THE CHARLIE-GIBBS FRACTURE ZONE: MEGABENTHIC BIODIVERSITY, COMMUNITY COMPOSITION AND THEIR ENVIRONMENTAL DRIVERS

by © Poppy Keogh

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Abstract

The Charlie-Gibbs Fracture Zone (CGFZ) is a topographically unique area on the Mid Atlantic Ridge (MAR) with numerous bathymetric features which create a heterogenous environment, optimal for the colonisation of cold-water sponge and corals. Previous studies have analysed the megabenthic communities North and South of the fracture zone, but not between the two parallel faults themselves. The region which was surveyed for this study is within the CGFZ North Marine Protected Area (MPA), where the benthic habitats currently remain unprotected from anthropogenic activities. This thesis aims to describe the biodiversity patterns and community composition of the CGFZ as well as their environmental drivers. We use video footage from five transects collected using a Remotely Operated Vehicle and multivariate statistical methods. Over 154,509 individual organisms belonging to 309 megafaunal morphospecies were identified from the video which covered almost 34 km of transect. Using species accumulation curves and generalized additive modelling, depth, slope and the presence of hard substratum were determined to be important factors in the distribution of megafaunal species richness and abundance. When the megafaunal community composition was examined, eight distinct communities were identified, all with multiple Vulnerable Marine Ecosystem indicator species present. These included but were not limited to a sea pen field alongside an *Acanella* sp. garden, and a community dominated by corals including the black coral *Stichopathes* sp., soft corals like *Anthomastus* sp., and scleractinians. Depth, slope and rugosity played a significant role in their differentiation and distribution of these communities. These results will help to inform the future decision making for this region, the CGFZ North MPA, where its protection status will come into debate in the next five years.

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List of Abbreviations

ABNJ	Areas Beyond National Jurisdiction
AMOC	Atlantic Meridional Overturning Circulation
ANOSIM	Analysis of Similarities
AUV	Autonomous Underwater Vehicle
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CGFZ	Charlie-Gibbs Fracture Zone
CMECS	Coastal and Marine Ecological Classification Standard
CTD	Conductivity, Temperature, Depth
CWC	Cold Water Corals
DWBC	Deep Western Boundary Current
ECOMAR	Ecosystems of the Sub-Polar Front and Charlie-Gibbs Fracture Zone
EEZ	Economic Exclusion Zones
EUNIS	European Nature Information System
FAO	Food and Agricultural Organization
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organisation
ISA	International Seabed Authority
MAR	Mid Atlantic Ridge
MPA	Marine Protected Area
MSFD	European Union’s Marine Strategy Framework Directive
NAC	North Atlantic Current
NAFO	Northwest Atlantic Fisheries Organization
NEAFC	Northeast Atlantic Fisheries Commission
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
ROV	Remotely Operated Vehicle

SDM	Species Distribution Models
SIMPER	Similarity Percentages
TASSE	Terrain Attribute Selection for Spatial Ecology
TOSCA	Tectonic Ocean Spreading at the Charlie Gibbs Fracture Zone
UNGA	United Nations General Assembly
VME	Vulnerable Marine Ecosystem

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Co-authorship Statement

The student’s contributions to the thesis manuscripts are as follows:

- Led the finalization of research questions
- Conducted analyses of video data from 2018 TOSCA survey.
- Conducted data analyses used for all chapters
- Drafted all thesis chapters and lead author on the resulting two papers (Chapters 2 & 3)

Co-supervisor Dr. Katleen Robert (Fisheries and Marine Institute, Memorial University of Newfoundland and Labrador) co-authored Chapters 2 and 3, contributed to project design, data collection, interpretation of results and helped improve manuscript drafts.

Co-supervisor Dr. Evan Edinger (Geography Department, Memorial University of Newfoundland and Labrador) co-authored Chapters 2 and 3, helped improve manuscript drafts.

Committee member Dr. Bárbara Neves (DFO) co-authored Chapter 3, and revisions to manuscript draft.

Rylan J. Command (MSc student, Fisheries and Marine Institute, Memorial University of Newfoundland and Labrador) co-authored Chapter 2, contributed Generalised Additive Model analysis and provided revisions to Chapter 2.

Dr. Aggeliki Georgiopoulou was Principal Investigator on the TOSCA survey, where the data for this study was collected, and co-authored Chapters 2 and 3.

This thesis is based on the following manuscripts:

Chapter 2:

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Chapter 3:

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1 Introduction

1.1 The Deep-sea and Biogeographic Boundaries

The deep sea, which is defined as being everything under 200 m depth, represents the largest habitat on earth, with over 62% of the ocean lying below 1000 m depth (Roberts, 2002). However, relatively little of the deep sea has been explored. For centuries, the deep sea was considered to be devoid of life, an expanse of sparsely populated or completely uninhabited abyssal plains. Research from the last five or six decades has revealed this to be untrue. We now know that the deep-sea comprises many regions of heterogenous habitats which occupy many bottom types across all five oceans (Harris et al., 2014). Similarly to mountain ranges influencing species dispersion and habitat distribution in the terrestrial environment, large, complex seabed topographical features affect biodiversity and species distribution in the deep sea. Mid-ocean ridges, seamounts and ocean trenches are some examples of these features (Alt et al., 2013; McClain, 2007). These can impact the oceanographic conditions of a region including current flow and water mass properties, as well as provide a variety of terrain types. The role which specific biogeographic boundaries play in the diversity and distribution of megabenthic deep-sea species is still relatively unstudied (Priede, 2013). This is the case especially with biogeographic transitional zones, such as mid-ocean ridges and the geological features associated with them, for example, fracture zones. These are areas with high bathymetric relief and heterogeneity, with increased exposure to large scale and local current systems (Calvert & Whitmarsh, 1986; Skolotnev et al., 2021). As a result, these areas could potentially harbour enhanced megabenthic faunal diversity, richness, and even rare species (Gebruk & Krylova, 2013; Spector, 2002).

1.2 The Charlie Gibbs-Fracture Zone as a Biogeographic Boundary

Studies on the Charlie-Gibbs Fracture Zone (CGFZ), situated at 53°N and between -25°E and -40°E in the North Atlantic Ocean, have confirmed the bathymetric and geological complexity of this area due to the presence of numerous physical features, including seamounts, vertical walls, and knolls to name a few (Alt et al., 2013; Calvert & Whitmarsh, 1986; Skolotnev et al., 2021). Its geological structure was first investigated in the 1980's during a seismic refraction and gravity survey which revealed that the oceanic crust at the CGFZ was abnormally thin (Calvert & Whitmarsh, 1986). The Mid Atlantic Ridge (MAR) itself, with its variable bathymetry creates a diverse array of different substrate environments (Priede et al., 2013). The CGFZ that offsets the MAR, creates a passage-way connection between the northeast and northwest Atlantic (Kristoffersen, 1978). The north-south biogeographic divide created by the subpolar front, which separates the subtropical gyre from the subpolar gyre and is relatively wide, may be an important contributor to the high species diversity observed north and south of the fracture zone, as the frontal zone will support specific patterns in productivity (Priede et al., 2013). The CGFZ is also an oceanic core complex, which is an uplifted portion within a fault zone that exposes lower crust and mantle rocks onto the seafloor at mid-ocean ridges (Calvert & Whitmarsh, 1986; MacLeod et al., 2009; Skolotnev et al., 2021). This creates the very high bathymetric relief and complexity in this region. These unique features, alongside the presumed impact on faunal diversity, led to the proposition for the establishment of one of the first network of High Seas MPAs (Marine Protected Area) as a precautionary approach to protect this understudied region of the North Atlantic (O'Leary et al., 2012; Smith & Jabour, 2018).

The CGFZ is a left lateral transform fault zone, comprising of two parallel faults, the Charlie and the Gibbs. A transform fault is one where two tectonic plates move past each other without creating or causing destruction to the lithosphere beneath (Windley, 1979). These two faults span across a large portion of the North Atlantic Ocean at approximately 52ºN (Fleming et al., 1970). This transform fault is divided into the north and south Charlie-Gibbs transverse valleys which create an important geomorphological boundary in the North Atlantic Ocean. This bathymetric feature separates the polar waters of Iceland from the warmer waters of the Azores (Gebruk et al., 2010). The CGFZ displaces the axis of the MAR by almost 370 km, which alters the movement of currents through the North Atlantic. Hence, the habitats of the CGFZ can be influenced by both the warmer waters of the North Atlantic Current and the colder waters north of the sub-polar front (Priede et al., 2013). The CGFZ has also been known as a passageway for deep ocean currents coming from the Northeast Atlantic into the western basin. The CGFZ plays an important role in the formation of the deep water masses which contribute to the middle layer of the Deep Western Boundary Current (DWBC) and hence is an integral part of the southward Atlantic circulation system (Schott et al., 1999). The Iceland-Scotland Overflow Water is what feeds through the CGFZ as the middle layer, into the western basin and enters the DWBC going southward (Schott et al., 1999). The

CGFZ has been identified as a hotspot for charismatic megafauna such as cetaceans and seabirds due to its highly productive surface waters which become important foraging grounds (Doksæter et al., 2008; Edwards et al., 2013).

Biogeographic boundaries in the deep sea can have significant effects on the species distribution in an area and can restrict larval dispersal. This can lead to substantial differences in community composition on either side of these boundaries (McClain & Hardy, 2010). The ECOMAR (Ecosystems of the Sub-Polar Front and Charlie-Gibbs Fracture Zone) project, which ran in two phases in 2003-2004 and 2007-2010, was one of the first studies to investigate species composition on the Northern regions of the MAR, and highlighted the CGFZ as an important biogeographic boundary, dividing the cold waters of the polar regions from the warmer waters of the Azores (Priede et al., 2013). Although the CGFZ has been described as the most important latitudinal biodiversity transitional zone on the MAR, the faunal communities which live on the fracture zone have not been substantially documented or described (Priede et al., 2013; Vecchione et al., 2010). The ECOMAR project examined the benthic communities at four stations to the north and south of the CGFZ, revealing a clear latitudinal distinction between communities. There was little difference found in the particle flux north and south of the CGFZ, but higher levels of resuspended particles could be responsible for the greater densities of filter and suspension feeders, specifically sponges, in the sampled northern areas (Abell et al., 2013; Bell et al., 2016). In comparison, the differences in community composition east and west of the ridge axis were much smaller (Bell et al., 2016). This study did not sample on the fracture zone itself and so the “transition zone” on the biogeographic boundary remains unstudied.

1.3 Marine Protected Areas in Areas Beyond National Jurisdiction: The CGFZ North and South MPA

The high seas, also referred to as Areas Beyond National Jurisdiction (ABNJ) refers to all ocean which lies past the 200 nautical mile boundary of the Economic Exclusion Zones (EEZ) of each sovereign state, which equates to 64% of the ocean’s surface (Evans et al., 2015; Smith & Jabour, 2018). ABNJ are inherently difficult to protect from anthropogenic activities. They are not governed directly by a single country or regional governing body, and with a lack of monitoring capacities to ensure good management practices, the legislative decision making process is slowed and often inadequate (Evans et al., 2015). This can mean that the biological communities within ABNJ can be at higher risk from activities such as mining and fishing, and would require ecosystem-based management plans just as much as regions within EEZ (O’Leary et al., 2012). Multiple governing bodies are involved in the management of ABNJ in the North Atlantic, including OSPAR (The Convention for the Protection of the Marine Environment of the North-East Atlantic), NEAFC (North East Atlantic Fisheries Commission), NAFO (Northwest Atlantic Fisheries Organization), the ISA (International Seabed Authority) and the IMO (International Maritime Organisation) (Amon et al., 2016; Ardron et al., 2008; Smith & Jabour, 2018).

Researchers and policy makers have been increasingly focused on the issues within the protocols in place to aid in the decision making surrounding the assessment and protection of biodiversity in ABNJ, specifically in regards to data availability and comparability (Clark, 2020; Long & Chaves, 2015; Orejas et al., 2020). One particular study recommended that the European Union’s Marine Strategy Framework Directive (MSFD) could be applied to ABNJ as long as the framework expands and incorporates guidelines on the inclusion of spatial and temporal scales of assessment, the assessment of cumulative impacts of anthropogenic activities, and using new indicators (where necessary), as well as adapting existing indicators of biodiversity that are relevant to the conservation and protection of deep-sea ecosystems (Orejas et al., 2020). They aim to support the objectives laid out by bodies such as OSPAR, CBD (Convention of Biological Diversity) and the UNGA (United Nations General Assembly) who are working towards policies to create a coherent approach to protecting and conserving deep-sea biodiversity in ABNJ (Orejas et al., 2020; Tunnicliffe et al., 2020). Much of the benthic habitats of the North Atlantic’s ABNJ still remain a mystery, and a lack of environmental and biological data means that decisions made regarding the protection of potentially vulnerable habitats is hindered and relies on the precautionary principle (Ardron et al., 2008). A report published by OSPAR in 2013 stated that there was not a sufficient amount of data on the biological composition and the distribution of ecologically important species, such as corals and sponges which create habitat for other species, in their North Atlantic maritime area to create a coherent network of MPAs (OSPAR, 2013). OSPAR has been successful in implementing the precautionary principle approach when it comes to the MPA network of the North Atlantic, despite significant gaps in the knowledge regarding the distribution of benthic habitats in this area.

The precautionary principle was the basis for the establishment of the Charlie-Gibbs MPA by OSPAR in 2010 to protect its ecosystems from anthropogenic activities such as commercial fishing and extractive processes (Edwards et al., 2013; O'Leary et al., 2012). Due to Iceland's application to extend its Economic Exclusion Zone (EEZ), the MPA was divided into north and south regions (O'Leary et al., 2012). The Northern portion of the MPA (which is within the potential extension area for Iceland's EEZ) has only the water column protected from anthropogenic activities and the benthos remains unprotected. The Charlie-Gibbs South MPA is under full protection from anthropogenic activities (including the benthos and the water column). The sites described within this thesis are within the CGFZ North MPA, where the benthic communities remain unprotected.

Anthropogenic activity can threaten the habitats within ABNJ, which are inherently understudied. Establishing effective MPAs in ABNJ will be one of the key measures to protect Vulnerable Marine Ecosystems (VMEs), including coral gardens and sponge aggregations. For this to be executed efficiently, more data from deep-sea ecosystems in ABNJ are needed, as well as better collaboration between the different governing bodies.

1.4 Anthropogenic Threats to Deep Sea Benthic Habitats

In recent years, numerous studies have highlighted the anthropogenic threats posed to deep-sea habitats, including climate change (Guinotte et al., 2006; Morato et al., 2020; Sweetman et al., 2017), plastic pollution (Courtene-Jones et al., 2020; Pereira et al., 2020), extractive processes such as mining for precious minerals (Jones et al., 2017; Niner et al., 2018; Simon-Lledó et al., 2019) and commercial fishing (Victorero et al., 2018). Commercial fishing and mining can lead to widespread habitat and biodiversity loss in deep-sea environments, while climate change will cause changes in the oceans' environmental properties and processes with knock-on effects for the biological functioning of the deep sea (Ramirez-Llodra et al., 2011; Sweetman et al., 2017).

Climate change will begin to cause deoxygenation, raised temperatures, altered pH levels, and disruptions to the food chain. These will in turn affect vital ecological mechanisms in the deep sea, including habitat formation, nutrient cycling, carbon sequestration, and primary production (Sweetman et al., 2017). In the North Atlantic, suitable habitats for cold-water corals are predicted to decrease by between 28%-100%, based on climate change projections into the year 2100, mainly due to acidification and deoxygenation (Morato et al., 2020; Steinacher et al., 2008). Reef building species, such as the well-known *Lophelia pertusa* (= *Desmophyllum pertusum*), have proved to be paramount in providing structure for the deep-sea habitats of the North Atlantic and were predicted to see the biggest reduction in suitable habitat by Morato et al., 2020. They create complex systems which support juvenile fish, and numerous sessile filter feeders, such as crinoids and soft corals (Arnaud-Haond et al., 2017; Davies et al., 2017a; Morato et al., 2020). Scleractinian corals can be especially impacted by ocean acidification, which causes a change in the water column's chemical properties (i.e., a decrease in aragonite saturation levels makes it increasingly difficult for species like *Desmophyllum pertusum* to calcify) (Jackson et al., 2014).

Deep-sea mining has become a topical point of discussion in the deep-sea community in recent years. The progression of the plans for mining in the Clarion-Clipper Zone, a region of abyssal plains in the central south Pacific Ocean, has led to numerous studies on the potential effects that mining practices could have on surroundings pelagic and benthic habitats (Amon et al., 2016; Bowden et al., 2016; Jones et al., 2017; Simon-Lledó et al., 2019). As contractors now begin to plan exploration for seafloor massive sulfide (SMS) deposits on the Mid-Atlantic Ridge (Dunn et al., 2018), it is important that all available literature is used in the assessment and prediction of the effects that mining for resources could have on the benthic habitats of the North Atlantic.

Deep-sea fishing, specifically bottom trawling, has been known to damage benthic habitats, to varying degrees depending on the habitats present, as it not only captures the target species of fish, but also the sessile benthic organisms, or non target species (Victorero et al., 2018). Commercial fishing in deep sea (below 200 m) did not truly start up until the 1960's as fishing gear became advanced enough to withstand the deep depths (Haedrich et al., 2001). Studies reveal that this transition coincided with the decline in shallower water fisheries (Roberts, 2002). As fishing technology advances, large commercial fishing vessels can fish further from shore, with larger gear and for longer periods of time, opening up the offshore deep-water benthos to increasing fishing pressures. Bottom trawling can have severe negative impacts on slow growing cold-water corals in deep waters, as the recolonization of areas which have been trawled are either extremely slow or in some cases, never return at all (Koslow et al., 2000; Roberts, 2002; Victorero et al., 2018). One study in the North Atlantic has shown the effectiveness of MPAs in the protection of cold-water coral species after closing the area to fisheries and the importance of the precautionary principle when conserving deep-sea benthic habitats (Bennecke & Metaxas, 2017; Huvenne et al., 2016).

Trawl fishing can not only lead to direct impacts on deep-sea benthic communities but can also lead to the presence of “ghost nets”, when trawl nets are lost or discarded at sea and continue to passively capture fish (Davies et al., 2007; Ramirez-Llodra et al., 2010). Marine litter has been recorded in numerous regions of the Atlantic, including continental slopes, submarine canyons and ocean ridges, and is becoming increasingly widespread in the deep-sea environment (Pham et al., 2014). Another form of plastic pollution of concern in the deep sea is microplastics. Evidence of microplastics have been found in both deep-sea fishes (Pereira et al., 2020) and the sediments (Courtene-Jones et al., 2020) of the North Atlantic.

As there are several threats caused by anthropogenic activities, new tools and procedures to define and identify the most vulnerable habitats in the deep-sea are being developed so that they can be specially targeted through future legislation.

1.5 Vulnerable Marine Ecosystems

The concept of Vulnerable Marine Ecosystems (VMEs) is an important tool when it comes to the protection of diverse areas of the deep-sea, especially in ABNJ. In the deep-sea context, VMEs include benthic communities which are highly vulnerable to anthropogenic activities and have slow recovery rates. These include, but are not limited to, cold-water coral (CWC) reefs, sponge aggregations, and Xenophyophore fields. There are a number of organisations which define VMEs differently, including the FAO (Food and Agricultural Organization), the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and the CBD. Some of the traits which they describe overlap and are common to all three organizations’ identification criteria, including:

uniqueness or rarity, slow growth rates/recovery rates, structural fragility, and habitat forming/structure forming (Ardron et al., 2014; Burgos et al., 2020).

Specific species which make up these recognised VMEs can be classed as VME indicator species (ICES, 2016). These species, for example *Desmophyllum pertusum*, Xenophyophores and the sponge *Geodia* sp., can be used to describe the presence of a VME. A sponge aggregation is an example of a VME, and *Geodia* sp. (a demosponge) is an example of an indicator species that may make up a sponge aggregation. ICES (International Council for the Exploration of the Sea) has a data portal displaying the distribution and abundance of VMEs and VME indicators (ICES, 2016).

The identification of VMEs and VME indicator species is particularly important when it comes to the management of fisheries and policy decisions made on high seas fisheries. The use of VMEs has helped to develop international guidelines, for example the *FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas* (Bensch et al., 2009; Davies et al., 2017b; FAO, 2009). These guidelines are important when identifying high impact activities for specific VMEs and implementing protective measures, for example, requiring that all NEAFC, who manage fisheries in the Northeast Atlantic, contracting parties cease fishing when a VME is encountered during fishing activity (NEAFC, 2008). These have been used to identify suitable places for protection in the High Seas, which can be challenging when little data are available (Bensch et al., 2009). ICES and the ISA are the main bodies which deal with these data, and VMEs have become a common language within these governing bodies which can be easily communicated to policy makers.

1.5.1 Geographical context: The North Atlantic

A precautionary principle is important where there is still a lack of data for these areas (Ardron et al., 2008). Sites which are protected include many of the named seamounts of the North Atlantic High Seas, including the Milne, Altair, and Antialtair seamounts. These are closed to bottom-fishing for 4-year periods, and then the closure is reviewed. Seamounts are viewed as likely harbouring VME indicator species, as per the NEAFC and OSPAR report on the bottom fishing areas in the ABNJ in the North Atlantic (OSPAR & NEAFC, 2015). The NAFO (Northwest Atlantic Fisheries Organization) has been taking precautionary practices to protect potential sites where VMEs are present in the North Atlantic High Seas (Auster et al., 2013).

Species Distribution Models (SDMs), also known as habitat suitability models, can predict the spatial extent of habitats or species, which has been useful for predicting VMEs and their indicator species (Burgos et al., 2020; Iturbide et al., 2015; Vierod et al., 2014). However, the use of SDMs to predict VMEs has been criticized for its low accuracy at finer scales (Thompson et al., 2016). Nevertheless, predictive modeling has become increasingly common for assessing the spatial distribution of benthic communities in ABNJ (Burgos et al., 2020; Vierod et al., 2014). These models often use presence only data, which can cause issues in model validation at large scales, due to using data sets with high sample selection bias as surveys target certain areas where the presence of VME indicator species is likely (Vierod et al., 2014). Since the presence of VME indicator taxa does not always guarantee the presence of a VME, previous studies have attempted to quantify the densities of a VME indicator taxa which are needed to satisfy the criteria for the presence of a VME based in the FAO standards (Howell et al., 2011). These kinds of studies are moving in the right direction for the quantification of VME characteristics that are needed to identify regions that need protection in ABNJ.

The presences or the predicted presences of VMEs are often used when legislators are deciding on MPA and other protected areas boundaries and the extent of their protection status. As the identification of VMEs in an area provides support for its protection from anthropogenic activities, our knowledge of their distribution is key in the decision process for establishing protected areas. The process going from the identification of a VME indicator or VME, to the establishment of a protected area has previously relied on very generalised recommendations from the United Nations General Assembly (UNGA). Recent work has been done to combine the varying identification criteria from different organisations (FAO, CCAMLR, and the CBD) to produce a standardized approach for the identification and protection of VMEs using a 10-step framework (Ardron et al., 2014). Steps within this framework include but are not limited to: considering areas that are already recognised for their potential ecological importance (e.g., seamounts and areas of high relief topography), gathering information on the distributions of likely VMEs and VME indicator species, alongside their environmental data, and compiling information on identified or likely fishing areas and impacts (Ardron & Secretariat, 2014).

Seamounts are described below as they are known biodiversity hotspots in the North Atlantic and are often used as an indicator for high levels of biodiversity or even the presence of VMEs, however, there are still many in the North Atlantic that remain un-surveyed.

1.6 Seamounts

Seamounts are widespread, estimated at more than 200,000 in all the world’s oceans, although most abundant in the Pacific Ocean. They are geomorphological features regarded as likely to harbour VMEs (Bensch et al., 2009). They exhibit a range of physiographies, topographies, and sizes, and occur at a wide range of depths and elevations. Ecosystems on seamounts can fulfil several VME criteria, such as rarity, high productivity and high biodiversity, fragility and slow recovery because of the member species that occur there (Clark et al., 2010). For these reasons, some experts recently called for the protection of all seamounts and their management as VMEs (Watling & Auster, 2021).

Seamounts are described globally as topographically isolated features, elevated more than 1,000 meters from the seafloor and are often considered to be biological “hotspots” (Harris & Baker, 2012; McClain, 2007; Morato et al., 2010; Staudigel et al., 2010). This means that they can be important components of biogeographic boundaries, which partly shape the biodiversity patterns of deep-sea habitats (Shank, 2010). Globally, less than 4% of seamounts have been surveyed, leaving our knowledge of seamounts and their associated benthic and fish communities very limited (Kvile et al., 2014; Victorero, Robert, et al., 2018). Seamount communities have demonstrated very slow, if any, recovery after deep-sea trawling practices, making them extremely vulnerable (Williams et al., 2010). Considering the likely presence of VMEs, it is vital that these features become better understood into the future to implement conservation plans. Efforts should be concentrated on surveying an increased number of seamounts which lie in ABNJ, which are under-represented in the surveyed seamount census (Staudigel et al., 2010; Wessel et al., 2010). Surveys in New Zealand revealed the devastating impact which bottom trawling can have on these habitats, with fragile long-living organisms, such as deep-sea corals, having sustained permanent damage and showing no signs of recovery even after decades of closed fisheries (Williams et al., 2010). There is one named seamount on the CGFZ, the Hecate seamount, which has only been surveyed once using a trawl as part of the 2004 MAR-ECO expedition, although the results from this trawl have not been discussed in the literature (Bergstad & Gebruk, 2008).

Seamounts in the North Atlantic have been found to host coral gardens, defined as relatively dense aggregations of colonies or individuals of one or more non-reef forming coral species, which promote high levels of biodiversity. Seamounts in the Azores have been found to host gardens populated with large gorgonians, such as *Callogorgia verticillata*, which is known to provide habitat for Chimaeras (García-Alegre et al., 2014). The reason behind the increased abundance of sessile, benthic assemblages on these features has been hypothesised in multiple studies. Seamounts create elevated, hard substrate for the attachment of sessile deep-sea fauna, like corals and sponges, forming increased surface area for habitat formation (Serrano et al., 2017). Increased concentrations of particulate matter and dissolved organic carbon (DOC) around seamounts could also play a role in biodiversity levels as enriched waters create a steady food supply for filter and suspension feeders (Kiriakoulakis et al., 2009). Another reason behind the elevated biodiversity in these areas could be related to the currents associated with seamounts, which can erode sediment, exposing bedrock and creating attachment substrate for sessile fauna (Taylor et al., 1975).

1.7 Thesis Summary and Knowledge Gap

My thesis consists of four chapters. The introduction illustrates the complexities of ecology on marine biogeographic boundaries, how MPAs are established in ABNJ and the issues involved in the process as well as VMEs and how they are defined. In this study, results are presented from the analysis of ROV (Remotely Operated Vehicle) video collected on the TOSCA (Tectonic Ocean Spreading at the Charlie-Gibbs Fracture Zone) survey in 2018.

Chapter 2, presents observed patterns of biodiversity, using multiple diversity indices, on the CGFZ. The CGFZ is a topographically unique area on the MAR with multiple bathymetric features which create a heterogenous environment, including a seamount, two knolls and a ridge. These types of marine landscapes are known to provide suitable habitats for various VMEs and often support dense aggregations of cold-water sponges and corals. I discuss the environmental variables, including substrate type, depth gradients and water column properties which may influence the spatial variation of the biodiversity.

Chapter 3, examines the megabenthic community composition of the CGFZ. Eight communities with multiple VME indicator species using a multivariate statistical analysis were identified. Each community was found to have unique environmental characteristics as well as distinct environmental factors that drive their distribution in the CGFZ North MPA.

The CGFZ remains a relatively understudied region of the North Atlantic High Seas. Previous studies have analysed the megabenthic communities North and South of the fracture zone (refer to map in Alt et al, 2013), but not between the two parallel faults themselves (Alt et al., 2019a; Gebruk & Krylova, 2013; Mortensen et al., 2008). The CGFZ South MPA is currently under full protection from anthropogenic activities based on the precautionary principle and informed partly by these previous studies. The CGFZ North MPA remains only partly protected, with the benthic communities being unprotected due to an outstanding application from Iceland to extend its EEZ boundaries. The results presented in this thesis help to inform the future decision making for the CGFZ North MPA, whether it will fall under Iceland's jurisdiction or it will remain an ABNJ and governed by OSPAR.

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2 Benthic megafaunal biodiversity of the Charlie-Gibbs Fracture Zone: spatial variation, potential drivers, and conservation status.

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Abstract

The Charlie-Gibbs Fracture Zone (CGFZ) is a prominent geological feature offsetting the Mid-Atlantic Ridge (MAR), consisting of two parallel fractures which create a highly variable seafloor bathymetry. It has been defined as the most important latitudinal biodiversity transitional zone on the MAR. Despite this recognition, the faunal communities living on the fracture zone have not been extensively described. A remotely operated vehicle (ROV) was utilized during the TOSCA (Tectonic Ocean Spreading at the Charlie-Gibbs Fracture Zone) survey. The survey included five ROV video transects at depths ranging between 560-2900 m. The objectives of the study were to use this video footage to quantify benthic megafaunal density and biodiversity patterns on the CGFZ and their environmental drivers. Species accumulation curves and generalized additive modelling show that depth and the presence of hard substrates play an important role in explaining species richness and abundance at the CGFZ. Coral taxa are more abundant between depths of 1,500 m and 2,000 m, while sponge taxa are most abundant between 1,750 m and 2,250 m. A dense sponge aggregation was identified on a ridge feature at 2,250 m depth. The high biodiversity and presence of dense sponge aggregations and coral gardens found in this study highlight the need for detailed surveys to help support decisions made by governing bodies on the protection status of the CGFZ.

Key words: Sponges, corals, deep sea, environmental drivers, North Atlantic.

2.1 Introduction

There has been a significant increase in deep-sea exploration and research from the last two decades to enhance our knowledge of diverse marine ecosystems, such as cold-water coral reefs (Buhl-Mortensen et al., 2010; Roberts et al., 2006), coral gardens (Bullimore et al., 2013), and sponge aggregations (Hawkes et al., 2019; Howell et al., 2016). Gathering knowledge on the biological composition and geographical distribution of these ecosystems is the first step towards developing coherent management and protection plans (Ardron & Secretariat, 2014). However, areas beyond national jurisdiction (ABNJ) remain relatively understudied (Blasiak & Yagi, 2016). These environments are especially difficult to study due to their remoteness, leading to a high cost of data collection (Serrano et al., 2017). Recent studies have looked at potential issues with effectively protecting ABNJ, such as how to determine the criteria for identifying ecologically significant areas and emplacing protection regulations in these remote areas of our oceans (Long & Chaves, 2015; Mossop, 2018). Solutions to these issues have begun to be discussed in recent years, for example, the expansion of the European Union's Marine Strategy Framework Directive to include guidelines on managing biodiversity beyond national jurisdiction (Orejas et al., 2020).

Although slightly better known than other ABNJ (Coro et al., 2016), the North Atlantic still has many knowledge gaps regarding the spatial distribution of deep ecosystems, and lacks uniformity in the collection of deep-sea data (Kazanidis et al., 2020). The Mid Atlantic Ridge (MAR), which divides the North Atlantic into eastern and western ocean basins, creates a biogeographic boundary which has a considerable effect on the biological communities that inhabit this region (Alt et al., 2019a; Bell et al., 2016; Gebruk & Krylova, 2013; Priede et al., 2013). The Charlie-Gibbs Fracture Zone (CGFZ) is an area of two parallel transform faults (the Charlie and the Gibbs), which offsets the MAR by over 340 km, making these the longest faults in the North Atlantic (Fig. 2.1), and which has also been recognized as an important biogeographic boundary (Calvert & Whitmarsh, 1986; Gebruk et al., 2010). Previous studies have looked at the differences in species composition and abundance on the MAR and found significant differences between the north and south of the CGFZ (Alt et al., 2019b; Bell et al., 2016; Gebruk & Krylova, 2013). There is still limited information on the biodiversity of the CGFZ region itself as previous studies included little sampling between the two transform faults. To our knowledge, the only published study of the megabenthic species of the CGFZ involved the analysis of 13 five-minute video transects, collected with a submersible as part of the 'Census of Marine Life' project (MAR-ECO) in 2003 (Gebruk & Krylova, 2013).

As an oceanic core complex, the CGFZ is characterized by a substantial amount of mid-ocean ridge igneous and metamorphic rocks (Skolotnev et al., 2021), providing the hard substratum crucially needed for attachment by many sessile species, including corals (Baker et al., 2012; Bell et al., 2016; Edinger et al., 2011; Miles, 2018; Mortensen et al., 2008; Robert et al., 2015). This diverse fauna includes reef-forming scleractinians and octocorals, as well as demosponges, hexactinellids, stalked crinoids and sessile holothurians. Biologically, the CGFZ core complex becomes especially important in the MAR region as it consists of a large bathyal habitat surrounded on either side by abyssal plains, and the presence of hard substratum would be expected to contribute to habitat heterogeneity and likely lead to a heightened biodiversity (Alt et al., 2019a; Priede et al., 2013). Previous coral observations recorded on the MAR in the region of the CGFZ described the presence of *Desmophyllum pertusum* (previously *Lophelia pertusa*), *Madrepora oculata* and *Solenosmilia variabilis,* although not in mounds or reefs (Mortensen et al., 2008). Species of octocorals and antipatharians were also recorded but not as coral gardens (Mortensen et al., 2008). One study described the dominance of hexactinellid sponges between depths of 1,700 and 2,500 m on the northern slope of the fracture zone, but not of a sponge aggregation specifically on the CGFZ (Gebruk & Krylova, 2013).

With the potential for highly diverse and dense biological communities on the CGFZ, anthropogenic threats to this region of the North Atlantic need to be carefully addressed to mitigate the risks of long-term damages. One of these risks includes the potential for future mining on the MAR (Cherkashova et al., 2010). In 2015, an area of the MAR was used in a case study by the International Seabed Authority (ISA), to investigate the use of "Areas of Particular Environmental Interest" or APEIs on mid-ocean ridges to mitigate the impacts of mining (Dunn et al., 2018). This same area currently has three ongoing seafloor massive sulfides, or polymetallic sulfides exploration contracts (Cherkashova et al., 2010; Murton et al., 2019). In a study looking at the implementation of APEIs on the MAR, it was stated that these should include bathymetric features of ecological importance, one of which being major transform faults that connect the east and west basins of the North Atlantic (Dunn et al., 2018).

One way to protect APEIs would be the implementation and effective regulation of a coherent network of Marine Protected Areas (MPA). As of 2012, the CGFZ was split into two MPAs, the CGFZ South MPA and the CGFZ North MPA (Smith & Jabour, 2018). The South MPA is under full protection from anthropogenic activities, including the water column, the seafloor and the subsoil, while the CGFZ North MPA is only partially protected, due to an outstanding submission from Iceland to extend the boundary of their economic exclusion zone (Hübner & Nordheim, 2019; Smith & Jabour, 2018). Hence, the seafloor and subsoil, including all benthic communities, of the CGFZ North MPA remain unprotected from anthropogenic activities. In 2022, this could include commercial fisheries, as the North East Atlantic Fisheries Organisation (NEAFC) will be reviewing the fisheries closure that has been instated in this region since 2009 (Hübner & Nordheim, 2019). Although a fisheries closure has been instated in this region since 2009, NEAFC will be reviewing its boundaries in 2022 (Hübner & Nordheim, 2019), which might or not be susceptible to commercial fisheries. Up until the 1990's, the CGFZ was host to multiple fisheries dominated by a Soviet/Russian fishing effort, targeting populations of demersal deep-water fish including the roundnose grenadier, redfish, orange roughy, and numerous shark species (WWF, 2008). If extended, the closure of this area to bottom trawling would be an integral part of the future preservation of the CGFZ benthic ecosystem.

The objective of this study was to describe megabenthic taxa abundance and diversity of the CGFZ and to determine what environmental factors influenced biodiversity in this area to help inform future sampling efforts and MPA management decision making.

These analyses were done using Remotely Operated Vehicle (ROV) video collected during the TOSCA (Tectonic Ocean Spreading at the Charlie-Gibbs Fracture Zone) expedition.

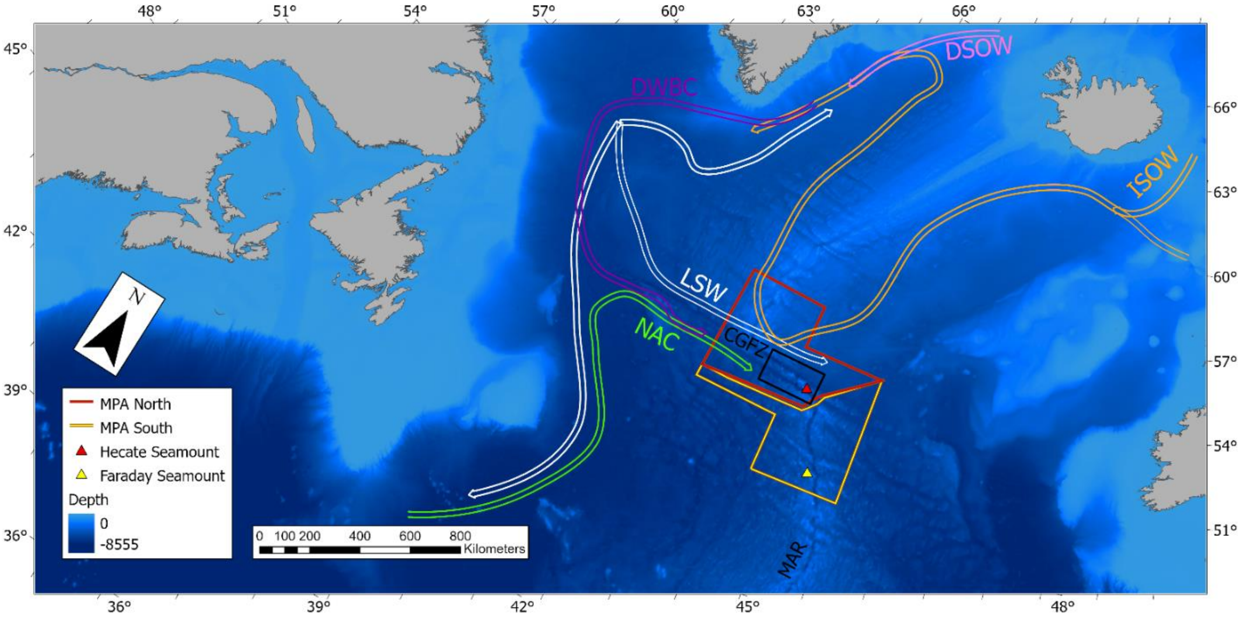


Figure 2.1. Location of CGFZ, the Hecate and Faraday seamounts, and study location for the TOSCA survey (in black box) in the North Atlantic Ocean, on the MAR. The boundaries of the North and South CGFZ MPA are shown in red and yellow, respectively. The North Atlantic Current (NAC) is shown in green. The Deep Western Boundary Current (DWBC) is shown in purple, the Labrador Sea Water (LSW) is in white, the Iceland-Scotland Overflow Water (ISOW) is in orange, and the Denmark Strait Overflow Water (DSOW) in pink (Racapé et al., 2019; Schott et al., 1999). Background bathymetry sourced from www.gebco.net.

2.2 Material and Methods

2.2.1 Study Site

The CGFZ is topographically unique as it includes north-south and east-west bathymetric barriers (the fracture zone itself and the MAR axis, respectively) (Gebruk & Krylova, 2013). The North Atlantic Current crosses the MAR over the CGFZ at 53°N (Fig. 2.1), which determines the boundary of the Sub-Polar Front at its northernmost point and creates an oceanographic boundary to the north and south due to differing water masses (Alt et al., 2019c; Priede et al., 2013; Read et al., 2010). The Subarctic Intermediate Water makes up the surface layer and is brought in by eastward flow, resulting in the freshest Labrador Sea Water occurring between 1,000 and 1,500m (Schott et al., 1999; Shor et al., 1980). The deeper water mass is the Iceland-Scotland Overflow Water (Fig. 2.1, see also appendix 5.1), found below 2,000m and originating from the Iceland-Scotland Ridge, in the North East Atlantic (Racapé et al., 2019; Schott et al., 1999). The Iceland-Scotland Overflow Water is driven west through the CGFZ by the Deep Western Boundary Current (Racapé et al., 2019; Read et al., 2010; Saunders, 1994). This complex oceanography may have positive effects on faunal diversity and distribution, by transporting organic matter to the deeper portions of the fracture zone.

The CGFZ has been examined for its unique geological characteristics, including the two left-lateral transform faults which are connected by a 40 km wide gap, also known as the intra-transform spreading centre (Skolotnev et al., 2021). The CGFZ is characterized by multiple large oceanic core complexes, which only form at slow spreading oceanic plate boundaries that have a limited supply of upwelling magma, such as at the MAR (Georgiopoulou et al., 2018; MacLeod et al., 2009; Skolotnev et al., 2021). These geological features create a unique and possibly ecologically functional substratum for the sessile benthic megafauna and associated communities of the CGFZ.

2.2.2 Data Collection

The ROV *Holland I* was utilised during the TOSCA expedition aboard the *Celtic Explorer* Research Vessel in 2018 (CE18008). The *Holland I* has a maximum depth range of 3,000 meters. HD videos were recorded along five ROV transects (Table 2.1; Fig. 2.2), with a high-definition oblique-facing camera (Kongsberg Maritime OE14-502a HDTV inspection camera), recording in 1080i resolution, at 25 frames per second with up to 7 phase alternating lines, to Ki-Pro disks in 2-hour segments. A 5 mega-pixel, OE 14366 Colour Zoom Camera recorded still images of observed organisms. The position of the ROV was continuously recorded using Ultra Short Baseline (USBL) systems (IXSEA GAPS USBL and Sonardyne Ranger 2 USBL). Shipboard bathymetry data was collected during the survey using the vessel's Kongsberg EM302 multi-beam echo-sounder (MBES), processed in Caris HIPS & SIPS, and exported to raster (projected as UTM Zone 25, 30 m resolution). A Seabird ROV-mounted CTD (Conductivity, Temperature, Depth) acquired data throughout all dives, logged using SeaSave 7 and converted to ASCII (American Standard Code for Information Interchange) using SBEDataProc. During the last 1,150 km of dive 9 the CTD malfunctioned, and therefore no CTD data was available for this portion of the dive. The ROV aimed to fly at 0.5 knots at an altitude of 1.5 m above the seabed, throughout the five dives (Table 2.1). A total of 67.5 hours of seabed video over 34 km, equaling 3.32 TB of HD video were collected.

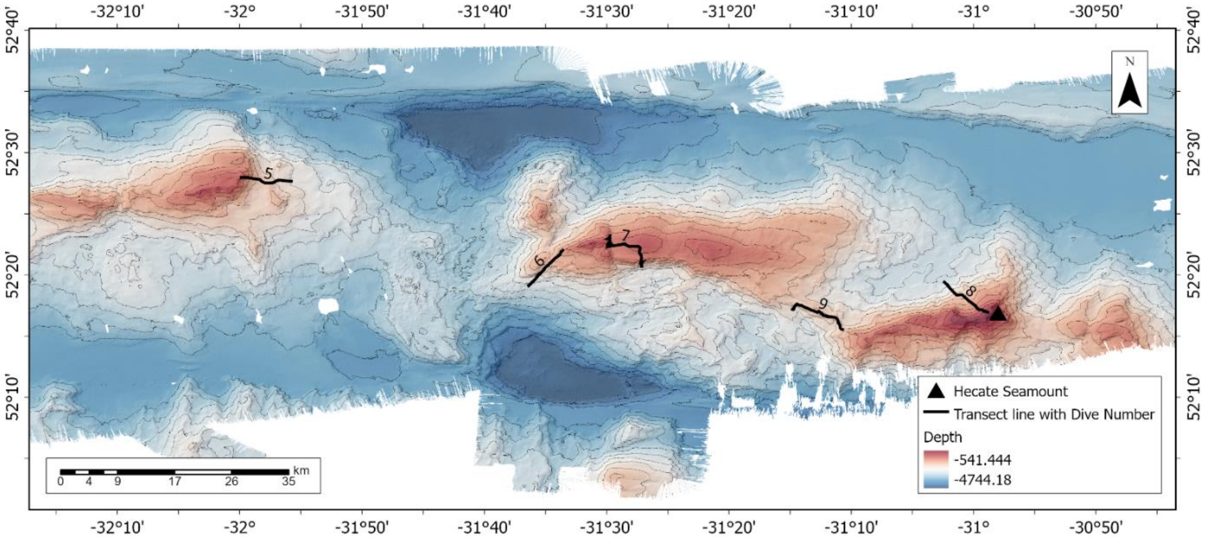


Figure 2.2. Detailed bathymetry of the Charlie-Gibbs Fracture zone and ROV video transect locations. Map shows TOSCA ROV transect lines as well as the ship-borne bathymetry of the area (30m resolution). Contour lines are at 250m depth intervals. Location of the Hecate Seamount is represented with a black triangle. For location see black box in Figure 2.1.

2.2.3 Video Analysis

The VARS (Video Annotation and Reference System) software developed by the Monterey Bay Aquarium Research Institute was utilised to annotate the ROV video transects (Schlining & Stout, 2006). Lasers beams with a 100 mm spacing were present in all videos for scaling purposes. Organisms larger than 20 mm were identified and assigned to a morphospecies (also known as Operational Taxonomic Unit) when species level identification could not be achieved due to the limitations of relying on video or still imagery alone (Howell et al., 2019). A species catalogue was created from still images collected during the ROV dives and was used as a reference for morphospecies occurrence throughout video analysis (see supplementary material). Resources used for the catalogue included the Catalogue of Atlantic Deep Sea Fauna (Howell et al., 2017), the Benthic Deepwater Animal Identification Guide V3 (NOAA, 2015), and species catalogue within PhD thesis (Alt, 2012), while the taxonomic nomenclature employed was based on WoRMS (World Register of Marine Species). Taxonomic experts (see acknowledgements) were contacted for the identification of the sponges and corals, as well as special groups such as Pennatulacea and Pycnogonida. Substrate types were also recorded according to the EUNIS (European Nature Information System) classification system for deep-sea seabed categories, which includes bedrock, boulders, mixed substrate (gravels), biogenic gravels, and sand (Moss, 2008).

Frames were extracted from the ROV videos at a rate of 1 every 5 seconds using the software Blender, and the two laser points were used to estimate field of view width to convert observed abundances into densities.

2.2.4 Statistical Analysis

Species observations, substrate types, CTD data (logging information on temperature and salinity), laser measurements were georeferenced using the USBL data from the ROV. This was done in the R program (version 3.6.2), using the '*eXtensible*' Time Series package. Slope was derived from the shipboard multibeam bathymetry at 30 m resolution, using the Benthic Terrain Modeller toolbox in ArcGIS Pro. ROV transects were subdivided into 50-meter sections (n=756) for the statistical analysis, and the midpoint coordinate of each section was used to extract slope and depth values. All organisms present within a 50-meter section were summed while the CTD data (temperature and salinity) and field of view width derived from the lasers were averaged for each section. Field of view area was calculated based on average field of view width multiplied by segment length (50 m), which was used to convert morphospecies abundances to densities. Each 50-meter section was allocated a dominant substrate type by determining the lengths of coverage for each substrate within a section.

The 50 m sections were used to derive species accumulations curves using the specaccum function from the ‘vegan’ package in the R program (Oksanen et al., 2020). Species accumulation curves were created for each dive and displayed by 250 m depth bands and substratum class. Species accumulation curves allow the examination of the expected number of observed species as a function of sampling effort (Gotelli & Colwell, 2001). Diversity indices for each 50m section (Shannon-Wiener H-index, Species Richness and Pielou’s Evenness) were calculated using the ‘vegan’ package. This was done for all observed morphospecies together as well as corals and sponges separately because of their status as vulnerable marine ecosystem indicators of ecological significance.

To examine further what environmental factors might be influencing biodiversity (i.e., taxa abundance and richness), generalized additive models (GAM) were employed. GAMs allow for modeling non-linear trends using smooth functions of covariates (Wood, 2011). Recent developments allow for the modelling of nested data, as well as spatial and temporal autocorrelation, using random effect smooths. Factors modelled as random effects are assumed to be a random sample of factor levels from a population of possible levels, and the intercept or shape of the modelled relationship is allowed to vary by factor level (Wood et al., 2016). Collectively, GAMs with nested structure are known as hierarchical generalized additive models, or HGAMs (Pedersen et al., 2019).

Here, phyla abundance (phyla level used for GAM only), species richness, Shannon-Wiener H-index, and Pielou's evenness were modeled using HGAMs. For abundance and species richness, models were fit using a negative binomial distribution to account for overdispersion, which is common in ecological data (Barry & Welsh, 2002), and to preserve the inherent count distribution in these variables. The total area covered by the camera field of view was included as an offset term in the richness and abundance models to preserve the count distribution of the response variables. For Shannon-Wiener H-index and Pielou's evenness, HGAMs were fit using only the non-zero observations and using the Gaussian distribution for the Shannon-Wiener H-index and the scaled-*t* distribution for Pielou's evenness. Each response was modelled as smooth functions of depth and slope. A tensor product smooth of latitude and longitude was used, with dive as a random effect, to account for spatial autocorrelation that may be present in the data, and to allow for correlation of observations within each dive. Models were fit using Restricted Maximum Likelihood Estimation to estimate smoothing parameters, since it is generally considered to be the most numerically stable (Wood, 2011; Wood et al., 2016).

After fitting HGAMs, model fit was assessed by examining residual plots and checking for concurvity. Concurvity can be thought of as a non-linear extension of multicolinearity (Connolly et al., 2013; Figueiras et al., 2005). Two variables are said to be concurve when a smooth function of one can be reconstructed using a smooth function of another variable. This influences parameter and standard error estimates analogous to the multicollinearity problem. Temperature and salinity were removed from the model due to concurvity. This analysis was completed using species and phyla abundance, density values were also calculated and displayed on transect maps to visualise the spatial variation of some taxa groups.

2.3 Results

2.3.1 Composition of all taxa

A total of 154,509 individual organisms belonging to 309 megafaunal morphospecies (metazoan and protistan) were identified from ROV video collected aboard the TOSCA expedition (example morphospecies shown in Fig. 2.4 and full species catalogue can be found in the supplementary material), throughout five ROV dives (see Table. 2.1). This is likely an underestimation due to the difficulty associated with identifying megafauna from video, and the potential presence of cryptic species. The five most abundant morphospecies (number of individual organisms observed for each morphospecies (n)) across all five ROV dives were Xenophyophore spp (n= 23,616), a stalked crinoid, possibly Bathycrinidae (Family) sp. (n= 15,952), the Bryozoan *Canda* sp. (n= 13,261), an encrusting Demosponge morphospecies (n= 11,395) and a Holothurian, *Psolus* sp. (n= 11,133). Cnidarians contained the largest number of morphospecies (most of them corals) but were not seen in high abundances (Fig. 2.3), with many species having a rare occurrence, indicating their importance at the CGFZ. Individual Xenophyophores were very frequently observed (n= 23,616) but could only be assigned to a single morphospecies. The echinoderms were also observed in high abundances (n= 40,077).

Table 2.1. Remotely Operated Vehicle dive information.

	ROV05	ROV06	ROV07	ROV08	ROV09
Start Date	25/05/2018	30/05/2018	31/05/2018	01/06/2018	02/06/2018
End Date	30/05/2018	30/05/2018	31/05/2018	01/06/2018	03/06/2018
Start Time (UTC)	14:01:53	6:52:51	0:59:56	0:28:37	11:53:57
End time (UTC)	1:06:06	19:39:27	19:02:13	12:48:18	1:54:31
Start Latitude (at the bottom)	52.46132029	52.3178975	52.3449766	52.3236988	52.2761865
Start Longitude	-31.92992534	-31.606659	-31.4523683	-31.0403533	-31.1969
End Latitude (off the bottom)	52.46610562	52.3668641	52.38680367	52.28240853	52.2586104
End Longitude	-31.99858147	-31.5599112	-31.49370983	-30.98067911	-31.1784563
Start Depth (m)	2533	2870	2199	2965	2412
End Depth (m)	2474	1597	1420	561	1908
Average Temperature (°C)	3.282	3.216	3.569	3.401	3.311
Average Salinity (PSU)	34.932	34.937	34.899	34.861	34.926
Total no. of Organisms	12,234	21,207	45,344	24,629	51,096
Total no. of Morphospecies	197	185	189	199	210

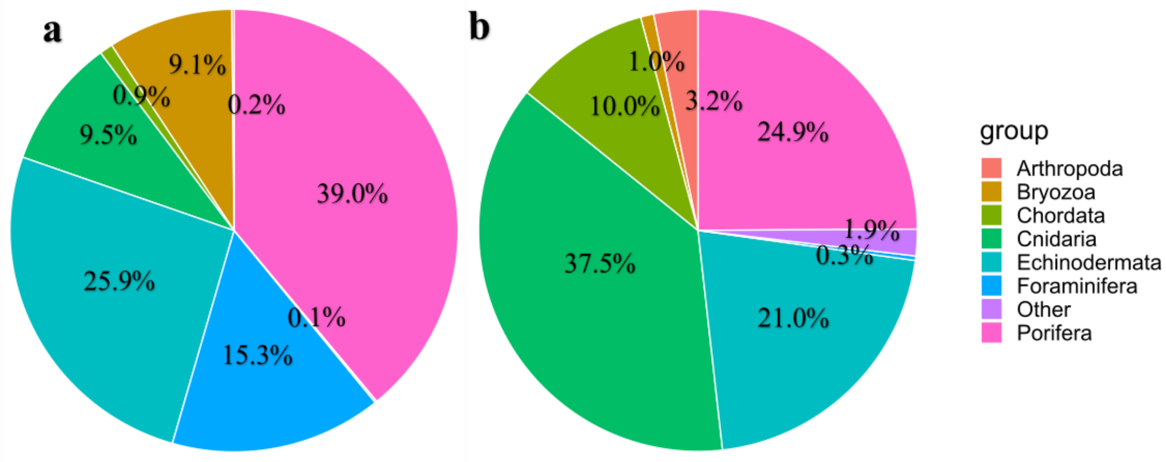


Figure 2.3. Pie charts showing (a) the proportions of individual organisms observed per Phylum and (b) the number of morphospecies per Phylum present in all ROV dives from the TOSCA survey. “Foraminifera” includes one morphospecies of Xenophyophore. “Other” includes Mollusca (Decapodiformes and Bivalvia) and Annelida (Bonellia sp., Sabellidae). Total number of individuals observed (n=154,509) and total number of morphospecies recorded (z=309).

Almost one third of all morphospecies observed in this analysis could be considered rare, with 28% of morphospecies (86 of 309) observed fewer than ten times, and 6% (19 morphospecies) seen only once in all five dives. The phyla that were the most taxonomically rich (number of morphospecies in each group (z)) included cnidarians (z= 116), sponges (z= 77) and Echinodermata (z= 65). Echinodermata consisted of 23 Asteroidea morphospecies, 14 Crinoidea morphospecies, 7 Echinoidea morphospecies, 8 Ophiuroidea and 13 Holothuridea. Chordata had a total of 31 morphospecies, which included only one morphospecies of Tunicate and 30 belonging to Gnathostomata, including morphospecies from Actinopterygii (z= 25), Elasmobranchii (z= 3) and

Holocephali (z= 2). The Phyla with lower morphospecies richness included Arthropoda (z= 10), Bryozoa (z= 3), Foraminifera (xenophyophores) (z=1) and Other (z=6). “Other” includes Mollusca (Decapodiformes and Bivalvia) and Annelida (*Bonellia* sp., Sabellidae), and one organism that could not be identified to Phylum level.

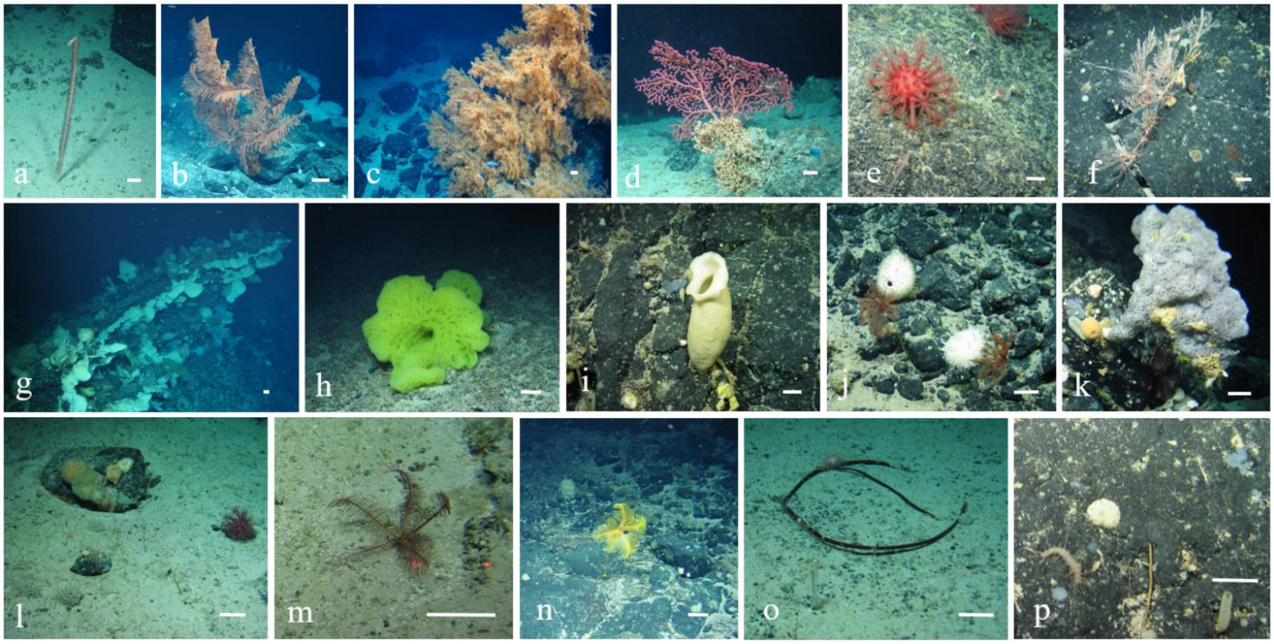


Figure 2.4. Megabenthic fauna of the Charlie Gibbs Fracture Zone. White bar for scale is 100 mm. a) *Balticina* (*Halipteris*) cf. *finmarchica*, b) Antipatharia sp., c) *Leiopathes* sp. with many fish and crustaceans taking refuge, d) *Paragorgia* sp. appears to be attached to *Solenosmilia variabilis*., e) *Anthomastus* sp., f) *Calyptrophora* sp. with multiple ophiuroids attached, g) Dense sponge aggregation observed on Dive 9, h) *Hertwigia falcifera*, (yellow colour morph), i) Hexactinellida sp., j) *Geodia* sp. (top left, white) and cf. *Polymastia corticata* (bottom right, white), k) Hexactinellida sp., l) Three Xenophyophoroidea can be seen in the bottom left with multiple different Demospongiae morphospecies on the boulder, m) Crinoidea, *Pentametrocrinus atlanticus*, n)

Anachalypsicrinus nefertini on bedrock, o) *Echinus* sp. observed in top right, alongside other Echinoidea morphospecies feeding on what appears to be kelp, Bathycrinidae (Family) sp. in bottom left, p) Holothurian, cf. *Synallactes* sp. (bottom left) and *Euplectella* sp. (bottom right).

2.3.2 Biodiversity and spatial patterns

The species accumulation curves for all morphospecies for each 250m depth band (Fig. 2.5c) showed the greatest number of morphospecies were found in three depth bands (1,500-1,749 m, 1,750-1,999 m and 2,000-2,249 m). A variety of substrate types were observed within the CGFZ (Fig. 2.6), and the species accumulation curves associated with each of these showed a higher number of morphospecies on bedrock, which was also the most frequent substrate type (Fig. 2.5b). Boulders and biogenic gravel had the next highest level of species occurrence after bedrock, although biogenic gravel was not sufficiently sampled, as it only covered approximately 6% of the seafloor throughout all five dives. Dive 9 was found to have a slightly higher morphospecies richness, followed by Dive 5 and Dive 8 (Fig. 2.5b). Dive 9, which followed a ridge feature and remained at a relatively constant depth as a result, was found to have a considerably higher ratio of bedrock cover (79%) compared to the other ROV dives (Dive 5 had 27.2%, Dive 6 had 51.6%, Dive 7 had 19.2%, and Dive 8 had 10.7% bedrock) (Fig. 2.7).

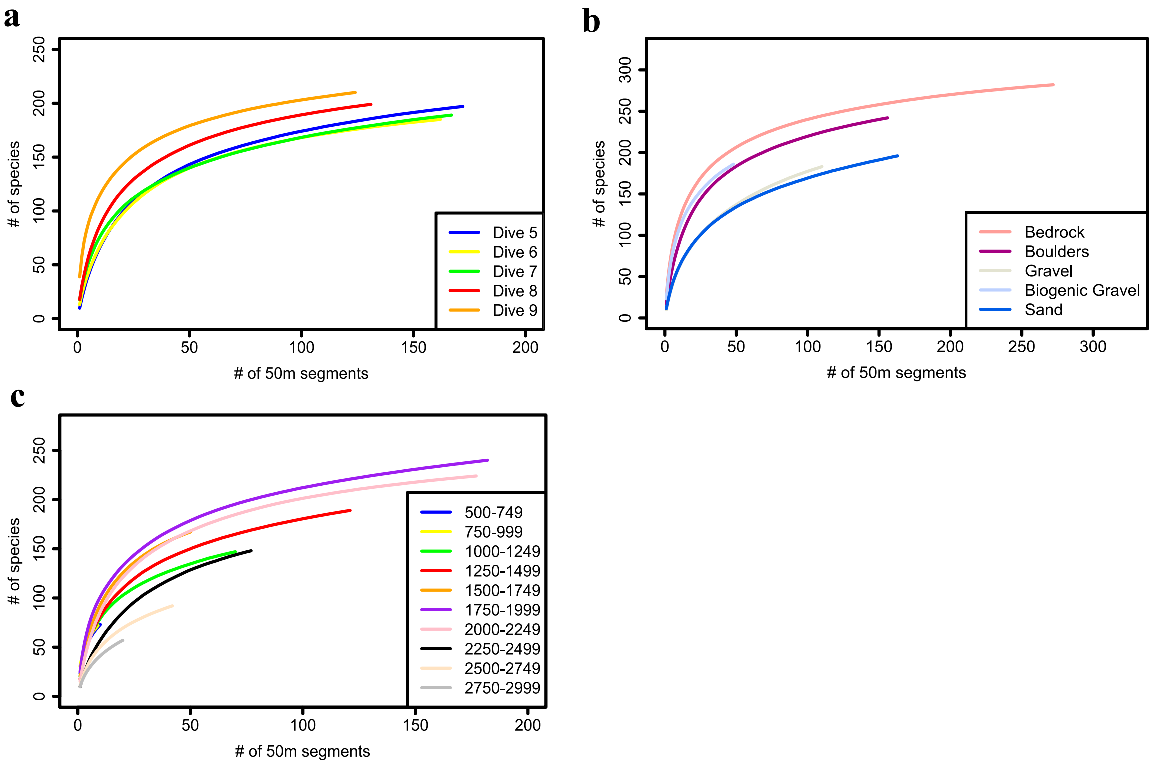


Figure 2.5. (a) Species accumulation curves for all ROV dives (b) for each substrate type (biogenic gravel includes coral rubble) and (c) for 250 m depth bands ranging from 500 m to 2,999 m. Y axes are number of morphospecies observed per 50 m segments; X axes are the number of 50 m segments sampled.

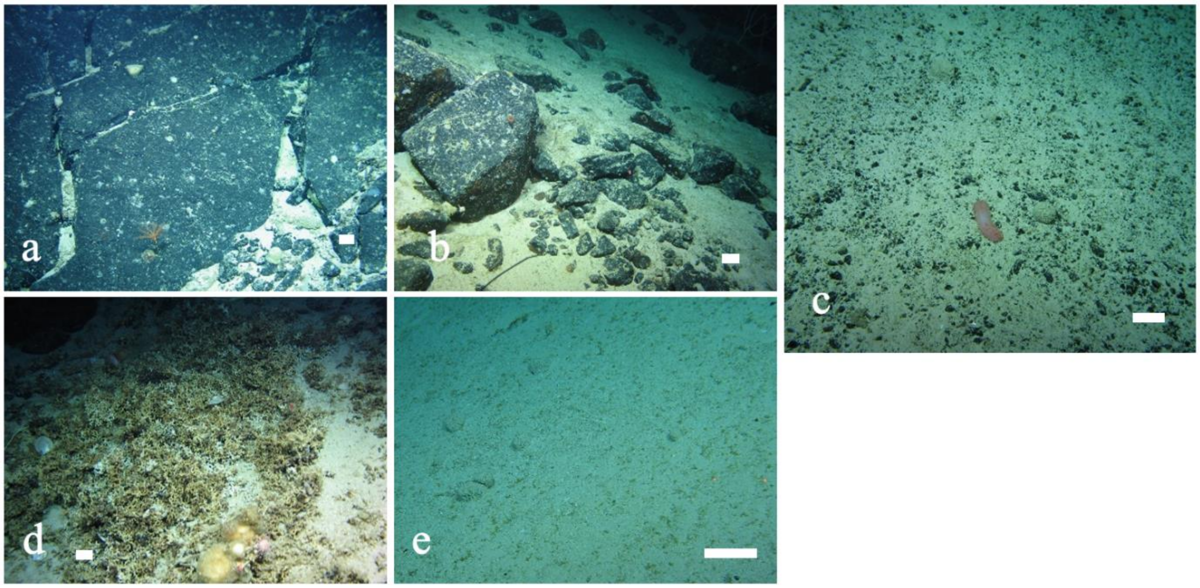


Figure 2.6. Representative images of substrate types at the Charlie-Gibbs Fracture Zone: (a) Bedrock, Dive 9 at approx. 2,200 m, (b) Boulders, Dive 8 at approx. 2,500 m, (c) Gravel, Dive 6 at approx. 2,000 m, (d) Biogenic gravel (includes coral rubble), Dive 5 at approx. 2,500 m, and (e) Sand, Dive 6 at approx. 2,000 m. White bar for scale is 100 mm.

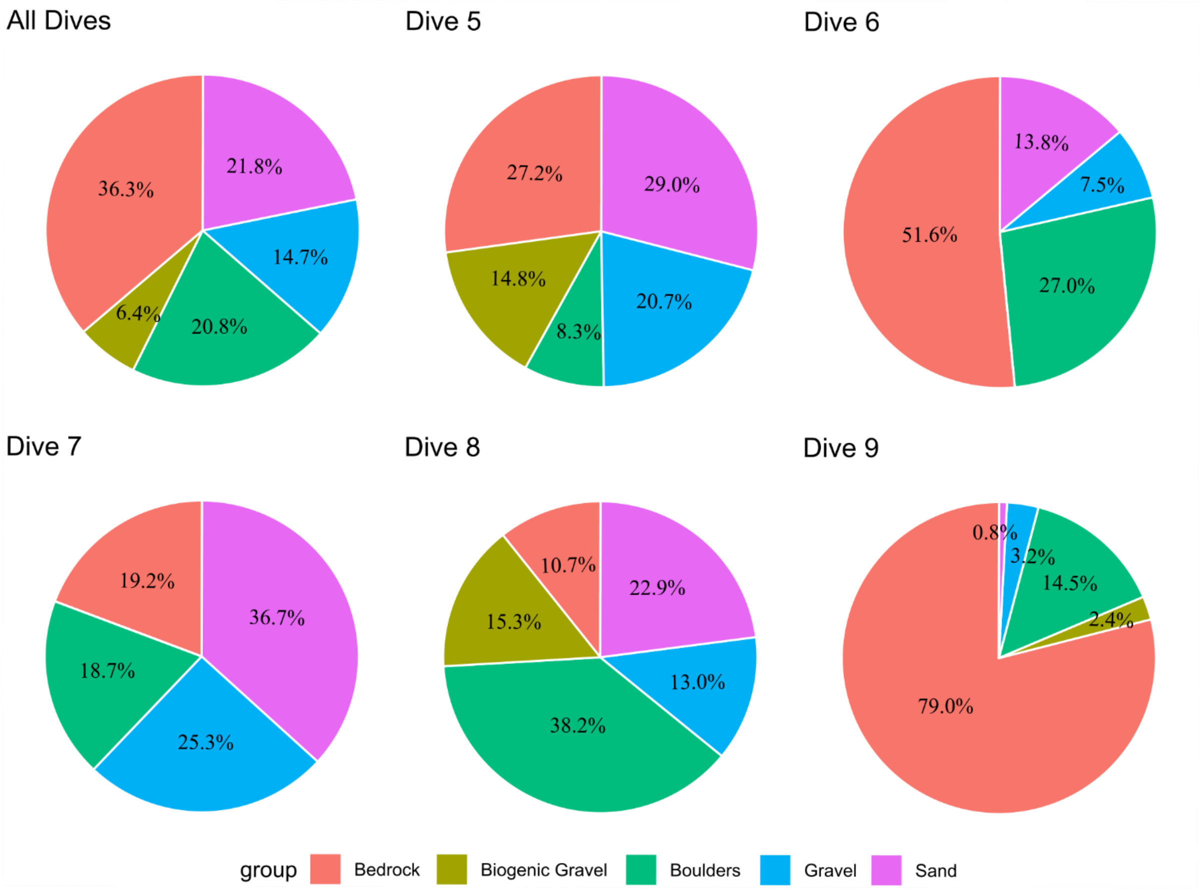


Figure 2.7. Pie charts showing the proportion of substrate types observed for each dive. Biogenic gravel includes coral rubble.

2.3.3 Composition and distribution of corals and other cnidarian morphospecies

In total, 14,631 individual cnidarians were recorded, belonging to 116 morphospecies from the five ROV dives at depths between 564 m and 2,884 m (Fig. 2.4a-f). Octocorallia (Alcyonacea, Pennatulacea) (z= 50) were almost equally as rich taxonomically as Hexacorallia (Antipatharia, Actiniaria and Scleractinia) (z= 54). Recorded morphospecies of Octocorallia included 16 morphospecies of order Pennatulacea and 31 of order Alcyonacea. Hexacorallia morphospecies were composed of orders Antipatharia with 24 morphospecies, Actiniaria with 21 recorded morphospecies, and Scleractinia with 9 morphospecies, including the reef-building *Solenosmilia variabilis* (Fig. 2.4d), observed only below 1,100 m. In addition to these taxonomically rich groups, one Ceriantharia morphospecies and two Hydrozoa morphospecies were recorded. There were likely multiple cryptic species in these groups, but image quality did not allow for further differentiation. A total of 9 morphospecies were not identified past phylum level. Species accumulation curves for cnidarian morphospecies for each depth band (Fig. 2.8a) suggested that the greatest number of morphospecies were found at the same depth bands (1,500-1,749 m, 1,750-1,999 m, and 2,000-2,249 m) as those hosting the highest richness for all species combined (Fig. 2.5). However, the 1,500-1,749 m band would have benefitted from additional sampling. Species accumulation curves for the number of cnidarian morphospecies per substrate type (Fig. 2.8b) showed a higher number of morphospecies on bedrock. Dive 8 exhibited a dense cluster of cnidarians, including scleractinian corals (presumably *Solenosmilia variabilis*), antipatharians (*Leiopathes* sp., *Bathypathes* sp., and *Stichopathes* sp.) and numerous soft coral morphospecies, near the peak of the seamount (Fig. 2.8a). The terrain was noticeably steeper here, with some vertical walls present.

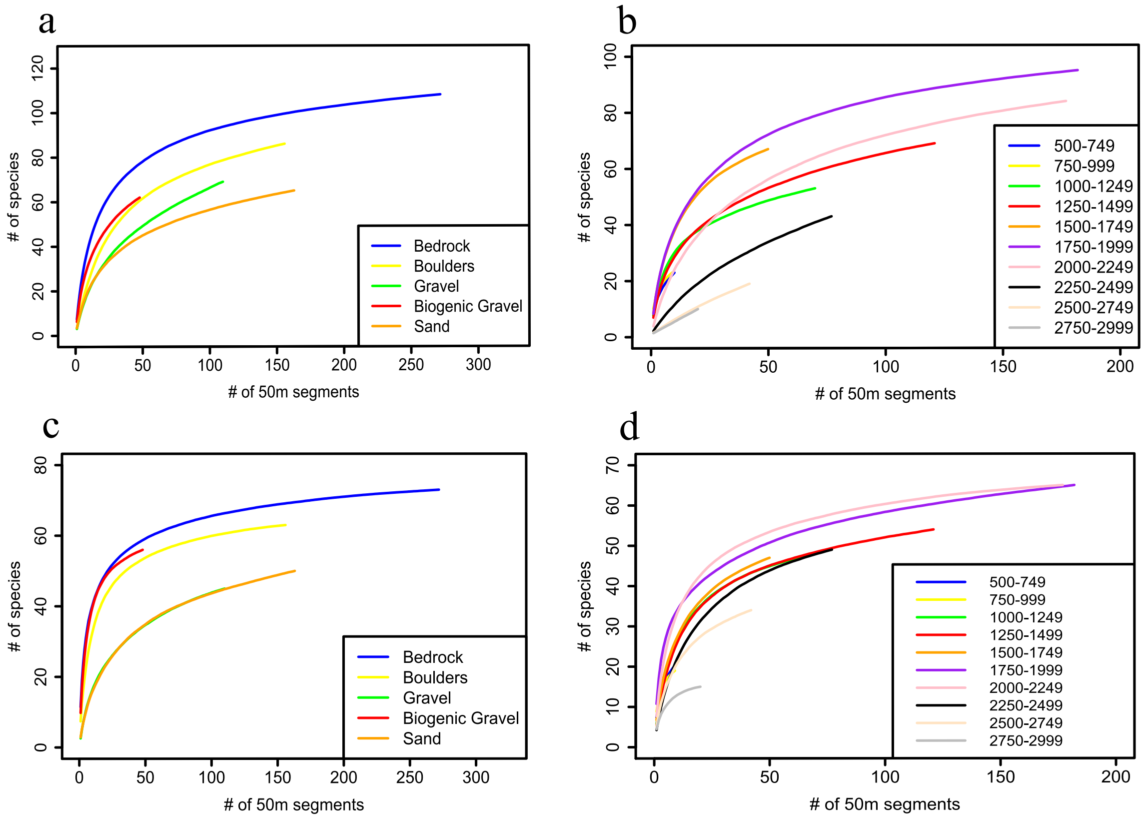
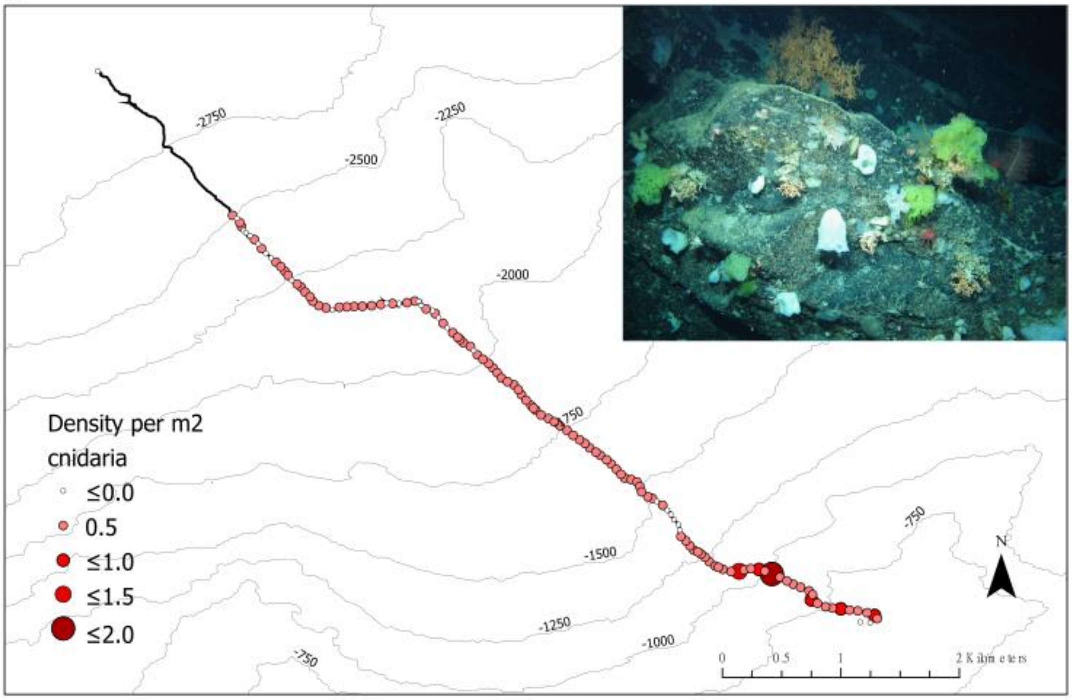


Figure 2.8 Species accumulation curve for cnidarians by substrate type (a), 250 m depth band ranging from 500 m to 2,999 m (b), sponge morphospecies by each substrate type (c) and 250 m depth bands ranging from 500 m to 2,999 m (d). Y axes are the number of species; X axes are the number of 50 m segments. Biogenic gravel includes coral rubble.

a


-2750
-2250
-2500
-2000
-1750
-750
-1500
-1250
-1000
-750
Density per m2
cnidaria
○ ≤0.0
● 0.5
● ≤1.0
● ≤1.5
● ≤2.0
N
0 0.5 1 2 Kilometers

b

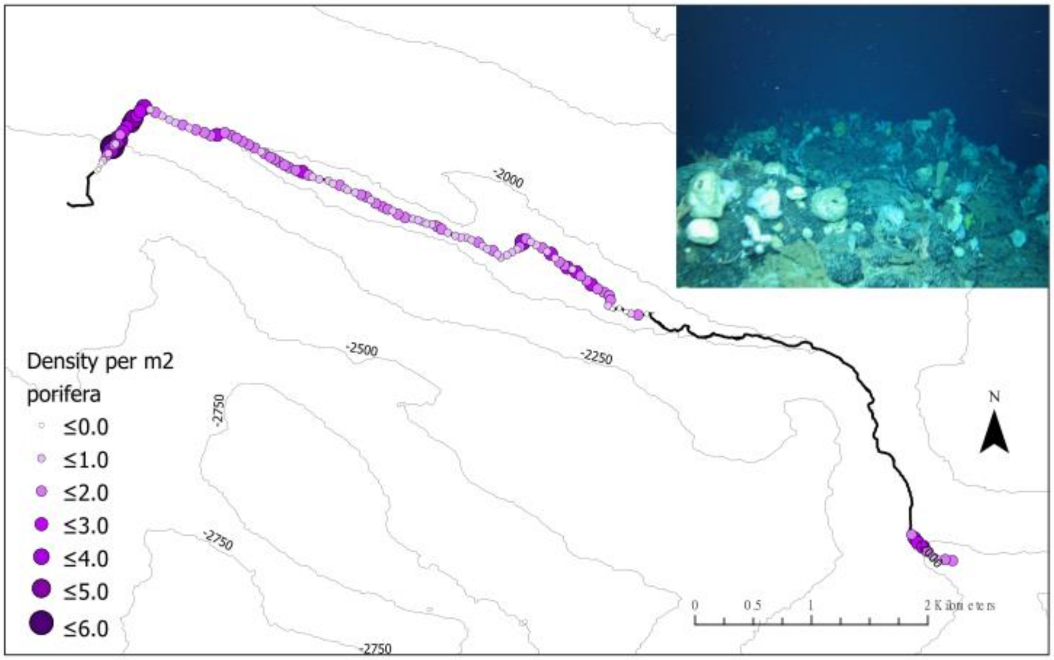

-2000
-2500
-2250
-2750
-2750
-2750
-1000
Density per m2
porifera
○ ≤0.0
● ≤1.0
● ≤2.0
● ≤3.0
● ≤4.0
● ≤5.0
● ≤6.0
N
0 0.5 1 2 Kilometers

Figure 2.9 (a) Bubble transect plot showing cnidarian densities on Dive 8 (Hecate seamount) and (b) sponge densities on Dive 9 (ridge feature). Image inserts show the areas on each transect with high densities of cnidarians and sponges. Each circle represents cnidarian/sponge observations for a 50 m section of the transect. White circles represent 50 m sections with no observations. No circles present represent the sections of the transect where visibility was too poor to annotate. These sections were removed from the analysis. Density values refer to number of cnidarians/sponges per m^2.

2.3.4 Composition and Distribution of sponges

A total of 60,280 individual sponges were recorded. Of the 77 morphospecies, 35 belonged to the demosponges and 27 morphospecies were within the hexactinellids (Fig. 2.4g-k). The remaining sponge morphospecies could only be identified to phylum level. Sponges made up a total of 39% of the individual organisms observed in this study. Species accumulation curves for sponge morphospecies showed that the greatest number of morphospecies were observed on bedrock, closely followed with biogenic gravels and boulders (Fig. 2.8c) and higher number of morphospecies were found in two depth bands (1,750-1,999 m and 2,000-2,249 m) (Fig. 2.10b). As could be expected for this taxa, sand and gravel had considerably lower numbers of morphospecies.

A dense sponge aggregation was observed spanning most of Dive 9 (Fig. 2.9b), between 2,400 and 1,820 m depth, and supporting many other benthic invertebrates, such as Ophiuroids, Crinoids, Bryozoans and Arthropods. Here, sponge densities were > 3 sponges per m^2 for almost 250 m of ROV transect (Fig. 2.9b).

2.3.5 Environmental Effects

Depth and slope had statistically significant effects on the Shannon-Wiener H-index (p-value of <0.0001). Shannon-Wiener H-index increased with depth down to a maximum at around 1,200 m, followed by a decline until 2,200 m (Fig. 2.10a). The Shannon-Wiener H-index increased steadily with increasing slope and then leveled off at a slope value of about 30° (Fig. 2.10b). This index was also significantly related to bedrock, gravel, and sand (<0.0001, Table 2.2). The Shannon-Wiener H-index increased with increased bedrock cover and it decreased with increased gravel and sand cover. Depth and slope also had significant effects on species richness (p-value of <0.0001). Species richness exhibited a continuous decline with depth, below approximately 1,100 m, but showed a steady increase as slope values increased (Fig. 2.10c, d). Species richness was significantly related to bedrock, gravel, and sand (<0.0001, Table 2.2). Similarly to the Shannon-Wiener H-index, it increased with increased bedrock cover and decreased with increased gravel and sand cover.

Depth significantly affected Pielou's evenness (p <0.0001) as well as slope with (p= 0.013) (Table. 2.2); Pielou's evenness started to increase slightly at about 1,400 m, then dropped and started to climb again at 2,250 m depth (Fig. 2.10e, f). Only sand was significant for Pielou's evenness (p <0.0001). Abundance by phyla slightly decreased with depth, except for Foraminifera (xenophyophores) which exhibited a sharp decline at about 2,250 m. Bryozoa exhibited a slight increase as depth decreased from about 1,000 m (Fig. 2.10g). Foraminifera exhibited distinct preferences for depth and slope in comparison to the remaining phyla as they decreased more rapidly at depths below 2,250 m and beyond slopes of 20°. Taxon abundance significantly changed with boulder, gravel, and sand cover ($p<0.0001$), where it decreased with increasing cover by these substrate types.

Table 2.2. Model summary table for parametric and smooth terms of final models. Intercept term corresponds to the "Bedrock" substrate level.

Shannon-Wiener H-index				
Term	**Estimate**	**Std. Error**	**Z Value**	**P-Value**
(Intercept)	1.924	0.273	7.055	<0.001
Biogenic gravels	0.02	0.1	0.201	0.841
Boulders	-0.095	0.061	-1.553	0.121
Gravel	-0.669	0.073	-9.185	<0.001
Sand	-0.598	0.066	-9.027	<0.001
Term	**EDF**	**Ref DF**	**Chi.sq**	**P-Value**
s(depth)	5.428	6.607	8.185	<0.001
s(slope)	3.564	4.414	7.547	<0.001
t2(coords.x1, cords.x2, dive)	6.711	46	6.603	<0.001
Species Richness				
Term	**Estimate**	**Std. Error**	**Z Value**	**P-Value**
(Intercept)	3.105	0.266	11.68	<0.001
Biogenic gravels	-0.044	0.088	-0.503	0.615
Boulders	-0.084	0.055	-1.542	0.123
Gravel	-0.413	0.069	-6.02	<0.001
Sand	-0.432	0.062	-6.962	<0.001
Term	**EDF**	**Ref DF**	**Chi.sq**	**P-Value**
s(depth)	4.278	5.339	73.28	<0.001
s(slope)	3.884	4.809	60.094	<0.001
t2(coords.x1, cords.x2, dive)	6.938	46	399.198	<0.001
Taxon Abundance				
Term	**Estimate**	**Std. Error**	**Z Value**	**P-Value**
(Intercept)	3.986	3.647	1.093	0.274

Biogenic gravels	0.027	0.133	0.203	0.839
Boulders	-0.353	0.078	-4.536	<0.001
Gravel	-0.424	0.096	-4.418	<0.001
Sand	-0.341	0.087	-3.916	<0.001

Term	**EDF**	**Ref DF**	**Chi.sq**	**P-Value**
s(depth)	39.502	47	1520.515	<0.001
s(slope)	31.916	47	292.103	<0.001
t2(coords.x1, cords.x2, dive)	6.938	46	536.547	<0.001

Pielou’s Evenness

Term	**Estimate**	**Std. Error**	**Z Value**	**P-Value**
(Intercept)	-0.64	2.491	-0.257	0.797
Biogenic gravels	-0.018	0.056	-0.318	0.75
Boulders	-0.031	0.034	-0.932	0.351
Gravel	-0.085	0.041	-2.078	0.038
Sand	-0.157	0.037	-4.26	<0.001

Term	**EDF**	**Ref DF**	**Chi.sq**	**P-Value**
s(depth)	7.232	8.233	69.513	<0.001
s(slope)	3.951	4.882	14.851	0.013
t2(coords.x1, cords.x2, dive)	15.62	64	383.583	<0.001

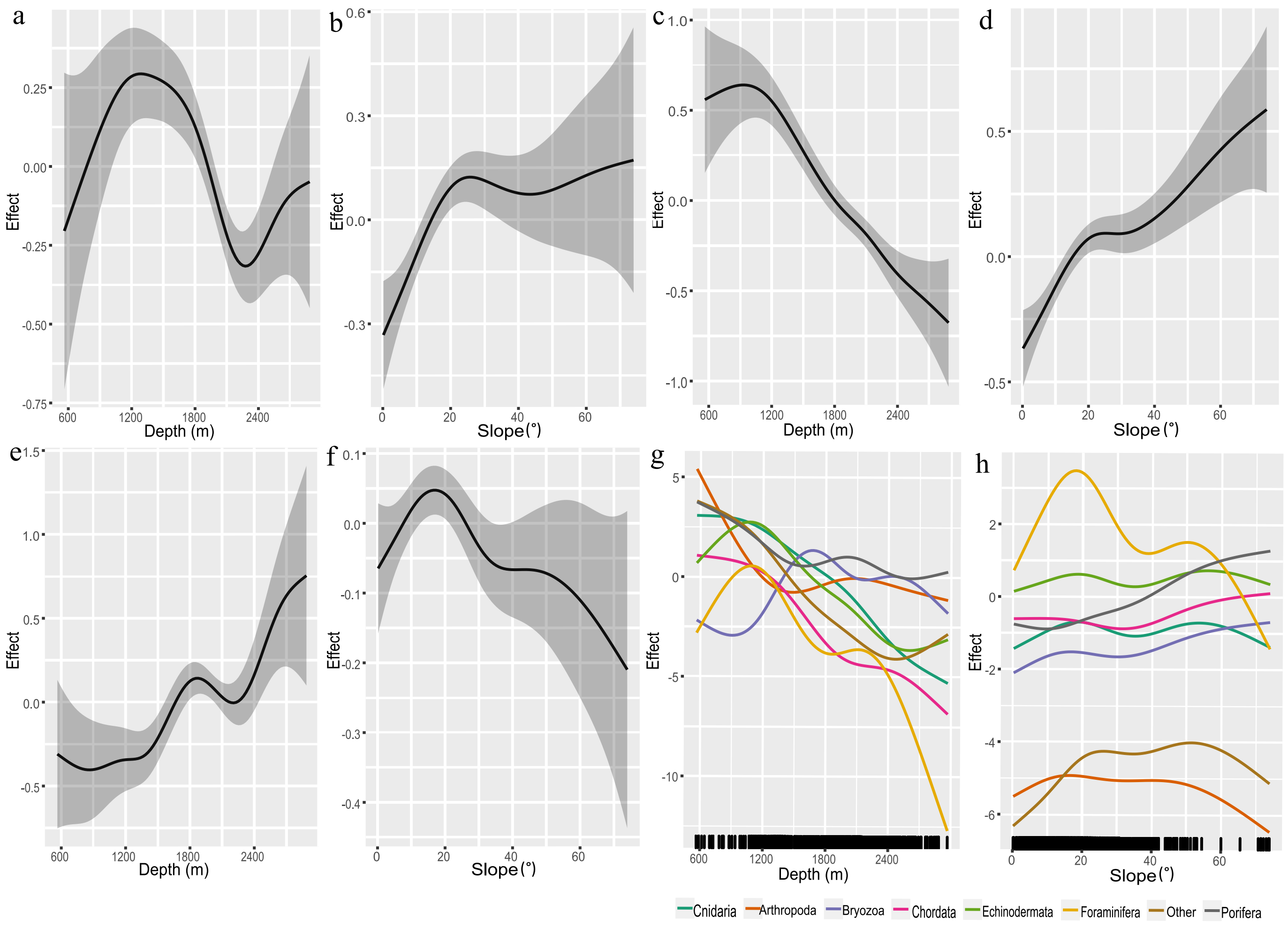


Figure 2.10. Smooth effects plots from each model. Depth and slope (on X axes) smooth for Shannon-Wiener H-index (a, b), species richness (c, d), Pielou's evenness (a, f), and abundance by phyla (g, h). Hashing on the x axis of g and h refers to number of sample points.

2.4. Discussion

Based on ROV video analysis of five transects at the CGFZ, higher levels of morphospecies biodiversity tended to occur at depths between 1,500-2,249 m and in areas characterised by bedrock and steeper slopes. Cnidarians showed the highest richness while sponges showed the highest number of individuals. A total of three Vulnerable Marine Ecosystem (VME) types were encountered, including coral and sponge gardens, and xenophyophore fields. A particularly dense sponge aggregation was observed throughout the ridge feature on dive 9.

2.4.1 Biodiversity patterns

Environmental factors, such as water mass transitions and currents present at around 2,000 m on the CGFZ may contribute to the increased biodiversity observed at 1,500-2,249 m. The CGFZ acts as a channel for the transport and western movement of deep water from the eastern North Atlantic (Racapé et al., 2019; Schott et al., 1999; Shor et al., 1980), including the Iceland-Scotland Overflow Water (ISOW) driven west through the CGFZ by the Deep Northern Boundary Current (Read et al., 2010; Saunders, 1994). Recent studies have examined the impacts that currents have on the biodiversity of the deep-sea benthic ecosystems of the North Atlantic (Johnson et al., 2013; Mohn et al., 2014). These have found that currents play an important role in the lateral transport of food particles at depths below 200 m, especially in areas where primary production may be lacking (Puerta et al., 2020). This has been suggested as leading to the increased occurrence of deep-sea suspension and filter feeders, such as corals and sponges, in highly hydrodynamic areas (Johnson et al., 2013; Mohn et al., 2014; Puerta et al., 2020). Boundaries between water masses have also been described as important regions for the redistribution of food particles to the deeper layers of the water column when internal waves at the interface of the two water masses mix and move particles down below the boundary layer (Puerta et al., 2020; White et al., 2005), or become trapped at the pycnocline and get moved around by internal waves (Dullo et al., 2008). The location of nepheloid layers, defined as elevated concentrations of suspended particulate matter in the water column, can also be affected by local hydrodynamics and the dominant current systems (Wilson et al., 2015). Past studies showed that below the 2,000 m mark, the CGFZ is filled mainly with ISOW which carries a substantial load of suspended sediment and is said to create a mid-water nepheloid layer at about 2,200 m depth (Schott et al., 1999; Shor et al., 1980). Water mass properties are important factors when considering the occurrence of coral gardens and sponge aggregations and have been suggested as a likely environmental driver in many recent studies (Amaro et al., 2016; Howell et al., 2016; Lacharité & Metaxas, 2018; Mohn et al., 2014; Puerta et al., 2020).

There were higher levels of species diversity found on areas of hard substrates (bedrock and boulders), which is a well documented pattern in the deep sea (Bell et al., 2016; Edinger et al., 2011; Orejas et al., 2009; Robert et al., 2014; Ross & Quattrini, 2007). Hard substrates are favourable for sessile filter feeders such as sponges, and suspension feeders such as corals and stalked crinoids, as they provides a stable attachment surface for optimal food capture (Bell et al., 2016; Mortensen et al., 2008). Dive 9, which exhibited the highest species richness, followed a ridge feature and so the depth remained relatively constant, and was dominated by bedrock. The expanse of hard-substratum combined with the likely local-scale topographic interaction with bottom currents (Grigg, 1997; Mortensen et al., 2008) appears to create an ideal environment for an extensive sponge aggregation (Fig. 2.9b) and coral gardens in the area.

Comparable levels of biodiversity were also observed in areas of biogenic gravels. Many studies have previously highlighted the association between naturally occurring coral rubble and high levels of biodiversity (Appah et al., 2020; Henry & Roberts, 2007; Jonsson et al., 2004). A recent study found the percentage cover of colonial benthic megafauna in the Porcupine Bank Canyon to be four times higher for coral reef and rubble compared to non reef habitat (Appah et al., 2020). Accumulations of scleractinian coral rubble were observed at several locations on the CGFZ. Judging from the depths at which they were found (Dive 7 shallowest point was 1,420 m), it could be *Solenosmilia variabilis* rubble as this was the only reef-forming scleractinian coral recorded in this study area, possibly destroyed by a slope collapse in the region. However, a recent geological expedition to the CGFZ (*R/V A. N. Strakhov* Expedition S50) discovered an abundance of fragments of fossil corals by dredging at 1,000 m depths and identified them as solitary *Desmophyllum dianthus* (Skolotnev et al., 2021).

2.4.2 Cnidarians of the CGFZ

Reports published following the MAR-ECO project have provided details on the cnidarian occurrences for certain regions of the Mid Atlantic Ridge, mainly between the southern part of the Reykjanes Ridge and the Azores (Mortensen et al., 2008). This MAR-ECO survey collected ROV video as well as trawl samples from sites north-west and south-east of the CGFZ. Only two morphospecies of Antipatharia were reported from the MAR-ECO data compared to 26 morphospecies observed in the current study, including five genera well known to the deep-sea ecosystems of the North Atlantic, *Stauropathes*, *Stichopathes*, *Leiopathes*, *Parantipathes* and *Bathypathes*. The only reef-forming scleractinian coral recorded during the TOSCA expedition was *Solenosmilia variabilis,* observed below 1,100 m, which aligns with previous studies detailing the depth ranges of *Desmophyllum pertusum* (found no deeper than 1,100 m) and *Solenosmilia variabilis* (found no shallower than 1,100 m) (Henry & Roberts, 2014; Howell et al., 2014). With 37 morphospecies from order Alcyonacea and 16 from Pennatulacea, these groups were again found to be much more diverse than previously reported for the region, with only 27 morphospecies within Octocorallia previously reported (Mortensen et al., 2008). ROV video quality has improved since the MAR-ECO expedition (Mortensen et al., 2008), and there is now a larger wealth of online species catalogues to aid in identification. The MAR-ECO surveys also had limited sampling of corals, and more than half (24 out of 41) of the morphospecies observations were made from bycatch on longlines and trawls (Bergstad & Gebruk, 2008; Mortensen et al., 2008). However, taking this into account alongside the current regime and the topographical complexity (including a seamount and ridge feature) of the CGFZ, it is possible that the benthic ecosystems between the parallel transform faults of the CGFZ contain a heightened level of biodiversity, specifically species richness, compared to the sites north and south of the CGFZ that were sampled during the MAR-ECO expeditions.

A higher level of cnidarian morphospecies occurrence was found on bedrock, which supports previous studies that found higher species richness for corals on hard substratum on the MAR (Mortensen et al., 2008; Watanabe et al., 2009). Mortensen et al. (2008) found that the number of coral taxa present in their study was strongly correlated with the percentage cover of hard substrates. A more recent study, focussing on similar areas on both sides of the CGFZ, found that although coral species richness increased with the hard substrate availability, coral abundance did not (Bell et al., 2016). Bell et al. (2016) found large areas of bedrock uninhabited by megafauna, a pattern also observed during Dive 7 of the TOSCA survey. From visual observations, much of Dive 7 appeared to have less marine snow (suspended organic detritus) compared to other dives in the region. There was an obvious lack of visible epifauna on many of the exposed bedrock and boulder fields, in comparison to the other dives with similar bedrock and boulder substratum. We hypothesize that the seemingly reduced amount of marine snow observed during Dive 7 might be a result of the orientation of the site with respect to the currents in this region, leading to a lack of visible benthic megafauna which rely on this as their primary food vectors.

2.4.3 Sponges of the CGFZ

The dense sponge aggregation observed during Dive 9 (Fig 2.4g., 2.9b) may be an important ecosystem engineer for the CGFZ. Even though deep-sea sponge aggregations are not as well known as their shallow-water counter parts, certain species have been found to provide important functional roles for other benthic fauna, which includes acting as complex three-dimensional habitats (Beazley et al., 2015; Howell et al., 2016;

Maldonado et al., 2017). The sponge aggregation observed on the CGFZ was dominated by demosponges and may be referred to as an ‘ostur’ or ‘cheese-bottom’, which is a term coined by Klitgaard & Tendal (2004) and defined as “a restricted area where large-sized sponges are strikingly common’’ (Klitgaard & Tendal, 2004). They described what is known as a “boreal ostur”, which occurs in areas including the Faroe Islands, Norway, Sweden, parts of the western Barents Sea and south of Iceland. Similar sponge ground compositions have been recorded on the Flemish Cap and the Grand Banks of Newfoundland in the Northwest Atlantic, including multiple species of *Geodia* sp. with encrusting Demosponge epibionts (Murillo et al., 2012, 2016). These are comparable, in terms of species composition and temperature range, to the osturs in the Northeast Atlantic (Murillo et al., 2016). Considering the geographic location of the TOSCA survey, just south of the Reykjanes Ridge, this sponge aggregation can also be considered as a boreal ostur. The presence of this type of sponge aggregation may also be driving the high levels of biodiversity observed in Dive 9, as the ostur may be acting as an ecosystem engineer, providing a complex three-dimensional habitat. No studies have previously examined the presence of this kind of sponge ground on the CGFZ.

The CGFZ has also been considered as a biogeographic transition zone for demosponges of the North Atlantic, as numerous species were found to have morphological differences due to limited gene flow between populations north and south of the fracture zone (Cárdenas & Rapp, 2015). One study described the variation in demosponge density at sites northeast, northwest, southeast and southwest of the CGFZ and found that the highest densities lay to the north of the fracture, and slightly higher densities again at the

Northwest site (Bell et al., 2016). These demosponge densities were, however, much lower than what we recorded, with highest densities of over 6 sponges per m^2 in this study. This could have an impact on the level of protection this region of the CGFZ may be granted in the future, as osturs are recognised as ecosystem engineers (Beazley & Kenchington, 2015).

2.4.4 Xenophyophores

The presence of large aggregations of the giant protists, Xenophyophores, on gently sloping sandy areas was notable as previous studies have found them to provide for refuge, feeding and mating sites for other deep-sea species (Gooday et al., 1992; Levin et al., 1991; Levin & Rouse, 2020). Their morphology is adapted specifically to trap particles from the water column to form their tests or to feed on (Levin et al., 1991). This in turn makes them attractive dwellings for small invertebrates and they have been described as biodiversity hotspots when found in large aggregations on sediments (Gooday, 1986; Levin et al., 1991). A recent study has even revealed that Xenophyophores can act as fish nurseries (Levin & Rouse, 2020). Xenophyophores were numerous in individual abundances (with densities of up to 6 individuals per m^2), despite only one morphospecies being identified, and they are expected to play a functional role in habitat provisions for the sandy regions of the CGFZ.

Based on results from the HGAM and species accumulation curves, the lowest diversity and richness was recorded in sandy regions of the CGFZ, but Xenophyophores likely harbour high levels of diversity within their structures (Gooday, 1986; Levin et al., 1991), which is difficult to observe from ROV video alone. Therefore, future research in this region should sample Xenophyophores and macrofauna to better understand their taxonomic diversity and role in structuring the biodiversity at the CGFZ.

2.4.5 Possible Anthropogenic Stressors on the benthic environment of the CGFZ

Evidence of anthropogenic disturbance was observed in the CGFZ and was especially evident during the Hecate seamount dive (Dive 8) which spanned a depth range of 2,340 m from the start point of 2,900 m to its peak at 560 m. A large fishing net was observed on the seamount at 800 m depth on a relatively steeply sloping bedrock, overlain with sand in some regions. The net appeared relatively new, with little to no biofouling, and it was observed close to large patches of dead hexactinellid sponges. It is uncertain whether the dead sponges were due to the impacts of previous trawl fishing, slope collapses on the seamount, or a combination of both factors. In addition to this, five glass bottles and a plastic bag were observed on the seamount, in comparison to only one bottle observed on Dive 5, a large cable on Dive 6, and one cable observed on Dive 9. At the seamount's peak, the fish *Hoplostethus atlanticus*, an endangered species (also known as Orange Roughy, see species catalogue in supplementary material), was observed. In the past, extensive Orange Roughy fisheries were conducted on the MAR, but these have since declined due to overexploitation and subsequent management by NEAFC and the EU (Bergstad, 2016). There is still a small fishery for Orange Roughy being conducted on Faraday Seamount by the Faroe Islands as per the OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) report on Seamounts (Kutti et al., 2019), but none are reported for the Hecate Seamount. Seamounts in the OSPAR maritime area are presumed to function as nurseries, feeding and spawning areas for a number of commercially important and threatened deep-sea fish species (Hareide & Garnes, 2001; Kutti et al., 2019). Regulating fishing activity where VMEs are present such as this site is important to preserve these, and other ecosystem functions associated with VMEs.

2.5 Conclusions

The CGFZ is highly diverse, both bathymetrically and biologically. The taxonomic composition and spatial distribution of ecologically important, e.g. habitat-forming, megafaunal groups on the CGFZ are driven by multiple environmental factors including substrate type, slope, and depth gradients. This study will help to direct ecologically driven sampling efforts on the CGFZ in the future for a better understanding of the rare and vulnerable species that are present. The confirmed presence of a boreal ostur, coral gardens, xenophyophore aggregations and other seamount species (Orange Roughy as an example) are important observations as the protection status of this region of the CGFZ will come into debate in the coming years. This study provides a detailed insight into the megafaunal biodiversity, its spatial variation, and their potential environmental drivers within the CGFZ North MPA, which is still only partially protected, leaving the seafloor vulnerable to exploitation. In conjunction with this study, morphospecies observations derived from video analysis were submitted to the ICES VME data call 2021 to be added to a database on the deep-sea ecosystems of the North Atlantic. We suggest this species data and biodiversity descriptions should be used in the future decisions made when reviewing the protection of this remote and topographically unique region of the North Atlantic.

2.6 References

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3 Vulnerable Marine Communities of the Charlie Gibbs Fracture Zone

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Abstract

Vulnerable Marine Ecosystems (VMEs) and their indicator species have historically been used to identify ecologically important areas of the marine environment. These definitions have been particularly important for Areas Beyond National Jurisdiction (ABNJ), where data on the benthic habitats is lacking. However, there still lacks a coherent and detailed definition for VMEs that goes beyond the recognition of their indicators. This study utilises ROV video from the CGFZ, a transform fault with multiple topographical features including a seamount, multiple knolls and a ridge, collected on the TOSCA survey in 2018. We conducted a community analysis from the species observations and determined the environmental factors which influence the composition and spatial variation of the megabenthic communities. Eight distinct communities were identified, each with varied species composition, substrate type, and depth ranges. Community 1, which contained species such as hexactinellid sponge *Hertwigia falcifera*, the black coral *Stichopathes* sp., soft corals like *Anthomastus* sp., and scleractinians *Solenosmilia variabilis*, had the highest species richness and to our knowledge, is unique to the CGFZ. The eight communities are defined as VMCommunities, following the recommendations of Watling and Auster (2021) as they each contain multiple VME indicator species and distinct environmental conditions. The VMCommunities are found within four topographical features, the Hecate seamount, two knolls and a ridge feature, which are defined here as VMEcosystems. The results from this study will help to inform the decisions that will be made on the protection status of the CGFZ.

3.1 Introduction

Areas Beyond National Jurisdiction (ABNJ) refer to all ocean which lies past the 200 nautical mile boundary of the Economic Exclusion Zones (EEZ) of each sovereign state (Smith & Jabour, 2018). The benthic communities in these regions remain largely understudied. This is mainly due to the barriers in data collection for ABNJ, which include the cost of offshore surveys, as well as the added remoteness and constraints to sampling once offshore (e.g., weather and equipment failure). Without adequate data, implementing protective measures for benthic habitats is difficult and often nonexistent for ABNJ (Evans et al., 2015). Mapping the presence, abundance, and the environmental conditions of ecologically important species, such as habitat-forming corals and sponges, in remote regions of the deep sea is a first step in creating and monitoring Marine Protected Areas (MPAs), and can help with predicting the distribution of sensitive ecosystems (Orejas et al., 2020).

The designation of Vulnerable Marine Ecosystems (VME) is *currently* an important conservation tool when it comes to the protection of diverse ABNJ. There are a number of organizations which define a VMEs characteristic differently, including the FAO (Food and Agricultural Organization), the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and the Convention on Biological Diversity (CBD). Some of the described characteristics overlap and are common to all the organizations' identification criteria, for example fragility, and habitat forming (see Chapter 1. of thesis) (Ardron et al., 2014; Burgos et al., 2020). Specific species which help to identify VMEs are termed VME indicator species (Morato et al., 2018). For example, an observation of *Paragorgia arborea*, can be used to predict the presence of a hard bottom gorgonian coral garden VME (Auster et al., 2013). The specific parameters depend on the region and the species in question, and not all have defined density thresholds. ICES (International Council for the Exploration of the Sea) hosts a data portal for the distribution and abundance of VMEs and VME indicators, and hold regular workshops to attempt to refine and update the lists of VMEs and their indicators (ICES, 2016). Presently known VMEs include, but are not limited to, cold-water coral (CWC) reefs, coral gardens, sponge aggregations, and Xenophyophore fields (ICES, 2016).

The identification of VMEs and VME indicator species has been historically important for the management of fisheries and policy decisions made on high seas fisheries. The use of the VME definition has helped to develop international guidelines. For example, in the FAO *International Guidelines for the Management of Deep-sea Fisheries in the High Seas*, one of the main principles is the prevention of adverse impact to VMEs which have been identified in ABNJ (FAO, 2009). Moreover, one of the recommendations from these guidelines is for improved data collection on VMEs and the impacts that fishing is having on their status (Bensch et al., 2009; Davies et al., 2017; FAO, 2009). NAFO (Northwest Atlantic Fisheries Organization) has been taking precautionary practices to protect potential sites where VMEs are likely present in the North Atlantic High Seas. In ABNJs, sites which are protected include many of the named seamounts of the North Atlantic High Seas, including the Milne, Altair, and Antialtair seamounts (Smith & Jabour, 2018). These are currently surveyed and closed to bottom-fishing as per the OSPAR report on seamounts of the North East Atlantic (Kutti et al., 2019). Seamounts are viewed as likely harboring VME indicator species, as per the North East Atlantic Fisheries Commission (NEAFC) and OSPAR report on the bottom fishing areas in ABNJs in the north Atlantic (OSPAR & NEAFC, 2015).

The process of identifying a VME or VME indicators to establishing a protected area has previously relied on very generalized recommendations from the United Nations General Assembly (UNGA), which called on the regional fisheries management organizations to identify the locations of VMEs and act to prevent direct adverse impacts from anthropogenic activities (Burgos et al., 2020; Vierod et al., 2014). Recent work has been done to combine the varying identification criteria from different organizations (FAO, CCAMLR, and the CBD) to produce a standardized approach for the identification and protection of VMEs using a 10-step framework (Ardron et al., 2014). Steps within this framework include but are not limited to: considering areas that are already recognized for their potential ecological importance (e.g., seamounts and areas of high relief topography), gathering information on the distributions of likely VMEs and VME indicator species alongside their environmental data, and compiling information on identified or likely fishing area and impacts (Ardron et al., 2014).

Even with this improved framework for the identification of VMEs, there still lacks a coherent and detailed definition for VMEs that goes beyond the recognition of their indicators. Watling & Auster (2021) put forward the concept of identifying several potentially Vulnerable Marine Communities (VMCommunities) within a larger VMEcosystem (which encompasses a larger topographic feature, such as a seamount) instead, as it better describes vulnerable deep-sea areas. This also lines up better with community analysis methods which are often applied for the examination and interpretation of deep-sea ecological data (Bridges et al., 2021; Meyer et al., 2020). Defining VMCommunities could create a more coherent system in the description and mapping of benthic communities in ABNJ that goes beyond the mapping of individual VME indicator species (Watling & Auster, 2021).

One area in the North Atlantic, which has not yet been surveyed for the presence of VMEs or their indicator species is the CGFZ (but see Chapter 2). The CGFZ currently lies well beyond the EEZ of any state, offsetting the Mid Atlantic Ridge (MAR) by 340 km with two left-lateral transform faults which are connected by a 40 km wide gap, also known as the intra-transform spreading center (Skolotnev et al., 2021). The CGFZ is characterized by multiple large oceanic core complexes, which only form at slow spreading oceanic plate boundaries that have a limited supply of upwelling magma, such as at the MAR (Georgiopoulou et al., 2018; MacLeod et al., 2009; Skolotnev et al., 2021). There is only one named seamount on the fracture zone itself, the Hecate seamount (358 km^2 surface area) (Hestermeyer et al., 2012). As this fracture zone is topographically unique (it includes north-south (CGFZ) and east-west (MAR) bathymetric barriers), and creates a north-south oceanographic boundary between differing water masses (Alt et al., 2019; Priede et al., 2013; Read et al., 2010), it has been recognized as an important biogeographical boundary in the North Atlantic (Gebruk & Krylova, 2013). These attributes create a unique and possibly ecologically important habitat for sessile benthic megafauna and associated communities.

The CGFZ was highlighted as a significant conservation area in the North Atlantic when one of the first High Seas MPA was proposed for establishment in 2012, the CGFZ MPA (Smith & Jabour, 2018). However, due to an outstanding application by Iceland to extend the boundaries of its EEZ, the northern portion of the MPA, now referred to as the CGFZ North MPA, has only been partially protected under OSPAR. The benthic habitats of the CGFZ North MPA are currently not protected from anthropogenic activities while this application is being processed.

The objective of this study, located within the CGFZ North MPA, was to describe megabenthic community composition and to identify the environmental variables, such as depth and slope, which influenced their differentiation and distribution. We aim for this to inform the decision process regarding the future of the CGFZ North MPA.

3.2 Methods

Analyses were completed using ROV video collected aboard the TOSCA (Tectonic Ocean Spreading at the Charlie-Gibbs Fracture Zone) survey in 2018. Refer to Chapter 2 for methods on data collection and video analysis.

3.2.1 Statistical Analysis

The same species matrix as described in Chapter 2 was employed for this analysis. Species observations, substrate types, CTD data (logging information on temperature and salinity) and laser measurements were georeferenced using the USBL data from the ROV. This was done in the R program (version 3.6.2), using the ‘eXtensible’ Time Series package. Depth was derived from the shipboard multibeam data in ArcGIS Pro. Slope, SD of slope (Standard Deviation), Eastness, Northness and Roughness (RDMV) were derived, at 30 m resolution, from the shipboard multibeam data using the TASSE toolbox in ArcGIS Pro (Lecours et al., 2017). RDMV (Relative deviation from mean value) can be defined as the variability in elevation within a sampled terrain unit. In the TASSE toolbox, RDMV is a measure of relative position, that identifies peaks (positive values) and valleys (negative values) and for this calculation, it is unit-less (Lecours, et al., 2017). Eastness and Northness are both computed from aspect in ArcGIS Pro. The aspect is converted to radians, the eastness is the sine of the aspect, while the northness is its cosine (Wilson et al., 2007). These both range from 1 to -1, for Eastness 1 denotes fully East, -1 is fully West while for Northness, 1 is fully North with -1 being South. Slope was computed using Horn's (1981) algorithm with the slope tool in ArcGIS. SD of slope is a measure of rugosity and is calculated using the focal statistics tool in ArcGIS. All terrain variables were computed within a 3 by 3 cell window size.

ROV transects were subdivided into 50-meter sections for the statistical analysis, and the midpoint coordinate of each section was used to extract terrain variables. We removed the rare morphospecies (< 10 observations in total) and all 50 m sections which had less than 10 individuals/colonies observed, leaving 676 sections for the analysis. All organisms present within a 50-meter section were summed while the CTD data (temperature and salinity) and image width derived from the lasers were averaged. Each 50 m section was allocated a dominant substrate type by determining the lengths of coverage for each substrate within a section. Substrate composition was quantified using the same methods as in Chapter 2.

We used a Hellinger transformation of the species matrix, as it is particularly suited to species abundance data, giving low weights to variables with low counts and many zeros (Borcard et al., 2011). We utilised a hierarchical clustering method with the Hellinger transformed species matrix to determine the communities using “nearest neighbor sorting” among sites to create a dendrogram (Borcard et al., 2011). The unweighted pair group method with arithmetic mean (UPGMA) was used when constructing the dendrogram. The optimal number of clusters was determined according to the Mantel statistic (Legendre & Fortin, 1989).

Analysis of Similarity (ANOSIM) was used to test for significant differences in morphospecies composition between the communities (Dufrêne & Legendre, 1997). These analyses operate on a ranked dissimilarity matrix to test the null hypothesis that there are no differences between the communities derived from hierarchical clustering. We implemented Similarity Percentages (SIMPER) methods to determine which species made important contributions to the community structure. The average dissimilarity between the 50 m sections from each community was computed and partitioned into contributions from each species. Species with high average values relative to the standard deviations are important for differentiating the communities (Clarke, 1993).

We applied DCA (Detrended correspondence analysis), an unconstrained ordination technique (Hill & Gauch, 1980), on the Hellinger transformed species matrix. DCA is an indirect gradient analysis that allows for the environmental data to be overlain on top of the species composition data. DCA identifies groups of samples with similar species composition, or communities as they will be referred to in this study, then tests the correlation between the environmental variables and the communities along the axes in multidimensional space (Correa-Metrio et al., 2014; Hill & Gauch, 1980).

A species accumulation curve was created to determine the expected number of morphospecies in each community derived from the dendrogram (Gotelli & Colwell, 2001). All analyses were completed using the ‘vegan’ package in the R program (version 3.6.2).

3.3 Results

A total of 154,509 individual organisms belonging to 309 megafaunal morphotaxa (metazoan and protistan) were identified from ROV video from 5 dives collected during the TOSCA expedition (full species catalogue can be found in the appendix). This is likely an underestimation due to the difficulty associated with identifying megafauna from video. Of the 309 morphospecies, 89 were seen in fewer than 10 of the 50 m sections and were not included in this analysis, leaving 220 morphospecies for this analysis.

3.3.1 Identification of Communities

The dendrogram was derived using UPGMA hierarchical clustering (Fig 3.1.) and was cut for nine groupings, based on the results of the Mantel statistic (r = 0.54 for 9 groupings).

Communities 2 and 3 were merged (Fig. 3.1.) based on their similarities on the DCA, SIMPER results, and visual observations of the community compositions, as well as similar environmental conditions (depth, slope range and dominant substrate types). Eight distinct communities remained.

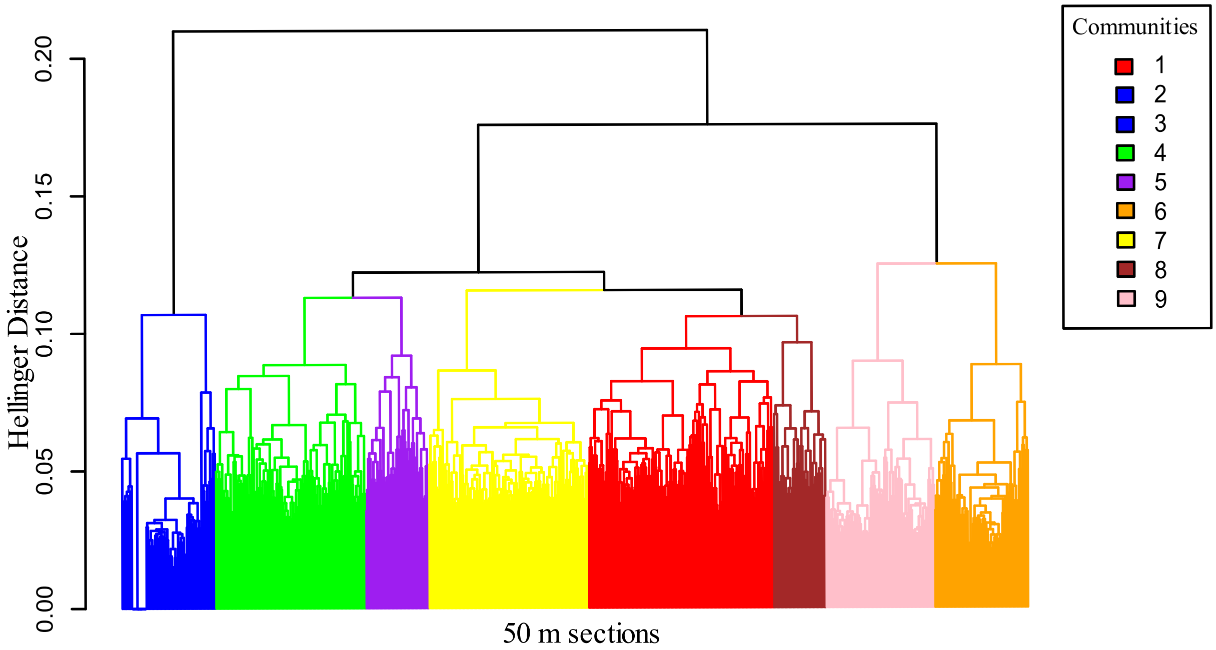

Figure 3.1. Dendrogram, based on hierarchical clustering (UPGMA) with 8 clusters after clusters 2 and 3 were merged. These color codes remain constant throughout the resulting plots.

The R statistic (the ratio between within-group and between-group dissimilarities) reported from ANOSIM was 0.66 (p-value of <0.001). An R value close to 1 indicates high separation between levels, which in this case, means that the communities were significantly different from each other, but that overlap of species occurred. In this case, this could result from the fact that taxa were difficult to differentiate based on imagery (e.g., encrusting sponges) and could not always be identified to species-level.

Table 3.1. Species community summary table, with previously known communities under the ICES VME guidelines (ICES, 2016). This table also shows the results of the SIMPER analysis (the 6 dominant species for each community). VME indicator species indicated with *.

Community Number	Top 6 dominant species (SIMPER)	Matching ICES VME description	Dominant substrate	Depth range	Number of 50 m sections per community
1.	*Psolus* sp., encrusting sponge sp 3, encrusting sponge sp. 8, Bathycrinidae sp.*, *Stichopathes* sp.*, sponge sp. 21.	Hard bottom sponge aggregation, sand emergent fauna (Bathycrinidae sp.) and hard bottom coral garden.	bedrock (43%) and biogenic gravel (28%)	560m-2600m	138
2.	Sponge sp. 17*, encrusting sponge sp. 7, encrusting sponge sp. 9, Demosponge sponge sp.13*, ophiuroid sp. 3, sponge sp. 20*	Sand emergent fauna - Soft-bottom sponge aggregation (Sponge sp. 17).	Sand (53%) and gravel (34%)	1800m-2300m	70
4.	Encrusting sponge sp. 8, encrusting sponge sp. 7, *Canda* sp., sponge sp. 20*, *Psolus* sp., Demosponge sponge sp. 7*	Hard bottom sponge aggregation. Bryozoan patches	Mostly bedrock (51%), and boulders (38%)	1400m-2800m	112

5.	Xenophyophore*, *Canda* sp., encrusting sponge sp. 7, encrusting sponge sp. 8, sponge sp. 20*, ophiuroid sp. 3	Sand emergent fauna - Xenophyophore field, bryozoan patches, and hard bottom sponge aggregation.	Mostly boulders (38%) and bedrock (32%), a little sand.	1600m-2500m	47
6.	Xenophyophore*, *Stichopathes* sp.*, *Canda* sp., cup coral sp. 3*, cup coral sp. 1*, Bathycrinidae sp.*	Sand emergent fauna – Xenophyophore and Soft bottom coral garden (*Stichopathes* sp.).	Sand (46%), and gravel (24%).	800m-2400m	70
7.	Sponge sp. 20*, *Canda* sp., glass sponge sp. 9*, encrusting sponge sp. 8, *Psolus* sp., ophiuroid sp. 8	Hard-bottom gorgonian and black coral garden, bryozoan patches and sponge aggregation.	Almost exclusively bedrock (83%) and boulders (14%)	1600m-2200m	119
8.	Bathycrinidae sp.*, *Canda* sp., *Psolus* sp., Xenophyophore*, encrusting sponge sp. 8*, sponge sp. 20*	Mud and sand emergent fauna-Bathycrinidae sp., Xenophyophore fields. Bryozoan patches.	Almost all found on boulders (44%), and bedrock (28%)	1000m-1600m	39
9.	Bathycrinidae sp*., Xenophyophore*, *Psolus* sp., encrusting sponge sp. 8, *Anthomastus* sp. 1*, Grenandier sp.	Soft-bottom coral gardens (*Acanella* sp.) and Sea pen field (3 morphospecies, including *Halipteris* sp. and *Pennatula* sp.). Mud and sand emergent fauna - Bathycrinidae sp. and Xenophyophores.	Sand (47%) and gravel (41%)	1000m-1700m	81

3.3.2 Description of Biological Communities

Description of the communities (i.e., dominant species, substrate, depth range, and number of sections) are given in Table 3.1. Community 1 (see Fig. 3.2 for representative images) included a mix of substrates, predominantly bedrock (43%), and biogenic gravel (28%) (Fig. 3.3). The species which contributed the most to the differentiation of the community was the sessile Holothurian, *Psolus* sp., with SIMPER results reporting a 43.71% contribution. Other important species included the stalked crinoid, Bathycrinidae sp., many species of encrusting demosponges, numerous species attached to or dwelling on rocks including small ophiuroids, cup corals and some larger glass sponges, notably *Hertwigia falcifera*. This community was dominated by smaller corals including the black coral *Stichopathes* sp., soft corals like *Anthomastus* sp., some scleractinians (*Solenosmilia variabilis* in small clumps, mostly found on vertical bedrock), and small, mainly encrusting sponges. The community was found within a relatively large depth range (560-2,600 m) and had the highest average slope out of all communities (Fig. 3.4). Dive 5, which lay to the west of the other four dives and followed the gently sloping side of a knoll, separated by a deep trench, was dominated by community 1 (and 2, see below), mainly in the section shallower than 2,000 m (Fig. 3.7b). This community was also found at the peak of the Hecate seamount (Dive 8), covering the top 600 m.

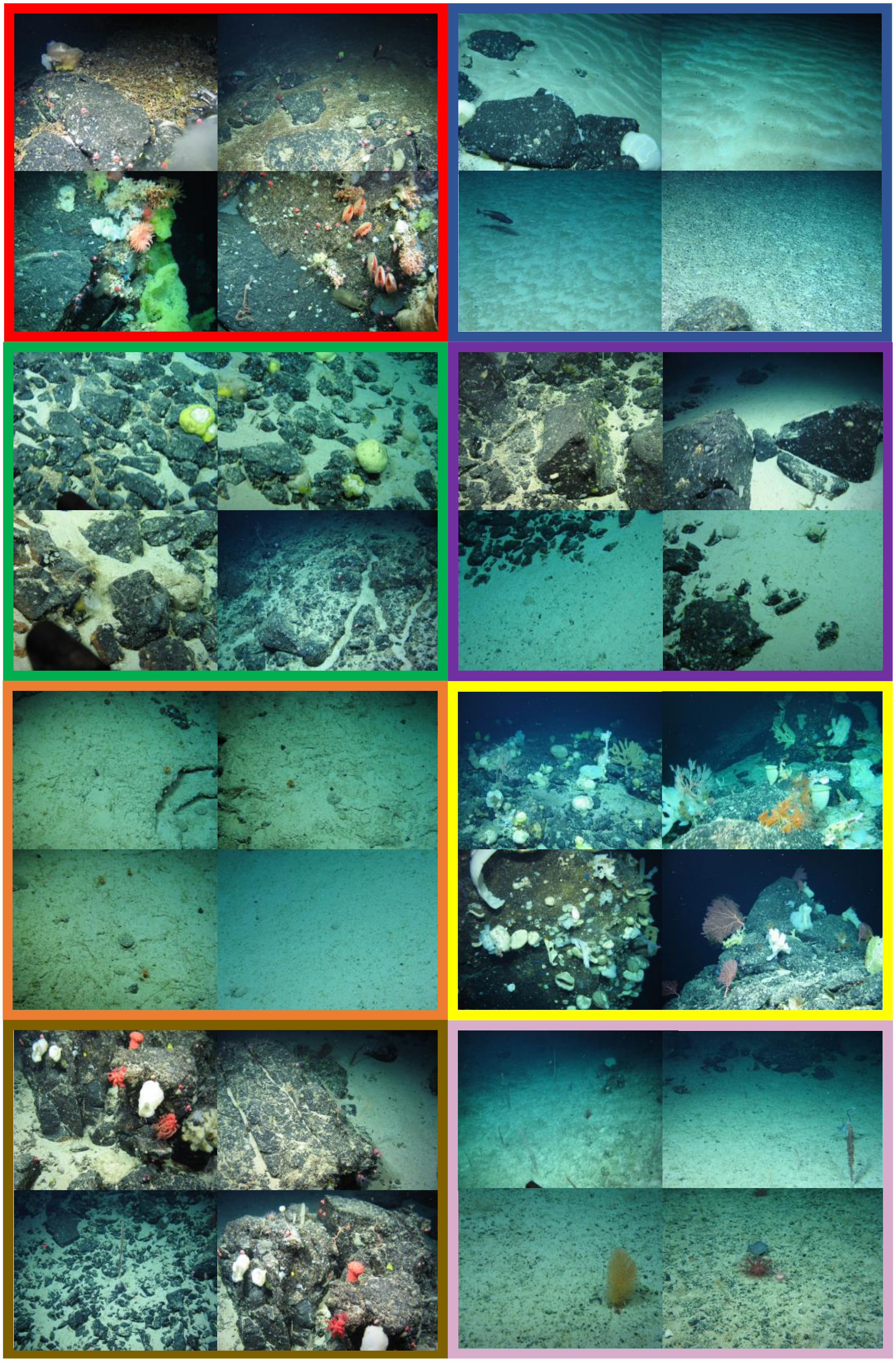

Figure 3.2. Colour-coded representative images of the eight VMCommunities of the CGFZ. Community 1 (red), community 2 (blue), community 4 (green), community 5 (purple), community 6 (orange), community 7 (yellow), community 8 (brown), community 9 (pink).

Community 2 (merged with Community 3) was predominantly found on sand (53%) and gravel (34%) (Fig. 3.3). With 9 contributing species, Sponge sp. 17 (sand emergent sponge) contributed 46.17% of the differentiation from other communities. Xenophyophores were also an important characterizing species for this community. Community 2 showed the lowest slope mean and a narrow depth range, found between 1,800- 2,300 m (Fig. 3.4). Community 2 had the highest salinity mean of 34.95 PSU and was predominantly east-facing (Fig. 3.4). This community had the lowest expected number of species (Fig. 3.6). The deeper portion of dive 5, below 2,000 m was dominated by community 2 (Fig. 3.7b). This community was predominantly found on the flattest area of the side of the knoll which dive 5 traversed, see Fig. 3.2 for representative images of this community.

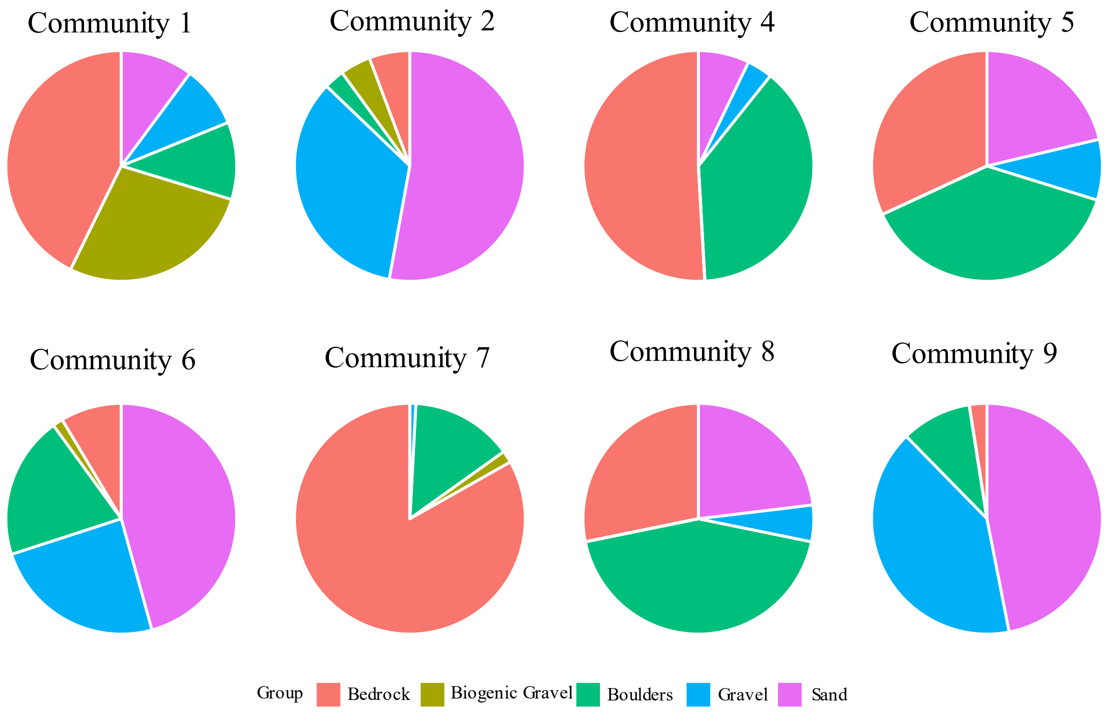

Figure 3.3. Pie charts showing the proportion of substrate type for each community.

Community 4 was found predominantly on bedrock (51%) and boulder dominated areas (38%) (Fig. 3.3). According to the SIMPER results, this community had 19 contributing species, mainly smaller sized species, with smaller sponges, encrusting and *Geodia* morphospecies, some crinoids, bryozoans and *Psolus* sp. Encrusting sponge sp. 8 was the most important species for differentiation with a 48.56% contribution according to the SIMPER analysis. This community was found to have the deepest mean depth, with a range from 2,100 - 2,700 m, the lowest mean temperature (~ 3.1°C), and one of the higher mean salinity values of all the communities, at 34.3 PSU (Fig. 3.4). Community 4 appeared to be predominantly south facing (Fig. 3.4). Dive 7 was dominated by community 4 for a stretch of approximately 1,100m at the start of the transect, and then began to transition to community 9 after 2,000m depth (Fig. 3.7d). Dive 6, which spanned the incline of the high relief area (a knoll connected to the Hecate seamount by a ridge) where Dive 7 was located, was mainly community 4, especially for the deeper portion of the dive, 2,250-2,800 m (Fig 3.7).

Community 5 was found predominantly on boulder dominated areas (38%) and bedrock (32%), with some interspersed sandy sections (21%) (Fig. 3.3). Xenophyophores were the most important differentiation morphospecies according to the SIMPER analysis, contributing 41.13%. *Canda* sp. (yellow bryozoan) as well as three encrusting sponge morphospecies, a vase-shaped species of Hexactinellida and an unidentified Plexauridae octocoral were also important contributing species. With a very mixed substrate type, the bedrock and boulders were relatively devoid (except for *Canda* sp. and encrusting sponges) of life and the Xenophyophores dominated the areas of sand. This community was found relatively deep (between 1,600m- 2,500m) and was predominantly west-facing (Fig. 3.4).

Community 6 was dominated by sand (46%) with a substantial amount of gravel (24%) and found between depths of 800- 2,400 m (Fig. 3.4). The species which were the important contributors included Xenophyophores (30.49% contribution to community differentiation), *Stichopathes* sp., a species of cup coral found on sand, Bathycrinidae sp. (sand-dwelling stalked crinoid), a sand/gravel dwelling species of Echinoidea (urchin), and *Actinaria* sp. This community had a relatively wide salinity range and one of the wider temperature ranges between 3.25°C and 3.5°C (Fig. 3.4). It appeared to be predominantly west-facing (Fig. 3.4). According to the species accumulation curve, community 6 had one of the lowest species occurrences (Fig. 3.5). The Hecate seamount (Dive 8) was dominated by community 6, but mostly the deeper regions (Fig. 3.7e).

Community 7 was almost exclusively bedrock (83%) and boulder dominated areas (14%). The main contributing species included a large demosponge, always attached to bedrock, sponge sp. 20 (56.10%), and *Canda* sp. (54.07%). This community included many encrusting sponges, multiple species of large rock-dwelling demosponges, notably *Geodia* sp. (minimum 4 different species), *Stelatta* sp., and cf. *Polymastia corticata*, many large, complex hexactinellids also dominated this community, especially *Hertwigia falcifera*. There were many ecologically important octocoral species in this community including *Paragorgia* sp., two species of Plexauridae, *Clavularia* sp., and *Corallium* sp. Species of Echinodermata included those attached to bedrock, stalked crinoids, and sessile holothurian *Psolus* sp., and ophiuroids associated with octocorals. This community had a narrow depth range between 1,600-2,200 m (Fig. 3.4). From visual observations and the SIMPER results, this community can be classified as a sponge aggregation and coral garden because of the species present and densities recorded (see Chapter 2 results). Community 7 had relatively low temperature and salinity ranges (Fig. 3.4). It showed the highest roughness out of all the communities (Fig. 3.4) and had the second highest species richness according (Fig. 3.6), following closely after community 1. This community was found almost exclusively on the ridge feature in dive 9 (Fig. 3.7f), which stayed at a relatively uniform depth throughout the transect (only varying 500 m in total). A 300 m stretch towards the end of dive 6, which is almost exclusively dominated by bedrock and boulders, is dominated by community 7.

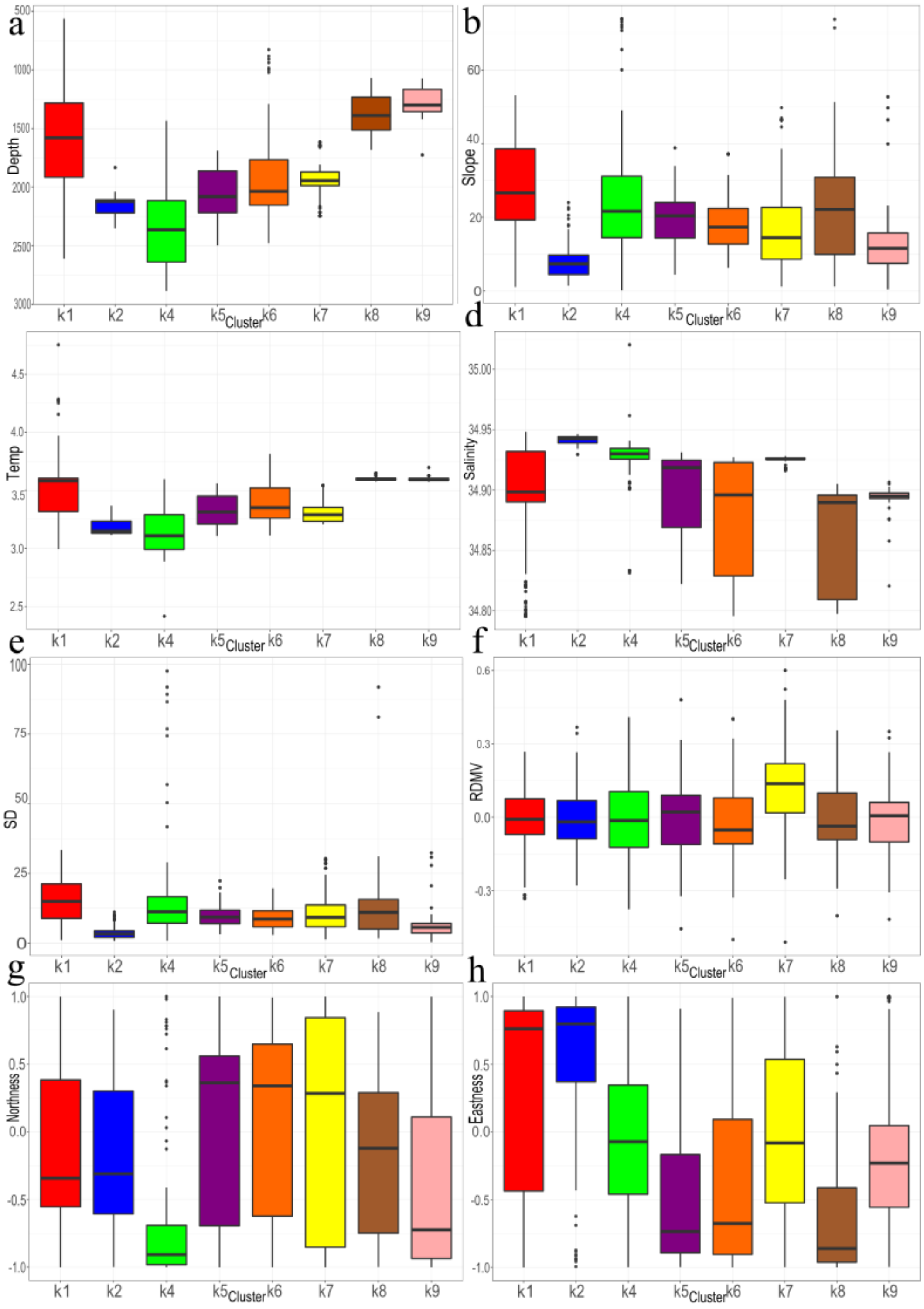
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Figure 3.4. Box plots for species communities (cluster) by (a) Depth, (b) Slope, (c) Temperature (°C), (d) Salinity (Practical Salinity Unit (PSU)), (e) SD of slope (Standard Deviation), measured in meters, (f) RDMV (Relative deviation from mean value), (g) Northness (1 denotes fully North, -1 denotes fully South), and (h) Eastness (1 denotes fully East, -1 denotes fully West). K2 and K3 were combined after examination and are now represented by K2.

Community 8 was found on boulders (44%), bedrock (28%) and some sand (23%) and was predominantly west-facing (Fig. 3.4). The main contributing species were Bathycrinidae sp. (78.64%), *Canda* sp., *Psolus* sp., and the Xenophyophore morphospecies present in this study. This community was found between depths of 1,000-1,600 m (Fig. 3.4) and was dominated by suspension feeders, such as the mushroom corals (*Anthomastus* sp.), sea pens (3 morphospecies, including *Halipteris* sp. and *Pennatula* sp.), stalked (Bathycrinidae sp.) and swimming (*Pentametrocrinus atlanticus*) crinoids, *Stichopathes* sp., as well as filter-feeding tube-shaped and encrusting sponge species. Compared to the others, this community had a relatively high mean slope and the second highest mean SD of slope (Fig. 3.4).

Community 9 was dominated by sand (47%) and gravel (41%) and found at depths between 1,000 m and 1,700 m. It had the shallowest mean depth range, a relatively low mean slope, as well as very narrow temperature and salinity ranges (Fig. 3.4). It appeared to be predominantly south and/or west facing (Fig. 3.4). This community had several main contributing species including a stalked species of crinoid, Bathycrinidae sp. (34.94%), xenophyophores, *Anthomastus* sp., grenadiers were numerous and the crinoid species *Pentametrocrinus atlanticus* was also representative for this community. This community had a sea pen field, with *Pennatula* sp. and *Halipteris* cf. *finmarchica*, alongside an *Acanella* sp. garden determined from visual observations and confirmed by the SIMPER results. The species accumulation curve showed that community 9 had one of the lowest expected number of species. Dive 7 was dominated by community 9, where the depth remained relatively constant between 1,250 m and 1,500 m, with much of the transect at the plateau of the knoll feature at 1,250 m, in an area of higher relief on the CGFZ, to the west of the Hecate seamount (Fig. 3.7).

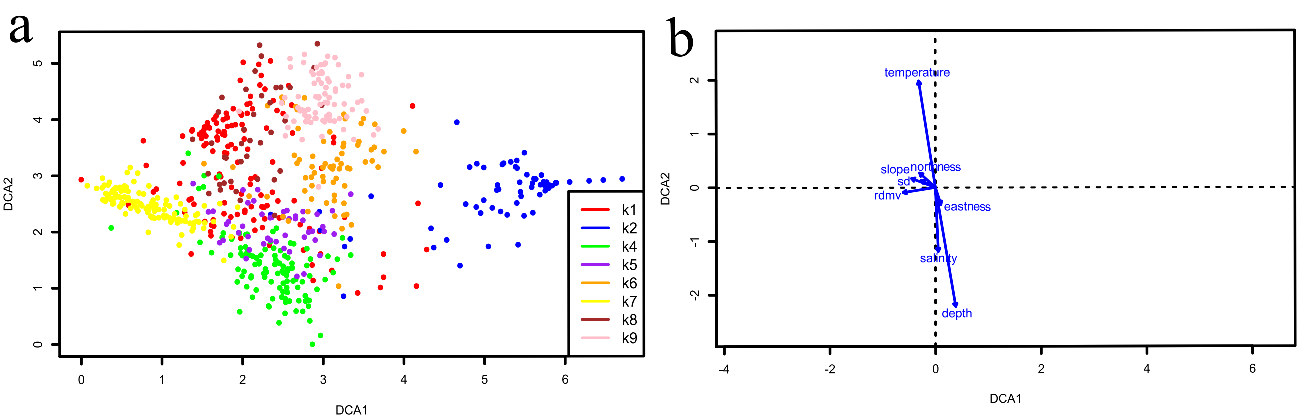

Figure 3.5. Detrended correspondence analysis (DCA) plots based on megabenthic species composition in 676 50 m sections from five ROV transects. (a) DCA plot shows the color-coded eight identified communities (2 and 3 combined), and (b) the environmental variables influencing their composition. Arrows indicate the relationship between the environmental variables and the ordination axes. The length of the arrows represents the strength of the correlation. According to the DCA, the most important environmental variables explaining differences in species composition between communities (Fig. 3.3) were depth ($r^2 = 0.78$) and temperature ($r^2 = 0.62$), followed by

salinity ($r^2 = 0.22$), which were all linked to axis one. The other variables had a smaller effect on the species composition (slope, SD, RDMV, Eastness and Northness), but are relevant for axis two of the DCA. Slope and SD of slope appear to be important for differentiating community 2, which was dominated by Xenophyophores, and found mainly on flatter sand covered terrain. According to the DCA, RDMV is important for the differentiation of community 7 (hard-bottom coral garden, hard-bottom gorgonian and black coral garden and sponge aggregation).

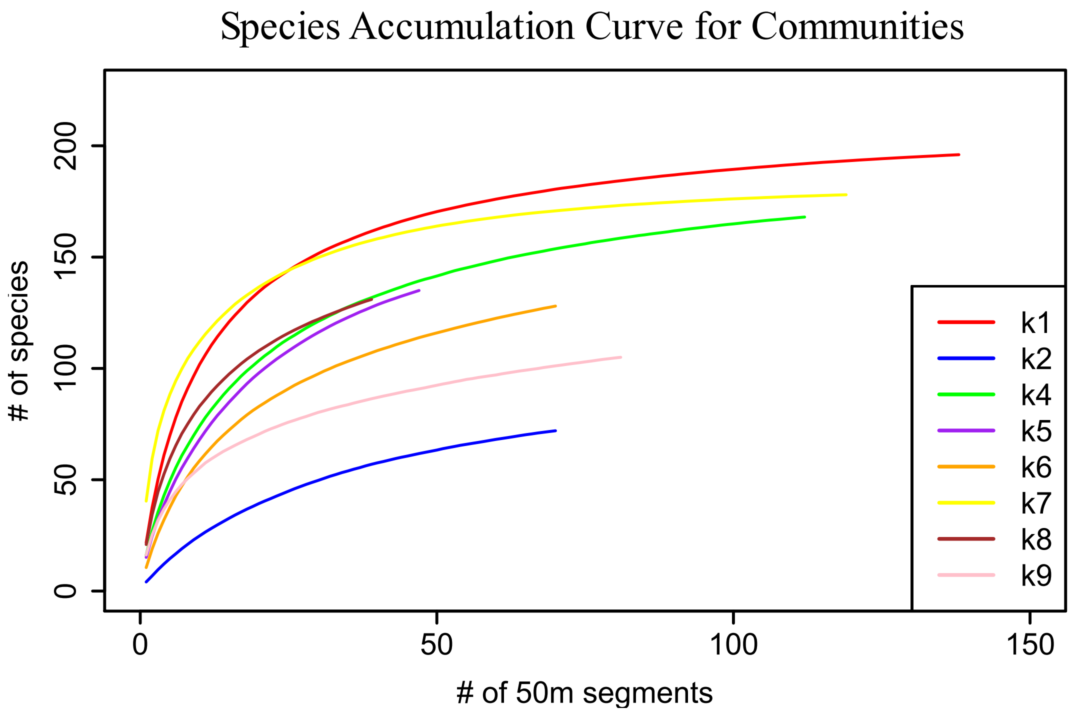

Figure 3.6. Species accumulation curves by each species community. Y axes are the number of species; X axes are the number of 50m segments.

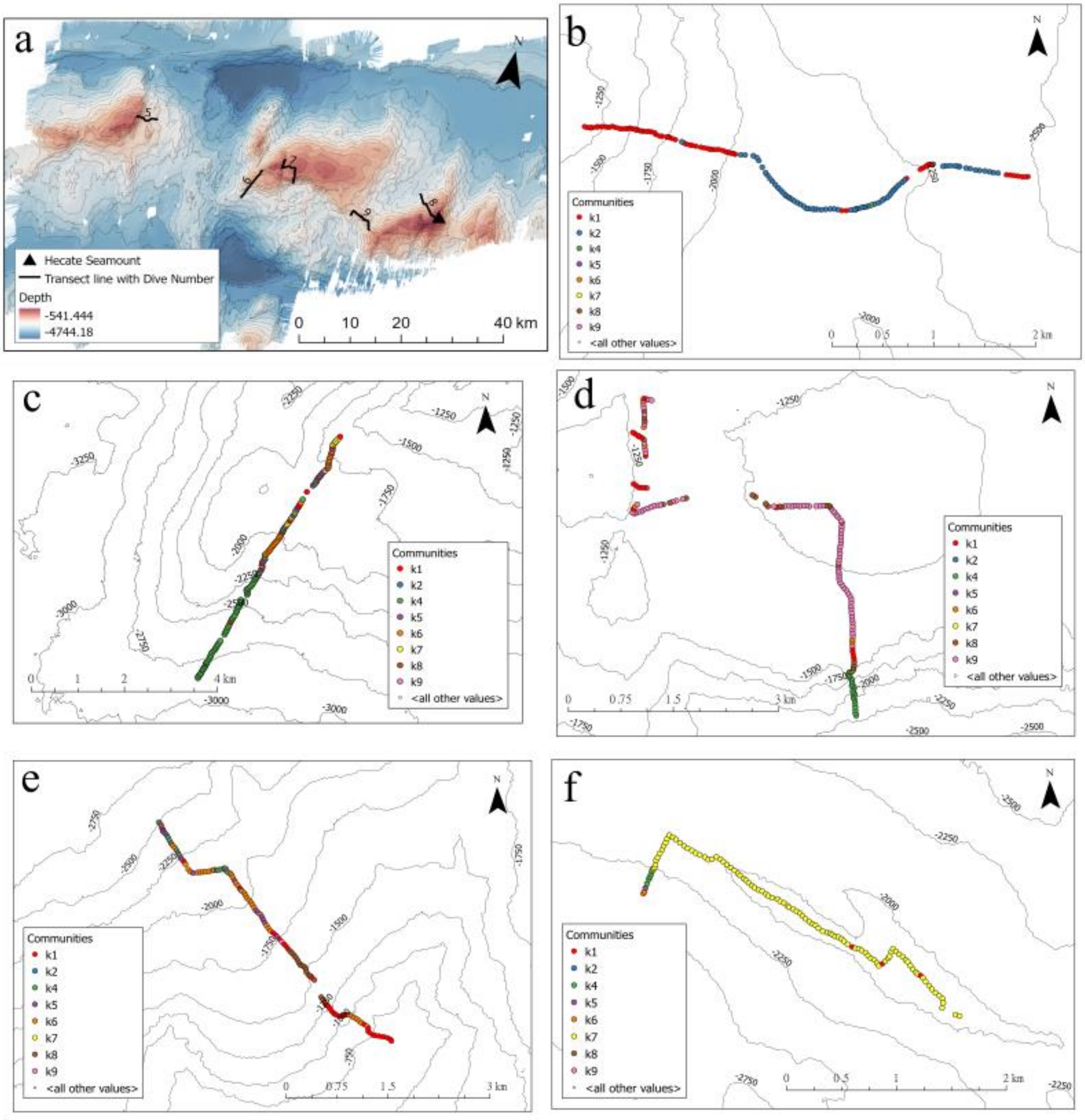

Figure3.7. (a) bathymetry map with all five dive transects. (b) Dive 5 transect on a knoll. (c) Dive 6 transect which climbs a knoll. (d) Dive 7 transect on the plateau of the knoll. (e) Dive 8 transect on the Hecate seamount. (f) Dive 9 transect on the ridge feature. Communities indicated by circles (one for each 50 m section of transect). Contour lines

are at 250 m intervals. Sections with low visibility are shown as gaps within the transects and were excluded from the analyses.

3.4 Discussion

Based on the ROV video footage that was collected and analyzed for this study, a total of eight distinct communities, which we designate as VMCommunities, inhabiting four topographic features: the Hecate seamount, a ridge and two knolls, were encountered and described. Depth was identified as the leading environmental driver of community differentiation, followed by temperature and salinity. This implies the importance of water mass properties, and the effect that water mass boundaries have on the distribution of the communities. Steeper slopes led to higher community heterogeneity on the CGFZ. The coral and sponge garden of community 7 had a high species richness and was found within a small depth range, but the community with the highest species richness was community 1. That community was found on the peak of the Hecate seamount, supporting the notion that seamount communities are characterized by depth stratification and associated environmental variable gradients. This community was not endemic to the seamount itself but may be to the CGFZ as, to our knowledge, it has not been described before in the literature.

3.4.1 Environmental Drivers of Community Composition

Depth was found to be the most important environmental factor driving community composition, with communities exhibiting clear preferences for specific depth ranges.

Community 9, the *Acanella* sp. garden and sea pen field had the shallowest mean depth and range while community 4, a hard bottom sponge aggregation, had the deepest range and mean depth. Numerous studies have described the importance that depth gradients play in benthic community composition in the deep sea (Jones & Brewer, 2012; Post et al., 2017). Many of these studies have examined the effects of depth gradients on benthic communities on seamounts (Bridges et al., 2021; Long & Baco, 2014; McClain et al., 2010), or on specific taxonomic groups (Howell et al., 2002), often focusing on reef-forming CWC (Baker et al., 2012; Robert et al., 2020; Tracey et al., 2011). The CGFZ has a highly complex topography, and this survey included a seamount, ridge feature, and two knolls within the ROV transects, which tells us that depth is an important environmental variable across multiple different topographical features in a region. This becomes clear when we examined the dives where depth changes rapidly on steep sides of a knoll feature and the Hecate seamount (Dives 6 and 8), and the heterogeneity in community types present was heightened.

Communities 8 and 9, which included an *Acanella* sp. garden, stalked crinoid fields and sea pen fields, were found, in this study, between very narrow temperature ranges and appeared to be mostly influenced by temperature on the DCA. This means that these VMEs are more sensitive to changes in temperature which could lead to habitat loss. For instance, a recent study suggested that acidification, warming and a significant decrease in food-availability will impact the suitable habitat for CWC in the North Atlantic (Morato et al., 2020). These authors found that *Acanella arbuscula* will be particularly sensitive to these effects and will likely have dramatically reduced refugia locations. The decrease in food availability will likely have strong negative impacts on the Northern region of the MAR specifically (Morato et al., 2020). Defining these as VMCommunities with specific environmental limits will help to steer legislative decision toward their protection from additional anthropogenic stressors such as bottom trawl fishing. These destructive fishing practices will make it increasingly difficult for this VMCommunity to recover from future climate change impacts.

With temperature and salinity being highly important in the differentiation of communities, these variables point to the importance of water mass properties at the CGFZ. The CGFZ is a topographical channel that facilitates the movement of deep water from the western basin in the North Atlantic to the eastern basin, over the MAR (Racapé et al., 2019; Schott et al., 1999; Shor et al., 1980). The North Atlantic Current (NAC), the Deep Western Boundary Current (DWBC), and the Labrador Sea Water (LSW) are all driven east through the fracture zone (Read et al., 2010; Saunders, 1994). This leads to a complex water mass structure in this region (see appendix 5.1). The NAC forms the Sub polar front while also marking the boundary between the subpolar and subtropical gyres (Bower et al., 2002; Hosia et al., 2008). At mid-water depths, until about 2,000 m, the cold and fresh LSW spreads from the north to west, while the warm, saline Mediterranean Water moves from the south to east (Bower et al., 2002). Underneath the LSW, below 2,000 m, the Iceland–Scotland Overflow Water (ISOW) moves west (Saunders, 1994). These create a boundary around the 2,000 m mark which may be influencing the community composition of the CGFZ benthic fauna, as for instance, 4 of the 8 communities have a mean depth within 100 m of the 2,000 m depth mark. This could be linked to the presence of nepheloid layers (see Chapter 2. Discussion for details on this). The hard bottom coral garden and sponge aggregation (community 7) mean depth is closest to 2,000 m and has the second highest species richness of the communities. CWC distribution in the North East Atlantic tend to be highly influenced by water mass properties and follow a specific water density envelope, where sections of the water column have optimal oceanographic properties for CWC habitat (Dullo et al., 2008). From the results of this study, aspect did not play a significant role in the differentiation of the communities overall, the two most easterly facing communities (the prevailing currents direction) exhibited both the highest and lowest species occurrence and had very different community compositions. More targeted sampling of the different topographic features with different aspects would determine whether this plays a more significant role in the biodiversity and composition of the communities.

Rugosity (RDMV) was identified as an important variable by the DCA and the boxplots, in determining the composition of community 7, which included an extensive gorgonian and black coral garden as well as dense sponge aggregations of demosponge and glass sponges. Rugosity has been identified as an important driver for CWC occurrence in many previous studies (Henry et al., 2010; Rengstorf et al., 2013; Robert et al., 2015) as well as community composition (Henry et al., 2013; Jones & Brewer, 2012). Rugosity is often used as a surrogate for hard-bottom seafloor types (Dunn & Halpin, 2009; Friedman et al., 2012), hence increased benthic habitat heterogeneity (Henry et al., 2010; Wilson et al., 2007) and heightened biodiversity (Dunn & Halpin, 2009; Price et al., 2019). Community 7, which is predominantly found on the ridge feature in this study, also exhibited heightened biodiversity and the highest sponge densities of > 3 sponges per m^2 for almost 250 m of transect (see results in Chapter 2 of this thesis). High rugosity values resulting from increased topographic complexity provides increased surface area for colonization of CWCs and sponges as well as advantageous positioning in the water column for food capture (Price et al., 2019). Rugosity measures may help predict where other dense coral gardens and sponge aggregations could likely occur on the CGFZ.

As high rugosity values tend to be associated with the presence of hard-bottom habitats (Dunn & Halpin, 2009), the ridge feature (dive 9), dominated by bedrock, had extensive coverage of gorgonian and black coral gardens (over 5,000 m), that existed alongside sponge aggregations. This observation is supported by previous studies of coral gardens and their tendency to occupy hard substrates with high levels of roughness (Henry et al., 2010; Rengstorf et al., 2013). Community 2 (sand emergent sponge aggregation) had the lowest mean slope and was dominated by sand and gravel; it can be assumed that this was a low-energy environment with minimal disturbance from currents (Gage, 1996). Community 1 was characterized by the presence of biogenic gravels as one of the main substrates. This consisted of mostly coral rubble and according to previous studies, this can lead to heightened macrofaunal biodiversity, although this has only been tested for other species of reef forming scleractinian corals (e.g. *Desmophyllum pertusum*) (Mortensen et al., 2012; Roberts et al., 2009).

3.4.2 Vulnerable Marine Communities of the CGFZ

Identifying VMEs is an important step in the *current* protocol for designating protected areas in the North Atlantic's High Seas (Ardron et al., 2014; Rowden et al., 2019), but the definitions for VMEs and their indicator species lack consensus and quantitative metrics (e.g. density thresholds) to be effectively used as conservation tools in the High Seas (Watling & Auster, 2021). A recent perspective piece outlined how these definitions are relatively unhelpful when determining which areas of the High Seas to protect as they use one indicator species to define an entire VME (Watling & Auster, 2021). A dense aggregation of gorgonian corals or sponges is defined as a VME, but Watling & Auster (2021) argue that this kind of aggregation is not simply a VME, but a community which makes up part of an entire ecosystem, for example, a seamount ecosystem. In the case of the CGFZ, we identified eight distinct VMCommunities, all with at least two VME indicator taxon present (e.g., coral, sponge), which makes up four VMEcosystems (the Hecate seamount, two knolls and a ridge feature). We propose the use of these alternative definitions for this ecologically vital area of the North Atlantic, in a bid to strengthen the future conservation implications, specifically with regards to the status of CGFZ North MPA.

Recent studies have been working on refining the definition of VMEs and creating a quantitative way to identify them (Ardron et al., 2014; Bullimore et al., 2013; Rowden et al., 2020; Williams et al., 2020). One of these studies details the density threshold of reef-forming stony corals required to declare a VME, in the NE Atlantic, suggested a threshold of 30% stony coral cover, as this can support adequate levels of biodiversity (Rowden et al., 2020). These densities were not observed in community 1, which was present at the peak of the Hecate seamount and on a knoll feature, where reef-forming CWC species were present (*Solenosmilia variabilis*), and therefore could not be defined as a reef VME under these parameters. However, we argue that this community, which might be unique to the CGFZ, should be considered as a VMCommunity based on its uniqueness, presence of multiple VME indicator species and their presumed associated biodiversity (e.g., *Solenosmilia variabilis*, *Stichopathes* sp., *Anthomastus* sp., cup corals, hexactinallid sponges and Bathycrinidae sp.), observations on several environmental conditions, and potential vulnerability to anthropogenic disturbances with long recovery times. This community shares some similarities to a community described by Bridges et al. (2021), as a *S. variabilis* reef with associated sponges and epifauna on a seamount, but comparatively different in species composition, and overall temperature, depth ranges and geographical location (Bridges et al., 2021).

Community 4 was characterized by demosponge and hexactinallid sponge aggregations and stalked crinoids as VME indicators found on predominantly hard substratum with dispersed areas of sand. This community is designated as a VMCommunity based on the presence of multiple VME indicator species and unique environemnal factors. The soft-bottom sponge aggregation (community 2) is dominated by what is likely a demosponge which appears to be all the same species. It is likely that this type of sand emergent sponge aggregation favors low energy environments for optimal sediment suspension concentrations needed for efficient filter feeding (Bates & Bell, 2017; Grant et al., 2019), which may be the case here as the community faces away from the prevailing current systems coming from the west. We designate this community as a VMCommunity under the VME guidelines with the presence of a VME indicator species and unique environmental conditions, as well as the potential for this community to host many other benthic species and playing an important role in sediment and nutrient cycling.

Recent descriptions of coral gardens define them only as comparatively dense aggregations of one or more coral species from within the groups Alcyonacea, Antipatharia, Pennatulacean, Scleractinia, and Stylasteridae (ICES, 2016). The coral garden of community 7 was identified based on the criteria laid out by (Bullimore et al., 2013). The community was identified by SIMPER analysis as being characterized by at least one species, namely *Paragorgia* sp. and Plexauridae sp. These are from the taxonomic groups listed as characteristic of a hard bottom coral garden and it is consistent with the definition used by the ICES 2015 report on VMEs (Auster et al., 2013; ICES, 2016). Previous studies have used methods such as kernel density modelling to asses the level of coral and sponge biomass needed to declare a VME in the NAFO Regulatory Area (Kenchington et al., 2014). The present study did not measure biomass, but a sponge aggregation was identified as part of a VMCommunity (community 7) due to its characterization by Demosponges (including *Geodia* sp. and encrusting demosponges) and several Hexactinellids densities. Sponge (which included Demosponges and Hexactinellids) densities were reported at more than 3 sponges per m^2 (see Chapter 2. results). Deep-sea, hard bottom sponge aggregations offer many ecosystem functions including providing habitat structure for breeding, feeding and rearing areas for other benthic organisms (Beazley et al., 2015; Murillo et al., 2012; Ramiro-Sánchez et al., 2019; Ríos et al., 2020) and have been known to create biodiversity hotspots, supporting many other megabenthic species of ophiuroids, crinoids and fish. They also play an important role in nutrient carbon and silica cycling in the water column as they filter the water to feed (Maldonado et al., 2017; Ríos et al., 2020). We suggest community 7, with both a dense sponge aggregation and extensive coral garden, should be defined as a VMCommunity as it is characterized by a unique combination of environmental variables, including facing the prevailing current systems, and contains numerous VME indicator species.

Community 5 contained a species of octocoral within the family Plexauridae, Xenophyophores and demosponges, and is hence defined as a VMCommunity in this study. Similarly to the hard-bottom coral gardens, the soft-bottom coral gardens observed in this study were characterized by at least one of the VME indicator coral species, in this case the black coral *Stichopathes* sp., and cup coral gardens (community 6) were observed on sand, extending over more than 25 m^2 of seafloor. This community included other VME indicator species, Bathycrinidae sp. (stalked crinoid fields), and Xenophyophores. We suggest communities 4, 5 and 6 be designated as a VMCommunities due to the presence of multiple VME indicator species within each community and unique environmental variables associated with each. Community 8 was defined by the presence of Bathycrinidae sp., a species of soft coral (*Anthomastus* sp.), multiple sea pens and glass sponges (all examples of VME indicator species) and is hence defined as a VMCommunity.

The *Acanella* sp. garden part of community 9 existed alongside fields of the stalked crinoid, *Bathycrinidae* sp., sea pen fields (*Halipteris* cf. *finmarchica*) and

Xenophyophores (all VME indicator species). *Acanella* sp. gardens have been found to harbor rich and diverse levels of fish species and are known to play an important role as nursery and feeding grounds for certain fish species (Edinger et al., 2007; Westerman et al., 2021). Sea pen fields, which were observed alongside the *Acanella* sp. gardens, have been also recognized as important sites for fish larvae nurseries in the Laurentian Channel and southern Grand Banks, offshore Atlantic Canada (Baillon et al., 2012). Aggregations of sea pens and other species in flat, sandy environments can provide structure and increase habitat heterogeneity (Bridges et al., 2021; Buhl-Mortensen et al., 2010; Miatta & Snelgrove, 2021). We define community 9, the sea pen field and *Acanella* sp. garden, as a VMCommunity as they exist in the same spatial area and under the same environmental conditions, on the flat-topped knoll feature, creating structure for many other benthic species on the CGFZ.

3.5 Conclusions

The next five years will be a crucial time for the protection status of this diverse and biologically heterogeneous region of the MAR, as its protection status will be revaluated based on the available data. With the identification of eight VMCommunities, including one which may be unique to the CGFZ and new to deep sea benthic ecology, with scleractinian and numerous soft coral species present, each including multiple VME indicator species, such as *Leiopathes* sp. and *Solenosmilia variabilis*, and unique environmental characteristics we recommend that the CGFZ North MPA be put under full protection. This should include the benthic communities as well as the water column, from all anthropogenic activities that may enact harm on the defined VMCommunities in this region. Because of its remoteness, this area has had minimal impact from anthropogenic activities and could be considered relatively pristine. Protecting pristine environments is particularly valuable, as they can be used as a reference of ecological health for habitats near by (Pandolfi et al., 2003).

3.6 References

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4 Conclusions

4.1 Conservation Implications

The Charlie-Gibbs Fracture Zone (CGFZ) is a topographically unique feature, offsetting the Mid-Atlantic Ridge in between the Azores and the Reykjavik Ridge. Substantial conservation efforts (namely by OSPAR) have been made for this area, based on the precautionary principle, where the presence of relatively diverse benthic habitats had been presumed (Ardron et al., 2008). This was based on observations of the benthic communities to the North and South of the fracture zone (Bergstad & Gebruk, 2008; Gebruk & Krylova, 2013; Mortensen et al., 2008) and observations of the activities of charismatic megafauna, mainly cetaceans and seabirds, in the pelagic and surface waters above the CGFZ (Edwards et al., 2013). However, the proposed protected area was divided into two parts, and the North and South MPAs were established. The North MPA, which includes many complex topographic features, such as seamounts, knolls, ridges, and trenches, was designated as being only partially protected under OSPAR guideline due to Iceland's application to extend its EEZ (Smith & Jabour, 2018). This has left the benthic communities of the CGFZ North MPA, covering a total of 178,766 km^2, unprotected from all possible anthropogenic activities, including destructive bottom trawl fishing (O'Leary et al., 2012). Even under current geopolitical challenges, the conservation status of this biodiverse area of the High Seas should be made a priority.

The data analysed in this study, over 67 hours of ROV video, was collected during the TOSCA survey of the megabenthic communities in areas with variable substrate types, ranging from flat sandy plains to steep vertical hard rock walls and sloping boulder fields. We reported data on the spatial variation and environmental drivers of the biodiversity as well as the community composition, their distribution and the environmental factors which determined their differentiation. In Chapter 2, it was revealed that the taxonomic composition and spatial distribution of ecologically important megafaunal groups, such as corals and sponges, are driven by multiple environmental factors including substrate type, slope, and depth gradients. Chapter 3 shed light on the diversity and composition of the megabenthic communities of the CGFZ, as eight VMCommunities were identified based on the presence of multiple VME indicator species, each with unique environmental characteristics. The communities included a seapen field with a *Acanella* sp. garden, a dense sponge aggregation with an antipatharian and gorgonian coral garden. A unique community of scleractinian coral, *Solenosmilia variabilis* and numerous soft corals was described with the highest species diversity of all eight communities. The indicator species within these communities have been designated as indicators based on certain characteristics such as their rarity, slow growth grates and habitat structure forming abilities.

4.2 Recommendations and What Should Be Done Next

Considering the results presented in this thesis, we strongly recommend that when the decisions regarding Iceland’s EEZ extension request is made, that regardless of the outcome, the CGFZ North MPA should be delineated as a fully protected area, which means including its benthic habitats. If Iceland’s request is not approved and this region of the CGFZ remains an ABNJ, then we assume OSPAR will reinstate the CGFZ North MPA to its full protection status, as originally proposed. If, however, the extension of Iceland’s EEZ is approved, we appeal to the Icelandic Government to implement this region as a new MPA under their jurisdiction. According to the Marine Protected Atlas, less than 1% of Iceland’s marine territory is fully protected from fishing practices by designated MPAs (*Iceland Marine Protection | Marine Protection Atlas*). If Iceland were to establish this as an MPA under their jurisdiction, their status as a nation motivated to conserve the rare and vulnerable benthic habitats of the deep-sea would be greatly improved. Through this study this region of the CGFZ, has been revealed as a taxonomically rich and biologically diverse area of the MAR, with evidence of at least 8 VMCommunities where rare, slow growing and structure forming species of CWC and sponges are present throughout.

The currently established MPAs in this region (i.e., the CGFZ South MPA) still lacks a comprehensive analysis of the composition and distribution of their benthic communities. We suggest additional ROV footage be collected in the CGFZ South MPA. Additional data should be collected in the North MPA from varied depth gradients, specifically depths 500 m to 750 m and 2,250 m to 3,000 m, which were under sampled in this study. Sampling across the multiple bathymetric feature types would also be beneficial and additional information on biogenic gravels, which were shown to have high biodiversity but was lacking samples. This will allow the development of predictive modeling to investigate the distribution of the VMCommunities across the entirety of the CGFZ.

Finer-scale modelling of the current dynamics of the region in and around the ridges, seamounts and slopes of this topographically complex area would answer more questions about the effects that the prevailing currents systems are having on the benthic communities and likely help with predicting their distribution. More data on the fine scale current direction and speed in this region would greatly improve the knowledge of the impacts this has and could help to inform legislators on the occurrence of VMCommunities across the entirety of the CGFZ.

Sample size limitations and challenges involved in the identification of megabenthic organisms from ROV video alone have meant that only a relatively limited set of analysis could be applied in this study. The collection of physical samples of the unknown VME indicator species (Fig. 4.1. for examples) would greatly improve our understanding of the species richness and ecological patterns, which is likely much higher than what was reported here.

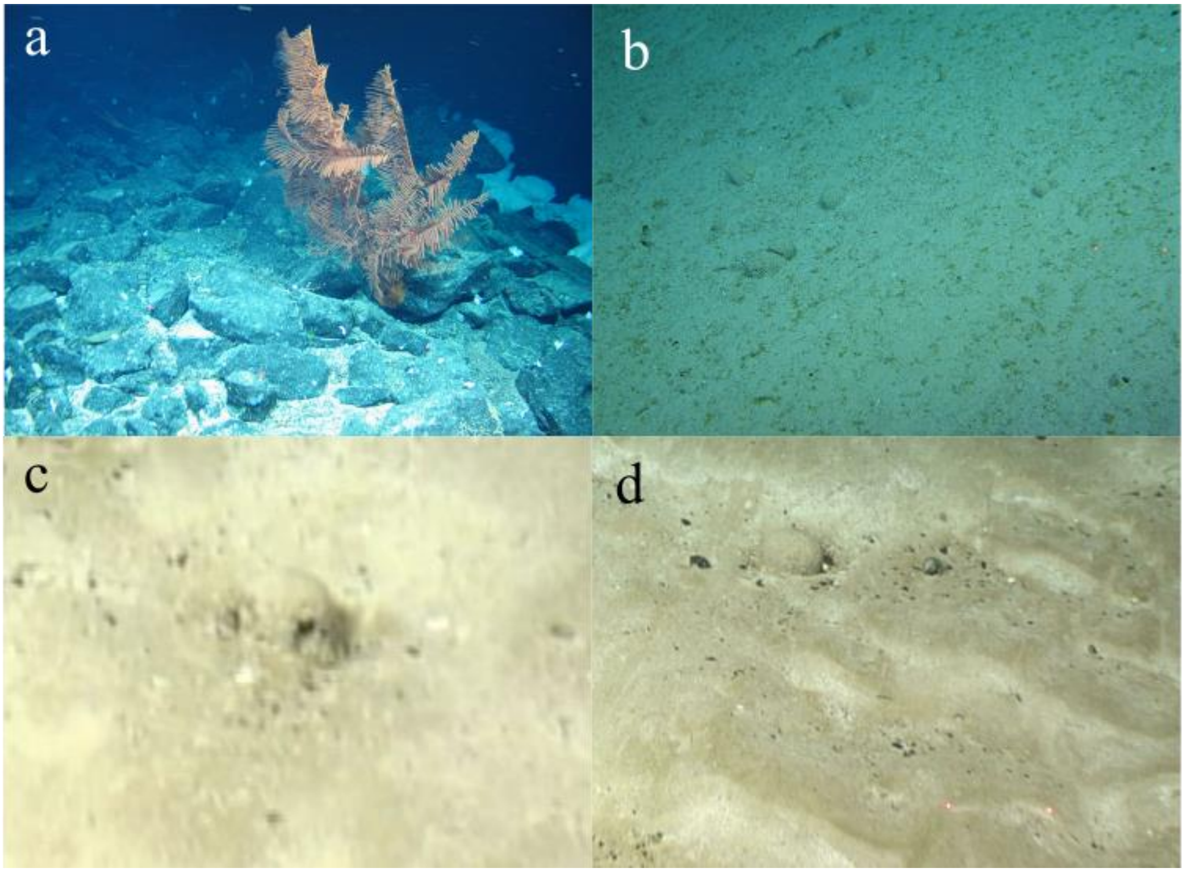

Figure 4.1. (a) Unknown black coral (Antipatharia) colony (b) Unknown Xenophyophore species, (c) and (d) unknown sponge species (Sponge sp. 17).

A study into the current fishing activities in this area would also be beneficial to the future decision making on this MPA, since currently there are no known reports on the fishing practices taking place in this region. This study revealed signs of recent fishing activity, specifically on the Hecate seamount, including a large trawl net. However, there is still a lot of ambiguity around the status of current fishing activities in this area. With the presence of eight VMCommunities with slow growing, fragile, sessile species, such as Xenophyophores, large glass sponges and antipatharian corals, some of which are very large and potentially hundreds of years old, these benthic communities are highly vulnerable to the potential impact of deep trawl fisheries. Due to its remoteness, this area has had some, albeit believed minimal, impact from anthropogenic activities and could potentially be considered a relatively pristine marine environment where keeping fishing activities to a minimum under higher protective measures would be particularly beneficial.

With the intention of making these data open source and available to other researchers as well as policy makers, they have been submitted to portals such as the ICES call for records on VME indicator species, as well as other ongoing research projects in the North Atlantic. These species observation data will also be made available online on the Pangea data repository in the hopes that they will be used to further and improve the protective measures implemented in the ABNJ of the North Atlantic.

4.3 References

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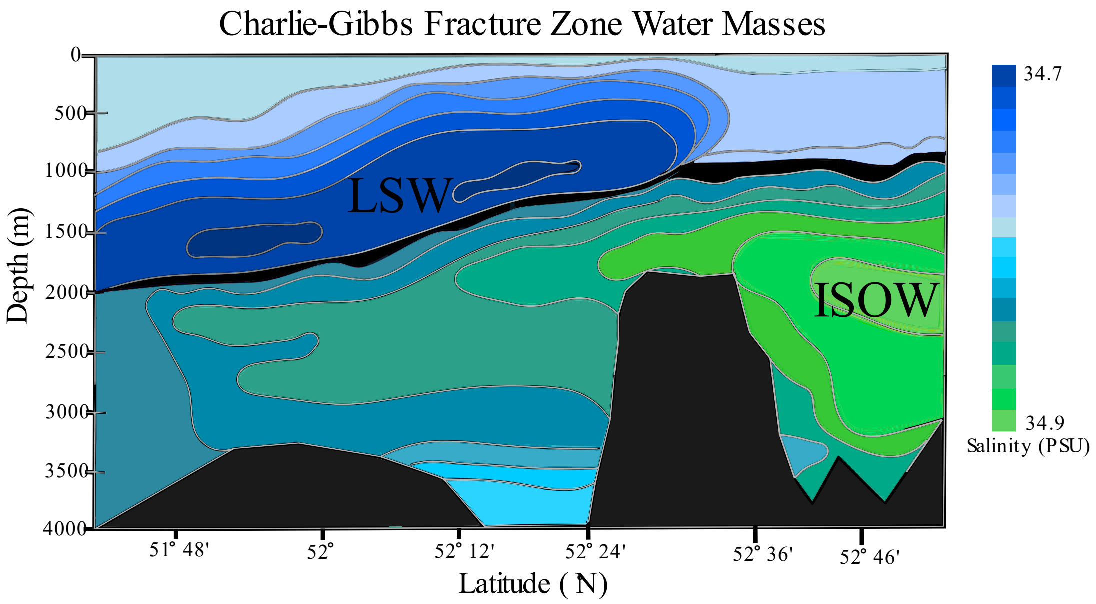
5 Appendix

5.1 Water masses over the Charlie-Gibbs Fracture Zone. LSW - Labrador Sea Water, ISOW - Iceland-Scotland Overflow Water. Salinity in PSU (Practical Salinity Unit). Figure adapted from Read et al 2020 and Schott et al 1999.



5.2 SIMPER Results for all communities

Significant codes: 0 ‘***’

0.001 ‘**’

0.01 ‘*’

0.05 ‘.’

0.1 ‘ ’

Communities 1 & 2

Species	Average	sd	ratio	ava	avb	cumsum	p
SPONGE17	0.3222275	0.237745	1.3553	0.55072	47.49153	0.3257	0.001 ***
HOLO2	0.1244303	0.135628	0.9174	43.71014	0.00000	0.4515	0.001 ***
ENCR7	0.0349839	0.050961	0.6865	8.07246	0.00000	0.4868	0.990
ENCR8	0.0302769	0.050793	0.5961	14.52899	0.01695	0.5174	1.000
SPONGE20	0.0300924	0.059612	0.5048	4.54348	0.03390	0.5478	0.994
ENCR3	0.0284494	0.086899	0.3274	16.78261	0.00000	0.5766	0.001 ***
STICHO1	0.0268545	0.057692	0.4655	9.27536	0.00000	0.6037	0.001 ***
CRINO6	0.0223768	0.056542	0.3958	10.84783	0.00000	0.6263	1.000
ENCR1	0.0196527	0.041917	0.4688	2.91304	0.00000	0.6462	0.001 ***
FORAM	0.0169782	0.037498	0.4528	7.21014	0.00000	0.6634	1.000
SPONGE21	0.0169230	0.046227	0.3661	8.47826	0.00000	0.6805	0.001 ***
OPHIURO2	0.0146785	0.040596	0.3616	2.51449	0.00000	0.6953	0.078 .
ENCR5	0.0146739	0.040315	0.3640	3.45652	0.00000	0.7101	0.001 ***
ENCR9	0.0141657	0.055215	0.2566	1.68116	0.03390	0.7245	0.001 ***
ENCR11	0.0115321	0.033733	0.3419	5.50000	0.00000	0.7361	0.001 ***
ANTHO1	0.0094459	0.021953	0.4303	2.44928	0.00000	0.7457	0.009 **
CUP2	0.0085629	0.013015	0.6579	2.25362	0.00000	0.7543	0.001 ***
OPHIURO5	0.0084382	0.043195	0.1954	1.08696	0.00000	0.7628	0.002 **
HEXACT3	0.0082984	0.024361	0.3406	2.78261	0.00000	0.7712	0.001 ***
CERIANTID	0.0080502	0.056256	0.1431	2.78261	0.00000	0.7794	0.060 .
SPONGE14	0.0075905	0.017561	0.4322	2.61594	0.00000	0.7870	0.001 ***
SCLERA1	0.0063666	0.017756	0.3586	2.18116	0.00000	0.7935	0.001 ***
CORALI	0.0060201	0.019150	0.3144	0.86957	0.00000	0.7996	0.077 .
ECHINO3	0.0056627	0.011484	0.4931	2.36232	0.01695	0.8053	0.005 **
CANDA	0.0053942	0.017024	0.3169	1.19565	0.01695	0.8107	1.000
SPONGE6	0.0049127	0.021960	0.2237	1.78986	0.00000	0.8157	0.013 *

Communities 1 &3

Species	Average	sd	ratio	ava	avb	cumsum	p
SPONGE17	0.2062099	0.152232	1.3546	0.550725	39.09091	0.2194	0.001 ***
HOLO2	0.1142254	0.127238	0.8977	43.710145	0.18182	0.3410	0.001 ***
ENCR7	0.0512250	0.052019	0.9847	8.072464	8.36364	0.3955	0.411

ENCR9	0.0462002	0.073071	0.6323	1.681159	8.36364	0.4446	0.001 ***
ENCR8	0.0282856	0.048533	0.5828	14.528986	0.09091	0.4747	0.999
SPONGE20	0.0272318	0.050536	0.5389	4.543478	0.81818	0.5037	0.952
ENCR3	0.0272017	0.083820	0.3245	16.782609	0.00000	0.5326	0.098 .
STICHO1	0.0247510	0.053698	0.4609	9.275362	0.00000	0.5590	0.047 *
CRINO6	0.0210962	0.053986	0.3908	10.847826	0.00000	0.5814	1.000
FORAM	0.0190529	0.037071	0.5140	7.210145	0.54545	0.6017	1.000
ENCR1	0.0181998	0.035986	0.5057	2.913043	0.36364	0.6211	0.068 .
OPHIURO3	0.0177950	0.053886	0.3302	0.775362	1.81818	0.6400	0.029 *
OPHIURO2	0.0166888	0.037863	0.4408	2.514493	0.72727	0.6578	0.150
SPONGE21	0.0159572	0.043615	0.3659	8.478261	0.00000	0.6747	0.057 .
DESMO13	0.0149155	0.024591	0.6066	0.434783	2.18182	0.6906	0.012 *
ENCR5	0.0130664	0.037285	0.3505	3.456522	0.00000	0.7045	0.046 *
ENCR11	0.0108712	0.032085	0.3388	5.500000	0.00000	0.7161	0.079 .
ANTHO1	0.0083714	0.018127	0.4618	2.449275	0.00000	0.7250	0.197
CUP2	0.0079555	0.011201	0.7102	2.253623	0.18182	0.7335	0.052 .
HEXACT3	0.0076883	0.022558	0.3408	2.782609	0.00000	0.7416	0.049 *
CERANTID	0.0075302	0.052490	0.1435	2.782609	0.00000	0.7497	0.054 .
OPHIURO5	0.0073435	0.037959	0.1935	1.086957	0.00000	0.7575	0.068 .
SPONGE14	0.0069623	0.016061	0.4335	2.615942	0.00000	0.7649	0.071 .
CANDA	0.0069490	0.014675	0.4735	1.195652	0.63636	0.7723	1.000
DESMO5	0.0067258	0.014704	0.4574	0.355072	0.63636	0.7794	0.102

Communities 1 & 4

Species	Average	sd	ratio	ava	avb	cumsum	p
ENCR8	0.1346699	0.132753	1.01444	14.528986	48.562500	0.1484	0.001 ***
ENCR7	0.1149189	0.129002	0.89083	8.072464	40.616071	0.2750	0.001 ***
CANDA	0.1065737	0.117727	0.90526	1.195652	33.937500	0.3925	0.001 ***
HOLO2	0.0969393	0.112471	0.86191	43.710145	5.669643	0.4993	0.001 ***
SPONGE20	0.0284391	0.045172	0.62957	4.543478	6.205357	0.5306	1.000
ENCR3	0.0240762	0.075561	0.31863	16.782609	0.116071	0.5572	0.001 ***
FORAM	0.0238959	0.037632	0.63499	7.210145	3.758929	0.5835	1.000
STICHO1	0.0206439	0.046247	0.44638	9.275362	0.303571	0.6062	0.001 ***
CRINO6	0.0200668	0.047936	0.41862	10.847826	1.482143	0.6284	1.000
ENCR1	0.0166783	0.030607	0.54492	2.913043	3.178571	0.6467	0.001 ***
SPONGE21	0.0138089	0.038215	0.36135	8.478261	0.071429	0.6620	0.001 ***
DESMO7	0.0115953	0.033428	0.34687	0.181159	4.133929	0.6747	0.001 ***
HEXACT2	0.0111230	0.015239	0.72991	1.304348	2.991071	0.6870	0.001 ***
ENCR5	0.0111149	0.031665	0.35102	3.456522	0.937500	0.6992	0.001 ***
OPHIURO2	0.0103211	0.030115	0.34272	2.514493	0.160714	0.7106	0.501
ENCR11	0.0100622	0.028734	0.35018	5.500000	0.553571	0.7217	0.001 ***
ENCR9	0.0099288	0.038456	0.25819	1.681159	0.312500	0.7326	0.006 **
BRYOZ1	0.0092678	0.015424	0.60087	0.289855	2.535714	0.7428	0.001 ***
OPHIURO3	0.0089523	0.015919	0.56236	0.775362	2.017857	0.7527	0.033 *
ANTHO1	0.0072194	0.014532	0.49679	2.449275	0.678571	0.7607	0.165

SPONGE14	0.0071356	0.015399	0.46339	2.615942	1.375000	0.7685	0.001 ***
CRINO3	0.0069319	0.013789	0.50271	0.797101	1.508929	0.7762	0.001 ***
CERANTID	0.0064290	0.044603	0.14414	2.782609	0.044643	0.7833	0.049 *
HEXACT3	0.0064128	0.019081	0.33608	2.782609	0.071429	0.7903	0.001 ***
CUP2	0.0061079	0.009546	0.63981	2.253623	0.178571	0.7971	0.013 *

Communities 1 & 5

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	0.1543971	0.126733	1.2183	7.210145	41.12766	0.1717	0.165
CANDA	0.1141279	0.142450	0.8012	1.195652	31.42553	0.2986	0.001 ***
HOLO2	0.1023106	0.111130	0.9206	43.710145	2.70213	0.4123	0.001 ***
ENCR7	0.0561431	0.077877	0.7209	8.072464	11.25532	0.4748	0.202
ENCR8	0.0462270	0.052199	0.8856	14.528986	7.61702	0.5262	0.930
SPONGE20	0.0300904	0.045562	0.6604	4.543478	4.12766	0.5596	0.994
ENCR3	0.0253125	0.078691	0.3217	16.782609	0.04255	0.5878	0.010 **
STICHO1	0.0218557	0.047935	0.4559	9.275362	0.02128	0.6121	0.006 **
ENCR1	0.0205615	0.032924	0.6245	2.913043	2.68085	0.6349	0.001 ***
CRINO6	0.0200535	0.049639	0.4040	10.847826	0.29787	0.6572	1.000
SPONGE21	0.0146901	0.039748	0.3696	8.478261	0.04255	0.6736	0.007 **
OPHIURO3	0.0145205	0.035315	0.4112	0.775362	3.10638	0.6897	0.001 ***
ENCR5	0.0112358	0.032921	0.3413	3.456522	0.17021	0.7022	0.007 **
OPHIURO2	0.0111396	0.031140	0.3577	2.514493	0.17021	0.7146	0.365
ENCR11	0.0110208	0.029369	0.3753	5.500000	0.29787	0.7268	0.004 **
ENCR9	0.0107926	0.037203	0.2901	1.681159	0.29787	0.7388	0.033 *
BRYOZ1	0.0088361	0.018645	0.4739	0.289855	1.80851	0.7487	0.003 **
ANTHO1	0.0073971	0.014352	0.5154	2.449275	0.14894	0.7569	0.188
CERANTID	0.0072473	0.046695	0.1552	2.782609	0.08511	0.7650	0.087 .
CUP2	0.0070255	0.009606	0.7313	2.253623	0.34043	0.7728	0.008 **
HEXACT3	0.0067924	0.019902	0.3413	2.782609	0.00000	0.7803	0.004 **
CRINO3	0.0064854	0.013962	0.4645	0.797101	0.72340	0.7875	0.010 **
SPONGE14	0.0064027	0.014157	0.4523	2.615942	0.04255	0.7946	0.007 **

OPHIURO5	0.0064021	0.030782	0.2080	1.086957	0.10638	0.8018	0.038 *
HEXACT2	0.0061454	0.009346	0.6575	1.304348	1.08511	0.8086	0.803

Communities 1 & 6

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	0.4110773	0.249557	1.6472	7.210145	130.48571	0.4322	0.001 ***
HOLO2	0.0925514	0.111542	0.8297	43.710145	0.90000	0.5295	0.001 ***
STICHO1	0.0284085	0.058083	0.4891	9.275362	5.45714	0.5593	0.001 ***
ENCR8	0.0257806	0.042565	0.6057	14.528986	1.55714	0.5864	1.000
ENCR7	0.0254314	0.037095	0.6856	8.072464	1.51429	0.6132	1.000
ENCR3	0.0250415	0.074697	0.3352	16.782609	0.87143	0.6395	0.001 ***
CRINO6	0.0208883	0.047799	0.4370	10.847826	2.07143	0.6614	1.000
SPONGE20	0.0196558	0.042266	0.4651	4.543478	0.55714	0.6821	1.000
SPONGE21	0.0144183	0.037766	0.3818	8.478261	0.47143	0.6973	0.004 **
CANDA	0.0138793	0.031757	0.4370	1.195652	3.55714	0.7119	1.000
ENCR1	0.0132044	0.029576	0.4465	2.913043	0.42857	0.7257	0.100 .
ENCR5	0.0103844	0.031293	0.3318	3.456522	0.24286	0.7367	0.003 **
OPHIURO2	0.0103244	0.029844	0.3459	2.514493	0.22857	0.7475	0.468
ENCR11	0.0092970	0.028009	0.3319	5.500000	0.04286	0.7573	0.003 **
CUP1	0.0090369	0.021075	0.4288	0.224638	2.08571	0.7668	0.001 ***
ENCR9	0.0089153	0.037363	0.2386	1.681159	0.05714	0.7762	0.045 *
CUP3	0.0077146	0.020923	0.3687	1.688406	3.22857	0.7843	0.001 ***
CUP2	0.0068266	0.009890	0.6903	2.253623	0.70000	0.7914	0.006 **
ANTHO1	0.0065865	0.015047	0.4377	2.449275	0.11429	0.7984	0.462
CERANTID	0.0064857	0.043776	0.1482	2.782609	0.07143	0.8052	0.114
HEXACT3	0.0062860	0.018775	0.3348	2.782609	0.02857	0.8118	0.002 **
ECHINO3	0.0060639	0.011262	0.5384	2.362319	1.11429	0.8182	0.001 ***
SPONGE14	0.0056921	0.013389	0.4251	2.615942	0.04286	0.8241	0.007 **
OPHIURO5	0.0054043	0.029906	0.1807	1.086957	0.01429	0.8298	0.029 *
OPHIURO3	0.0052586	0.011131	0.4724	0.775362	1.02857	0.8354	0.836
SCLERA1	0.0049579	0.013784	0.3597	2.181159	0.10000	0.8406	0.004 **

Communities 1 & 7

Species	Average	sd	ratio	ava	avb	cumsum	p
CANDA	0.0930281	0.079392	1.17176	1.195652	54.067227	0.1030	0.001 ***
SPONGE20	0.0870104	0.059758	1.45605	4.543478	56.100840	0.1994	0.001 ***
HOLO2	0.0701520	0.074232	0.94504	43.710145	22.621849	0.2771	0.001 ***
ENCR8	0.0423527	0.042491	0.99674	14.528986	22.722689	0.3240	1.000
HEXACT9	0.0398582	0.039675	1.00462	0.572464	23.638655	0.3681	0.001 ***
CRINO9	0.0263923	0.032495	0.81220	0.123188	14.521008	0.3974	0.001 ***
OPHIURO8	0.0261189	0.035569	0.73433	0.224638	17.327731	0.4263	0.001 ***
DESMO9	0.0254891	0.027893	0.91382	0.304348	14.672269	0.4545	0.001 ***
ENCR7	0.0225631	0.029435	0.76653	8.072464	11.033613	0.4795	1.000
OPHIURO2	0.0217880	0.044859	0.48570	2.514493	13.352941	0.5036	0.001 ***
ENCR3	0.0184922	0.057971	0.31899	16.782609	1.218487	0.5241	0.007 **
HEXACT8	0.0184434	0.017082	1.07970	0.260870	10.941176	0.5445	0.001 ***
DESMO13	0.0182696	0.018513	0.98684	0.434783	10.974790	0.5648	0.001 ***
CRINO4	0.0180862	0.028960	0.62453	0.847826	10.873950	0.5848	0.001 ***
CRINO6	0.0139289	0.035139	0.39639	10.847826	1.100840	0.6002	1.000
DESMO15	0.0135637	0.019647	0.69039	0.586957	6.890756	0.6153	0.001 ***
STICHO1	0.0134030	0.031153	0.43023	9.275362	0.218487	0.6301	0.149
GEODIA3	0.0133162	0.018196	0.73182	0.282609	8.184874	0.6448	0.001 ***
ENCR1	0.0131337	0.017635	0.74473	2.913043	6.815126	0.6594	0.050 *
SPONGE21	0.0105702	0.027388	0.38594	8.478261	0.672269	0.6711	0.023 *
CNID3	0.0093767	0.019605	0.47828	0.137681	5.050420	0.6815	0.001 ***
DESMO5	0.0088345	0.015104	0.58492	0.355072	5.873950	0.6913	0.001 ***
FORAM	0.0087980	0.021736	0.40476	7.210145	0.100840	0.7010	1.000
DESMO18	0.0086078	0.017103	0.50329	0.021739	4.798319	0.7105	0.001 ***

CNID9	0.0085699	0.011535	0.74292	0.036232	4.613445	0.7200	0.001 ***

Communities 1 & 8

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.2019381	0.144842	1.39420	10.84783	78.64103	0.2302	0.001 ***
HOLO2	0.1055014	0.098518	1.07089	43.71014	23.43590	0.3505	0.001 ***
CANDA	0.0635856	0.088717	0.71673	1.19565	28.46154	0.4229	0.847
ENCR8	0.0355293	0.041769	0.85061	14.52899	8.41026	0.4634	1.000
FORAM	0.0337472	0.037783	0.89318	7.21014	10.28205	0.5019	1.000
SPONGE20	0.0305695	0.047530	0.64316	4.54348	6.02564	0.5368	0.993
STICHO1	0.0250421	0.042800	0.58509	9.27536	4.94872	0.5653	0.002 **
ENCR7	0.0234749	0.034166	0.68709	8.07246	2.53846	0.5921	1.000
ENCR3	0.0231236	0.072508	0.31891	16.78261	0.17949	0.6184	0.028 *
SPONGE21	0.0206248	0.045771	0.45061	8.47826	3.23077	0.6419	0.001 ***
ANTHO1	0.0172698	0.021313	0.81031	2.44928	5.51282	0.6616	0.001 ***
ENCR1	0.0140982	0.027779	0.50751	2.91304	1.41026	0.6777	0.102
PENNAT9	0.0119102	0.033424	0.35634	0.08696	4.12821	0.6913	0.001 ***
ENCR5	0.0116895	0.029841	0.39173	3.45652	1.82051	0.7046	0.007 **
CUP2	0.0114260	0.015562	0.73425	2.25362	3.56410	0.7176	0.001 ***
PENTA	0.0100071	0.019929	0.50213	0.88406	3.53846	0.7290	0.001 ***
OPHIURO2	0.0100000	0.028398	0.35214	2.51449	0.58974	0.7404	0.524
HEXACT2	0.0097592	0.011818	0.82578	1.30435	3.20513	0.7516	0.001 ***
ENCR11	0.0093250	0.026924	0.34635	5.50000	0.17949	0.7622	0.012 *
SPONGE14	0.0091290	0.015023	0.60768	2.61594	1.64103	0.7726	0.001 ***
CUP4	0.0086726	0.017572	0.49354	0.89130	2.23077	0.7825	0.001 ***
ENCR9	0.0080515	0.035753	0.22520	1.68116	0.00000	0.7917	0.130
CERANTID	0.0063854	0.041965	0.15216	2.78261	0.15385	0.7989	0.117
SCLERA1	0.0059668	0.013849	0.43085	2.18116	0.82051	0.8057	0.009 **
HEXACT3	0.0059211	0.018077	0.32756	2.78261	0.00000	0.8125	0.009 **

Communities 1 & 9

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.2722368	0.190217	1.43119	10.847826	134.93827	0.2917	0.001 ***
FORAM	0.2432399	0.178546	1.36233	7.210145	132.03704	0.5522	0.001 ***
HOLO2	0.0769953	0.094168	0.81764	43.710145	8.20988	0.6347	0.001 ***
ENCR8	0.0233840	0.037940	0.61635	14.528986	5.44444	0.6598	1.000
ENCR3	0.0211451	0.066827	0.31642	16.782609	0.48148	0.6824	0.004 **
ENCR7	0.0180593	0.027392	0.65928	8.072464	0.60494	0.7018	1.000
STICHO1	0.0170071	0.037646	0.45177	9.275362	1.12346	0.7200	0.024 *
SPONGE20	0.0143199	0.031359	0.45665	4.543478	1.18519	0.7354	1.000
SPONGE21	0.0115996	0.032542	0.35645	8.478261	0.02469	0.7478	0.010 **
ANTHO1	0.0100750	0.013182	0.76429	2.449275	4.40741	0.7586	0.001 ***
ENCR1	0.0095386	0.021681	0.43995	2.913043	0.40741	0.7688	0.858
GRENADIER	0.0084710	0.015169	0.55844	0.789855	3.08642	0.7779	0.001 ***
ENCR5	0.0080956	0.025554	0.31681	3.456522	0.61728	0.7865	0.052 .
ECHINO3	0.0079337	0.009366	0.84707	2.362319	2.66667	0.7950	0.001 ***
ENCR11	0.0078205	0.024390	0.32065	5.500000	0.00000	0.8034	0.020 *
OPHIURO2	0.0072542	0.022977	0.31571	2.514493	0.00000	0.8112	0.920
CUP2	0.0070780	0.009944	0.71179	2.253623	2.07407	0.8188	0.002 **
CERANTID	0.0069181	0.035817	0.19315	2.782609	1.03704	0.8262	0.051 .
PENNAT4	0.0060018	0.012074	0.49708	0.282609	2.54321	0.8326	0.001 ***
ENCR9	0.0059928	0.025416	0.23579	1.681159	0.00000	0.8390	0.303
OPHIURO1	0.0051914	0.007876	0.65918	0.173913	2.02469	0.8446	0.001 ***
PENTA	0.0051704	0.007493	0.69005	0.884058	2.12346	0.8501	0.001 ***
SPONGE14	0.0051360	0.010807	0.47524	2.615942	0.65432	0.8556	0.024 *
HEXACT3	0.0051038	0.015304	0.33349	2.782609	0.02469	0.8611	0.004 **

PENNAT9	0.0048054	0.010940	0.43927	0.086957	1.88889	0.8663	0.007 **

Communities 2 & 3

Species	Average	sd	ratio	ava	avb	cumsum	p
SPONGE17	0.2711817	0.1794788	1.5109	47.49153	39.09091	0.4747	0.001 ***
ENCR7	0.0612214	0.0595829	1.0275	0.00000	8.36364	0.5819	0.227
ENCR9	0.0548549	0.0797605	0.6877	0.03390	8.36364	0.6779	0.001 ***
OPHIURO3	0.0224464	0.0687535	0.3265	0.01695	1.81818	0.7172	0.006 **
DESMO13	0.0205179	0.0298873	0.6865	0.01695	2.18182	0.7531	0.002 **
SPONGE20	0.0093273	0.0165023	0.5652	0.03390	0.81818	0.7694	1.000
OPHIURO2	0.0078463	0.0219808	0.3570	0.00000	0.72727	0.7832	0.553
DESMO5	0.0076804	0.0175386	0.4379	0.00000	0.63636	0.7966	0.065 .
FORAM	0.0068385	0.0227473	0.3006	0.00000	0.54545	0.8086	1.000
ISIDAE1	0.0057955	0.0170959	0.3390	0.00000	0.54545	0.8187	0.004 **
POLYM1	0.0050450	0.0114149	0.4420	0.01695	0.45455	0.8275	0.019 *
GEODIA3	0.0046309	0.0083900	0.5519	0.16949	0.36364	0.8357	0.504
DESMO15	0.0043501	0.0140640	0.3093	0.00000	0.54545	0.8433	0.541
CANDA	0.0043176	0.0075698	0.5704	0.01695	0.63636	0.8508	1.000
DESMO6	0.0043174	0.0093703	0.4608	0.05085	0.45455	0.8584	0.318
SPONGE13	0.0042613	0.0091623	0.4651	0.05085	0.72727	0.8658	0.001 ***
ENCR1	0.0041956	0.0093948	0.4466	0.00000	0.36364	0.8732	0.995
SPONGE5	0.0039487	0.0065958	0.5987	0.00000	0.54545	0.8801	0.011 *
ECHINO1	0.0035144	0.0084707	0.4149	0.13559	0.18182	0.8863	0.003 **
OPHIURO4	0.0032764	0.0079701	0.4111	0.01695	0.45455	0.8920	0.145
CNID3	0.0031214	0.0103022	0.3030	0.00000	0.27273	0.8974	0.418
CRAB2	0.0029179	0.0042866	0.6807	0.22034	0.27273	0.9026	0.003 **
CNID5	0.0029001	0.0093760	0.3093	0.00000	0.36364	0.9076	0.001 ***
DESMO4	0.0029001	0.0093760	0.3093	0.00000	0.36364	0.9127	0.001 ***
COLOS	0.0028265	0.0067534	0.4185	0.16949	0.09091	0.9177	0.003 **

Communities 2 & 4

Species	Average	sd	ratio	ava	avb	cumsum	p

SPONGE17	0.2884697	0.1930262	1.49446	47.49153	0.035714	0.2893	0.001 ***
ENCR8	0.1814405	0.1448110	1.25295	0.01695	48.562500	0.4712	0.001 ***
ENCR7	0.1593929	0.1512677	1.05371	0.00000	40.616071	0.6310	0.001 ***
CANDA	0.1429556	0.1350195	1.05878	0.01695	33.937500	0.7743	0.001 ***
SPONGE20	0.0210186	0.0348554	0.60302	0.03390	6.205357	0.7954	1.000
FORAM	0.0192937	0.0360999	0.53445	0.00000	3.758929	0.8148	1.000
HEXACT2	0.0146436	0.0188758	0.77579	0.01695	2.991071	0.8295	0.001 ***
DESMO7	0.0145295	0.0397355	0.36566	0.00000	4.133929	0.8440	0.001 ***
BRYOZ1	0.0119712	0.0185387	0.64574	0.00000	2.535714	0.8560	0.001 ***
OPHIURO3	0.0103856	0.0181245	0.57301	0.01695	2.017857	0.8664	0.031 *
HOLO2	0.0093838	0.0331736	0.28287	0.00000	5.669643	0.8758	1.000
ENCR1	0.0077920	0.0170065	0.45818	0.00000	3.178571	0.8837	0.972
GEODIA4	0.0067467	0.0225113	0.29970	0.00000	1.991071	0.8904	0.001 ***
DESMO6	0.0067260	0.0231878	0.29007	0.05085	1.848214	0.8972	0.008 **
CRINO3	0.0062538	0.0101857	0.61397	0.01695	1.508929	0.9034	0.009 **
OPHIURO1	0.0037330	0.0100294	0.37220	0.13559	0.437500	0.9072	0.022 *
CRINO6	0.0034973	0.0116629	0.29987	0.00000	1.482143	0.9107	1.000
DESMO3	0.0034608	0.0130676	0.26484	0.00000	0.955357	0.9142	0.010 **
ANACH	0.0031378	0.0062600	0.50125	0.01695	0.633929	0.9173	0.001 ***
HOLO8	0.0022125	0.0066760	0.33141	0.00000	0.276786	0.9195	0.001 ***
ENCR4	0.0019517	0.0098333	0.19848	0.00000	0.330357	0.9215	0.751
CRINO14	0.0019239	0.0060578	0.31758	0.00000	0.428571	0.9234	0.001 ***
HOLO1	0.0018883	0.0054093	0.34908	0.00000	0.330357	0.9253	0.001 ***
ENCR9	0.0018739	0.0147732	0.12684	0.03390	0.312500	0.9272	0.933
SPONGE14	0.0018703	0.0097941	0.19097	0.00000	1.375000	0.9291	0.966

Communities 2 & 5

Species	Average	sd	ratio	ava	avb	cumsum	p

SPONGE17	0.3098164	0.1707520	1.8144	47.49153	0.00000	0.3106	0.001 ***
FORAM	0.2157333	0.1270503	1.6980	0.00000	41.12766	0.5269	0.001 ***
CANDA	0.1554562	0.1648725	0.9429	0.01695	31.42553	0.6828	0.001 ***
ENCR7	0.0701478	0.0998404	0.7026	0.00000	11.25532	0.7531	0.017 *
ENCR8	0.0459716	0.0519209	0.8854	0.01695	7.61702	0.7992	0.880
SPONGE20	0.0289114	0.0409138	0.7066	0.03390	4.12766	0.8282	0.991
HOLO2	0.0202053	0.0394796	0.5118	0.00000	2.70213	0.8485	1.000
OPHIURO3	0.0178565	0.0441492	0.4045	0.01695	3.10638	0.8664	0.001 ***
ENCR1	0.0158891	0.0283820	0.5598	0.00000	2.68085	0.8823	0.030 *
BRYOZ1	0.0114612	0.0229066	0.5003	0.00000	1.80851	0.8938	0.001 ***
HEXACT2	0.0062153	0.0111723	0.5563	0.01695	1.08511	0.9000	0.710
PLEXA1	0.0059032	0.0158994	0.3713	0.00000	0.72340	0.9059	0.010 **
CRINO3	0.0054250	0.0098358	0.5516	0.01695	0.72340	0.9114	0.096 .
OPHIURO8	0.0047263	0.0120369	0.3926	0.00000	0.65957	0.9161	0.978
OPHIURO1	0.0032681	0.0090176	0.3624	0.13559	0.57447	0.9194	0.165
CUP1	0.0027631	0.0076860	0.3595	0.05085	0.57447	0.9222	0.313
ENCR9	0.0025253	0.0085074	0.2968	0.03390	0.29787	0.9247	0.796
CUP2	0.0024175	0.0058167	0.4156	0.00000	0.34043	0.9271	0.996
ISIDAE1	0.0024009	0.0045725	0.5251	0.00000	0.38298	0.9295	0.172
ENCR11	0.0020213	0.0062682	0.3225	0.00000	0.29787	0.9316	0.818
ECHINO1	0.0019451	0.0049908	0.3897	0.13559	0.12766	0.9335	0.001 ***
CRINO6	0.0017972	0.0058176	0.3089	0.00000	0.29787	0.9353	1.000
CLAVU1	0.0017959	0.0088813	0.2022	0.00000	0.25532	0.9371	0.654
CRAB2	0.0017656	0.0036358	0.4856	0.22034	0.08511	0.9389	0.001 ***
HEXACT8	0.0017458	0.0048184	0.3623	0.00000	0.29787	0.9406	1.000

Communities 2 & 6

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	5.553e-01	0.2100919	2.64334	0.00000	130.48571	0.5564	0.001 ***
SPONGE17	2.830e-01	0.2026965	1.39635	47.49153	0.00000	0.8399	0.001 ***
CANDA	1.510e-02	0.0377698	0.39989	0.01695	3.55714	0.8550	1.000
CUP1	1.215e-02	0.0259683	0.46776	0.05085	2.08571	0.8672	0.001 ***
STICHO1	1.172e-02	0.0486764	0.24079	0.00000	5.45714	0.8790	0.397
ENCR7	8.620e-03	0.0213451	0.40386	0.00000	1.51429	0.8876	1.000
CUP3	7.071e-03	0.0232916	0.30359	0.00000	3.22857	0.8947	0.001 ***
ENCR8	6.943e-03	0.0141868	0.48937	0.01695	1.55714	0.9016	1.000
CRINO6	4.705e-03	0.0158714	0.29647	0.00000	2.07143	0.9063	1.000
HOLO9	4.693e-03	0.0138387	0.33909	0.00000	0.64286	0.9110	0.001 ***

OPHIURO3	3.926e-03	0.0090635	0.43317	0.01695	1.02857	0.9150	0.950
HOLO2	3.812e-03	0.0105297	0.36201	0.00000	0.90000	0.9188	1.000
PENNAT4	3.687e-03	0.0183565	0.20084	0.05085	0.40000	0.9225	0.174
BRYOZ1	3.428e-03	0.0082603	0.41504	0.00000	0.82857	0.9259	0.946
SPONGE20	3.263e-03	0.0082982	0.39316	0.03390	0.55714	0.9292	1.000
OPHIURO1	3.137e-03	0.0097243	0.32262	0.13559	0.54286	0.9323	0.190
ECHINO3	2.659e-03	0.0089395	0.29746	0.01695	1.11429	0.9350	0.890
ACTIN1	2.615e-03	0.0098821	0.26459	0.01695	0.97143	0.9376	0.170
CUP2	2.203e-03	0.0063127	0.34894	0.00000	0.70000	0.9398	1.000
GRENADIER	2.109e-03	0.0052456	0.40197	0.11864	0.28571	0.9419	0.896
ENCR3	2.099e-03	0.0087643	0.23954	0.00000	0.87143	0.9440	0.952
ACTIN19	1.980e-03	0.0120360	0.16450	0.00000	0.17143	0.9460	0.001 ***
HEXACT2	1.922e-03	0.0055793	0.34456	0.01695	0.34286	0.9480	1.000
ENCR1	1.920e-03	0.0049418	0.38852	0.00000	0.42857	0.9499	1.000
HOLO8	1.838e-03	0.0057769	0.31809	0.00000	0.38571	0.9517	0.005 **

Communities 2 & 7

Species	Average	sd	ratio	ava	avb	cumsum	p
SPONGE17	0.1334140	0.1229605	1.0850	47.49153	0.000000	0.1336	0.001 ***
CANDA	0.1147158	0.0884097	1.2975	0.01695	54.067227	0.2485	0.001 ***
SPONGE20	0.1118478	0.0626005	1.7867	0.03390	56.100840	0.3606	0.001 ***
HEXACT9	0.0487383	0.0443881	1.0980	0.00000	23.638655	0.4094	0.001 ***
HOLO2	0.0455708	0.0481006	0.9474	0.00000	22.621849	0.4550	0.862
ENCR8	0.0448397	0.0446178	1.0050	0.01695	22.722689	0.5000	0.966
CRINO9	0.0323382	0.0373348	0.8662	0.00000	14.521008	0.5323	0.001 ***
DESMO9	0.0312983	0.0317681	0.9852	0.00000	14.672269	0.5637	0.001 ***
OPHIURO8	0.0312951	0.0403150	0.7763	0.00000	17.327731	0.5950	0.001 ***
HEXACT8	0.0226309	0.0191695	1.1806	0.00000	10.941176	0.6177	0.001 ***
DESMO13	0.0223057	0.0212540	1.0495	0.01695	10.974790	0.6401	0.001 ***
OPHIURO2	0.0215001	0.0498892	0.4310	0.00000	13.352941	0.6616	0.002 **
CRINO4	0.0210960	0.0329691	0.6399	0.00000	10.873950	0.6827	0.001 ***
ENCR7	0.0202851	0.0311127	0.6520	0.00000	11.033613	0.7030	1.000
DESMO15	0.0164707	0.0231102	0.7127	0.00000	6.890756	0.7195	0.001 ***

GEODIA3	0.0161317	0.0208987	0.7719	0.16949	8.184874	0.7357	0.001 ***
ENCR1	0.0124370	0.0140875	0.8828	0.00000	6.815126	0.7482	0.227
CNID3	0.0112150	0.0228892	0.4900	0.00000	5.050420	0.7594	0.001 ***
DESMO5	0.0104652	0.0172860	0.6054	0.00000	5.873950	0.7699	0.001 ***
DESMO18	0.0104262	0.0197044	0.5291	0.00000	4.798319	0.7803	0.001 ***
CNID9	0.0104240	0.0132873	0.7845	0.00000	4.613445	0.7908	0.001 ***
DESMO7	0.0098126	0.0225900	0.4344	0.00000	6.537815	0.8006	0.047 *
GEODIA1	0.0081136	0.0072572	1.1180	0.00000	4.075630	0.8087	0.001 ***
CRINO13	0.0077682	0.0212954	0.3648	0.00000	2.932773	0.8165	0.001 ***
PARAGO1	0.0077090	0.0113941	0.6766	0.00000	3.361345	0.8242	0.001 ***

Communities 2 & 8

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.2661069	0.1419946	1.87406	0.00000	78.64103	0.2666	0.001 ***
SPONGE17	0.2626656	0.2023789	1.29789	47.49153	0.00000	0.5297	0.001 ***
CANDA	0.0791772	0.1038795	0.76220	0.01695	28.46154	0.6091	0.261
HOLO2	0.0679066	0.0673945	1.00760	0.00000	23.43590	0.6771	0.040 *
FORAM	0.0360187	0.0397843	0.90535	0.00000	10.28205	0.7132	1.000
SPONGE20	0.0287190	0.0465414	0.61706	0.03390	6.02564	0.7420	0.983
ENCR8	0.0286179	0.0313538	0.91274	0.01695	8.41026	0.7706	1.000
ANTHO1	0.0200112	0.0236995	0.84437	0.00000	5.51282	0.7907	0.001 ***
PENNAT9	0.0156102	0.0405519	0.38494	0.00000	4.12821	0.8063	0.001 ***
HEXACT2	0.0127091	0.0141655	0.89719	0.01695	3.20513	0.8190	0.001 ***
CUP2	0.0126311	0.0186611	0.67687	0.00000	3.56410	0.8317	0.001 ***
STICHO1	0.0120444	0.0182619	0.65954	0.00000	4.94872	0.8438	0.335
PENTA	0.0115366	0.0228266	0.50540	0.00000	3.53846	0.8553	0.001 ***
SPONGE21	0.0115286	0.0394526	0.29221	0.00000	3.23077	0.8669	0.080 .
CUP4	0.0102616	0.0209811	0.48909	0.00000	2.23077	0.8772	0.001 ***
ENCR7	0.0088602	0.0126618	0.69976	0.00000	2.53846	0.8860	1.000
ENCR1	0.0070925	0.0135846	0.52210	0.00000	1.41026	0.8931	0.965
SPONGE14	0.0067586	0.0135224	0.49981	0.00000	1.64103	0.8999	0.011 *
ENCR5	0.0056049	0.0105119	0.53319	0.00000	1.82051	0.9055	0.311
PENNAT4	0.0049709	0.0116901	0.42523	0.05085	1.02564	0.9105	0.041 *
PENNAT18	0.0043610	0.0138539	0.31479	0.00000	1.25641	0.9149	0.001 ***
GRENADIER	0.0034287	0.0064270	0.53349	0.11864	0.64103	0.9183	0.292
HEXACT7	0.0030803	0.0074144	0.41545	0.00000	0.64103	0.9214	0.007 **
HEXACT25	0.0027481	0.0038561	0.71266	0.00000	1.00000	0.9241	0.122

CRINO3	0.0027262	0.0050213	0.54293	0.01695	0.64103	0.9269	0.897

Communities 2 & 9

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	3.503e-01	1.946e-01	1.80021	0.00000	134.93827	0.3510	0.001 ***
FORAM	3.174e-01	1.820e-01	1.74386	0.00000	132.03704	0.6691	0.001 ***
SPONGE17	1.909e-01	1.458e-01	1.30928	47.49153	0.00000	0.8604	0.001 ***
GRENADIER	1.112e-02	1.820e-02	0.61095	0.11864	3.08642	0.8716	0.001 ***
ANTHO1	1.011e-02	1.398e-02	0.72310	0.00000	4.40741	0.8817	0.005 **
HOLO2	9.239e-03	2.343e-02	0.39431	0.00000	8.20988	0.8910	1.000
ENCR8	8.359e-03	1.636e-02	0.51101	0.01695	5.44444	0.8993	1.000
ECHINO3	8.035e-03	9.074e-03	0.88553	0.01695	2.66667	0.9074	0.001 ***
PENNAT4	7.052e-03	1.150e-02	0.61319	0.05085	2.54321	0.9145	0.001 ***
OPHIURO1	6.779e-03	9.600e-03	0.70614	0.13559	2.02469	0.9212	0.001 ***
PENNAT9	6.032e-03	1.303e-02	0.46297	0.00000	1.88889	0.9273	0.005 **
PENTA	5.555e-03	7.132e-03	0.77892	0.00000	2.12346	0.9329	0.005 **
ACANEL1	5.437e-03	8.614e-03	0.63115	0.01695	1.60494	0.9383	0.001 ***
CUP2	5.431e-03	1.123e-02	0.48343	0.00000	2.07407	0.9437	0.190
PENNAT18	3.962e-03	1.062e-02	0.37313	0.00000	1.37037	0.9477	0.001 ***
CUP4	3.870e-03	1.305e-02	0.29654	0.00000	1.16049	0.9516	0.065 .
PENNAT2	2.827e-03	5.793e-03	0.48795	0.01695	0.70370	0.9544	0.001 ***
CERANTID	2.560e-03	4.686e-03	0.54634	0.00000	1.03704	0.9570	0.448
ASTERO10	2.139e-03	4.119e-03	0.51916	0.00000	0.65432	0.9591	0.001 ***
LEPIDION	2.088e-03	3.631e-03	0.57496	0.00000	0.70370	0.9612	0.001 ***
ACTIN4	2.046e-03	4.450e-03	0.45969	0.00000	0.93827	0.9633	0.120
HEXACT2	2.045e-03	4.488e-03	0.45555	0.01695	0.69136	0.9653	1.000
SPONGE20	1.840e-03	5.982e-03	0.30760	0.03390	1.18519	0.9672	1.000
STICHO1	1.586e-03	4.310e-03	0.36800	0.00000	1.12346	0.9688	1.000
ENCR1	1.498e-03	5.218e-03	0.28700	0.00000	0.40741	0.9703	1.000

Communities 3 & 4

Species	Average	sd	ratio	ava	avb	cumsum	p
SPONGE17	0.1911610	0.1318495	1.44984	39.09091	0.035714	0.2059	0.001 ***
ENCR8	0.1630027	0.1362433	1.19641	0.09091	48.562500	0.3814	0.001 ***
ENCR7	0.1346081	0.1320881	1.01908	8.36364	40.616071	0.5264	0.002 **
CANDA	0.1277415	0.1253796	1.01884	0.63636	33.937500	0.6640	0.004 **
ENCR9	0.0378349	0.0601930	0.62856	8.36364	0.312500	0.7048	0.001 ***
SPONGE20	0.0210335	0.0310209	0.67804	0.81818	6.205357	0.7274	0.994
FORAM	0.0194982	0.0333879	0.58399	0.54545	3.758929	0.7484	1.000

OPHIURO3	0.0193393	0.0433488	0.44613	1.81818	2.017857	0.7692	0.017 *
DESMO7	0.0133174	0.0372854	0.35718	0.00000	4.133929	0.7836	0.071 .
DESMO13	0.0130775	0.0214951	0.60839	2.18182	0.276786	0.7977	0.045 *
HEXACT2	0.0129844	0.0167126	0.77692	0.00000	2.991071	0.8116	0.004 **
BRYOZ1	0.0107587	0.0169823	0.63352	0.00000	2.535714	0.8232	0.024 *
HOLO2	0.0096672	0.0318860	0.30318	0.18182	5.669643	0.8336	1.000
ENCR1	0.0086124	0.0157542	0.54667	0.36364	3.178571	0.8429	0.702
DESMO6	0.0080780	0.0215226	0.37533	0.45455	1.848214	0.8516	0.070 .
GEODIA4	0.0062025	0.0211761	0.29290	0.00000	1.991071	0.8583	0.054 .
CRINO3	0.0061578	0.0092093	0.66865	0.27273	1.508929	0.8649	0.101
DESMO5	0.0054872	0.0120524	0.45528	0.63636	0.446429	0.8708	0.207
OPHIURO2	0.0052609	0.0148068	0.35531	0.72727	0.160714	0.8765	0.808
ISIDAE1	0.0040382	0.0111947	0.36073	0.54545	0.241071	0.8809	0.032 *
OPHIURO4	0.0033282	0.0075343	0.44174	0.45455	0.294643	0.8844	0.128
CRINO6	0.0032203	0.0109109	0.29515	0.00000	1.482143	0.8879	1.000
DESMO3	0.0031738	0.0121357	0.26152	0.00000	0.955357	0.8913	0.105
POLYM1	0.0031172	0.0074759	0.41697	0.45455	0.080357	0.8947	0.203
SPONGE5	0.0029531	0.0053583	0.55113	0.54545	0.169643	0.8979	0.052 .

Communities 3 & 5

Species	Average	sd	ratio	ava	avb	cumsum	p
SPONGE17	0.2060268	0.1230009	1.6750	39.09091	0.00000	0.2215	0.001 ***
FORAM	0.1889037	0.1222286	1.5455	0.54545	41.12766	0.4247	0.086 .
CANDA	0.1377767	0.1531303	0.8997	0.63636	31.42553	0.5728	0.002 **
ENCR7	0.0703163	0.0796375	0.8830	8.36364	11.25532	0.6484	0.110
ENCR8	0.0406203	0.0467599	0.8687	0.09091	7.61702	0.6921	0.856
ENCR9	0.0403984	0.0602895	0.6701	8.36364	0.29787	0.7356	0.001 ***
OPHIURO3	0.0261832	0.0535179	0.4892	1.81818	3.10638	0.7637	0.004 **
SPONGE20	0.0248864	0.0343588	0.7243	0.81818	4.12766	0.7905	0.953
HOLO2	0.0177351	0.0348159	0.5094	0.18182	2.70213	0.8096	0.997
ENCR1	0.0147548	0.0247460	0.5962	0.36364	2.68085	0.8254	0.175
DESMO13	0.0136264	0.0211941	0.6429	2.18182	0.10638	0.8401	0.031 *
BRYOZ1	0.0101819	0.0208293	0.4888	0.00000	1.80851	0.8510	0.033 *

DESMO5	0.0057424	0.0109992	0.5221	0.63636	0.29787	0.8572	0.182
OPHIURO2	0.0056631	0.0149435	0.3790	0.72727	0.17021	0.8633	0.728
HEXACT2	0.0055136	0.0099573	0.5537	0.00000	1.08511	0.8692	0.762
CRINO3	0.0055057	0.0089614	0.6144	0.27273	0.72340	0.8751	0.157
ISIDAE1	0.0052469	0.0110151	0.4763	0.54545	0.38298	0.8808	0.005 **
PLEXA1	0.0051434	0.0140589	0.3658	0.00000	0.72340	0.8863	0.173
OPHIURO8	0.0041437	0.0107060	0.3870	0.00000	0.65957	0.8908	0.924
POLYM1	0.0032399	0.0074507	0.4348	0.45455	0.02128	0.8942	0.189
DESMO15	0.0030747	0.0102696	0.2994	0.54545	0.00000	0.8976	0.730
SPONGE13	0.0029725	0.0069078	0.4303	0.72727	0.00000	0.9007	0.001 ***
SPONGE5	0.0029689	0.0048570	0.6113	0.54545	0.06383	0.9039	0.051 .
DESMO6	0.0028975	0.0064184	0.4514	0.45455	0.06383	0.9071	0.580
CUP2	0.0027596	0.0051574	0.5351	0.18182	0.34043	0.9100	0.908
GEODIA3	0.0026296	0.0049269	0.5337	0.36364	0.06383	0.9129	0.864

Communities 3 & 6

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	5.003e-01	0.2135226	2.3431	0.54545	130.48571	0.5128	0.001 ***
SPONGE17	1.874e-01	0.1338175	1.4001	39.09091	0.00000	0.7048	0.001 ***
ENCR7	3.919e-02	0.0441078	0.8886	8.36364	1.51429	0.7450	0.716
ENCR9	3.630e-02	0.0588158	0.6171	8.36364	0.05714	0.7822	0.002 **
CANDA	1.526e-02	0.0338297	0.4511	0.63636	3.55714	0.7978	1.000
OPHIURO3	1.520e-02	0.0453460	0.3351	1.81818	1.02857	0.8134	0.049 *
DESMO13	1.239e-02	0.0211795	0.5848	2.18182	0.10000	0.8261	0.066 .
STICHO1	1.115e-02	0.0466347	0.2392	0.00000	5.45714	0.8375	0.351
CUP1	1.053e-02	0.0228835	0.4601	0.00000	2.08571	0.8483	0.004 **
CUP3	6.735e-03	0.0223063	0.3019	0.00000	3.22857	0.8552	0.065 .
SPONGE20	6.723e-03	0.0117708	0.5711	0.81818	0.55714	0.8621	1.000
ENCR8	6.380e-03	0.0128075	0.4982	0.09091	1.55714	0.8686	1.000
OPHIURO2	5.437e-03	0.0153811	0.3535	0.72727	0.22857	0.8742	0.745

DESMO5	5.110e-03	0.0115752	0.4415	0.63636	0.25714	0.8794	0.281
CRINO6	4.469e-03	0.0151820	0.2944	0.00000	2.07143	0.8840	1.000
HOLO9	4.056e-03	0.0119135	0.3405	0.00000	0.64286	0.8882	0.015 *
HOLO2	4.002e-03	0.0092979	0.4304	0.18182	0.90000	0.8923	1.000
ISIDAE1	3.910e-03	0.0113270	0.3452	0.54545	0.10000	0.8963	0.037 *
ENCR1	3.663e-03	0.0069175	0.5296	0.36364	0.42857	0.9001	0.995
BRYOZ1	3.143e-03	0.0076420	0.4113	0.00000	0.82857	0.9033	0.834
POLYM1	3.046e-03	0.0076678	0.3972	0.45455	0.05714	0.9064	0.210
PENNAT4	2.861e-03	0.0151712	0.1886	0.00000	0.40000	0.9093	0.329
CUP2	2.827e-03	0.0058698	0.4816	0.18182	0.70000	0.9122	0.913
ECHINO3	2.805e-03	0.0084909	0.3303	0.09091	1.11429	0.9151	0.671
SPONGE5	2.784e-03	0.0048494	0.5740	0.54545	0.11429	0.9180	0.059 .

Communities 3 & 7

Species	Average	sd	ratio	ava	avb	cumsum	p
CANDA	0.1073203	0.0837247	1.2818	0.63636	54.067227	0.1121	0.035 *
SPONGE20	0.1042083	0.0605009	1.7224	0.81818	56.100840	0.2210	0.001 ***
SPONGE17	0.0961017	0.0884040	1.0871	39.09091	0.000000	0.3214	0.040 *
HEXACT9	0.0462560	0.0425310	1.0876	0.00000	23.638655	0.3697	0.001 ***
HOLO2	0.0429175	0.0458547	0.9359	0.18182	22.621849	0.4145	0.716
ENCR8	0.0424764	0.0423905	1.0020	0.09091	22.722689	0.4589	0.866
CRINO9	0.0303216	0.0353133	0.8586	0.18182	14.521008	0.4906	0.001 ***
OPHIURO8	0.0298370	0.0387351	0.7703	0.00000	17.327731	0.5218	0.004 **
DESMO9	0.0293384	0.0301041	0.9746	0.18182	14.672269	0.5524	0.001 ***
ENCR7	0.0273357	0.0323821	0.8442	8.36364	11.033613	0.5810	0.972
OPHIURO2	0.0218162	0.0476482	0.4579	0.72727	13.352941	0.6038	0.069 .

HEXACT8	0.0214776	0.0183187	1.1724	0.00000	10.941176	0.6262	0.001 ***
DESMO13	0.0207825	0.0191496	1.0853	2.18182	10.974790	0.6479	0.001 ***
CRINO4	0.0200683	0.0316048	0.6350	0.00000	10.873950	0.6689	0.004 **
ENCR9	0.0195321	0.0345892	0.5647	8.36364	0.042017	0.6893	0.019 *
DESMO15	0.0156793	0.0214374	0.7314	0.54545	6.890756	0.7057	0.007 **
GEODIA3	0.0150387	0.0196519	0.7653	0.36364	8.184874	0.7214	0.002 **
ENCR1	0.0117696	0.0132596	0.8876	0.36364	6.815126	0.7337	0.369
CNID3	0.0109602	0.0214731	0.5104	0.27273	5.050420	0.7451	0.019 *
DESMO5	0.0103338	0.0164450	0.6284	0.63636	5.873950	0.7559	0.029 *
DESMO18	0.0098910	0.0188565	0.5245	0.00000	4.798319	0.7662	0.019 *
CNID9	0.0098723	0.0126324	0.7815	0.00000	4.613445	0.7766	0.003 **
OPHIURO3	0.0095196	0.0264144	0.3604	1.81818	2.974790	0.7865	0.129
DESMO7	0.0094191	0.0218461	0.4312	0.00000	6.537815	0.7963	0.179
GEODIA1	0.0074716	0.0067608	1.1051	0.27273	4.075630	0.8042	0.001 ***

Communities 3 & 8

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.2427917	0.1382143	1.7566	0.00000	78.64103	0.2495	0.001 ***
SPONGE17	0.1746431	0.1337655	1.3056	39.09091	0.00000	0.4289	0.001 ***
CANDA	0.0737596	0.0972336	0.7586	0.63636	28.46154	0.5047	0.434
HOLO2	0.0627255	0.0637414	0.9841	0.18182	23.43590	0.5692	0.233
ENCR7	0.0357184	0.0423265	0.8439	8.36364	2.53846	0.6059	0.815
FORAM	0.0340294	0.0362437	0.9389	0.54545	10.28205	0.6408	0.999
ENCR9	0.0338702	0.0570311	0.5939	8.36364	0.00000	0.6757	0.002 **
SPONGE20	0.0267510	0.0404878	0.6607	0.81818	6.02564	0.7031	0.914
ENCR8	0.0262691	0.0293165	0.8961	0.09091	8.41026	0.7301	0.997
ANTHO1	0.0182345	0.0221558	0.8230	0.00000	5.51282	0.7489	0.001 ***
PENNAT9	0.0141420	0.0371840	0.3803	0.00000	4.12821	0.7634	0.003 **
OPHIURO3	0.0118344	0.0436614	0.2710	1.81818	0.00000	0.7756	0.093 .
DESMO13	0.0115801	0.0204001	0.5676	2.18182	0.23077	0.7875	0.098 .

HEXACT2	0.0113519	0.0122145	0.9294	0.00000	3.20513	0.7991	0.022 *
STICHO1	0.0112400	0.0174592	0.6438	0.00000	4.94872	0.8107	0.348
CUP2	0.0111404	0.0168594	0.6608	0.18182	3.56410	0.8221	0.002 **
PENTA	0.0106510	0.0214623	0.4963	0.00000	3.53846	0.8331	0.004 **
SPONGE21	0.0106083	0.0363731	0.2917	0.00000	3.23077	0.8440	0.206
CUP4	0.0091630	0.0182847	0.5011	0.00000	2.23077	0.8534	0.004 **
ENCR1	0.0070834	0.0114861	0.6167	0.36364	1.41026	0.8607	0.835
SPONGE14	0.0061508	0.0122842	0.5007	0.00000	1.64103	0.8670	0.111
OPHIURO2	0.0055246	0.0143637	0.3846	0.72727	0.58974	0.8727	0.721
ENCR5	0.0050096	0.0093443	0.5361	0.00000	1.82051	0.8778	0.341
DESMO5	0.0050021	0.0109281	0.4577	0.63636	0.35897	0.8829	0.299
PENNAT4	0.0043185	0.0106814	0.4043	0.00000	1.02564	0.8874	0.163

Communities 3 & 9

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	3.267e-01	1.874e-01	1.7436	0.00000	134.93827	0.3301	0.001 ***
FORAM	2.918e-01	1.741e-01	1.6763	0.54545	132.03704	0.6248	0.001 ***
SPONGE17	1.334e-01	1.056e-01	1.2633	39.09091	0.00000	0.7596	0.004 **
ENCR7	2.786e-02	3.324e-02	0.8383	8.36364	0.60494	0.7878	0.967
ENCR9	2.672e-02	4.460e-02	0.5992	8.36364	0.00000	0.8148	0.004 **
GRENADIER	1.030e-02	1.695e-02	0.6079	0.00000	3.08642	0.8252	0.005 **
ANTHO1	9.422e-03	1.295e-02	0.7276	0.00000	4.40741	0.8347	0.143
HOLO2	9.144e-03	2.232e-02	0.4097	0.18182	8.20988	0.8439	1.000
DESMO13	8.538e-03	1.493e-02	0.5717	2.18182	0.06173	0.8525	0.297
OPHIURO3	8.234e-03	2.936e-02	0.2805	1.81818	0.00000	0.8609	0.221
ENCR8	7.928e-03	1.530e-02	0.5183	0.09091	5.44444	0.8689	1.000
ECHINO3	7.329e-03	8.247e-03	0.8887	0.09091	2.66667	0.8763	0.025 *
PENNAT4	6.479e-03	1.056e-02	0.6135	0.00000	2.54321	0.8828	0.058 .
OPHIURO1	6.103e-03	8.675e-03	0.7036	0.00000	2.02469	0.8890	0.012 *
PENNAT9	5.605e-03	1.224e-02	0.4579	0.00000	1.88889	0.8946	0.060 .
CUP2	5.303e-03	1.009e-02	0.5253	0.18182	2.07407	0.9000	0.330
PENTA	5.185e-03	6.708e-03	0.7730	0.00000	2.12346	0.9052	0.071 .
ACANEL1	5.002e-03	7.991e-03	0.6259	0.00000	1.60494	0.9103	0.004 **
SPONGE20	4.660e-03	8.542e-03	0.5456	0.81818	1.18519	0.9150	1.000
PENNAT18	3.716e-03	1.009e-02	0.3684	0.00000	1.37037	0.9188	0.053 .
CUP4	3.564e-03	1.200e-02	0.2969	0.00000	1.16049	0.9224	0.158
OPHIURO2	3.095e-03	1.008e-02	0.3072	0.72727	0.00000	0.9255	0.945
DESMO5	2.965e-03	7.627e-03	0.3888	0.63636	0.08642	0.9285	0.710
PENNAT2	2.633e-03	5.110e-03	0.5153	0.09091	0.70370	0.9311	0.017 *
ENCR1	2.511e-03	5.420e-03	0.4633	0.36364	0.40741	0.9337	1.000

Communities 4 & 5

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	0.1402207	0.1161590	1.2071	3.758929	41.12766	0.1833	0.433
CANDA	0.1389726	0.1298648	1.0701	33.937500	31.42553	0.3650	0.001 ***
ENCR8	0.1217814	0.1220409	0.9979	48.562500	7.61702	0.5242	0.001 ***
ENCR7	0.1217372	0.1202645	1.0122	40.616071	11.25532	0.6834	0.001 ***
SPONGE20	0.0268732	0.0338958	0.7928	6.205357	4.12766	0.7185	1.000
HOLO2	0.0200375	0.0385750	0.5194	5.669643	2.70213	0.7447	1.000
OPHIURO3	0.0160127	0.0321986	0.4973	2.017857	3.10638	0.7656	0.001 ***
ENCR1	0.0145265	0.0227885	0.6374	3.178571	2.68085	0.7846	0.049 *
BRYOZ1	0.0130423	0.0190221	0.6856	2.535714	1.80851	0.8017	0.001 ***
DESMO7	0.0116208	0.0335926	0.3459	4.133929	0.02128	0.8169	0.022 *
HEXACT2	0.0110343	0.0134600	0.8198	2.991071	1.08511	0.8313	0.001 ***
CRINO3	0.0061912	0.0084970	0.7286	1.508929	0.72340	0.8394	0.014 *
GEODIA4	0.0054272	0.0191581	0.2833	1.991071	0.00000	0.8465	0.009 **
DESMO6	0.0053381	0.0191516	0.2787	1.848214	0.06383	0.8535	0.135
PLEXA1	0.0042579	0.0114020	0.3734	0.142857	0.72340	0.8590	0.167
OPHIURO8	0.0039572	0.0091932	0.4304	0.357143	0.65957	0.8642	0.998
CRINO6	0.0037871	0.0103615	0.3655	1.482143	0.29787	0.8691	1.000
OPHIURO1	0.0033271	0.0082620	0.4027	0.437500	0.57447	0.8735	0.098 .
DESMO3	0.0028452	0.0107476	0.2647	0.955357	0.04255	0.8772	0.084 .
ENCR9	0.0027916	0.0125250	0.2229	0.312500	0.29787	0.8809	0.811
ANACH	0.0026527	0.0045580	0.5820	0.633929	0.21277	0.8843	0.001 ***
ENCR11	0.0022397	0.0077963	0.2873	0.553571	0.29787	0.8873	0.870
ENCR5	0.0021783	0.0056222	0.3875	0.937500	0.17021	0.8901	0.983
DESMO5	0.0021386	0.0052458	0.4077	0.446429	0.29787	0.8929	0.997
SPONGE14	0.0020533	0.0093526	0.2195	1.375000	0.04255	0.8956	0.936

Communities 4 & 6

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	0.3905297	0.2259052	1.7287	3.758929	130.48571	0.4180	0.001 ***
ENCR8	0.1236460	0.1238787	0.9981	48.562500	1.55714	0.5503	0.001 ***
ENCR7	0.1099863	0.1221425	0.9005	40.616071	1.51429	0.6680	0.001 ***

CANDA	0.0996126	0.1065454	0.9349	33.937500	3.55714	0.7746	0.001 ***
SPONGE20	0.0158492	0.0266215	0.5954	6.205357	0.55714	0.7916	1.000
DESMO7	0.0107399	0.0317527	0.3382	4.133929	0.04286	0.8031	0.014 *
STICHO1	0.0100185	0.0415211	0.2413	0.303571	5.45714	0.8138	0.626
HOLO2	0.0100009	0.0292332	0.3421	5.669643	0.90000	0.8245	1.000
HEXACT2	0.0097533	0.0134123	0.7272	2.991071	0.34286	0.8349	0.001 ***
BRYOZ1	0.0092822	0.0140562	0.6604	2.535714	0.82857	0.8449	0.001 ***
OPHIURO3	0.0083891	0.0139977	0.5993	2.017857	1.02857	0.8538	0.152
CUP1	0.0081290	0.0182925	0.4444	0.062500	2.08571	0.8625	0.001 ***
ENCR1	0.0066112	0.0138208	0.4783	3.178571	0.42857	0.8696	0.998
CRINO6	0.0062203	0.0157084	0.3960	1.482143	2.07143	0.8763	1.000
CUP3	0.0058555	0.0197955	0.2958	0.008929	3.22857	0.8825	0.001 ***
GEODIA4	0.0050878	0.0180631	0.2817	1.991071	0.05714	0.8880	0.002 **
DESMO6	0.0048378	0.0181861	0.2660	1.848214	0.04286	0.8932	0.181
CRINO3	0.0044503	0.0075572	0.5889	1.508929	0.20000	0.8979	0.298
HOLO9	0.0030476	0.0093900	0.3246	0.008929	0.64286	0.9012	0.001 ***
OPHIURO1	0.0030403	0.0082648	0.3679	0.437500	0.54286	0.9044	0.167
DESMO3	0.0028495	0.0101227	0.2815	0.955357	0.17143	0.9075	0.043 *
HOLO8	0.0024352	0.0057780	0.4215	0.276786	0.38571	0.9101	0.001 ***
ECHINO3	0.0022418	0.0075133	0.2984	0.053571	1.11429	0.9125	0.987
ANACH	0.0021192	0.0045155	0.4693	0.633929	0.01429	0.9148	0.001 ***
PENNAT4	0.0020984	0.0116645	0.1799	0.008929	0.40000	0.9170	0.728

Communities 4 & 7

Species	Average	sd	ratio	ava	avb	cumsum	p
CANDA	0.0876271	0.0782599	1.1197	33.937500	54.067227	0.1055	0.006 **
SPONGE20	0.0860631	0.0583650	1.4746	6.205357	56.100840	0.2091	0.001 ***
ENCR8	0.0714503	0.0840364	0.8502	48.562500	22.722689	0.2951	0.008 **
ENCR7	0.0657839	0.0823256	0.7991	40.616071	11.033613	0.3743	0.005 **
HOLO2	0.0397743	0.0432834	0.9189	5.669643	22.621849	0.4222	0.992

HEXACT9	0.0397405	0.0386738	1.0276	0.491071	23.638655	0.4700	0.001 ***
CRINO9	0.0260451	0.0314612	0.8278	0.178571	14.521008	0.5014	0.001 ***
OPHIURO8	0.0258462	0.0348904	0.7408	0.357143	17.327731	0.5325	0.001 ***
DESMO9	0.0252452	0.0271346	0.9304	0.267857	14.672269	0.5629	0.001 ***
OPHIURO2	0.0183300	0.0435641	0.4208	0.160714	13.352941	0.5849	0.001 ***
HEXACT8	0.0182949	0.0165816	1.1033	0.589286	10.941176	0.6070	0.001 ***
DESMO13	0.0181403	0.0181400	1.0000	0.276786	10.974790	0.6288	0.001 ***
CRINO4	0.0174501	0.0283373	0.6158	0.232143	10.873950	0.6498	0.001 ***
DESMO7	0.0136511	0.0271553	0.5027	4.133929	6.537815	0.6662	0.001 ***
DESMO15	0.0132366	0.0189875	0.6971	0.053571	6.890756	0.6822	0.001 ***
GEODIA3	0.0132358	0.0177255	0.7467	0.071429	8.184874	0.6981	0.001 ***
ENCR1	0.0118402	0.0138355	0.8558	3.178571	6.815126	0.7124	0.300
CNID3	0.0091208	0.0191328	0.4767	0.000000	5.050420	0.7234	0.001 ***
DESMO5	0.0087814	0.0148486	0.5914	0.446429	5.873950	0.7339	0.001 ***
DESMO18	0.0085201	0.0168160	0.5067	0.000000	4.798319	0.7442	0.001 ***
CNID9	0.0084622	0.0111994	0.7556	0.053571	4.613445	0.7544	0.001 ***
FORAM	0.0078049	0.0167577	0.4658	3.758929	0.100840	0.7638	1.000
DESMO6	0.0077710	0.0146667	0.5298	1.848214	3.109244	0.7731	0.001 ***
HEXACT2	0.0076801	0.0088694	0.8659	2.991071	4.218487	0.7824	0.085 .
OPHIURO3	0.0071109	0.0160049	0.4443	2.017857	2.974790	0.7909	0.335

Communities 4 & 8

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.1948016	0.1348792	1.4443	1.482143	78.64103	0.2226	0.001 ***
CANDA	0.1143319	0.1040389	1.0989	33.937500	28.46154	0.3532	0.001 ***
ENCR8	0.1090499	0.1209409	0.9017	48.562500	8.41026	0.4778	0.001 ***

ENCR7	0.1026202	0.1197693	0.8568	40.616071	2.53846	0.5950	0.001 ***
HOLO2	0.0558091	0.0583546	0.9564	5.669643	23.43590	0.6588	0.338
FORAM	0.0308300	0.0331301	0.9306	3.758929	10.28205	0.6940	1.000
SPONGE20	0.0275755	0.0373768	0.7378	6.205357	6.02564	0.7255	0.999
ANTHO1	0.0150328	0.0192485	0.7810	0.678571	5.51282	0.7427	0.001 ***
PENNAT9	0.0113180	0.0312116	0.3626	0.017857	4.12821	0.7556	0.001 ***
HEXACT2	0.0112031	0.0122627	0.9136	2.991071	3.20513	0.7684	0.001 ***
DESMO7	0.0100941	0.0306399	0.3294	4.133929	0.02564	0.7799	0.072 .
STICHO1	0.0097101	0.0158351	0.6132	0.303571	4.94872	0.7910	0.568
CUP2	0.0090463	0.0146517	0.6174	0.178571	3.56410	0.8014	0.001 ***
PENTA	0.0087599	0.0185872	0.4713	0.035714	3.53846	0.8114	0.001 ***
SPONGE21	0.0087386	0.0304953	0.2866	0.071429	3.23077	0.8213	0.217
ENCR1	0.0085950	0.0145692	0.5899	3.178571	1.41026	0.8312	0.892
BRYOZ1	0.0085118	0.0134810	0.6314	2.535714	0.66667	0.8409	0.008 **
CUP4	0.0072861	0.0147212	0.4949	0.151786	2.23077	0.8492	0.001 ***
OPHIURO3	0.0066005	0.0131449	0.5021	2.017857	0.00000	0.8568	0.457
SPONGE14	0.0063296	0.0124478	0.5085	1.375000	1.64103	0.8640	0.016 *
ENCR5	0.0049147	0.0085326	0.5760	0.937500	1.82051	0.8696	0.436
GEODIA4	0.0048475	0.0173882	0.2788	1.991071	0.05128	0.8751	0.036 *
CRINO3	0.0047652	0.0072365	0.6585	1.508929	0.64103	0.8806	0.217
DESMO6	0.0046218	0.0174946	0.2642	1.848214	0.02564	0.8859	0.292
PENNAT4	0.0034058	0.0088791	0.3836	0.008929	1.02564	0.8898	0.195

Communities 4 & 9

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.2707769	0.1783023	1.5186	1.482143	134.93827	0.2826	0.001 ***
FORAM	0.2344994	0.1659375	1.4132	3.758929	132.03704	0.5273	0.001 ***
ENCR8	0.0958490	0.1034480	0.9265	48.562500	5.44444	0.6273	0.001 ***
ENCR7	0.0869348	0.1019131	0.8530	40.616071	0.60494	0.7180	0.001 ***
CANDA	0.0786718	0.0879860	0.8941	33.937500	0.00000	0.8001	0.210
HOLO2	0.0135911	0.0313927	0.4329	5.669643	8.20988	0.8143	1.000
SPONGE20	0.0126840	0.0218984	0.5792	6.205357	1.18519	0.8275	1.000
DESMO7	0.0085281	0.0267451	0.3189	4.133929	0.00000	0.8364	0.105
ANTHO1	0.0082563	0.0111698	0.7392	0.678571	4.40741	0.8451	0.041 *
GRENADIER	0.0082009	0.0144426	0.5678	0.080357	3.08642	0.8536	0.001 ***
HEXACT2	0.0072519	0.0095271	0.7612	2.991071	0.69136	0.8612	0.286
BRYOZ1	0.0063444	0.0111040	0.5714	2.535714	0.00000	0.8678	0.090 .

ECHINO3	0.0060402	0.0070240	0.8599	0.053571	2.66667	0.8741	0.001 ***
OPHIURO3	0.0053061	0.0106221	0.4995	2.017857	0.00000	0.8797	0.824
ENCR1	0.0053039	0.0120475	0.4402	3.178571	0.40741	0.8852	1.000
PENNAT4	0.0052721	0.0088189	0.5978	0.008929	2.54321	0.8907	0.003 **
OPHIURO1	0.0052331	0.0075300	0.6950	0.437500	2.02469	0.8961	0.001 ***
PENNAT9	0.0046508	0.0105619	0.4403	0.017857	1.88889	0.9010	0.017 *
PENTA	0.0043337	0.0058552	0.7401	0.035714	2.12346	0.9055	0.009 **
CUP2	0.0042702	0.0087440	0.4884	0.178571	2.07407	0.9100	0.792
ACANEL1	0.0040775	0.0067881	0.6007	0.000000	1.60494	0.9142	0.001 ***
GEODIA4	0.0040226	0.0152942	0.2630	1.991071	0.00000	0.9184	0.021 *
DESMO6	0.0037964	0.0150438	0.2524	1.848214	0.00000	0.9224	0.524
CRINO3	0.0032336	0.0057860	0.5589	1.508929	0.02469	0.9258	0.868
PENNAT18	0.0031216	0.0088337	0.3534	0.000000	1.37037	0.9290	0.001 ***

Communities 5 & 6

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	0.3494682	0.2130006	1.6407	41.12766	130.48571	0.4789	0.001 ***
CANDA	0.1060631	0.1291273	0.8214	31.42553	3.55714	0.6243	0.001 ***
ENCR7	0.0461816	0.0722422	0.6393	11.25532	1.51429	0.6876	0.644
ENCR8	0.0301785	0.0377317	0.7998	7.61702	1.55714	0.7289	1.000
SPONGE20	0.0185704	0.0291646	0.6367	4.12766	0.55714	0.7544	1.000
HOLO2	0.0141053	0.0277821	0.5077	2.70213	0.90000	0.7737	1.000
OPHIURO3	0.0134704	0.0315195	0.4274	3.10638	1.02857	0.7922	0.004 **
ENCR1	0.0110447	0.0205727	0.5369	2.68085	0.42857	0.8073	0.470
STICHO1	0.0103788	0.0432757	0.2398	0.02128	5.45714	0.8215	0.531
CUP1	0.0094505	0.0185934	0.5083	0.57447	2.08571	0.8345	0.001 ***
BRYOZ1	0.0090760	0.0168063	0.5400	1.80851	0.82857	0.8469	0.003 **
CUP3	0.0063325	0.0206543	0.3066	0.04255	3.22857	0.8556	0.002 **
CRINO6	0.0051494	0.0142393	0.3616	0.29787	2.07143	0.8626	1.000
HEXACT2	0.0046583	0.0080890	0.5759	1.08511	0.34286	0.8690	0.994
PLEXA1	0.0040190	0.0110187	0.3647	0.72340	0.10000	0.8745	0.265
CRINO3	0.0037533	0.0071054	0.5282	0.72340	0.20000	0.8797	0.559
HOLO9	0.0034076	0.0094651	0.3600	0.08511	0.64286	0.8843	0.001 ***
OPHIURO8	0.0032478	0.0086242	0.3766	0.65957	0.07143	0.8888	0.999
ACTIN1	0.0030573	0.0089093	0.3432	0.19149	0.97143	0.8930	0.106
OPHIURO1	0.0030050	0.0083990	0.3578	0.57447	0.54286	0.8971	0.243
CUP2	0.0029980	0.0058216	0.5150	0.34043	0.70000	0.9012	0.989
PENNAT4	0.0024227	0.0114430	0.2117	0.04255	0.40000	0.9045	0.500
ECHINO3	0.0023496	0.0078787	0.2982	0.02128	1.11429	0.9078	0.949

ENCR3	0.0019581	0.0075342	0.2599	0.04255	0.87143	0.9104	0.956
ISIDAE1	0.0018955	0.0034652	0.5470	0.38298	0.10000	0.9130	0.487

Communities 5 & 7

Species	Average	sd	ratio	ava	avb	cumsum	p
CANDA	0.0971125	0.0852701	1.1389	31.42553	54.06723	0.1130	0.004 **
SPONGE20	0.0904698	0.0570686	1.5853	4.12766	56.10084	0.2183	0.001 ***
FORAM	0.0833896	0.0795899	1.0477	41.12766	0.10084	0.3153	1.000
HEXACT9	0.0423713	0.0396141	1.0696	0.02128	23.63866	0.3646	0.001 ***
ENCR8	0.0382747	0.0355817	1.0757	7.61702	22.72269	0.4091	0.999
HOLO2	0.0381087	0.0416512	0.9149	2.70213	22.62185	0.4535	0.986
ENCR7	0.0313357	0.0441769	0.7093	11.25532	11.03361	0.4899	0.997
CRINO9	0.0277830	0.0324716	0.8556	0.06383	14.52101	0.5223	0.001 ***
OPHIURO8	0.0271877	0.0358110	0.7592	0.65957	17.32773	0.5539	0.001 ***
DESMO9	0.0269038	0.0278704	0.9653	0.06383	14.67227	0.5852	0.001 ***
OPHIURO2	0.0193606	0.0452469	0.4279	0.17021	13.35294	0.6077	0.006 **
HEXACT8	0.0193239	0.0168664	1.1457	0.29787	10.94118	0.6302	0.001 ***
DESMO13	0.0192956	0.0186153	1.0365	0.10638	10.97479	0.6527	0.001 ***
CRINO4	0.0184410	0.0293998	0.6272	0.04255	10.87395	0.6741	0.001 ***
DESMO15	0.0141235	0.0197277	0.7159	0.00000	6.89076	0.6906	0.001 ***
GEODIA3	0.0139997	0.0182548	0.7669	0.06383	8.18487	0.7069	0.001 ***
ENCR1	0.0126165	0.0145280	0.8684	2.68085	6.81513	0.7215	0.204
OPHIURO3	0.0098705	0.0224797	0.4391	3.10638	2.97479	0.7330	0.053 .
CNID3	0.0097057	0.0199334	0.4869	0.00000	5.05042	0.7443	0.001 ***
DESMO5	0.0091211	0.0152920	0.5965	0.29787	5.87395	0.7549	0.001 ***
DESMO18	0.0090557	0.0175010	0.5174	0.00000	4.79832	0.7655	0.001 ***
CNID9	0.0090110	0.0116062	0.7764	0.00000	4.61345	0.7760	0.001 ***
DESMO7	0.0087938	0.0206101	0.4267	0.02128	6.53782	0.7862	0.132
GEODIA1	0.0070054	0.0063232	1.1079	0.10638	4.07563	0.7943	0.001 ***

CLAUVU1	0.0068260	0.0199874	0.3415	0.25532	3.01681	0.8023	0.008 **

Communities 5 & 8

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.2093528	0.1313705	1.5936	0.29787	78.64103	0.2471	0.001 ***
CANDA	0.1246955	0.1216262	1.0252	31.42553	28.46154	0.3943	0.001 ***
FORAM	0.1206702	0.1153644	1.0460	41.12766	10.28205	0.5368	0.792
HOLO2	0.0571076	0.0567444	1.0064	2.70213	23.43590	0.6042	0.316
ENCR7	0.0426214	0.0697547	0.6110	11.25532	2.53846	0.6545	0.755
ENCR8	0.0343384	0.0360447	0.9527	7.61702	8.41026	0.6950	0.991
SPONGE20	0.0288124	0.0373793	0.7708	4.12766	6.02564	0.7290	0.967
ANTHO1	0.0158871	0.0197471	0.8045	0.14894	5.51282	0.7478	0.001 ***
PENNAT9	0.0121249	0.0323259	0.3751	0.02128	4.12821	0.7621	0.001 ***
ENCR1	0.0118521	0.0194479	0.6094	2.68085	1.41026	0.7761	0.370
OPHIURO3	0.0112969	0.0305860	0.3694	3.10638	0.00000	0.7894	0.044 *
STICHO1	0.0100864	0.0161349	0.6251	0.02128	4.94872	0.8013	0.509
CUP2	0.0096279	0.0147347	0.6534	0.34043	3.56410	0.8127	0.001 ***
HEXACT2	0.0095704	0.0102671	0.9321	1.08511	3.20513	0.8240	0.007 **
SPONGE21	0.0093994	0.0317517	0.2960	0.04255	3.23077	0.8351	0.218
PENTA	0.0093735	0.0193589	0.4842	0.00000	3.53846	0.8461	0.001 ***
BRYOZ1	0.0082063	0.0161195	0.5091	1.80851	0.66667	0.8558	0.029 *
CUP4	0.0077302	0.0148715	0.5198	0.02128	2.23077	0.8650	0.001 ***
SPONGE14	0.0054893	0.0105951	0.5181	0.04255	1.64103	0.8714	0.074 .
ENCR5	0.0045742	0.0081195	0.5634	0.17021	1.82051	0.8768	0.440
CRINO3	0.0042867	0.0068421	0.6265	0.72340	0.64103	0.8819	0.395
PLEXA1	0.0039144	0.0105209	0.3721	0.72340	0.25641	0.8865	0.312
PENNAT4	0.0037723	0.0091306	0.4131	0.04255	1.02564	0.8910	0.185
OPHIURO8	0.0036665	0.0084070	0.4361	0.65957	0.43590	0.8953	0.992
PENNAT18	0.0035458	0.0116159	0.3052	0.00000	1.25641	0.8995	0.010 **

Communities 5 & 9

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	2.906e-01	0.1755735	1.6553	0.29787	134.93827	0.3554	0.001 ***

FORAM	2.081e-01	0.1550048	1.3424	41.12766	132.03704	0.6098	0.001 ***
CANDA	8.213e-02	0.1058441	0.7759	31.42553	0.00000	0.7102	0.165
ENCR7	3.400e-02	0.0557331	0.6101	11.25532	0.60494	0.7518	0.970
ENCR8	2.426e-02	0.0280860	0.8636	7.61702	5.44444	0.7814	1.000
HOLO2	1.526e-02	0.0264952	0.5758	2.70213	8.20988	0.8001	1.000
SPONGE20	1.390e-02	0.0216032	0.6434	4.12766	1.18519	0.8171	1.000
OPHIURO3	9.067e-03	0.0238576	0.3801	3.10638	0.00000	0.8282	0.126
GRENADIER	8.817e-03	0.0149456	0.5899	0.06383	3.08642	0.8390	0.001 ***
ANTHO1	8.533e-03	0.0114103	0.7478	0.14894	4.40741	0.8494	0.067 .
ENCR1	8.152e-03	0.0157692	0.5169	2.68085	0.40741	0.8594	0.930
ECHINO3	6.498e-03	0.0071606	0.9074	0.02128	2.66667	0.8673	0.003 **
OPHIURO1	5.815e-03	0.0081496	0.7135	0.57447	2.02469	0.8744	0.001 ***
BRYOZ1	5.657e-03	0.0129645	0.4364	1.80851	0.00000	0.8813	0.305
PENNAT4	5.653e-03	0.0090163	0.6269	0.04255	2.54321	0.8882	0.012 *
PENNAT9	4.981e-03	0.0110151	0.4522	0.02128	1.88889	0.8943	0.046 *
CUP2	4.950e-03	0.0088748	0.5578	0.34043	2.07407	0.9004	0.414
PENTA	4.633e-03	0.0060629	0.7641	0.00000	2.12346	0.9060	0.034 *
ACANEL1	4.381e-03	0.0070286	0.6233	0.00000	1.60494	0.9114	0.001 ***
HEXACT2	3.672e-03	0.0058405	0.6287	1.08511	0.69136	0.9159	1.000
PENNAT18	3.340e-03	0.0092358	0.3616	0.00000	1.37037	0.9200	0.004 **
CUP4	3.163e-03	0.0104202	0.3036	0.02128	1.16049	0.9238	0.230
PLEXA1	2.790e-03	0.0078673	0.3547	0.72340	0.06173	0.9273	0.726
CRINO3	2.485e-03	0.0052324	0.4750	0.72340	0.02469	0.9303	0.961
OPHIURO8	2.320e-03	0.0061458	0.3774	0.65957	0.04938	0.9331	1.000

Communities 6 & 7

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	0.2381464	0.1660544	1.4341	130.48571	0.10084	0.2452	0.001 ***
SPONGE20	0.0901251	0.0561405	1.6054	0.55714	56.10084	0.3379	0.001 ***
CANDA	0.0893255	0.0742887	1.2024	3.55714	54.06723	0.4299	0.008 **
HEXACT9	0.0396551	0.0380466	1.0423	0.00000	23.63866	0.4707	0.001 ***
HOLO2	0.0362959	0.0407844	0.8899	0.90000	22.62185	0.5081	0.998
ENCR8	0.0357475	0.0365856	0.9771	1.55714	22.72269	0.5449	1.000
CRINO9	0.0259480	0.0310198	0.8365	0.04286	14.52101	0.5716	0.001 ***
OPHIURO8	0.0257711	0.0345730	0.7454	0.07143	17.32773	0.5981	0.001 ***
DESMO9	0.0251929	0.0268165	0.9395	0.02857	14.67227	0.6241	0.001 ***
HEXACT8	0.0183655	0.0163069	1.1262	0.00000	10.94118	0.6430	0.001 ***
OPHIURO2	0.0183354	0.0431822	0.4246	0.22857	13.35294	0.6619	0.003 **
DESMO13	0.0180287	0.0178605	1.0094	0.10000	10.97479	0.6804	0.001 ***
CRINO4	0.0172916	0.0280665	0.6161	0.00000	10.87395	0.6982	0.001 ***
ENCR7	0.0172884	0.0260859	0.6627	1.51429	11.03361	0.7160	1.000
GEODIA3	0.0131320	0.0175291	0.7492	0.04286	8.18487	0.7295	0.001 ***
DESMO15	0.0131189	0.0186671	0.7028	0.00000	6.89076	0.7430	0.001 ***
ENCR1	0.0101866	0.0118827	0.8573	0.42857	6.81513	0.7535	0.681
CNID3	0.0090432	0.0188601	0.4795	0.00000	5.05042	0.7628	0.001 ***
DESMO5	0.0085617	0.0146352	0.5850	0.25714	5.87395	0.7716	0.001 ***
DESMO18	0.0084558	0.0166127	0.5090	0.00000	4.79832	0.7804	0.001 ***
CNID9	0.0083926	0.0110214	0.7615	0.00000	4.61345	0.7890	0.001 ***
DESMO7	0.0083226	0.0196934	0.4226	0.04286	6.53782	0.7976	0.146
STICHO1	0.0073665	0.0304935	0.2416	5.45714	0.21849	0.8051	0.904
GEODIA1	0.0065579	0.0061115	1.0730	0.10000	4.07563	0.8119	0.001 ***
HEXACT2	0.0062435	0.0074712	0.8357	0.34286	4.21849	0.8183	0.792

Communities 6 & 8

Species	Average	sd	ratio	ava	avb	cumsum	p
FORAM	0.3493958	0.2309886	1.51261	130.48571	10.28205	0.3806	0.001 ***
CRINO6	0.1914567	0.1347988	1.42031	2.07143	78.64103	0.5892	0.001 ***
CANDA	0.0643366	0.0830901	0.77430	3.55714	28.46154	0.6593	0.795
HOLO2	0.0513333	0.0556110	0.92308	0.90000	23.43590	0.7152	0.562
ENCR8	0.0217307	0.0246091	0.88303	1.55714	8.41026	0.7389	1.000
SPONGE20	0.0203256	0.0348140	0.58383	0.55714	6.02564	0.7610	1.000
STICHO1	0.0175969	0.0398665	0.44140	5.45714	4.94872	0.7802	0.083 .
ANTHO1	0.0145123	0.0191380	0.75829	0.11429	5.51282	0.7960	0.001 ***
PENNAT9	0.0112432	0.0307311	0.36586	0.05714	4.12821	0.8083	0.001 ***
ENCR7	0.0097165	0.0151038	0.64331	1.51429	2.53846	0.8188	1.000
CUP2	0.0094400	0.0144289	0.65424	0.70000	3.56410	0.8291	0.001 ***
SPONGE21	0.0092942	0.0300365	0.30943	0.47143	3.23077	0.8392	0.213
PENTA	0.0087029	0.0182644	0.47650	0.02857	3.53846	0.8487	0.001 ***
HEXACT2	0.0086556	0.0102652	0.84320	0.34286	3.20513	0.8582	0.055 .
CUP1	0.0074469	0.0176177	0.42269	2.08571	0.02564	0.8663	0.001 ***
CUP4	0.0071494	0.0148264	0.48221	0.14286	2.23077	0.8741	0.001 ***
CUP3	0.0056891	0.0188462	0.30187	3.22857	0.10256	0.8803	0.009 **
ENCR1	0.0052146	0.0093738	0.55629	0.42857	1.41026	0.8859	0.999
PENNAT4	0.0048802	0.0135596	0.35991	0.40000	1.02564	0.8913	0.051 .
SPONGE14	0.0048756	0.0100388	0.48568	0.04286	1.64103	0.8966	0.122
ENCR5	0.0043074	0.0080557	0.53470	0.24286	1.82051	0.9013	0.521
BRYOZ1	0.0037850	0.0071909	0.52636	0.82857	0.66667	0.9054	0.831
ECHINO3	0.0036328	0.0074230	0.48940	1.11429	0.71795	0.9093	0.474
PENNAT18	0.0033247	0.0108957	0.30513	0.01429	1.25641	0.9130	0.010 **
HOLO9	0.0027685	0.0090649	0.30541	0.64286	0.00000	0.9160	0.001 ***

Communities 6 & 9

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	2.665e-01	0.1752668	1.52051	2.07143	134.93827	0.3874	0.001 ***
FORAM	2.533e-01	0.1809231	1.40013	130.48571	132.03704	0.7556	0.001 ***
STICHO1	9.321e-03	0.0357833	0.26048	5.45714	1.12346	0.7691	0.689
HOLO2	8.979e-03	0.0202552	0.44331	0.90000	8.20988	0.7822	1.000
ENCR8	8.871e-03	0.0139736	0.63485	1.55714	5.44444	0.7951	1.000
CANDA	8.461e-03	0.0230187	0.36756	3.55714	0.00000	0.8074	1.000
GRENADIER	7.942e-03	0.0140768	0.56416	0.28571	3.08642	0.8189	0.001 ***
ANTHO1	7.772e-03	0.0109048	0.71268	0.11429	4.40741	0.8302	0.129
ECHINO3	7.078e-03	0.0081469	0.86880	1.11429	2.66667	0.8405	0.001 ***
PENNAT4	5.997e-03	0.0104838	0.57207	0.40000	2.54321	0.8492	0.002 **
CUP1	5.860e-03	0.0132448	0.44244	2.08571	0.02469	0.8577	0.001 ***
OPHIURO1	5.292e-03	0.0079644	0.66450	0.54286	2.02469	0.8654	0.001 ***
CUP3	5.149e-03	0.0170733	0.30158	3.22857	0.11111	0.8729	0.005 **
ENCR7	4.942e-03	0.0109937	0.44953	1.51429	0.60494	0.8801	1.000
CUP2	4.900e-03	0.0088129	0.55598	0.70000	2.07407	0.8872	0.438
PENNAT9	4.663e-03	0.0103325	0.45128	0.05714	1.88889	0.8940	0.042 *
PENTA	4.299e-03	0.0057413	0.74887	0.02857	2.12346	0.9003	0.031 *
ACANEL1	4.021e-03	0.0066290	0.60652	0.02857	1.60494	0.9061	0.001 ***
PENNAT18	3.125e-03	0.0086881	0.35967	0.01429	1.37037	0.9106	0.003 **
CUP4	3.013e-03	0.0097388	0.30940	0.14286	1.16049	0.9150	0.238
SPONGE20	2.633e-03	0.0058112	0.45316	0.55714	1.18519	0.9188	1.000
ACTIN1	2.282e-03	0.0068573	0.33279	0.97143	0.32099	0.9222	0.241
OPHIURO3	2.273e-03	0.0058194	0.39059	1.02857	0.00000	0.9255	1.000
PENNAT2	2.191e-03	0.0043427	0.50452	0.14286	0.70370	0.9287	0.001 ***
HOLO9	2.111e-03	0.0065454	0.32252	0.64286	0.00000	0.9317	0.002 **

Communities 7 & 8

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.1200113	0.1026463	1.1692	1.100840	78.64103	0.1372	0.020 *
CANDA	0.0896431	0.0723771	1.2386	54.067227	28.46154	0.2396	0.040 *
SPONGE20	0.0802650	0.0556009	1.4436	56.100840	6.02564	0.3314	0.001 ***
HOLO2	0.0453520	0.0427647	1.0605	22.621849	23.43590	0.3832	0.803
HEXACT9	0.0375311	0.0370689	1.0125	23.638655	0.35897	0.4261	0.001 ***
ENCR8	0.0343970	0.0335330	1.0258	22.722689	8.41026	0.4654	0.999
CRINO9	0.0247954	0.0301347	0.8228	14.521008	0.00000	0.4938	0.001 ***
OPHIURO8	0.0245187	0.0335303	0.7312	17.327731	0.43590	0.5218	0.001 ***
DESMO9	0.0240360	0.0260908	0.9212	14.672269	0.02564	0.5493	0.001 ***

OPHIURO2	0.0177928	0.0417424	0.4263	13.352941	0.58974	0.5696	0.035 *
HEXACT8	0.0173579	0.0158512	1.0951	10.941176	0.15385	0.5894	0.001 ***
DESMO13	0.0171490	0.0173680	0.9874	10.974790	0.23077	0.6090	0.001 ***
FORAM	0.0167139	0.0204709	0.8165	0.100840	10.28205	0.6281	1.000
CRINO4	0.0165265	0.0272216	0.6071	10.873950	0.02564	0.6470	0.001 ***
ENCR7	0.0164101	0.0246851	0.6648	11.033613	2.53846	0.6658	1.000
GEODIA3	0.0125009	0.0169944	0.7356	8.184874	0.10256	0.6801	0.001 ***
DESMO15	0.0124634	0.0179894	0.6928	6.890756	0.12821	0.6943	0.001 ***
ENCR1	0.0098353	0.0114176	0.8614	6.815126	1.41026	0.7056	0.737
ANTHO1	0.0097932	0.0139572	0.7017	1.260504	5.51282	0.7168	0.015 *
CNID3	0.0086247	0.0182278	0.4732	5.050420	0.00000	0.7266	0.001 ***
DESMO5	0.0081892	0.0141516	0.5787	5.873950	0.35897	0.7360	0.003 **
DESMO18	0.0080708	0.0160809	0.5019	4.798319	0.00000	0.7452	0.001 ***
CNID9	0.0080019	0.0106882	0.7487	4.613445	0.00000	0.7543	0.001 ***
DESMO7	0.0079777	0.0191555	0.4165	6.537815	0.02564	0.7635	0.227
HEXACT2	0.0070728	0.0077413	0.9136	4.218487	3.20513	0.7715	0.399

Communities 7 & 9

Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	0.1773877	0.1326908	1.3369	1.100840	134.93827	0.1814	0.001 ***
FORAM	0.1575185	0.1237297	1.2731	0.100840	132.03704	0.3425	0.074 .
CANDA	0.0787791	0.0653686	1.2052	54.067227	0.00000	0.4231	0.177
SPONGE20	0.0775264	0.0511417	1.5159	56.100840	1.18519	0.5024	0.001 ***
HEXACT9	0.0340077	0.0337353	1.0081	23.638655	0.02469	0.5371	0.001 ***
HOLO2	0.0329085	0.0363036	0.9065	22.621849	8.20988	0.5708	1.000
ENCR8	0.0313090	0.0317472	0.9862	22.722689	5.44444	0.6028	1.000
OPHIURO8	0.0223163	0.0308096	0.7243	17.327731	0.04938	0.6256	0.001 ***
CRINO9	0.0221169	0.0269150	0.8217	14.521008	0.12346	0.6482	0.001 ***
DESMO9	0.0214990	0.0234887	0.9153	14.672269	0.00000	0.6702	0.001 ***
OPHIURO2	0.0158616	0.0389620	0.4071	13.352941	0.00000	0.6865	0.023 *
HEXACT8	0.0157264	0.0143815	1.0935	10.941176	0.00000	0.7025	0.001 ***
DESMO13	0.0154670	0.0157632	0.9812	10.974790	0.06173	0.7184	0.001 ***
CRINO4	0.0149457	0.0247682	0.6034	10.873950	0.08642	0.7336	0.001 ***

ENCR7	0.0144720	0.0233032	0.6210	11.033613	0.60494	0.7484	1.000
GEODIA3	0.0111655	0.0152192	0.7336	8.184874	0.17284	0.7599	0.001 ***
DESMO15	0.0110914	0.0158242	0.7009	6.890756	0.00000	0.7712	0.001 ***
ENCR1	0.0087867	0.0106368	0.8261	6.815126	0.40741	0.7802	0.938
CNID3	0.0077085	0.0162835	0.4734	5.050420	0.00000	0.7881	0.001 ***
DESMO5	0.0074106	0.0130761	0.5667	5.873950	0.08642	0.7956	0.001 ***
DESMO7	0.0072959	0.0178033	0.4098	6.537815	0.00000	0.8031	0.247
DESMO18	0.0072344	0.0145846	0.4960	4.798319	0.00000	0.8105	0.001 ***
CNID9	0.0071458	0.0095469	0.7485	4.613445	0.00000	0.8178	0.001 ***
ANTHO1	0.0060447	0.0090021	0.6715	1.260504	4.40741	0.8240	0.688
GEODIA1	0.0056715	0.0053709	1.0560	4.075630	0.04938	0.8298	0.001 ***

Communities 8 & 9

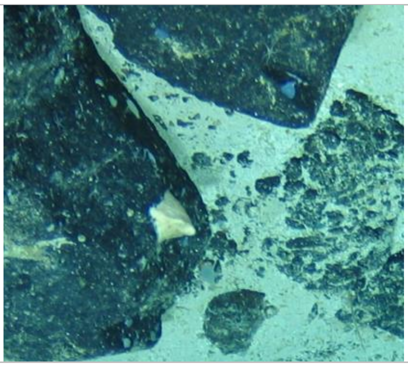
Species	Average	sd	ratio	ava	avb	cumsum	p
CRINO6	2.178e-01	0.1615384	1.34855	78.64103	134.93827	0.2971	0.001 ***
FORAM	2.097e-01	0.1651458	1.26996	10.28205	132.03704	0.5831	0.001 ***
CANDA	4.947e-02	0.0734839	0.67322	28.46154	0.00000	0.6506	0.994
HOLO2	4.449e-02	0.0477394	0.93200	23.43590	8.20988	0.7112	0.822
ENCR8	1.921e-02	0.0210951	0.91074	8.41026	5.44444	0.7374	1.000
SPONGE20	1.578e-02	0.0278606	0.56651	6.02564	1.18519	0.7590	1.000
ANTHO1	1.386e-02	0.0153301	0.90412	5.51282	4.40741	0.7779	0.001 ***
PENNAT9	1.158e-02	0.0246443	0.46990	4.12821	1.88889	0.7937	0.001 ***
PENTA	8.822e-03	0.0146806	0.60092	3.53846	2.12346	0.8057	0.001 ***
CUP2	8.603e-03	0.0124815	0.68930	3.56410	2.07407	0.8174	0.001 ***
STICHO1	8.260e-03	0.0133910	0.61684	4.94872	1.12346	0.8287	0.730
GRENADIER	7.358e-03	0.0134428	0.54735	0.64103	3.08642	0.8387	0.001 ***
CUP4	7.012e-03	0.0128081	0.54744	2.23077	1.16049	0.8483	0.001 ***
SPONGE21	6.832e-03	0.0241333	0.28310	3.23077	0.02469	0.8576	0.445
HEXACT2	6.553e-03	0.0073677	0.88939	3.20513	0.69136	0.8665	0.626
PENNAT4	5.962e-03	0.0093394	0.63837	1.02564	2.54321	0.8747	0.015 *
ENCR7	5.642e-03	0.0078588	0.71796	2.53846	0.60494	0.8824	1.000
ECHINO3	5.586e-03	0.0065768	0.84943	0.71795	2.66667	0.8900	0.020 *
PENNAT18	5.065e-03	0.0114266	0.44324	1.25641	1.37037	0.8969	0.001 ***
OPHIURO1	4.756e-03	0.0070695	0.67270	0.20513	2.02469	0.9034	0.004 **
SPONGE14	4.259e-03	0.0078659	0.54151	1.64103	0.65432	0.9092	0.231
ENCR1	3.823e-03	0.0067848	0.56342	1.41026	0.40741	0.9144	1.000
ACANEL1	3.821e-03	0.0063569	0.60102	0.10256	1.60494	0.9196	0.001 ***
ENCR5	3.570e-03	0.0064125	0.55679	1.82051	0.61728	0.9245	0.676
LEPIDION	2.045e-03	0.0029972	0.68239	0.43590	0.70370	0.9273	0.003 **

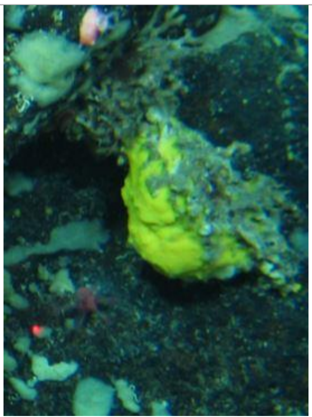
5.3 Species Catalogue – Charlie-Gibbs Fracture Zone

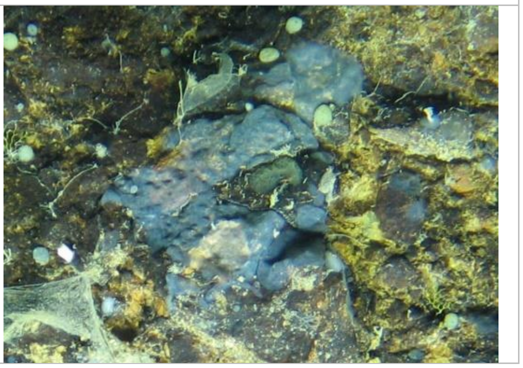
In this catalogue, all observed morphospecies from the TOSCA (Tectonic Ocean Spreading at the Charlie-Gibbs Fracture Zone) survey are compiled as a reference guide. Information on the taxonomic status are given as well as the species names when applicable. Names of the taxonomic experts identifying the species are given for each species. All morphospecies were observed by the ROV *Holland I* video camera along five ROV transects (indicated by dive number in the catalogue), with a high-definition oblique-facing camera. No physical samples that were collected on the TOSCA survey were documented here, only morphospecies observed from the video.

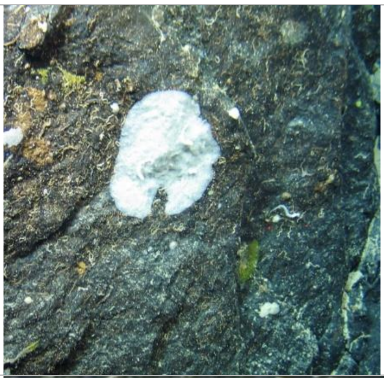
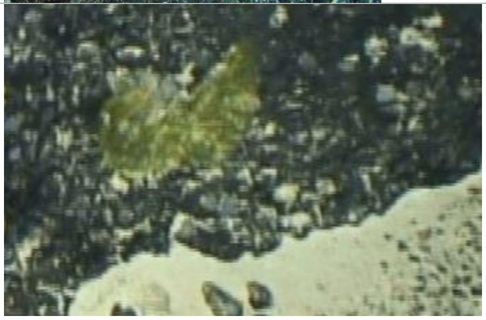
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** SPONGE2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 8**		
Phylum: Porifera **Class:** **Order:** **Family:**	**Morphospecies code:** SPONGE5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		

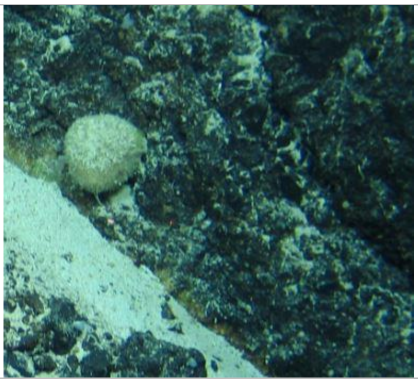
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** SPONGE6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** SPONGE11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**	Possibly Cladorhizidae (J. Xavier)	
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** SPONGE12	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** SPONGE13	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		

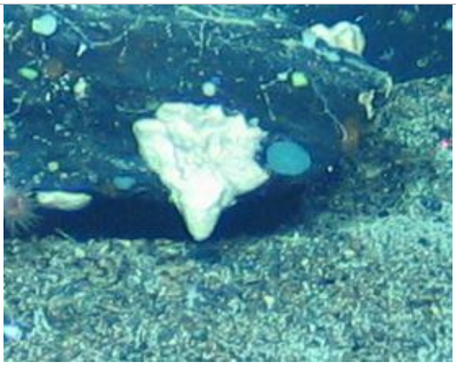
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** SPONGE14	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** SPONGE17	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		
Phylum: Porifera **Class:** **Order:** **Family:**	**Morphospecies code:** SPONGE18	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 8**		
Phylum: Porifera **Class:** **Order:** **Family:**	**Morphospecies code:** SPONGE20	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Porifera **Class:** **Order:** **Family:**	**Morphospecies code:** SPONGE21	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 8**		
Phylum: Porifera **Class:** **Order:** **Family:**	**Morphospecies code:** SPONGE22	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 9**		
Phylum: Porifera **Class:** **Order:** **Family:**	**Morphospecies code:** SPONGE23	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** ENCR1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		

Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** ENCR3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** ENCR4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** ENCR5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** ENCR6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**		

Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** ENCR8	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** ENCR9	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** ENCR10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 8**		
Phylum: Porifera **Class:** **Order:** **Family:**	**Morphospecies code:** ENCR12	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**		

Phylum: Porifera **Class:** Demospongiae **Order:** **Family:**	**Morphospecies code:** DEMOS3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**	**Could be a Tetractinellida but difficult to say (J. Xavier)**	
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:**	**Morphospecies code:** DEMOS5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**	Stelletta or Geodia sp.	
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:**	**Morphospecies code:** DEMOS6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**	Stelletta or Geodia sp.	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Demospongiae **Order:** Tetractinellida **Family:** Geodiidae **Genus:** *Geodia* **Species:** *G. phlegraei*	**Morphospecies code:** DEMOS7 *Geodia phlegraei*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**	(Sollas, 1880)	

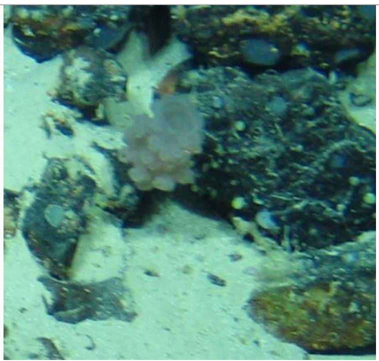
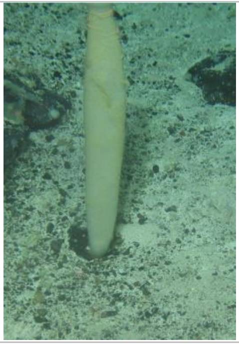
Phylum: Porifera **Class:** Demospongiae **Order:** Tetractinellida **Family:** Geodiidae **Genus:** *Geodia* **Species:**	**Morphospecies code:** DEMOS8 *Geodia* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** DEMOS9	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** DEMOS10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**		
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** DEMOS11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		

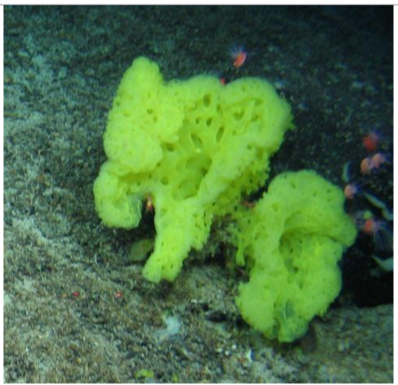
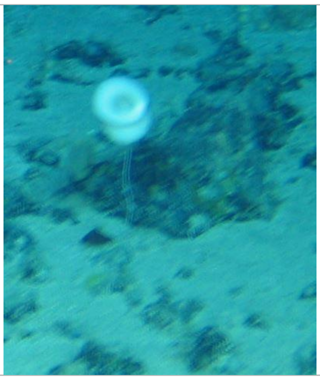
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

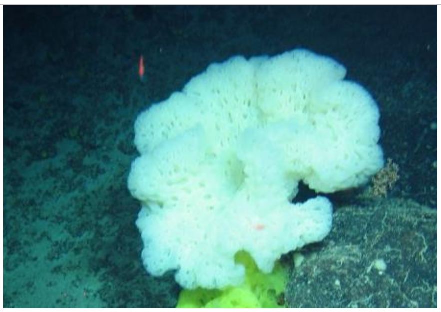
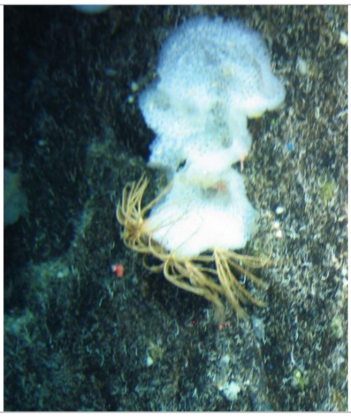
Phylum: Porifera **Class:** Demospongiae **Order:** Haplosclerida **Family:** Chalinidae **Genus:** *Haliclona* **Species:** *H. magna*	**Morphospecies code:** DEMOS12 cf. *Haliclona (Halichoclona) magna*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**	(Vacelet, 1969)	
Phylum: Porifera **Class:** Demospongiae **Order:** Tetractinellida **Family:** Geodiidae **Genus:** *Geodia* **Species:** *G. macandrewii*	**Morphospecies code:** DEMOS13 cf. *Geodia macandrewii*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**	(Bowebank, 1858)	
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** DEMOS15	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**	Possibly within family Axinellidae but too difficult to say for sure	
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** DEMOS17	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**		

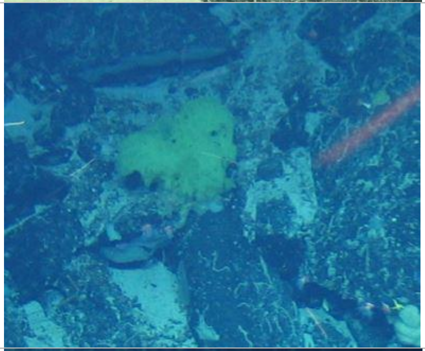
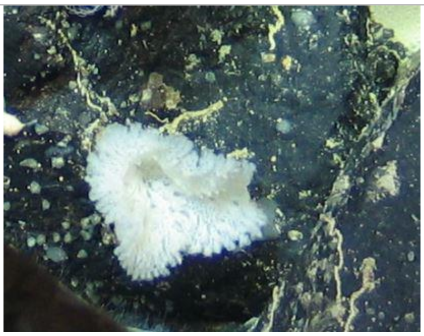
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** DEMOS18	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**		

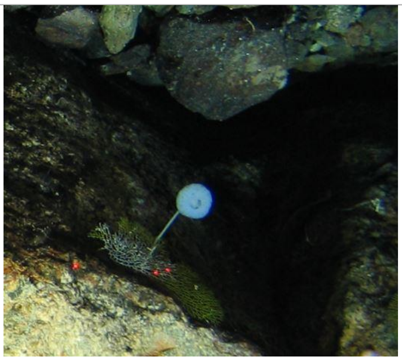
TAXONOMY	NAME	HABITAT	NOTES	IMAGE
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** *Geodia* **Species:** *G. megastrella*	**Morphospecies code:** GEODIA1 *Geodia megastrella*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**	(Carter, 1876)	
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** *Geodia* **Species:** *G. megastrella*	**Morphospecies code:** GEODIA2 *Geodia megastrella*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**	(Carter, 1876)	
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** *Geodia* **Species:**	**Morphospecies code:** GEODIA3 *Geodia* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		

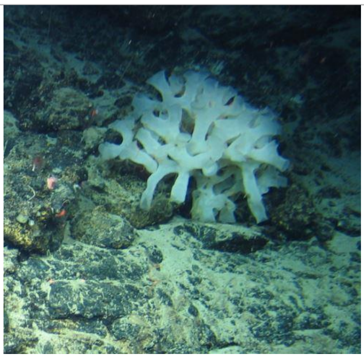
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** *Geodia* **Species:** *G. hentscheli*	**Morphospecies code:** GEODIA4 cf. *Geodia hentscheli*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**	(Cárdenas, Rapp, Schander & Tendal, 2010)	
Phylum: Porifera **Class:** Demospongiae **Order:** **Family:** **Genus:** *Polymastia* **Species:** P. *corticata*	**Morphospecies code:** POLYM1 cf. *Polymastia corticata*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**	(Ridley & Dendy, 1886)	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**		
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**		

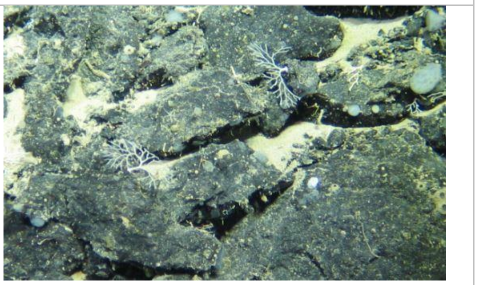
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** *Hertwigia* **Species:** H. *falcifera*	**Morphospecies code:** HEXACT3 *Hertwigia falcifera*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**	yellow color morph (more common) (J. Xavier) (Schmidt, 1880)	
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** *Hertwigia* **Species:** H. *falcifera*	**Morphospecies code:** HEXACT4 cf. *Hertwigia falcifera*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 8**	Probably the same as HEXACT3, just different growth form (J. Xavier)	
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** *Amphidiscella* **Species:**	**Morphospecies code:** HEXACT6 *Amphidiscella* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**		

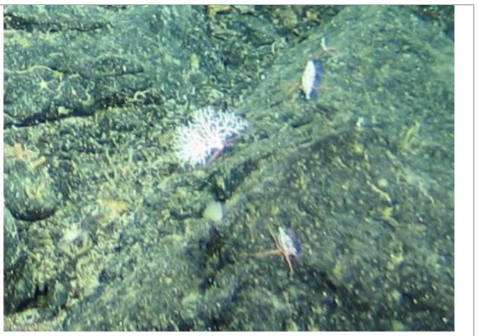
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** *Asconema* **Species:**	**Morphospecies code:** HEXACT7 *Asconema* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**		
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT8	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**		
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** *Hertwigia* **Species:** *H. falcifera*	**Morphospecies code:** HEXACT9 *Hertwigia falcifera*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 5**	(Schmidt, 1880) white color morph	
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 6**		
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT13	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**		
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT14	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**	Not certain it is a Hexactinellida (J. Xavier)	
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT15	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**	Not certain it is a Hexactinellida or Demospongiae (J. Xavier)	

Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** *Farrea* **Species:**	**Morphospecies code:** HEXACT16 *Farrea* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT17	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 7**	Possibly *Sympagella* or *Amphidiscella* (J. Xavier)	
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT18	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** J. Xavier **Dive: 8**	Possibly *Hertwigia* sp. (J. Xavier)	
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT20	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**		

Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT21	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 7**		
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT22	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 8**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT24	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 8**		
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT25	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 7**		

Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT26	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 9**		
Phylum: Porifera **Class:** Hexactinellida **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HEXACT27	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
Phylum: Porifera **Class:** Hexactinellida **Order:** Lyssacinosida **Family:** Euplectellida **Genus:** **Species:**	**Morphospecies code:** EUPL1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**	This could be *Euplectella, Dictyaulus, Regadrella* (J. Xavier)	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Bryozoa **Class:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** BRYOZ1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		

Phylum: Bryozoa **Class:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** BRYOZ2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
Phylum: Bryozoa **Class:** Gymnolaemata **Order:** **Family:** **Genus:** *Canda* **Species:**	**Morphospecies code:** CANDA *Canda* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Megan McCuller **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 9**		

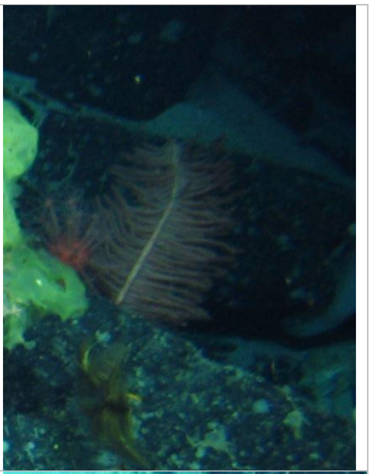
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** *Stauropathes* **Species:** *S. arctica*	**Morphospecies code:** ANTIPATHARIA4 cf. *Stauropathes arctica*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 5**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 9**		

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** *Stauropathes* **Species:** *S. arctica*	**Morphospecies code:** ANTIPATHARIA7 cf. *Stauropathes arctica*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Parantipathes* **Species:**	**Morphospecies code:** ANTIPATHARIA8 *Parantipathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA9	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 9**		

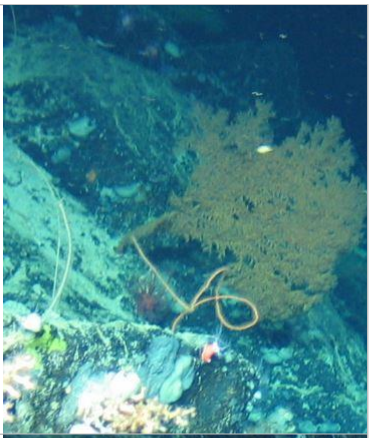
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 9**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 9**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA12	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		

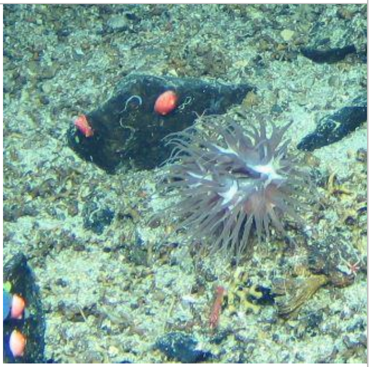
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANTIPATHARIA13	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Bathypathes* **Species:**	**Morphospecies code:** BATHY1 *Bathypathes* n.sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 9**	*Bathypathes* n.sp. under description (T. Molodtsova)	
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Bathypathes* **Species:**	**Morphospecies code:** BATHY2 *Bathypathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 7**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Bathypathes* **Species:**	**Morphospecies code:** BATHY3 *Bathypathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Bathypathes* **Species:**	**Morphospecies code:** BATHY4 *Bathypathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Bathypathes* **Species:**	**Morphospecies code:** BATHY5 *Bathypathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**		

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Bathypathes* **Species:**	**Morphospecies code:** BATHY6 *Bathypathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 9**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Leiopathidae **Genus:** *Leiopathes* **Species:**	**Morphospecies code:** LEIOPAT *Leiopathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 5**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Parantipathes* **Species:**	**Morphospecies code:** PARAN1 *Parantipathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		

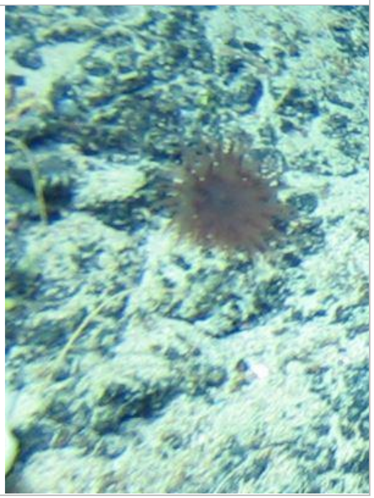
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Parantipathes* **Species:**	**Morphospecies code:** PARAN2 *Parantipathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Parantipathes* **Species:** P. *hirondelle*	**Morphospecies code:** PARAN3 cf. *Parantipathes hirondelle*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 8**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Parantipathes* **Species:**	**Morphospecies code:** PARAN4 *Parantipathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 7**		

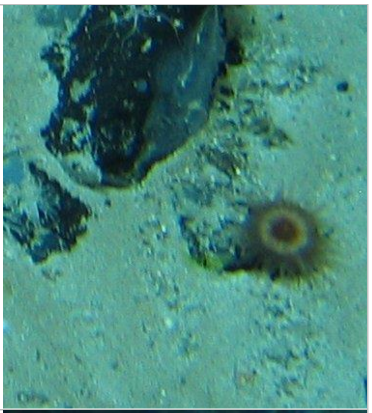
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Stauropathes* **Species:**	**Morphospecies code:** STAURO *Stauropathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Antipathidae **Genus:** *Stichopathes* **Species:**	**Morphospecies code:** STICHO1 *Stichopathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Antipatharia **Family:** Schizopathidae **Genus:** *Parantipathes* **Species:**	**Morphospecies code:** TRISSO1 *Parantipathes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 9**	Misidentified as a member of Trissopathes genus	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

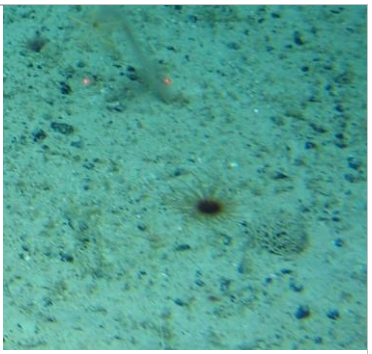
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 5**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** Actinernidae **Genus:** *Actinernus* **Species:**	**Morphospecies code:** ANEMONE2 *Actinernus* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 5**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** Liponematidae **Genus:** *Liponema* **Species:**	**Morphospecies code:** ANEMONE3 cf *Liponema*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** T. Molodtsova **Dive: 5**		

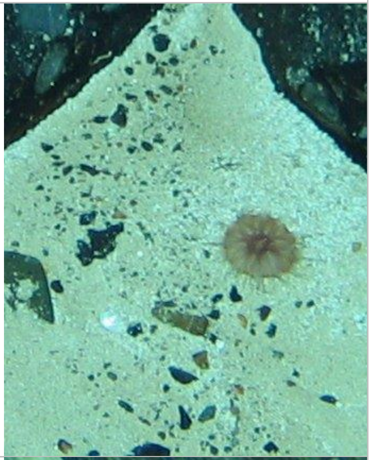
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 7**		

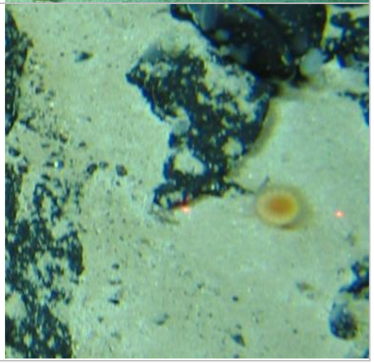
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 8**	Possibly Actinoscyphia sp. (P. Keogh)	
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 7**	Actinostolidae sp.? (P Keogh)	

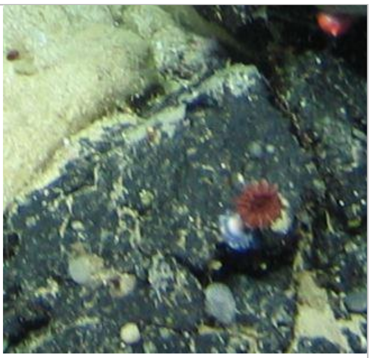
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** P. Keogh **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE8	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**	Possibly *Bolocera tuediae* (P. Keogh)	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Corallimorpharia **Family:** Corallimorphidae **Genus:** *Corallimorphus* **Species:**	**Morphospecies code:** ANEMONE9 *Corallimorphus* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Tina Molodtsova **Dive: 7**		

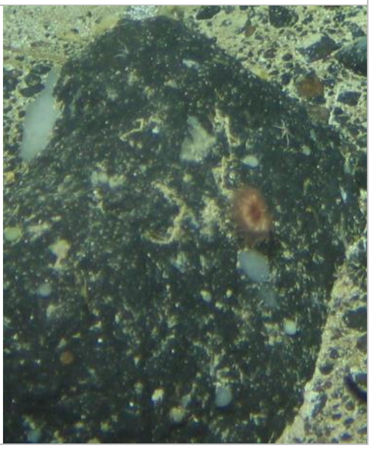
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE12	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE13	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**	Possibly *Phelliactis hertwigii* (P. Keogh)	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

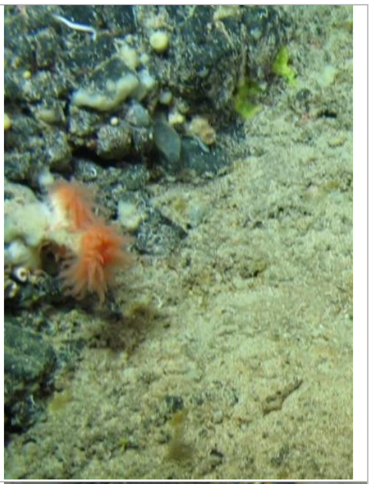
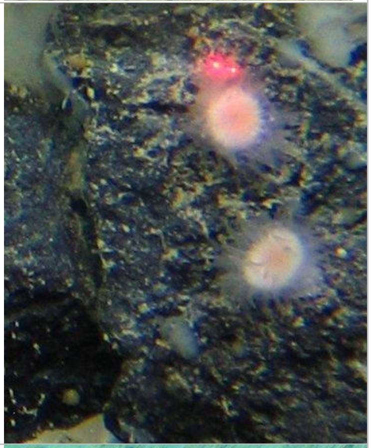
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Ceriantharia **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE14 ? Ceriantharia?	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Tina Molodtsova **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Ceriantharia **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE15 ? Ceriantharia?	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Tina Molodtsova **Dive: 9**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE18	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE19 ?Scleractinia	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Tina Molodtsova **Dive: 8**	Probably *Flabellum* sp. (T. Molodtsova)	

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE20	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE21 ? Scleractinia?	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Tina Molodtsova **Dive: 5**	looks like something flat, as Fungiocysthus (T. Molodtsova)	
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** Hormathiidae **Genus:** **Species:**	**Morphospecies code:** ANEMONE22 Hormathiidae	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Tina Molodtsova **Dive: 8**		

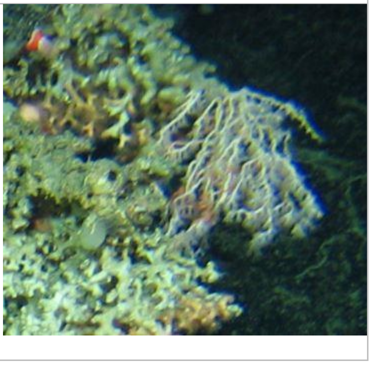
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE23	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Actiniaria **Family:** **Genus:** **Species:**	**Morphospecies code:** ANEMONE24	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Ceriantharia **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CERANTID	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Tina Molodtsova **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** CUP1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** CUP2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** CUP3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** CUP4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		

TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** CUP5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		

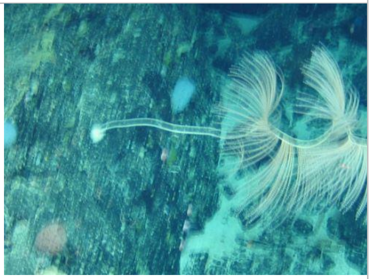
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** CUP6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** **Genus:** **Species:**	**Morphospecies code:** CUP7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** Flabellidae **Genus:** *Flabellum* **Species:**	**Morphospecies code:** CUP8 *Flabellum* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Tina Molodtsova **Dive: 8**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Hexacorillia **Order:** Scleractinia **Family:** Caryophylliidae **Genus:** *Solenosmilia* **Species:**	**Morphospecies code:** SCLERA1 *Solenosmilia* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Rebecca Ross **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Coralliidae **Genus:** *Corallium* **Species:**	**Morphospecies code:** CORALI *Corallium* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OCTOCORAL 1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		

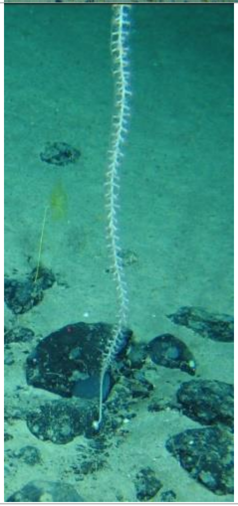
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OCTOCORAL2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Acanthogorgiidae **Genus:** *Acanthogorgia* **Species:**	**Morphospecies code:** ACANT1 *Acanthogorgia* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** **Genus:** **Species:**	**Morphospecies code:** ALCYONACEA1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		

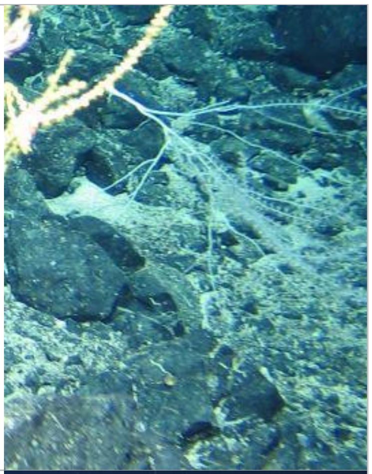
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** **Genus:** **Species:**	**Morphospecies code:** ALCYONACEA2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** **Genus:** **Species:**	**Morphospecies code:** ALCYONACEA3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Alcyoniidae **Genus:** *Anthomastus* **Species:**	**Morphospecies code:** ANTHO1 *Anthomastus* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		

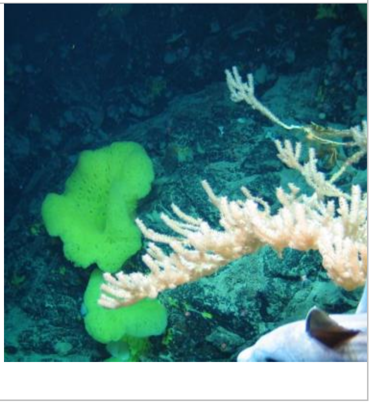
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Alcyoniidae **Genus:** *Anthomastus* **Species:**	**Morphospecies code:** ANTHO2 *Anthomastus* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Alcyoniidae **Genus:** *Anthomastus* **Species:**	**Morphospecies code:** ANTHO3 *Anthomastus* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Chrysogorgiidae **Genus:** *Chrysogorgia* **Species:**	**Morphospecies code:** CRYSOG1 *Chrysogorgia* sp	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 9**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

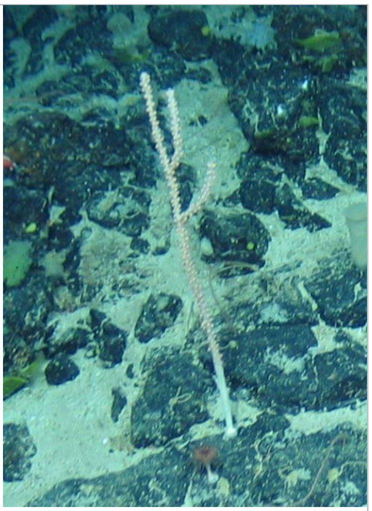
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Chrysogorgiidae **Genus:** *Chrysogorgia* **Species:**	**Morphospecies code:** CRYSOG2 *Chrysogorgia* sp	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 9**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Chrysogorgiidae **Genus:** *Chrysogorgia* **Species:**	**Morphospecies code:** CRYSOG3 *Chrysogorgia* sp	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Chrysogorgiidae **Genus:** *Iridogorgia* **Species:**	**Morphospecies code:** IRIDOG1 *Iridogorgia* sp	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 9**		

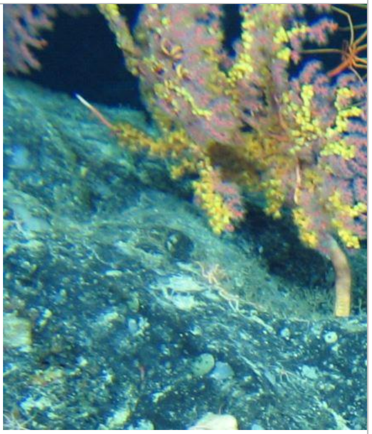
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Clavulariidae **Genus:** *Clavularia* **Species:**	**Morphospecies code:** CLAVU1 *Clavularia* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 6**		

TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** *Acanella* **Species:**	**Morphospecies code:** ACANEL1 *Acanella* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** **Species:**	**Morphospecies code:** ISIDIDAE1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		

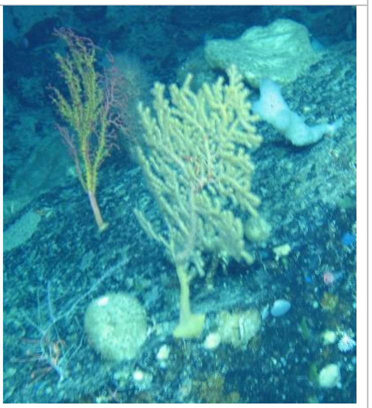
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** **Species:**	**Morphospecies code:** ISIDIDAE2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** **Species:**	**Morphospecies code:** ISIDIDAE3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** **Species:**	**Morphospecies code:** ISIDIDAE4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** **Species:**	**Morphospecies code:** ISIDIDAE5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**	**merged with ISIDIDAE9**	
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** **Species:**	**Morphospecies code:** ISIDIDAE7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** **Species:**	**Morphospecies code:** ISIDIDAE10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**	Probably the same as ISIDIDAE4 (Poppy Keogh)	

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Isididae **Genus:** **Species:**	**Morphospecies code:** ISIDIDAE11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Paragorgiidae **Genus:** **Species:**	**Morphospecies code:** PARAGO1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Paragorgiidae **Genus:** **Species:**	**Morphospecies code:** PARAGO5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Paragorgiidae **Genus:** **Species:**	**Morphospecies code:** PARAGO6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Paragorgiidae **Genus:** **Species:**	**Morphospecies code:** PARAGO7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Paragorgiidae **Genus:** **Species:**	**Morphospecies code:** PARAGO8	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		

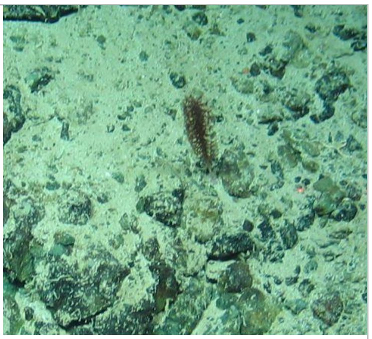
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Plexauridae **Genus:** **Species:**	**Morphospecies code:** PLEXAURIDAE1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		

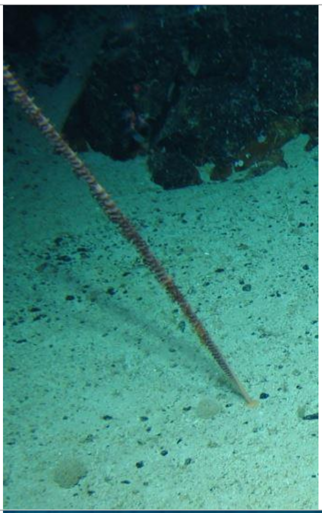
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Plexauridae **Genus:** **Species:**	**Morphospecies code:** PLEXAURIDAE2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 9**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Primnoidae **Genus:** *Calyptrophora* **Species:**	**Morphospecies code:** CALYPT1 *Calyptrophora* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 9**		

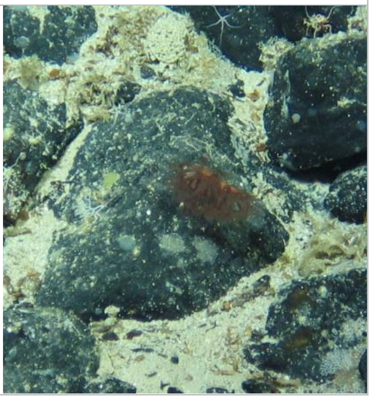
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Alcyonacea **Family:** Primnoidae **Genus:** **Species:**	**Morphospecies code:** PRIMNO1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Renata Arantes **Dive: 9**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** **Genus:** **Species:**	**Morphospecies code:** PENNATULA1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** Anthoptilidae **Genus:** *Anthoptilum* **Species:** *A. grandiflorum*	**Morphospecies code:** PENNATULA2 *Anthoptilum* cf. *grandiflorum*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Raissa Hogan **Dive: 7**		

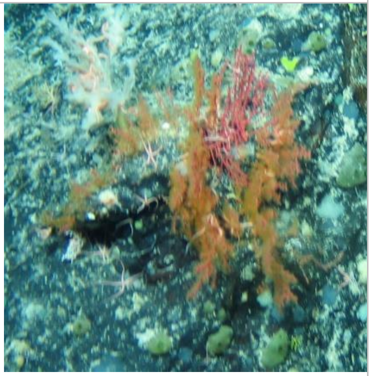
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** Anthoptilidae **Genus:** *Anthoptilum* **Species:**	**Morphospecies code:** PENNATULA3 *Anthoptilum* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Raissa Hogan **Dive: 8**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** **Genus:** **Species:**	**Morphospecies code:** PENNATULA4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** **Genus:** **Species:**	**Morphospecies code:** PENNATULA6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** Anthoptilidae **Genus:** *Anthoptilum* **Species:**	**Morphospecies code:** PENNATULA8 *Anthoptilum* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Raissa Hogan **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** Halipteridae **Genus:** *Halipteris* **Species:** *H. finmarchica*	**Morphospecies code:** PENNATULA9 *Halipteris* cf. *finmarchica*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Raissa Hogan **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** **Genus:** **Species:**	**Morphospecies code:** PENNATULA10 *Pennatula* sp. or *Ptilella*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Raissa Hogan **Dive: 5**		

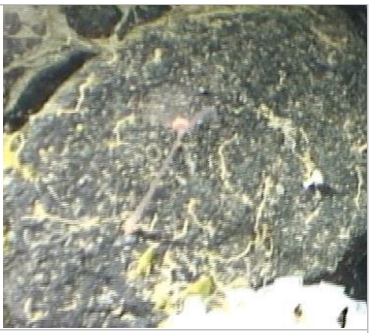
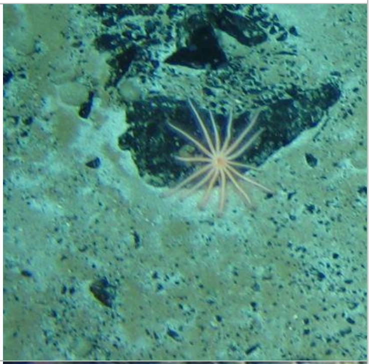
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** **Genus:** **Species:**	**Morphospecies code:** PENNATULA11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** **Genus:** **Species:**	**Morphospecies code:** PENNATULA12	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** **Genus:** **Species:**	**Morphospecies code:** PENNATULA16	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** Halipteridae **Genus:** *Halipteris* **Species:** *finmarchica*	**Morphospecies code:** PENNATULA17 *Halipteris* cf. *finmarchica*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Raissa Hogan **Dive: 7**	Probably the same as PENNATULA9 (P Keogh)	
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** Halipteridae **Genus:** *Halipteris* **Species:**	**Morphospecies code:** PENNATULA18 *Halipteris* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Raissa Hogan **Dive: 7**	Probably the same as PENNATULA9 (P Keogh)	

TAXONOMY	NAME	HABITAT	NOTES	IMAGE
Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** **Genus:** **Species:**	**Morphospecies code:** PENNATULA19	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		

Phylum: Cnidaria **Class:** Anthozoa **Subclass:** Octocorallia **Order:** Pennatulacea **Family:** Umbellulidae **Genus:** *Umbellula* **Species:**	**Morphospecies code:** UMBELLULA 1 *Umbellula* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Raissa Hogan **Dive: 6**		
Phylum: Cnidaria **Class:** **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CNID1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Cnidaria **Class:** **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CNID3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Cnidaria **Class:** **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CNID7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Cnidaria **Class:** **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CNID8	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Cnidaria **Class:** **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CNID9	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Cnidaria **Class:** **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CNID10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Cnidaria **Class:** **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CNID11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Cnidaria **Class:** Hydrozoa **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HYDRO1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		

Phylum: Cnidaria **Class:** Hydrozoa **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HYDRO2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**	Probably the same as HYDRO1	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**	Possibly a Brisingidae (*H. coronate* / *B. endecacnemos*) (P. Keogh)	
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**	Possibly *Henricia sanguinolenta* (P. Keogh)	
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		

Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**	Possibly *Porania pulvillis* (P. Keogh)	
Phylum: hehexactdermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**	Possibly *Porania pulvillis* (P. Keogh)	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO9	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**	Possibly *Hymenaster* sp. (P. Keogh)	

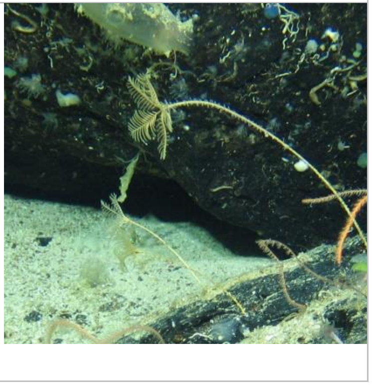
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO12	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO13	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		

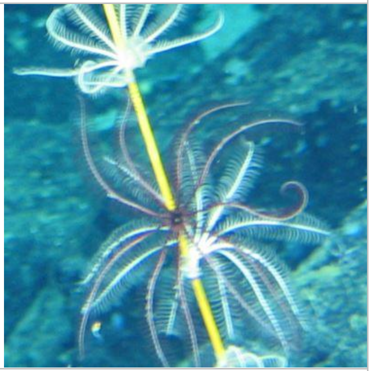
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO14	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO18	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO19	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO20	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO21	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO22	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO23	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO24	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		

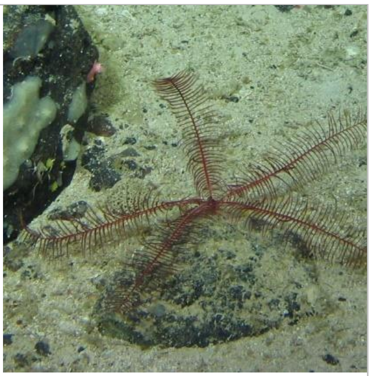
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASTERO25	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive:**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Asteroidea **Subclass:** **Order:** Brisingida **Family:** Brisingidae **Genus:** **Species:**	**Morphospecies code:** BRISIN1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**	Possibly *Novodinia* sp. (P. Keogh)	
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** Hyocrinida **Family:** Hyocrinidae **Genus:** *Anachalypsicrinus* **Species:** *A. nefertiti*	**Morphospecies code:** ANACH *Anachalypsicrinus nefertiti*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		

Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		

TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** Comatulida **Family:** Bathycrinidae **Genus:** *Bathycrinidae* **Species:**	**Morphospecies code:** CRINO6 *Bathycrinidae* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		

Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO9	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO12	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

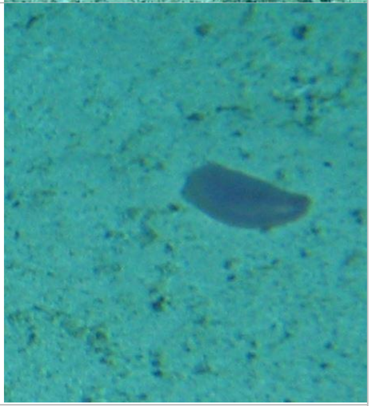
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO13	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO14	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** CRINO15	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		

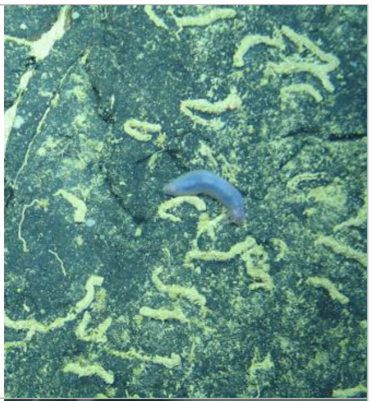
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** Comatulida **Family:** Pentametrocrinidae **Genus:** *Pentametrocrinus* **Species:** *P. atlanticus*	**Morphospecies code:** PENTA *Pentametrocrinus atlanticus*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Crinoidea **Subclass:** **Order:** Comatulida **Family:** Septocrinidae **Genus:** *Zeuctocrinus* **Species:** *Z. gisleni*	**Morphospecies code: ZEUCT** *Zeuctocrinus gisleni*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Echinodermata **Class:** Echinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ECHINO1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**	Possibly *Echinothuroidea* sp.	
Phylum: Echinodermata **Class:** Echinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ECHINO2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		

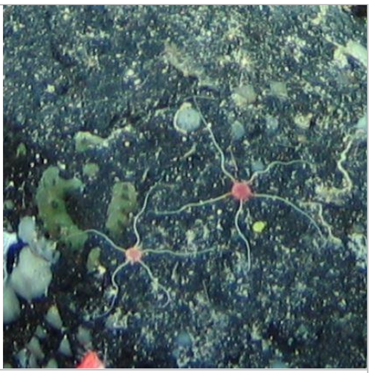
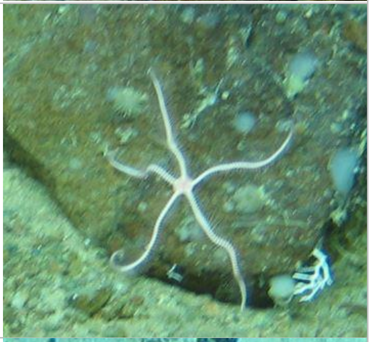
Phylum: Echinodermata **Class:** Echinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ECHINO3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Echinodermata **Class:** Echinoidea **Subclass:** **Order:** **Family:** **Genus:** *Echinus* **Species:**	**Morphospecies code:** ECHINO4 cf. *Echinus* dp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		

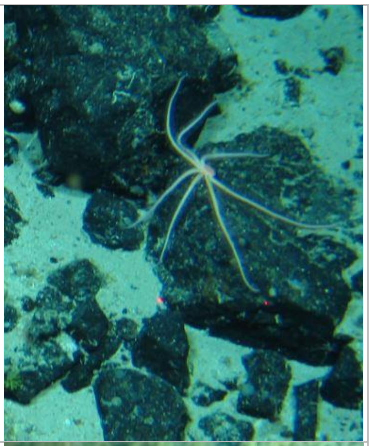
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Echinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ECHINO5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Echinodermata **Class:** Echinoidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ECHINO6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		

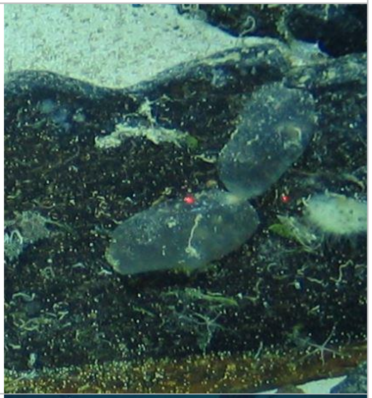
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** Actinopoda **Order:** Synallactida **Family:** Synallactidae **Genus:** *Synallactes* **Species:**	**Morphospecies code:** HOLO1 cf. *Synallactes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** **Order:** **Family:** **Genus:** *Psolus* **Species:**	**Morphospecies code:** HOLO2 *Psolus* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HOLO4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** Actinopoda **Order:** *Elasipodida* **Family:** Laetmogonidae **Genus:** *Benthogone* **Species:**	**Morphospecies code:** HOLO5 cf. *Benthogone* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		

Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** Actinopoda **Order:** Elasipodida **Family:** Elpidiidae **Genus:** *Amperima* **Species:**	**Morphospecies code:** HOLO6 cf. *Amperima* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HOLO7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HOLO8	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HOLO10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HOLO11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** HOLO12	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Echinodermata **Class:** Holothuroidea **Subclass:** Actinopoda **Order:** Holothuriida **Family:** Mesothuriidae **Genus:** *Mesothuria* **Species:** *M. intestinalis*	**Morphospecies code:** HOLO13 cf. *Mesothuria intestinalis*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Echinodermata **Class:** Ophiuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OPHIURO1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		

Phylum: Echinodermata **Class:** Ophiuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OPHIURO2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Echinodermata **Class:** Ophiuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OPHIURO3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Ophiuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OPHIURO4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Ophiuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OPHIURO5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		

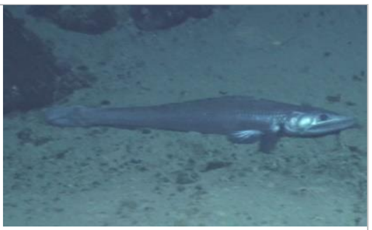
Phylum: Echinodermata **Class:** Ophiuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OPHIURO7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Echinodermata **Class:** Ophiuroidea **Subclass:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** OPHIURO8	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		

TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Chordata **Class:** Ascidiacea **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ASCID Ascidiacea spp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**	Blue Hake (P. Keogh)	

Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP5	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		

Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP7	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP8	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP9	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

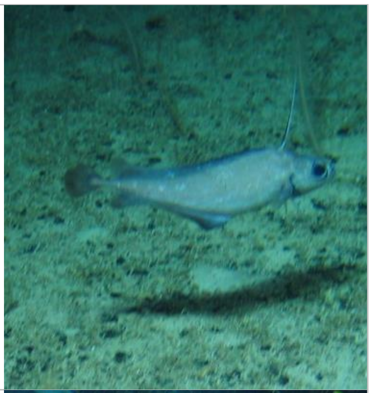
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP10	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP11	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP14	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**	Possibly *Sebastes mentella* (P. Keogh)	
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP15	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		

Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP16	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		

TAXONOMY	NAME	HABITAT	NOTES	IMAGE
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP17	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP18	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP19	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		

Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP20	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Chordata **Class:** Actinopterygii **Order:** Trachichthyiformes **Family:** Trachichthyidae **Genus:** *Hoplostethus* **Species:** *H. atlanticus*	**Morphospecies code:** ACTP21 *cf. Hoplostethus atlanticus*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**	Orange Roughy (P. Keogh)	
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP22	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**	Possibly the same as ACTP21, Orange Roughy (P. Keogh)	
Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ACTP23	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		

Phylum: Chordata **Class:** Actinopterygii **Order:** **Family:** **Genus:** **Species:**	**Morphospecis code:** ACTP24	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		
Phylum: Chordata **Class:** Actinopterygii **Order:** Gadiformes **Family:** Macrouridae **Genus:** **Species:**	**Morphospecies code:** GRENADIER	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Chordata **Class:** Actinopterygii **Order:** Notacanthiformes **Family:** Halosauridae **Genus:** **Species:**	**Morphospecies code:** HALOSAURIDAE Halosauridae sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

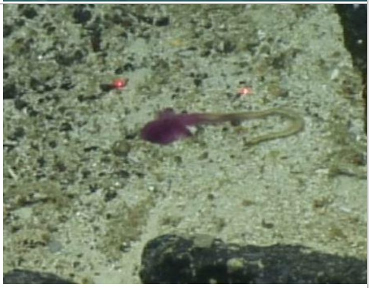
Phylum: Chordata **Class:** Actinopterygii **Order:** Gadiformes **Family:** Moridae **Genus:** *Lepidion* **Species:**	**Morphospecies code:** LEPIDION *Lepidion* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		
Phylum: Chordata **Class:** Actinopterygii **Order:** Zeiformes **Family:** Oreosomatidae **Genus:** *Neocyttus* **Species:** *N. helgae*	**Morphospecies code:** OREO *Neocyttus helgae*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**	Common name is Oreo (P. Keogh)	
Phylum: Foraminifera **Class:** Xenophyophorea **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** FORAM	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		

Phylum: Annelida **Class:** Polychaeta **Order:** Sabellida **Family:** Sabellidae **Genus:** **Species:**	**Morphospecies code:** SABELLI	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Arthropoda **Class:** Pycnogonida **Order:** Pantopoda **Family:** Colossendeidae **Genus:** *Colossendeis* **Species:**	**Morphospecies code:** COLOS *Colossendeis* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Jamie Maxwell **Dive: 6**		
Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** Chirostylidae **Genus:** *Chirostylidae* **Species:**	**Morphospecies code:** CRAB1 *Chirostylidae* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** Munidopsidae **Genus:** *Munidopsis* **Species:**	**Morphospecies code:** CRAB2 *Munidopsis* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		

Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** **Genus:** **Species:**	**Morphospecies code:** CRAB3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** Paguridae **Genus:** **Species:**	**Morphospecies code:** CRAB4	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** Munididae **Genus:** *Munida* **Species:**	**Morphospecies code:** CRAB5 *Munida* sp	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** **Genus:** **Species:**	**Morphospecies code:** CRAB6	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 9**		

Phylum: Arthropoda **Class:** Malacostraca **Order:** Isopoda **Family:** **Genus:** **Species:**	**Morphospecies code:** ISOPOD1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** Lithodidae **Genus:** *Neolithodes* **Species:**	**Morphospecies code:** NEOLI *Neolithodes* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** **Genus:** **Species:**	**Morphospecies code:** SHRIMP1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**
Phylum: Arthropoda **Class:** Malacostraca **Order:** Decapoda **Family:** **Genus:** **Species:**	**Morphospecies code:** SHRIMP2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**		

Phylum: Mollusca **Class:** Bivalvia **Order:** Limida **Family:** Limidae **Genus:** *Acesta* **Species:**	**Morphospecies code:** BIVALV1 *Acesta* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Mollusca **Class:** Cephalopoda **Order:** Octopoda **Family:** Stauroteuthidae **Genus:** *Stauroteuthis* **Species:**	**Morphospecies code:** OCTO1 *Stauroteuthis* sp.	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 5**		
Phylum: Mollusca **Class:** Cephalopoda **Order:** Octopoda **Family:** **Genus:** **Species:**	**Morphospecies code:** OCTO2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Mollusca **Class:** Cephalopoda **Order:** Octopoda **Family:** **Genus:** **Species:**	**Morphospecies code:** OCTO3	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
TAXONOMY	**NAME**	**HABITAT**	**NOTES**	**IMAGE**

Phylum: Mollusca **Class:** Cephalopoda **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** SQUID1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: Mollusca **Class:** Cephalopoda **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** SQUID2	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 7**	Not a squid, probably and Octopod (P. Keogh)	
Phylum: Hemichordata **Class:** Enteropneusta **Order:** Enteropneusta (temporary name) **Family:** Torquaratoridae **Genus:** *Yoda* **Species:** *Y. purpurata*	**Morphospecies code:** YODA *Yoda purpurata*	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 8**		
Phylum: **Class:** **Order:** **Family:** **Genus:** **Species:**	**Morphospecies code:** ANIMAL1	**Gear:** ROV **Photo by:** *Holland I* 2018 **Identified by:** Poppy Keogh **Dive: 6**		

END