIG, B., BENESCH, S., 1995. Enzymes and enzyme inhibitors from marine sponges. *Toxicon*, **33,** 304.

MEESTERS, E., KNIJM, R., WILLEMSEN, P., PENNARTZ, R., ROEBERS, ROEBERS, G. & VAN SOEST, R.W.N., 1991. Sub-rubble communities of Curaçao and Bonaire coral reefs. *Coral Reefs,* **10,** 189-197.

MEYLAN, A., 1990. Nutritional characteristics of sponges in the diet of the hawksbill turtle. *Eretmochelys imbricata.* Pages 471-477 *in* Rützler, K., ed. *New perspectives in sponge biology.* Smithsonian Institution Press, Washington.

MÜLLER, W.E.G., MÜLLER, I.M., & GAMULIN, V., 1994. On the monophyletic evolution of the Metazoa. *Brazilian Journal of Medical Biology,* **27**, 2083–2096.

MÜLLER, W.E.G., SCHRÖDER, H.C., SKOROKHOD, A., BÜNZ, C., MÜLLER, I.M. & GREBENJUK, V.A., 2001. Contribution of sponge genes to unravel the genome of the hypothetical ancestor of Metazoa (Urmetazoa). *Gene,* **276,** 161–173.

NAMIKOSHI, M., SUZUKI, S., MEGURO, S., NAGAI, H., KOIKE, Y., KITAZAWA, A., KOBAYASHI, H., ODA, T. & YAMODA, J., 2004. Manoalide derivatives from a marine sponge *Luffeniella sp.* collected in Palau. *Fisheries Science,* **70(1),** 152.

PANG, R.K., 1973. The ecology of some Jamaican excavating sponges. *Bulletin of Marine Science,* **23,** 227-243.

PILE, A.J., 1997. Finding Reswig's missing carbon: quantification of sponge feeding using dual beam flow cytometry. *Proceedings of the Eighth International Coral Reef Symposium,* **2,** 1403-1410.

RIBEIRO, S.M., OMENA, E.P. & MURICY, G., 2003. Macrofauna associated to *Mycale microsigmatosa* (Porifera: Demospongiae) in Rio de Janeiro State, SE Brazil. *Estuarine, Coastal and Shelf Science,* **57,** 951-959.

RÜTZLER, K., 1970. Spatial competition among Porifera: Solution by epizoism. *Oecologia,* **5,** 85-95.

RÜTZLER, K., 1990. Associations between Caribbean sponges and photosynthetic organisms. Pages 455-466 *in* Rützler, K., ed. *New perspectives in sponge biology.* Smithsonian Institution Press, Washington.

SARÀ, M., 1970. Competition and cooperation in sponge populations. *Symposium of the Zoological Society of London,* **25,** 273-285.

SELVIN, J., LIPTON, A.P., 2004. *Dendrilla nigra*, a marine sponge, as potential source of antibacterial substances for managing shrimp diseases. *Aquaculture,* **236,** 277-283

SHEN, Y-C., LU, C-H., KUO, Y-H. & CHAKRABORTY, R., 2003. Isolation of Sesquiterpenoids from the sponge *Dysidea avara* and chemical modification of Avarol as potential anti-tumour agents. *Natural Product Letters,* **17,** 83-89.

SOEST, R.W.N. VAN, 1986. Identification keys for Caribbean Porifera. *Unpublished copy obtained from the Porifera section of the Natural History Museum Library,* London. 76pp.

THOMPSON, J.E., WALKER, R.P., FAULKNER, D.J., 1985. Screening and bioassays for biologically active substances from forty marine sponges species from San Diego, CA, USA**.** *Marine Biology,* **88,** 11–21.

TZIVELEKA, A., VAGIAS, C. & ROUSSIS, V., 2003. Natural products with anti-HIV activity from marine organisms. *Current Topics in Medicinal Chemistry,* **3(13),** 1512-1535.

VACELET, J., FIALAMEDIONI, A., & FISHER, C.R., 1995. A methanotrophic carnivorous sponge. *Nature,* **377,** 296-296.

VILLAMIZAR, E. & LAUGHLIN, R.A., 1991. Fauna associated with the sponges *Aplysinia archeri* and *Aplysinia lacunosa* in a coral reef of the Archipelago de Los Roques, National Park, Venezuela. Pages 522-542 *in* J. Reitner & H. Keupp. Eds. *Fossil and recent sponges.* Springer-Verlag, Berlin.

VINCENTE, V.P., 1978. An ecological evaluation of the West Indian Demosponge *Anthosigmella varians* (Hadromerida: Spirastrellida). *Bulletin of Marine Science,* **28,** 771-777.

WILKINSON, C.R. & CHESSIRE, A.C., 1990. Comparisons of sponge populations across the Barrier reefs of Australia and Belize: evidence for higher productivity in the Caribbean. *Marine Ecology Progress Series,* **67,** 285-294.

WILSON, H.P., VAN, 1904. The sponges. *Memoirs of the Museum of Comparative Zoology,* **30(1),** 1-164.

WULFF, J.L., 1984. Sponge-mediated coral reef growth and rejuvenation. *Coral Reefs,* **3,** 157-163.

WULFF, J.L., 1994. Sponge-feeding by Caribbean angelfishes, trunkfishes and filefishes. Pages 265-271 *in* R.W.M. van Soest, T.M.G. van Kempen & J.C. Braeckman, eds. *Sponges in time and space*. Balkema, Rotterdam.

WULFF, J.L., 1996. Do the same sponge species live on both the Caribbean and eastern Pacific sides of the Isthmus of Panama? *Bulletin de l'Institut Royal des Sciences naturelles de Belgique,* **66,** 165-173.

WULFF, J.L., 1997A. Causes and consequences of differences in sponge diversity and abundance between the Caribbean and Eastern Pacific of Panama. *Proceedings of the Eighth International Coral Reef Symposium,* **2,** 1377-1382.

WULFF, J.L., 1997B, Parrotfish predation on cryptic sponges of Caribbean coral reefs. *Marine Biology,* **129,** 41-52.

WULFF, J.L., 2001. Assessing and monitoring coral reef sponges: Why and how? *Bulletin of Marine Science,* **69(2),** 831-846.

WULFF, J.L. & BUSS, L.W., 1979. Do sponges hold coral reefs together? *Nature,* **Vol. 281(5731),** 474-475.

ZEA, S., 1994. Patterns of coral and sponge abundance in stressed coral reefs at Santa Marta, Colombian Caribbean. Pages 257-263 *in* R.W.M. van Soest, T.M.G. van Kempen & J.C. Braeckman, eds. *Sponges in time and space*. Balkema, Rotter

Appendix 1.

The Sponge

The sponge is not, as you suppose,
A funny kind of weed;
He lives below the deep blue sea,
An animal like you and me,
Though not so good a breed.

And when sponges go to sleep,
The fearless diver dives;
He prongs them with a cruel prong,
And, what I think is rather wrong,
He also prongs their wives.

I know you'd rather not believe,
Such dreadful things are done;
Alas, alas, it is the case,
And every time you wash your face,
You use a skeleton.

So that is why I seldom wash,
However black I am,
But use my flannel, if I must,
Though even that, to be quite just,
Was once a little lamb.

A.P.H. in "Punch", 1921.

Site No.	% mean coral cover (unpub. data, Guzmán)	Brown/Black *Sigmadocia sp.* 1.	Lilac *Callyspongia sp.*	Lilac Haplosclerid 1.	Orange *Sigmadocia sp.*	Orange *Haliclonia sp.*	Turquoise Haplosclerid 2.	Grey Blue *Sigmadocia sp.* 2.	Site I
F1-1	44.7	3	0	0	0	0	0	0	F1-1
F1-2	44.7	1.5	0	0	0	0	0	0	F1-2
F1-3	44.7	0.5	0	0	0	0	0	0	F1-3
F1-4	44.7	0.5	0	0	0	0	0	0	F1-4
F1-5	44.7	0.5	0	0	0	0	0	0	F1-5
F1-6	44.7	1	0	0	0	0	0	0	F1-6
F1-7	44.7	2	0	0	0	0	0	0	F1-7
F1-8	44.7	0.75	0.25	0	0	0	0	0	F1-8
F1-9	44.7	0.25	0	0	0	0	0	0	F1-9
F1-10	44.7	0	0	0	0	0	0	0	F1-1
F1-11	44.7	0.5	0	0	0	0	0	0	F1-1
F1-12	44.7	0.25	0	0	0	0	0	0	F1-1
F1-13	44.7	0.25	0.25	0	0	0	0	0	F1-1
F1-14	44.7	0.75	0.25	0	0	0	0	0	F1-1
F1-15	44.7	0	0	0	0	0	0	0	F1-1
F1-16	44.7	1.75	0.25	0	0	0	0	0	F1-1
F1-17	44.7	0.5	0	0	0	0	0	0	F1-1
F1-18	44.7	2.5	0	0	0	0	0	0	F1-1
F1-19	44.7	0.5	0	0	0	0	0	0	F1-1
F1-20	44.7	0.5	0	0	0	0	0	0	F1-2
F1-21	44.7	0.5	0	0	0	0	0	0	F1-2
F1-22	44.7	0.25	0	0	0	0	0	0	F1-2
F1-23	44.7	0.25	0	0	0	0	0	0	F1-2
F1-24	44.7	1.5	0	0	0	0	0	0	F1-2
F1-25	44.7	0.25	0	0	0	0	0	0	F1-2
F1-26	44.7	0.25	0	0	0	0	0	0	F1-2
F1-27	44.7	0	0	0	0	0	0	0	F1-2

F1-28	44.7	0.25	0	0	0	0	0	0	F1-2
F1-29	44.7	0.25	0	0	0	0	0	0	F1-2
F1-30	44.7	1	0	0	0	0	0	0	F1-3
Site No.	(unpub. data, Guzmán)	*Sigmadocia sp.* 1.	*Callyspongia sp.*	Haplosclerid 1.	*Sigmadocia sp.*	*Haliclonia sp.*	Haplosclerid 2.	*Sigmadocia sp.* 2.	Site
C2-1	19.7	0	0.25	0	0	0	0	0	C2-1
C2-2	19.7	1.5	5	1.75	0	0	0	0	C2-2
C2-3	19.7	0	2	0	1	0	0	0	C2-3
C2-4	19.7	0.25	2	0	0	0	0	0	C2-4
C2-5	19.7	0.25	2	0	0	0	0	0	C2-5
C2-6	19.7	2	1	0	0.25	0	0	0	C2-6
C2-7	19.7	3	4	0	0	0	0	0	C2-7
C2-8	19.7	0	1	0	0.25	0	0	0	C2-8
C2-9	19.7	0.25	0.5	0	0	0	0.25	0	C2-9
C2-10	19.7	1	0.25	0	0	0	0	0	C2-1
C2-11	19.7	0	2	0	0	0	0	0	C2-1
C2-12	19.7	0	0	0	0	0	0.25	0	C2-1
C2-13	19.7	0	1	0	0	0	0	0	C2-1
C2-14	19.7	0	0.5	0	2	0	0.25	0.25	C2-1
C2-15	19.7	0.5	0	0	0	0	0	0	C2-1
C2-16	19.7	0.5	3	0	0	0	0	0	C2-1
C2-17	19.7	0	2	0	0	0	0	0	C2-1
C2-18	19.7	0	2.5	0	0	0	0	0	C2-1
C2-19	19.7	0.5	0.75	0	0	0	0	0	C2-1
C2-20	19.7	0.25	3.5	0	0	0	0	0	C2-2
C2-21	19.7	0	3.5	0	0	0	0	0	C2-2
C2-22	19.7	0	1	0	0	0	0	0	C2-2
C2-23	19.7	0	2	0	0	0	0	0	C2-2
C2-24	19.7	0.25	0.5	0	0	0	0	0	C2-2
C2-25	19.7	0.5	0.5	0	0	0	0	0	C2-2
C2-26	19.7	0.25	2	0	1	0	0	0	C2-2
C2-27	19.7	0.75	0	0	0.25	0	0	0	C2-2

C2-28	19.7	0.5	1.5	0	0	0	0	0	C2-2
C2-29	19.7	0.75	0.25	0	0	0	0	0	C2-2
C2-30	19.7	1	5	0	0	0	0	0	C2-3
Site No.	(unpub. data, Guzmán)	*Sigmadocia sp.* 1.	*Callyspongia sp.*	Haplosclerid 1.	*Sigmadocia sp.*	*Haliclonia sp.*	Haplosclerid 2.	*Sigmadocia sp.* 2.	Site I
C3-1	12.9	0	0	0	0	0	0	0	C3-1
C3-2	12.9	0	0.25	0	0	0	0	0	C3-2
C3-3	12.9	0	0	0	0	0	0	0	C3-3
C3-4	12.9	0	0	0.5	0	0	0	0	C3-4
C3-5	12.9	0.25	0.25	0.25	0	0	0	0	C3-5
C3-6	12.9	0	0.25	0.75	0	0	0	0	C3-6
C3-7	12.9	0.25	0.25	0.5	0	0	0	0	C3-7
C3-8	12.9	0	0.25	0	0	0	0	0	C3-8
C3-9	12.9	0.25	0.25	0	0	0	0	0	C3-9
C3-10	12.9	1	0.25	0	0	0	0	0	C3-1
C3-11	12.9	0	0.25	0	0	0	0	0.25	C3-1
C3-12	12.9	0.25	0	0	0	0	0	0	C3-1
C3-13	12.9	0	0	0	0	0	0	0	C3-1
C3-14	12.9	0	0	0	0	0	0	0	C3-1
C3-15	12.9	0	0.5	0	0	0	0	0	C3-1
C3-16	12.9	0	0.5	0	0	0	0	0	C3-1
C3-17	12.9	0	0	0	0	0	0	0	C3-1
C3-18	12.9	0	0	0	0	0	0	0	C3-1
C3-19	12.9	0	0	0	0	0	0	0	C3-1
C3-20	12.9	0	0.5	0.25	0	0	0	0	C3-2
C3-21	12.9	0	0.25	0	0	0	0	0	C3-2
C3-22	12.9	0.25	0.25	0	0	0	0	0	C3-2
C3-23	12.9	0.25	0.25	0.25	0	0	0	0	C3-2
C3-24	12.9	0.25	0	0.5	0	0	0	0	C3-2
C3-25	12.9	0	0.25	0	0	0	0	0	C3-2
C3-26	12.9	0	0	0	0	0	0	0	C3-2
C3-27	12.9	0	0	0	0	0	0	0	C3-2

C3-28	12.9	0.5	0.25	0.25	0	0	0	0	C3-2
C3-29	12.9	0	0.25	0	0	0	0	0	C3-2
C3-30	12.9	0	0.25	0	0	0	0	0	C3-3
Site No.	% mean coral cover (unpub. data, Guzmán)	Brown/Black *Sigmadocia sp.* 1.	Lilac *Callyspongia sp.*	Lilac Haplosclerid 1.	Orange *Sigmadocia sp.*	Orange *Haliclonia sp.*	Turquoise Haplosclerid 2.	Grey Blue *Sigmadocia sp.* 2.	Site I
F4-1	76	0	0.75	0	0	0	0	0	F4-1
F4-2	76	0	0	0.25	0	0	0	0	F4-2
F4-3	76	0	0	0	0	0	0	0	F4-3
F4-4	76	0.25	0	0	0	0	0	0	F4-4
F4-5	76	0	0	1.25	0	0	0	0	F4-5
F4-6	76	0	0	0	8.25	0	0	0	F4-6
F4-7	76	0.25	0	0	0	0	0	0	F4-7
F4-8	76	0.5	0.25	0	0	0	0	0	F4-8
F4-9	76	2.5	2.5	0	0	0	0	0	F4-9
F4-10	76	2.5	2.5	0	0	0	0	0	F4-1
F4-11	76	0.25	0	1	0	0	0	0	F4-1
F4-12	76	0	0.25	0	0	0	0	0	F4-1
F4-13	76	0	0.25	0	0.25	0	0	0	F4-1
F4-14	76	0.25	0	0.25	0	0	0	0	F4-1
F4-15	76	0	0	0.25	0.25	0	0	0	F4-1
F4-16	76	0.75	0	0.5	0	0	0	0	F4-1
F4-17	76	0.25	0	0.25	0.5	0	0	0	F4-1
F4-18	76	0.25	0	0.75	0.25	0	0	0	F4-1
F4-19	76	0.5	0	0.25	0.25	0	0	0	F4-1
F4-20	76	0.25	0	0.75	0.25	0	0	0	F4-2
F4-21	76	0	0	0.25	0.25	0	0	0.25	F4-2
F4-22	76	0.25	0	0.5	0	0	0	0	F4-2
F4-23	76	0.25	0.5	0	0	0	0	0	F4-2
F4-24	76	0.25	0	0.25	0	0	0	0	F4-2
F4-25	76	0	0	1	0	0	0	0	F4-2
F4-26	76	0.25	0	0	0.25	0	0	0	F4-2

F4-27	76	0	0	0.25	0	0	0	0	F4-2
F4-28	76	0	0	0.25	0.5	0	0	0	F4-2
F4-29	76	0	0	0.25	0	0	0	0	F4-2
F4-30	76	0.25	0.25	0	0	0	0	0	F4-3
Site No.	(unpub. data, Guzmán)	*Sigmadocia sp.* 1.	*Callyspongia sp.*	Haplosclerid 1.	*Sigmadocia sp.*	*Haliclonia sp.*	Haplosclerid 2.	*Sigmadocia sp.* 2.	Site
T5-1	36.1	0.25	0	0	0	0	0	0	T5-1
T5-2	36.1	0.25	0	0	0	0	0	0	T5-2
T5-3	36.1	0.25	0	0	0	0	0	0	T5-3
T5-4	36.1	0.25	0	0	0	0	0	0	T5-4
T5-5	36.1	0	0	0	0	0	0	0	T5-5
T5-6	36.1	0.25	0	0	0	0	0	0	T5-6
T5-7	36.1	0.25	0	0	0	0	0	0	T5-7
T5-8	36.1	0.25	0	0	0	0	0	0	T5-8
T5-9	36.1	0.25	0	0	0	0	0	0	T5-9
T5-10	36.1	0	0	0	0	0	0	0	T5-1
T5-11	36.1	0.25	0	0	0	0	0	0	T5-1
T5-12	36.1	0.25	0	0	0	0	0	0	T5-1
T5-13	36.1	0.25	0	0	0	0	0	0	T5-1
T5-14	36.1	0.75	0	0	0	0	0	0	T5-1
T5-15	36.1	0	0	0	0	0	0	0	T5-1
T5-16	36.1	0.25	0	0	0	0	0	0	T5-1
T5-17	36.1	0	0	0	0	0	0	0	T5-1
T5-18	36.1	0.25	0	0	0	0	0	0	T5-1
T5-19	36.1	0	0	0	0	0	0	0	T5-1
T5-20	36.1	0	0	0	0	0	0	0	T5-2
T5-21	36.1	0.25	0	0	0	0	0	0	T5-2
T5-22	36.1	0.25	0	0	0	0	0	0	T5-2
T5-23	36.1	0.5	0	0	0	0	0	0	T5-2
T5-24	36.1	0.25	0	0	0	0	0	0	T5-2
T5-25	36.1	0.25	0	0	0	0	0	0	T5-2
T5-26	36.1	0	0	0	0	0	0	0	T5-2

T5-27	36.1	0	0	0	0	0	0	0	T5-2
T5-28	36.1	0.25	0	0	0	0	0	0	T5-2
T5-29	36.1	0.5	0	0	0	0	0	0	T5-2
T5-30	36.1	0	0	0	0	0	0	0	T5-3
Site No.	(unpub. data, Guzmán)	*Sigmadocia sp.* 1.	*Callyspongia sp.*	Haplosclerid 1.	*Sigmadocia sp.*	*Haliclonia sp.*	Haplosclerid 2.	*Sigmadocia sp.* 2.	Site I
F6-1	83	1	2	0	0	0	0	0	F6-1
F6-2	83	0.25	0	0	0	0	0	0	F6-2
F6-3	83	0	0.25	0	0	0	0	0	F6-3
F6-4	83	0	0.25	0	0	0	0	0	F6-4
F6-5	83	1	0	0	0	0	0	0	F6-5
F6-6	83	0.25	0.25	0	0	0	0	0	F6-6
F6-7	83	1.5	0	0.25	0	0	0	0	F6-7
F6-8	83	0.5	0.25	0	0	0	0	0	F6-8
F6-9	83	0.75	0.25	0.5	0	0	0	0	F6-9
F6-10	83	2.5	1	0	0	0	0	0.25	F6-1
F6-11	83	0.5	0	0.5	0	0	0	0	F6-1
F6-12	83	0.25	0	5	0	0	0	0	F6-1
F6-13	83	1.5	0	0.25	0	0	0	0	F6-1
F6-14	83	1.25	0.25	1	0	0	0	0	F6-1
F6-15	83	2.25	0.25	0	0	0	0	0	F6-1
F6-16	83	0.25	0	0.25	0	0	0	0	F6-1
F6-17	83	0.25	0	0.25	0	0	0	0	F6-1
F6-18	83	2	0	2.5	0	0	0	0	F6-1
F6-19	83	1	0	0.25	0	0	0	0	F6-1
F6-20	83	0.25	0	1.5	0	0	0	0	F6-2
F6-21	83	0.25	0	1.25	0	0	0	0	F6-2
F6-22	83	0.25	0	2.5	0	0	0	0	F6-2
F6-23	83	3	0	0.25	0	0	0	0	F6-2
F6-24	83	0.75	0	0.25	0	0	0	0	F6-2
F6-25	83	1.75	0	0.5	0	0	0	0	F6-2
F6-26	83	1.25	0	1.25	0	0	0	0	F6-2

F6-27	83	0	0	0	0	0	0	0	F6-2
F6-28	83	1	1	0	0	0	0	0	F6-2
F6-29	83	0.25	0	1	0	0	0	0	F6-2
F6-30	83	0.25	0	0	0	0	0	0	F6-3
Site No.	(unpub. data, Guzmán)	*Sigmadocia sp.* 1.	*Callyspongia sp.*	Haplosclerid 1.	*Sigmadocia sp.*	*Haliclonia sp.*	Haplosclerid 2.	*Sigmadocia sp.* 2.	Site
T7-1	40.3	0	0	0.5	0	0	0	0	T7-1
T7-2	40.3	0	0	2	0	0	0	0.25	T7-2
T7-3	40.3	0	2	0	0	0	0	0	T7-3
T7-4	40.3	0	0	1	0	0	0	0	T7-4
T7-5	40.3	0	0	0.5	0	0	0	0	T7-5
T7-6	40.3	0	0	0.75	0	0	0	0	T7-6
T7-7	40.3	0	0	0	0	0	0	2.5	T7-7
T7-8	40.3	0	0.25	0	0	0	0	0	T7-8
T7-9	40.3	4.5	0.25	0.25	0	0	0	0	T7-9
T7-10	40.3	0	0	0.5	0	0	0	0	T7-1
T7-11	40.3	0.25	0	0.25	0	0	0	0	T7-1
T7-12	40.3	0.25	0	0.25	0	0	0	0	T7-1
T7-13	40.3	0.25	0	0.25	0	0	0	0	T7-1
T7-14	40.3	0.5	0	0	0	0	0	0	T7-1
T7-15	40.3	0	11	0	0	0	0	0	T7-1
T7-16	40.3	0.25	0.25	0	0	0	0	0.25	T7-1
T7-17	40.3	0.25	0	0	0	0	0	0	T7-1
T7-18	40.3	0.25	0.25	0	0	0	0	0	T7-1
T7-19	40.3	0	0	0	0.25	0	0	0	T7-1
T7-20	40.3	0	0	0.25	0	0	0	0	T7-2
T7-21	40.3	0	0	0	0	0	0	0	T7-2
T7-22	40.3	0	0	0	0	0	0	0	T7-2
T7-23	40.3	0	0.25	0	0	0	0	0	T7-2
T7-24	40.3	0.25	0	0.25	0	0	0	0	T7-2
T7-25	40.3	0	0	0	0	0	0	0	T7-2

T7-26	40.3	0	0	0	0	0	0	0	T7-2
T7-27	40.3	0.25	0.25	0	0	0	0	0	T7-2
T7-28	40.3	0.5	0	0.5	0	0	0	0	T7-2
T7-29	40.3	0	0	0	0	0	0	0	T7-2
T7-30	40.3	0	0	0.25	0	0	0	0	T7-3
Site No.	(unpub. data, Guzmán)	*Sigmadocia sp.* 1.	*Callyspongia sp.*	Haplosclerid 1.	*Sigmadocia sp.*	*Haliclonia sp.*	Haplosclerid 2.	*Sigmadocia sp.* 2.	Site
F8-1	93.7	0	0	0.75	0	0	0	0	F8-1
F8-2	93.7	0	0	1.75	0	0	0	0	F8-2
F8-3	93.7	0	0	0	0	0	0	0	F8-3
F8-4	93.7	0.25	0	0	0	0	0	0	F8-4
F8-5	93.7	0	0	0	0	0	0	0	F8-5
F8-6	93.7	0	0	0	0	0	0	0	F8-6
F8-7	93.7	0	0	0	0	0	0	0	F8-7
F8-8	93.7	0	0	0	0	0	0	0	F8-8
F8-9	93.7	0	0	0	0	0	0	0	F8-9
F8-10	93.7	0.25	0	0	0	0	0	0	F8-1
F8-11	93.7	0	0	0	0	0	0	0	F8-1
F8-12	93.7	0.25	0	0.25	0	0	0	0	F8-1
F8-13	93.7	0.25	0	0	0	0	0	0	F8-1
F8-14	93.7	0	0	0.25	0	0	0	0	F8-1
F8-15	93.7	0.5	0	0	0	0	0	0	F8-1
F8-16	93.7	0	0	0	0	0	0	0	F8-1
F8-17	93.7	0	0	0	0	0	0	0	F8-1
F8-18	93.7	2.5	0	0	0	0	0	0	F8-1
F8-19	93.7	0	0	0	0	0	0	0	F8-1
F8-20	93.7	0.5	0	0	0	0	0	0	F8-2
F8-21	93.7	0.25	0	0	0	0	0	0	F8-2
F8-22	93.7	0	0	0	0	0	0	0	F8-2
F8-23	93.7	0	0	0	0	0	0	0	F8-2
F8-24	93.7	0	0	0	0	0	0	0	F8-2
F8-25	93.7	0	0	0	0	0	0	0	F8-2

F8-26	93.7	0.25	0	0	0	0	0	0	F8-2
F8-27	93.7	0	0	0	0	0	0	0	F8-2
F8-28	93.7	0	0	0	0	0	0	0	F8-2
F8-29	93.7	0	0	0.25	0	0	0	0	F8-2
F8-30	93.7	0	0	1	0	0	0	0	F8-3
Site No.	% mean coral cover (unpub. data,	Brown/Black *Sigmadocia sp.*	Lilac *Callyspongia*	Lilac Haplosclerid	Orange *Sigmadocia*	Orange *Haliclonia*	Turquoise Haplosclerid	Grey Blue *Sigmadocia sp.*	Site I
F9-1	80.7	0.5	0	0	0	0	0	0	F9-1
F9-2	80.7	1.25	0	0.25	0	0	0	0	F9-2
F9-3	80.7	1.25	0	0.25	0.25	0	0	0	F9-3
F9-4	80.7	0.25	0	0.25	0	0	0	0	F9-4
F9-5	80.7	0.75	0	0	0.25	0	0	0	F9-5
F9-6	80.7	1.75	0	0	0	0	0	0	F9-6
F9-7	80.7	1.25	0	0.25	0	0	0	0	F9-7
F9-8	80.7	0.75	0	2.5	0	0	0	0	F9-8
F9-9	80.7	0.25	0	0	0	0	0	0	F9-9
F9-10	80.7	0	0.5	0.25	0	0	0	0	F9-1
F9-11	80.7	4.75	0	0.5	0	0	0	0	F9-1
F9-12	80.7	1	0	0	0.25	0	0	0	F9-1
F9-13	80.7	0.75	0	0	0.25	0	0	0	F9-1
F9-14	80.7	0.25	0	0	0	0	0	0	F9-1
F9-15	80.7	0.75	0	0.25	0.25	0	0	0	F9-1
F9-16	80.7	0.5	0.5	0.5	0	0	0	0	F9-1
F9-17	80.7	0.75	0	0	0	0	0	0	F9-1
F9-18	80.7	0.5	0	1.25	0	0	0	0	F9-1
F9-19	80.7	0.5	0	0	0	0	0	0	F9-1
F9-20	80.7	1.5	0	0.25	0	0	0	0	F9-2
F9-21	80.7	1	0	0.25	0	0	0	0	F9-2
F9-22	80.7	0.75	0	0.25	0	0	0	0	F9-2
F9-23	80.7	0	0	0.5	0	0	0	0	F9-2
F9-24	80.7	0	0	1	0	0	0	0	F9-2
F9-25	80.7	0	0	0.75	0	0	0	0	F9-2

F9-26	80.7	0.25	0	0.5	0	0	0	0	F9-2
F9-27	80.7	0.25	0	2.5	0	0	0	0.25	F9-2
F9-28	80.7	0.25	0.25	1.5	0	0	0	0	F9-2
F9-29	80.7	0.25	0.5	0.25	0	0	0	0.25	F9-2
F9-30	80.7	2	0.5	0	0	0	0	0	F9-3
Site No.	% mean coral cover (unpub. data,	Brown/Black *Sigmadocia sp.*	Lilac *Callyspongia*	Lilac Haplosclerid	Orange *Sigmadocia*	Orange *Haliclonia*	Turquoise Haplosclerid	Grey Blue *Sigmadocia sp.*	Site I
C10-1	12.4	2.5	1	2.5	0	0.25	0.75	0	C10-
C10-2	12.4	0	1.25	0.25	6	0.5	0	0	C10-
C10-3	12.4	0.25	0	2.25	8	0	0.25	0.25	C10-
C10-4	12.4	0.5	1	0.5	0.25	0	0	0	C10-
C10-5	12.4	0	0.25	0.25	0	0	0	0	C10-
C10-6	12.4	0.25	0.25	0	0	0	0	0	C10-
C10-7	12.4	0.25	0.25	0.25	0	0	0	0	C10-
C10-8	12.4	0	0.75	0	0	0	0	0.25	C10-
C10-9	12.4	0	1	1	0	0	0	0	C10-
C10-10	12.4	0.25	0.5	0.25	0	0	0	0	C10-
C10-11	12.4	0.5	0.5	0.75	0	0	0	0	C10-
C10-12	12.4	0	1	2.75	0	0	0.25	0	C10-
C10-13	12.4	0	0	0.25	0	0	0	0	C10-
C10-14	12.4	0	0	0.25	0.25	0	0	0	C10-
C10-15	12.4	0.25	1	3	0	0	0	0.25	C10-
C10-16	12.4	0	0	0	0.25	0	0	0	C10-
C10-17	12.4	0	0.25	0	0	0	0	0.25	C10-
C10-18	12.4	0	0.25	0	0	0	0	0.25	C10-
C10-19	12.4	0	0	0.25	0	0	0	0	C10-
C10-20	12.4	0	0	0.25	0	0	0	0.25	C10-
C10-21	12.4	1	0.25	1	0	0	0	0	C10-
C10-22	12.4	0.25	0.25	0.75	3	0	0	0	C10-
C10-23	12.4	0.25	0.5	0.25	2	0	0	0.5	C10-
C10-24	12.4	0	0.25	0	0	0	0	0	C10-
C10-25	12.4	0	0.25	0	0	0	0	0	C10-

C10-26	12.4	0	0.25	0.75	0	0	0	0	C10-
C10-27	12.4	0.25	0	0	0	0	0	0	C10-
C10-28	12.4	1	0.25	0.5	0.5	0	0	0	C10-
C10-29	12.4	0.75	0	0.5	0	0	0	0	C10-
C10-30	12.4	0	0	0	0.5	0	0.25	0	C10-

Cream *Geodia sp.*	Clear/red dots Pocilosclerid	Orange *Chondrilla sp.*	Red Asterophorid sp.	Black *Haliclona sp.*	Yellow *Suberites sp.*	White *Clatherina sp.*	Red Hadromerid sp.	Beige *Halichondria sp.*	Site No.	B F sp
0	0	0	0	0	0	0	0	0	F1-1	
0	0	0	0	0	0	0	0	0	F1-2	
0	0	0	0	0	0	0	0	0	F1-3	
0	0	0	0	0	0	0	0	0	F1-4	
0	0	0	0	0	0	0	0	0	F1-5	
0	0	0	0	0	0	0.5	0	0	F1-6	
0	0	0	0	0	0	0	0	0	F1-7	
0	0	0	0	0	0	0	0	0	F1-8	
0	0	0	0	0	0	0	0	0	F1-9	
0	0	0	0	0	0	0	0	0	F1-10	
0	0	0	0	0	0	0	0	0	F1-11	
0	0	0	0	0	0	0	0	0	F1-12	
0	0	0	0	0	0	0	0	0	F1-13	
0	0	0	0	0	0	0	0	0	F1-14	
0	0	0	0	0	0	0	0	0	F1-15	
0	0	0	0	0	0	0	0	0	F1-16	
0	0	0	0	0	0	0	0	0	F1-17	
0	0	0	0	0	0	0	0	0	F1-18	
0	0	0	0	0	0	0	0	0	F1-19	
0	0	0	0	0	0	0	0	0	F1-20	
0	0	0	0	0	0	0	0	0	F1-21	
0	0	0	0	0	0	0	0	0	F1-22	
0	0	0	0	0	0	0	0	0	F1-23	
0	0	0	0	0	0	0	0	0	F1-24	
0	0	0	0	0	0	0	0	0	F1-25	
0	0	0	0	0	0	0	0	0	F1-26	
0	0	0	0	0	0	0	0	0	F1-27	

0	0	0	0	0	0	0	0	0	F1-28	
0	0	0	0	0	0	0	0	0	F1-29	
0	0	0	0	0	0	0	0	0	F1-30	
Geodia sp.	dots Pocilosclerid	*Chondrilla sp.*	Asterophorid sp.	*Haliclona sp.*	*Suberites sp.*	*Clatherina sp.*	Hadromerid sp.	*Halichondria sp.*	Site No.	F sp
0	0	0	0	0	0	0.25	0	0	C2-1	
0	0	0	0	0	0	0	0	0	C2-2	
0	0	0	0	0	0	0	0	0	C2-3	
0	0	0	0	0	0	1	0	0	C2-4	
0	0	0	0	0	0	0.25	0	0	C2-5	
0	0	0	0	0	0	0	0	0	C2-6	
0	0	0	0	0	0	0	0	0	C2-7	
0	0	0	0	3	0	0	0	0	C2-8	
0	0	0	0	0	0	0	0	0	C2-9	
0	0	0	0	0	0	0	0	0	C2-10	
0	0	0	0	0	0	0	0	0	C2-11	
0	0	0	0	0	0	0	0	0	C2-12	
0	0	0	0	0	0	0	0	0	C2-13	
0	0	0	0	0	0	0	0	0	C2-14	
0	0	0	0	0	0	0	0	0	C2-15	
0	0	0	0	0	0	0	0	0	C2-16	
0	0	0	0	0	0	0	0	0	C2-17	
0	0	0	0	0	0	0	0	0	C2-18	
0	0	0	0	0	0	0	0	0	C2-19	
0	0	0	0	0	0	0	0	0	C2-20	
0	0	0	0	0	0	0	0	0	C2-21	
0	0	0	0	0	0	0	0	0	C2-22	
0	0.25	0	0	0	0	0	0	0	C2-23	
0	0	0	0	0	0	0	0	0	C2-24	
0	0	0	0	0	0	0	0	0	C2-25	
0	0	0	0	0	0	0	0	0	C2-26	
0	0.25	1	0	0.25	0	0	0	0	C2-27	

0	0	0	0	8	0	0	0	0	C2-28	
0	0	0	0	0	0	0	0	0	C2-29	
0	0	0	0	0	0	0	0	0	C2-30	
Geodia sp.	dots Pocilosclerid	*Chondrilla sp.*	Asterophorid sp.	*Haliclona sp.*	*Suberites sp.*	*Clatherina sp.*	Hadromerid sp.	*Halichondria sp.*	Site No.	H sp
0	0	1	0	0	0	0	0	0	C3-1	
0	0	0	0	0	0	0	0	0	C3-2	
0	0	0	0	0	0	0	0	0	C3-3	
0	0	0	0	0	0	0	0	0	C3-4	
0	0	0	0	0	0	0	0	0	C3-5	
0	0	0	0	0	0	0	0	0	C3-6	
0	0	0	0	0	0	0	0	0	C3-7	
0	0	0	0	0	0	0	0	0	C3-8	
0	0	0	0	0	0	0	0	0	C3-9	
0	0	0	0	0	0	0	0	0	C3-10	
0	0	0	0	0	0	0	0	0	C3-11	
0	0	0	0	0	0	0	0	0	C3-12	
0	0	0	0	0	0	0	0	0	C3-13	
0	0	0	0	0	0	0	0	0	C3-14	
0	0	0	0	0	0	0	0	0	C3-15	
0	0	0	0	0	0	0	0	0	C3-16	
0	0	0	0	0	0	0	0	0	C3-17	
0	0	0	0	0	0	0	0	0	C3-18	
0	0	0	0	0	0	0	0	0	C3-19	
0	0	0	0	0	0	0	0	0	C3-20	
0	0	0	0	0	0	0	0	0	C3-21	
0	0	0	0	0	0	0	0	0	C3-22	
0	0	0	0	0	0	0	0	0	C3-23	
0	0	0	0	0	0	0	0	0	C3-24	
0	0	0	0	0	0	0	0	0	C3-25	
0	0	0	0	0	0	0	0	0	C3-26	
0	0	0	0	0	0	0	0	0	C3-27	

0	0	0	0	0	0	0	0	0	C3-28	
0	0	0	0	0	0	0	0	0	C3-29	
0	0	0	0	0	0	0	0	0	C3-30	
Cream *Geodia sp.*	Clear/red dots Pocilosclerid	Orange *Chondrilla sp.*	Red Asterophorid sp.	Black *Haliclona sp.*	Yellow *Suberites sp.*	White *Clatherina sp.*	Red Hadromerid sp.	Beige *Halichondria sp.*	Site No.	E F sp
0	0	0.25	0	0	0	0	0	0	F4-1	
0	0	0	0	0	0	0	0	0	F4-2	
0	0	0	0	0	0	0	0	0	F4-3	
0	0	0	0	0	0	0	0	0	F4-4	
0	0	0	0	0	0	0	0	0	F4-5	
0	0	0	0	0	0	0	0	0	F4-6	
0	0	0	0	0	0	0	0	0	F4-7	
0	0	0	0	0	0	0	0	0	F4-8	
0	0	0	0	0	0	0	0	0	F4-9	
0	0	0	0	0	0	0	0	0	F4-10	
0	0	0	0	0	0	0	0	0	F4-11	
0	0	0	0	0	0	0	0	0	F4-12	
0	0	0	0	0	0	0	0	0	F4-13	
0	0	0	0	0	0	0	0	0	F4-14	
0	0	0	0	0	0	0	0	0	F4-15	
0	0	0	0	0	0	0	0	0	F4-16	
0	0	0	0	0	0	0	0	0	F4-17	
0	0	0	0	0	0	0	0	0	F4-18	
0	0	0	0	0	0	0	0	0	F4-19	
0	0	0	0	0	0	0	0	0	F4-20	
0	0	0	0	0	0	0	0	0	F4-21	
0	0	0	0	0	0	0	0	0	F4-22	
0	0	0	0.25	0	0.25	0	0	0	F4-23	
0	0	0	0	0	0	0	0	0	F4-24	
0	0	0	0	0	0	0	0	0	F4-25	
0	0	0	0	0	0	0	0	0	F4-26	

0	0	0	0	0	0	0	0	0	F4-27	
0	0	0	0	0	0	0	0	0	F4-28	
0	0	0	0	0	0	0	0	0	F4-29	
0	0	0	0	0	0	0	0	0	F4-30	
Geodia sp.	dots Pocilosclerid	*Chondrilla sp.*	Asterophorid sp.	*Haliclona sp.*	*Suberites sp.*	*Clatherina sp.*	Hadromerid sp.	*Halichondria sp.*	Site No.	F sp
0	0	0	0	0	0	0	0	0	T5-1	
0	0	0	0	0	0	0	0	0	T5-2	
0	0	0	0	0	0	0	0	0	T5-3	
0	0	0	0	0	0	0	0	0	T5-4	
0	0	0	0	0	0	0	0	0	T5-5	
0	0	0	0	0	0	0	0	0	T5-6	
0	0	0	0	0	0	0	0	0	T5-7	
0	0	0	0	0	0	0	0	0	T5-8	
0	0	0	0	0	0	0	0	0	T5-9	
0	0	0	0	0	0	0	0	0	T5-10	
0	0	0	0	0	0	0	0	0	T5-11	
0	0	0	0	0	0	0	0	0	T5-12	
0	0	0	0	0	0	0	0	0	T5-13	
0	0	0	0	0	0	0	0	0	T5-14	
0	0	0	0	0	0	0	0	0	T5-15	
0	0	0	0	0	0	0	0	0	T5-16	
0	0	0	0	0	0	0	0	0	T5-17	
0	0	0	0	0	0	0	0	0	T5-18	
0	0	0	0	0	0	0	0	0	T5-19	
0	0	0.25	0	0	0	0	0	0	T5-20	
0	0	0	0	0	0	0	0	0	T5-21	
0	0	0	0	0	0	0	0	0	T5-22	
0	0	0	0	0	0	0	0	0	T5-23	
0	0	0	0	0	0	0	0	0	T5-24	
0	0	0	0	0	0	0	0	0	T5-25	
0	0	0	0	0	0	0	0	0	T5-26	

0	0	0	0	0	0	0	0	0	T5-27	
0	0	0	0	0	0	0	0	0	T5-28	
0	0	0	0	0	0	0	0	0	T5-29	
0	0	0	0	0	0	0	0	0	T5-30	
Geodia sp.	dots Pocilosclerid	*Chondrilla sp.*	Asterophorid sp.	*Haliclona sp.*	*Suberites sp.*	*Clatherina sp.*	Hadromerid sp.	*Halichondria sp.*	Site No.	F sp
0	0	0	0.25	0	0	0	0	0	F6-1	
0	0	0	0	0	0	0	0	0	F6-2	
0	0	0	0	0	0	0	0	0	F6-3	
0	0	0.25	0	0	0	0	0	0	F6-4	
0	0	0	0	0	0	0	0	0	F6-5	
0	0	0	0	0	0	0	0	0	F6-6	
0	0	0	0	0	0	0	0	0	F6-7	
0	0	0	0	0	0	0	0	0	F6-8	
0	0	0	0	0	0	0	0	0	F6-9	
0	0	0	0	0	0	0	0	0	F6-10	
0	0	0	0	0	0	0	0	0	F6-11	
0	0	0	0	0	0	0	0	0	F6-12	
0	0	0	0	0	0	0	0	0	F6-13	
0	0	0	0	0	0	0	0	0	F6-14	
0	0	0	0	0	0	0	0	0	F6-15	
0	0	0	0	0	0	0	0	0	F6-16	
0	0	0	0	0	0	0	0	0	F6-17	
0	0	0	0	0	0	0	0	0	F6-18	
0	0	0	0	0	0	0	0	0	F6-19	
0	0	0	0	0	0	0	0	0	F6-20	
0	0	0	0	0	0	0	0	0	F6-21	
0	0	0	0	0	0	0	0	0	F6-22	
0	0	0	0	0	0	0	0	0	F6-23	
0	0.25	0	0	0	0	0	0	0	F6-24	
0	0	0	0	0	0	0	0	0	F6-25	
0	0	0	0	0	0	0	0	0	F6-26	

0	0	0	0	0	0	0	0	0	F6-27	
0	0	0	0	0	0	0	0	0	F6-28	
0	0	0	0	0	0	0	0	0	F6-29	
0	0	0	0	0	0	0	0	0	F6-30	
Geodia sp.	dots Pocilosclerid	*Chondrilla sp.*	Asterophorid sp.	*Haliclona sp.*	*Suberites sp.*	*Clatherina sp.*	Hadromerid sp.	*Halichondria sp.*	Site No.	H sp
0	0	0	0	0	0	0	0	0	T7-1	
0	0	0	0.25	0	0	0	0	0	T7-2	
0	0	0	0	0	0	0	0	0	T7-3	
0	0	0	0	0	0	0	0	0	T7-4	
0	0	0	0	0	0	0	0	0	T7-5	
0	0	0	0	0	0	0	0	0	T7-6	
0	0	0	0	0	0	0	0	0	T7-7	
0	0	0	0	0	0	0	0	0	T7-8	
0	0	0	0	0	0	0.5	0	0	T7-9	
0	0	0	0	0	0	0	0	0	T7-10	
0	0	0	0	0	0	0	0	0	T7-11	
0	0	0	0	0	0	0	0	0	T7-12	
0	0	0	0	0	0	0	0	0	T7-13	
0	0	0	0	0	0	0	0	0	T7-14	
0	0	0.25	0	0	0.25	0	0	0	T7-15	
0	0.25	0.5	0	0	0	0	0	0	T7-16	
0	0.25	0	0	0	0	0	0	0	T7-17	
0	0	0	0	0	0	0	0	0	T7-18	
0	0	0	0	0	0	0	0	0	T7-19	
0	0	0	0	0	0	0	0	0	T7-20	
0	0	0	0	0	0	0	0	0	T7-21	
0	0	0	0	0	0	0	0	0	T7-22	
0	0	0	0	0	0	0	0	0	T7-23	
0	0	0	0	0	0	0	0	0	T7-24	
0	0	3	0	0	0	0	0	0	T7-25	

0	0	0	0	0	0	0	0	0	T7-26	
0	0	0.25	0	0	0	0	0	0	T7-27	
0	0	0	0	0	0	0	0	0	T7-28	
0	0	0	0	0	0	0	0	0	T7-29	
0	0	0	0	0	0	0	0	0	T7-30	
Geodia sp.	dots Pocilosclerid	*Chondrilla sp.*	Asterophorid sp.	*Haliclona sp.*	*Suberites sp.*	*Clatherina sp.*	Hadromerid sp.	*Halichondria sp.*	Site No.	F sp
0	0	0	0	0	0	0	0	0	F8-1	
0	0	0	0	0	0	0	0	0	F8-2	
0	0	0	0	0	0	0	0	0	F8-3	
0	0	0	0	0	0	0	0	0	F8-4	
0	0	0	0	0	0	0	0	0	F8-5	
0	0	0	0	0	0	0	0	0	F8-6	
0	0	0	0	0	0	0	0	0	F8-7	
0	0	0	0	0	0	0	0	0	F8-8	
0	0	0	0	0	0	0	0	0	F8-9	
0	0	0	0	0	0	0	0	0	F8-10	
0	0	0	0	0	0	0	0	0	F8-11	
0	0	0	0	0	0	0	0	0	F8-12	
0	0	0.25	0.25	0	0	0	0	0	F8-13	
0	0	0	0	0	0	0	0	0	F8-14	
0	0	0	0	0	0	0	0	0	F8-15	
0	0	0	0	0	0	0	0	0	F8-16	
0	0	0	0	0	0	0	0	0	F8-17	
0	0	0	0	0	0	0	0	0	F8-18	
0	0	0	0	0	0	0	0	0	F8-19	
0	0	0	0	0	0	0	0	0	F8-20	
0	0	0	0	0	0	0	0	0	F8-21	
0	0	0	0	0	0	0	0	0	F8-22	
0	0	0	0	0	0	0	0	0	F8-23	
0	0	0	0	0	0	0	0	0	F8-24	
0	0	0	0	0	0	0	0	0	F8-25	

0	0	0	0	0	0	0	0	0	F8-26	
0	0	0	0	0	0	0	0	0	F8-27	
0	0	0	0	0	0	0	0	0	F8-28	
0	0	0	0	0	0	0	0	0	F8-29	
0	0	0	0	0	0	0	0	0	F8-30	
Cream *Geodia*	Clear/red dots	Orange *Chondrilla*	Red Asterophorid	Black *Haliclona*	Yellow *Suberites*	White *Clatherina*	Red Hadromerid	Beige *Halichondria*	Site No.	E F
0	0	0	0	0	0	0	0	0	F9-1	
0	0	0	0	0	0	0	0	0	F9-2	
0	0	0	0	0	0	0	0	0	F9-3	
0	0	0	0	0	0	0	0	0	F9-4	
0	0	0	0	0	0	0	0	0	F9-5	
0	0	0	0	0	0	0	0	0	F9-6	
0	0	0	0	0	0	0	0	0	F9-7	
0	0	0	0	0	0	0	0	0	F9-8	
0	0	0	0	0	0	0	0	0	F9-9	
0	0	0	0	0	0	0	0	0	F9-10	
0	0	0	0	0	0	0	0	0	F9-11	
0	0	0	0	0	0	0	0	0	F9-12	
0	0	0	0	0	1	0	0	0.25	F9-13	
0	0	0	0	0	0	0	0	0	F9-14	
0	0	0	0	0	0	0	0	0	F9-15	
0	0	0	0	0	0	0	0	0	F9-16	
0	0	0	0	0	0.25	0	0	0	F9-17	
0	0	0	0	0	0	0	0	0	F9-18	
0	0	0	0	0	0	0	0	0	F9-19	
0	0	0	0	0	0	0	0	0	F9-20	
0	0	0	0	0	0	0	0	0	F9-21	
0	0	0	0	0	0	0	0	0	F9-22	
0	0	0	0	0	0	0	0	0	F9-23	
0	0	0	0	0	0	0	0	0	F9-24	
0	0	0	0	0	0.25	0	0	0.75	F9-25	

0	0	0	0	0	0	0	0	0	F9-26	
0	0	0	0	0	0	0	0	0	F9-27	
0	0	0	0	0	0	0	0	0	F9-28	
0	0	0	0	0	0	0	0	0	F9-29	
0	0	0	0	0	0	0	0	0	F9-30	
Cream *Geodia*	Clear/red dots	Orange *Chondrilla*	Red Asterophorid	Black *Haliclona*	Yellow *Suberites*	White *Clatherina*	Red Hadromerid	Beige *Halichondria*	Site No.	E F
0	0	0	0.25	0	0.25	0	0	0	C10-1	
0	0	0	0	0	0.25	0.25	0	0	C10-2	
0	0	0	0	0	0.25	0	0	0	C10-3	
0	0	0	0	0	0	0.25	0	0	C10-4	
0	0	0	0	0	0	0.5	0	0	C10-5	
0	0	0.5	0	0	0	0.5	0	0	C10-6	
0	0	0	0	0	0	0.25	0	0	C10-7	
0	0	0	0	0	0	0	0	0	C10-8	
0	0	0	0	0	0	0	0	0	C10-9	
0.25	0	0	0	0	0	0	0	0	C10-10	
0	0	0	0	0	0	0.25	0	0	C10-11	
0	0	0	0	0	0	0	0	0	C10-12	
0	0	0	0	0	0	0	0	0	C10-13	
0	0.25	0.25	0	0	0	0	0	0	C10-14	
0	0	0	0	0	0	0.25	0	0	C10-15	
0	0	0.5	0	0	0	0.25	0.25	0	C10-16	
0	0	0	0	0	0.5	0.25	0	0	C10-17	
0	0	0	0	0	0	0	0	0	C10-18	
0	0	0.25	0	0	0	0	0	0	C10-19	
0	0	0.25	0.25	0	0	0	0	0	C10-20	
0	0	0.5	0.25	0	0	0	0	0	C10-21	
0	0	0.25	0	0	0	0.25	0	0	C10-22	
0	0	0.25	0	0	0	0	0	0	C10-23	
0	0	0.25	0.25	0	0	0	0	0	C10-24	
0	0	0	0.5	0	0	0	0	0	C10-25	

0	0	0.25	0	0	0	0	0	0	C10-26	
0	0.25	0	0	0	0	0	0	0	C10-27	
0	0	0.75	0	0	0	1	0	0	C10-28	
0	0	0.25	0	0	0	0.25	0	0	C10-29	
0	0	0.75	0	0	0	0.25	0	0	C10-30	

Brown *Spirastrella sp.* 1.	Purple Haplosclerid 3.	Orange *Spirastrella sp.*	Red *Spirastrella sp.*	Pink Haplosclerid 3	Total Sponge % Cover
0	0	0	0	0	3
0	0	0	0	0	1.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	1.5
0	0	0	0	0	2
0	0	0	0	0	1
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0.5
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	1
0	0	0	0	0	0
0	0	0	0	0	2
0	0	0	0	0	0.5
0	0	0	0	0	2.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	1.5
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0

0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	1
Spirastrella sp. 1.	Haplosclerid 3.	Orange *Spirastrella sp.*	*Spirastrella sp.*	Haplosclerid 3	Total Sponge % Cover
0	0	0	0	0	0.5
0	0	0	0	0	8.25
0	0	0	0	0	3
0	0	0	0	0	3.25
0	0	0	0	0	2.5
0	0	0	0	0	3.25
0	0	0	0	0	7
0	0	0	0	0	4.25
0	0	0	0	0	1
0	0	0	0	0	1.25
0	0	0	0	0	2
0	0	0	0	0	0.25
0	0	0	0	0	1
0	0	0	0	0	3
0	0	0	0	0	0.5
0	0	0	0	0	3.5
0	0	0	0	0	2
0	0	0	0	0	2.5
0	0	0	0	0	1.25
0	0	0	0	0	3.75
0	0	0	0	0	3.5
0	0	0	0	0	1
0	0	0	0	0	2.25
0	0	0	0	0	0.75
0	0	0	0	0	1
0	0	0	0	0	3.25
0	0	0	0	0	2.5

0	0	0	0	0	10
0	0	0	0	0	1
0	0	0	0	0	6
Spirastrella sp. 1.	Haplosclerid 3.	Orange *Spirastrella sp.*	*Spirastrella sp.*	Haplosclerid 3	Total Sponge % Cover
0	0	0	0	0	1
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0.5
0	0	0	0	0	0.75
0	0	0	0	0	1
0	0	0	0	0	1
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	1.25
0	0	0	0	0	0.5
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0.75
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	0.75
0	0	0	0	0	0.75
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0

0	0	0	0	0	1
0	0	0	0	0	0.25
0	0	0	0	0	0.25
Brown *Spirastrella sp.* 1.	Purple Haplosclerid 3.	Orange *Spirastrella sp.*	Red *Spirastrella sp.*	Pink Haplosclerid 3	Total Sponge % Cover
0	0	0	0	0	1
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	1.25
0	0	0	0	0	8.25
0	0	0	0	0	0.25
0	0	0	0	0	0.75
0	0	0	0	0	5
0	0	0	0	0	5
0	0	0	0	0	1.25
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	1.25
0	0	0	0	0	1
0	0	0	0	0	1.25
0	0	0	0	0	1
0	0	0	0	0	1.25
0	0	0	0	0	0.75
0	0	0	0	0	0.75
0	0	0	0	0	1.25
0	0	0	0	0	0.5
0	0	0	0	0	1
0	0	0	0	0	0.5

0	0	0	0	0	0.25
0	0	0	0	0	0.75
0	0	0	0	0	0.25
0	0	0	0	0	0.5
Spirastrella sp. 1.	Haplosclerid 3.	Orange *Spirastrella sp.*	*Spirastrella sp.*	Haplosclerid 3	Total Sponge % Cover
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.75
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0

0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	0
Spirastrella sp. 1.	Haplosclerid 3.	Orange *Spirastrella sp.*	*Spirastrella sp.*	Haplosclerid 3	Total Sponge % Cover
0	0	0	0	0	3.25
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	1
0	0	0	0	0	0.5
0	0	0	0	0	1.75
0	0	0	0	0	0.75
0	0	0	0	0	1.5
0	0	0	0	0	3.75
0	0	0	0	0	1
0	0	0	0	0	5.25
0	0	0	0	0	1.75
0	0	0	0	0	2.5
0	0	0	0	0	2.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	4.5
0	0	0	0	0	1.25
0	0	0	0	0	1.75
0	0	0	0	0	1.5
0	0	0	0	0	2.75
0	0	0	0	0	3.25
0	0	0	0	0	1.25
0	0	0	0	0	2.25
0	0	0	0	0	2.5

0	0	0	0	0	0
0	0	0	0	0	2
0	0	0	0	0	1.25
0	0	0	0	0	0.25
Spirastrella sp. 1.	Haplosclerid 3.	Orange *Spirastrella sp.*	*Spirastrella sp.*	Haplosclerid 3	Total Sponge % Cover
0	0	0	0	0	0.5
0	0	0	0	0	2.5
0	0	0	0	0	2
0	0	0	0	0	1
0	0	0	0	0	0.5
0	0	0	0	0	0.75
0	0	0	0	0	2.5
0	0	0	0	0	0.25
0	0	0	0	0	5.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	11.5
0	0	0	0	0	1.5
0	0	0	0	0	0.5
0	0	0	0	0	0.5
0	0	0	0	0	0.25
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	3

0	0	0	0	0	0
0	0	0	0	0	0.75
0	0	0	0	0	1
0	0	0	0	0	0
0	0	0	0	0	0.25
Spirastrella sp. 1.	Haplosclerid 3.	Orange *Spirastrella sp.*	*Spirastrella sp.*	Haplosclerid 3	Total Sponge % Cover
0	0	0	0	0	0.75
0	0	0	0	0	1.75
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0.5
0	0	0	0	0	0.75
0	0	0	0	0	0.25
0	0	0	0	0	0.5
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	2.5
0	0	0	0	0	0
0	0	0	0	0	0.5
0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

0	0	0	0	0	0.25
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0.25
0	0	0	0	0	1
Brown *Spirastrella sp.*	Purple Haplosclerid	Orange *Spirastrella sp.*	Red *Spirastrella*	Pink Haplosclerid	Total Sponge % Cover
0	0	0	0	0	0.5
0	0	0	0	0	1.5
0	0	0	0	0	1.75
0	0	0	0	0	0.5
0	0	0	0	0	1
0	0	0	0	0	1.75
0	0	0	0	0	1.5
0	0	0	0	0	3.25
0	0	0	0	0	0.25
0	0	0	0	0	0.75
0	0	0	0	0	5.25
0	0	0	0	0	1.25
0	0	0	0	0	2.25
0	0	0	0	0	0.25
0	0	0	0	0	1.25
0	0	0	0	0	1.5
0	0	0	0	0	1
0	0	0	0	0	1.75
0	0	0	0	0	0.75
0	0	0	0	0	1.75
0	0	0	0	0	1.25
0	0	0	0	0	1
0	0	0	0	0	0.5
0	0	0	0	0	1
0	0	0	0	0	1.75

0	0	0	0	0	0.75
0	0	0	0	0	3
0	0	0	0	0	2
0	0	0	0	0	1.25
0	0	0	0	0	2.5
Brown *Spirastrella sp.*	Purple Haplosclerid	Orange *Spirastrella sp.*	Red *Spirastrella*	Pink Haplosclerid	Total Sponge % Cover
0.25	0	0	0	0	7.75
0	0.25	0	0	0	8.75
0	0	0	0	0	11.25
0	0	0	0	0	2.5
0	0	0	0	0	1
0	0	0	0	0	1.5
0	0	0	0	0	1
0	0.25	0	0	0	1.25
0	0	0	0	0	2
0	0	0	0	0	1.25
0	0	0	0	0	2
0	0	0	0	0	4
0	0	0	0	0	0.25
0	0	0	0	0	1
0	0	0	0	0	4.75
0	0.25	3	0	0.25	4.75
0	0	0	0	0	1.25
0	0	0	0.25	0	0.75
0	0	0	0	0	0.75
0	0	0	0.25	0	1.25
0.25	0	0	0	0	3.25
0	0	0	0	0	4.75
0.25	0	0	0.25	0	4.25
0	0	0	0	0	0.75
0	0	0	0	0	0.75

0	0	0	0	0	1.25
0.25	0	0	0	0	0.75
0	0	0	0	0	4
0	0	0	0	0	1.75
0	0	0	0	0	1.75