Benthic and fish community composition on mesophotic reefs in Grand Cayman

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Benthic and fish community composition on mesophotic reefs in Grand Cayman

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Mesophotic Coral Ecosystems (MCEs) represent unique ecological habitats that range from 30m to 150m deep, harbouring phylogenetically distinct species and offering refuge for many taxa during times of environmental stress. Yet owing to inaccessibility of ecosystems at these depths, most MCEs remain unexplored, with quantifications of ecological communities in these habitats lacking across many regions. Here, using open- and closed-circuit technical diving, we quantified benthic and fish community composition at four mesophotic reef sites (45m depth) in Grand Cayman. We show significant differences in benthic community composition over a small spatial scale driven by disparate coverage of sponges, crustose coralline algae, and sand/rubble, yet consistent patterns of macroalgal dominance representing >50% coverage at each site and low hard coral cover at an average of 2.4%. Reef fish species richness, biomass, and density was consistent across sites, however the relative contribution of individual species to community composition differed significantly. Macrocarnivores were found to be the dominant contributors to biomass, with invertivores the most speciose, and omnivores and planktivores at the highest densities, consistent with previous descriptions of mesophotic fish assemblages in other regions. Similarly, the low hard coral cover and high macroalgae and sponge cover of the benthic communities also appear ecologically similar to several described mesophotic reefs yet is not uniform across the Caribbean. The ecological organisation of Grand Cayman's MCEs may result from a variety of factors such as isolation from other major land masses, geology, local geography, and anthropogenic activity at both the local and global scale and highlight the importance of continued exploration and documentation of MCE communities.

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2 **Grand Cayman**

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Abstract

Mesophotic Coral Ecosystems (MCEs) represent unique ecological habitats that range from 30m to 150m deep, harbouring phylogenetically distinct species and offering refuge for many taxa during times of environmental stress. Yet owing to inaccessibility of ecosystems at these depths, most MCEs remain unexplored, with quantifications of ecological communities in these habitats lacking across many regions. Here, using open- and closed-circuit technical diving, we quantified benthic and fish community composition at four mesophotic reef sites (45m depth) in Grand Cayman. We show significant differences in benthic community composition over a small spatial scale driven by disparate coverage of sponges, crustose coralline algae, and sand/rubble, yet consistent patterns of macroalgal dominance representing >50% coverage at each site and low hard coral cover at an average of 2.4%. Reef fish species richness, biomass, and density was consistent across sites, however the relative contribution of individual species to community composition differed significantly. Macrocarnivores were found to be the dominant contributors to biomass, with invertivores the most speciose, and omnivores and planktivores at the highest densities, consistent with previous descriptions of mesophotic fish assemblages in other regions. Similarly, the low hard coral cover and high macroalgae and sponge cover of the benthic communities also appear ecologically similar to several described mesophotic reefs yet is not uniform across the Caribbean. The ecological organisation of Grand Cayman's MCEs may result from a variety of factors such as isolation from other major land masses, geology, local geography, and anthropogenic activity at both the local and global scale and highlight the importance of continued exploration and documentation of MCE communities.

Introduction

Mesophotic Coral Ecosystems (MCEs) represent globally distributed, deeper water ecosystems, typically found between depths of 30 and 150 meters (Pyle and Copus 2019). Comprised of light-dependent scleractinian corals, these ecosystems also contain a variety of taxa including sponges, macroalgae, encrusting algae, and soft coral colonies (Hinderstein et al. 2010). Despite the ecological importance of MCEs for harbouring marine biodiversity, which contributes to coastal ecosystem services (Holstein et al. 2019), MCEs have historically received less attention than their shallow water counterparts due primarily to limited access using traditional SCUBA. However, as diving and submersible technology has advanced, so has access to the mesophotic, resulting in a dramatic increase in scientific investigation and biodiversity assessments (Pyle and Copus, 2019). This recent surge has primarily focused on Caribbean MCEs, which are typically located in regions with high anthropogenic activity, comprising roughly 55% of MCE focused publications as of 2018 (Laverick et al. 2018). These studies have been crucial in documenting the biodiversity of MCEs, highlighting the ecologically and biologically distinct nature of these systems (Kahng et al. 2010) with prominent differences in both benthic (Stefanoudis, et al. 2019, Lesser et al, 2018) and fish assemblages (Garcia-Sais et al. 2008, Stefanoudis, et al. 2019, Lesser et al, 2018, Pinheiro et al, 2016) compared to shallow water ecosystems. Within MCEs, observed breaks in biodiversity are documented at approximately 60m, distinguishing the upper and lower mesophotic zones (Lesser et al. 2018). While the defined depth range is influenced by topography, light intensity is also a major driving factor affecting community composition and defining species boundaries (Perez Castro et al. 2022; Laverick et al. 2017). Such physical factors of the environment differ among and within locations, however, resulting in strong differences in communities and distributions among various MCEs, warranting continued assessments of community composition.

The benthic composition of MCEs of the Cayman Islands has been the focus of previous work by Slattery & Lesser (2019), who focused primarily on sponge communities over limited spatial distribution and described a "sponge belt" (Slattery & Lesser, 2019). Mesophotic sponges in Grand Cayman were also the focus of Macartney et al. (2021), whose work was concentrated on a single species. While Carpenter et al. (2022) assessed the benthic composition of corals and key functional groups on MCEs across Little Cayman Island, their study did not include Grand Cayman. Importantly, none of the previous mesophotic studies in the Cayman Islands included assessments of fish communities, nor the interaction of benthic habitat and fish assemblages, highlighting a critical knowledge gap in our understanding of these ecosystems in Grand Cayman.

Variations in benthic habitat often corresponds to changes in fish community composition. For example, in the Seychelles shallow reefs with high macroalgal cover had higher densities of generalist fish species and lacked specialists, whereas reefs with high coral cover had higher abundances of specialised corallivores species (Chong-Seng et al, 2012). In the Philippines, a positive association was found between hard coral cover and biomass of planktivores, piscivores, and corallivores, while a negative association was found between hard coral cover and detritivores and sand feeders (Russ et al, 2021). In the Caribbean, studies have found a positive correlation between macroalgae density and herbivorous fish assemblages on shallow reefs but fail to show an impact of coral cover on fish populations (Sandin et al, 2008) mesophotic studies

83   in the Gulf of Mexico have also shown a difference of fish assemblages in relation with benthic
84   composition, with high fish biomass associated with coralline algal reefs (Voss et al, 2014). As
85   these patterns vary across locations and depths, it is important to include assessments of both
86   benthic habitat and fish communities to accurately characterize MCEs, which was previously
87   lacking for MCEs in Grand Cayman.
88
89   Here, we characterize the biodiversity and community composition of mesophotic reefs across
90   several sites on Grand Cayman Island. Using benthic photogrammetry and *in situ* visual surveys
91   we provide a holistic description of benthic community composition, including scleractinian
92   corals and key functional groups, as well as of fish community assemblages. Given the
93   hypothesized role of MCEs as areas of refuge for preserving biodiversity under future climate
94   change scenarios (e.g. DRRH; Bongaerts et al. 2010), baseline characterizations of these habitats
95   are crucial for increasing our understanding of mesophotic ecosystem function and informing
96   marine spatial planning and management.

Materials and Methods:

The present study was carried out off the coast of Grand Cayman (19.329858 -81.252361), the biggest and most populated of the 3 islands that compose the Cayman Islands (Cayman Islands' 2021 Census Report, ESO). Four sites situated around the West Bay peninsula were surveyed: Ghost Mountain (19.402300 -81.385680), Roundabout (19.384333 -81.318300), La Mesa (19.321680 -81.393080), and Lighthouse Point (19.372954 -81.421855) (Fig. 1). The sites were situated off the wall, with a steep slope except for lighthouse point that is characterized by a more gradual slope (personal observation). They were composed of an alternance of hard-bottom and sandy substrate

Fish surveys were conducted along 30m by 2m transects at a depth of 45m (n=3-5 per site; total area 60m^2). All fish encountered along the transects were identified to species, counted, and categorised into size classes based on total length: 0-5, 5-10, 10-20, 20-30, 30-40, and >40 cm. Following the surveys, fish data were classified into one of five food web classes: herbivore, invertivore, omnivore, macrocarnivore, and planktivore based on data available on www.fishbase.org (Houde and Zastrow 1993; Welcomme 1988), a data base by Froese and Pauly (2000). Density was calculated as the total number of individuals per transect (no. of fish/60m^2 transect). Biomass was calculated using the formula:

$$\frac{(a \times L^b)}{N}$$

Where L is the estimated length using the upper end of the size class category, and N is the number of individuals of that size class (Bohnsack and Harper 1988; Kulbicki et al. 1993). Values for a and b were obtained for each species on www.fishbase.org (Houde and Zastrow, 1993; Welcomme, 1988). When these values were not available for a particular species, data for a congeneric species were used. Species richness is the total number of species per transect and diversity is based on the Shannon-Weaver index of diversity (Shannon & Weaver, 1949):

$$- \sum P_i (\log P_i)$$

with P_i being the proportion of each species in the sample.

At each of the four sites, a 10m x 10m plot was laid on the benthos using transect tapes, with the lower edge at 45m depths. Time lapse images were taken of benthos within each plot at one second intervals by two divers that swam in a lawnmower pattern approximately 1m above the benthos, using two GoPro Hero 10 cameras mounted onto a PVC frame with 2 lights (Sola Video 2500 Flood). Eight targets were laid haphazardly on the substrate within the plot to assist with building a digital 3D model of the studied area using the software AGIsoft Metashape Pro (version 1.8.3). This was then converted into a 2D orthomosaics and exported as a PNG that was subsequently split into ~1m^2 replicate quadrats using Photoshop (version 24.3) and scaled on the pictured measuring tape. ImageJ (version 1.53t) software was then used to scale each image for further analysis. Within each quadrat all scleractinian corals were identified to the highest taxonomic level possible based on image quality. Species within the general *Agaricia*, *Siderastrea*, and *Orbicella*, were limited to genus. Surface area of each colony was then

140 measured using the freehand tool (in cm^2). Total surface area of all corals relative to the size of
141 the quadrat was then used to calculate percent coral cover.
142
143 Benthic composition of other key functional groups was then assessed visually for eight
144 categories: Crustose Coralline Algae (CCA), Soft Coral (SC), Sand and Rubble (S/R), Turf
145 Algae (TA), Recently Dead Coral (RDC), Macroalgae (MA), and Other (soft coral plumes, fish,
146 targets, blurry and indistinguishable area, etc.). Measurements and visual assessment of the
147 functional groups were conducted by the same person throughout the data collection phase to
148 limit bias and errors.
149
150 Statistical analyses were conducted on R version 4.1.0 (R Core Team, 2023).
151 Fish density, biomass, diversity, coral diversity index and richness were compared among sites
152 and among food webs with non-parametric Kruskal-Wallis' tests (Kruskal and Wallis 1952), as
153 they did not meet the assumption of normality (Shapiro and Wilk 1965), followed by post-hoc
154 analysis using the Dunns test (Dunn 1964) in the FSA package (Ogle, 2021). The fish coral
155 diversity index met the assumption of normality (Shapiro and Wilk 1965) and were compared
156 among sites with a one-way analysis of variance (ANOVA), followed by a post hoc analysis
157 using Tuckey's test (Tuckey 1949).
158 Benthic functional group composition among sites did not meet the assumptions of normality
159 (Shapiro and Wilk 1965) and was therefore compared using a Kruskal Wallis with a Dunn's test
160 as a post hoc. "Other", while being measured as a functional group, is not integrated into any of
161 the mentioned statistical analyses. By being an imprecise category that is compensating for a
162 various array of non-benthic category measures or photomosaic inconsistence, it was judged
163 irrelevant to the aim of the study and the measured percentages have been scaled accordingly.
164
165 To assess dissimilarity in the benthic composition and fish community composition among sites,
166 we used non-Metric Multi-Dimensional scaling (nMDS) models from the Vegan package
167 (Oksanen et al. 2011). Models were based on a Bray-Curtis dissimilarity matrix of community
168 composition for both benthic composition, fish species composition, and reef fish trophic
169 community. A dissimilarity matrix rather than distance matrix (Jaccard 1901) is preferable for
170 our dataset which reflects community composition, as Bray-Curtis dissimilarity has less
171 sensitivity to the absence of species within the matrix compared to the distance (metric) based
172 counterparts. To statistically compare the dissimilarity between sites for community
173 composition, we used a PERMANOVA test with the dissimilarity matrix as the response, and
174 site as the predicting factor.

Results

In total 48 fish species were recorded across all four sites ranging from 30 at Lighthouse Point to 24 at Roundabout, however, median species richness per transects did not differ significantly among sites (P>0.05; Kruskal Wallis) (Fig. 2A). However, according to the species accumulation curve, the number of surveys conducted in no enough to account for the full species composition, and thus this is likely an underestimate of diversity (Supplemental Fig. S Fish biomass also did not differ significantly among sites (P>0.05; Kruskal Wallis), Lighthouse Point had the highest median biomass (5936.296 ± 1026.23g/transect), while Ghost Mountain had the lowest (3211.59 ± 797.70 g/transect) (Fig. 2B). The median fish density was significantly different (X^2=-2.74, P=0.03) between Lighthouse Point (157 ± 30.39 fish per transect) and La Mesa (63 ± 10.08 fish per transect) (Fig. 2C Shannon-Weiner diversity index was significantly different between Ghost Mountain and La Mesa (X^2= 0.726, P=0.019), being respectively the least diverse with a median index value of 1.65 ± 0.14 and the most diverse with a median value of 2.31 ± 0.15 g 2D).

For trophic guilds specifically, invertivores were the most species rich group of fish with a median of 10 ± 1.31 species recorded and planktivores were the least with a median species richness of 3 ± 0.4 (Fig. 3A Macrocarnivores had the highest median biomass (6693.41 ± 1434.09 g/transect; Fig. 3B) while planktivores had the lowest median biomass (789.6238 ± 394.81 g/transect). Omnivores had the highest median density (200 ± 4.42 of fish per transect; Fig. 3C). Significant differences were found in species richness (X^2=12.169, P=0.016 fish density (X^2=17.031, P=0.001) and biomass (X^2=9.622, P=0.047) among trophic guilds. Higher species richness was observed for invertivores compared to planktivores (X^2=3.13, P=0.017), while macrocarnivores had significantly lower density compared to planktivores (X^2=-2.816, P=0.043) and omnivores (X^2=-3.697, P=0.002). Shannon diversity index values did not differ significantly (P>0.05, ANOVA) among trophic groups.

Across sites, 20 famillies of fish were recorded (Fig. 4 he basslet family (*Grammatidae*), had the highest density per square meter with a mean value of 19.048 ± 7.554 % (Fig. 4A), accounting for 0.59 ± 0.317 % of the total fish biomass (Fig. 4B). Members of the snapper family (*Lutjanidae*) had the highest average biomass (10.432 ± 3.974 %) but only accounted for 0.071 ± 0.031% of the recorded density (Fig 4A and 4B).

Across the surveyed sites, *Gramma melacara,* had the highest frequency by density at three sites, with 53.78% at Ghost Mountain, 35.91% at Roundabout and 24.75% at Lighthouse Point, while *Chromis cyanea* had the highest frequency at La Mesa of 20.61% (Fig. 4C). *Scarus taeniopterus* had the highest frequency by biomass at Ghost Mountain at 28.02%, while *Lutjanus analis* had the highest frequency by biomass at La Mesa at 41.85%, and Roundabout at 25.46% (Fig. 4D). At Lighthouse Point, *Lutjanus mahogoni* had the highest frequency by biomass at 20.91% (Fig. 4D). Out of the 48 observed species, only 13 were found across all sites and 22 species were endemic to one site.

Macroalgae percent cover was significantly higher than all other functional groups across all four sites (Fig 5; Table 1) with a median surface coverage of 63.378 ± 1.125%, while hard coral cover was significantly lower than all other functional groups, with a median of 0.662 ± 0.285% (Fig.

221 5; Table 1). Sponge cover did not differ significantly from either sand/rubble or CCA cover,
222 however, sand/rubble cover was significantly higher than CCA (Fig. 5; Table 1).
223

224 *Agaricia* was the dominant coral genus at all four sites (Fig. 6) ranging from 77% at Ghost
225 Mountain to 54% at Lighthouse Point. *Siderastrea* and *Orbicella* were present in moderate
226 frequency at all sites, *Montastraea* and *Porites* were consistently present but in low coverage,
227 and *Mycetophyllia* was only recorded in La Mesa. Shannon-Weiner diversity of coral species
228 showed no significant differences between sites (P>0.05, Kruskal-Wallis)
229

230 Multivariate analyses revealed the benthic composition of sites were significantly dissimilar
231 (PERMNOVA value = 11.69, P = 0.0001). Lighthouse Point appears to be the most unique
232 site based on benthic composition (Fig 6A), related to high sand/rubble coverage (Fig 6B) The
233 trophic composition of fish communities (Fig 6C) was also significantly different among sites
234 (PERMANOVA, F value = 2.76, P=0.0058) as was the species composition (Fig. 6E;
235 PERMANOVA, F value = 2.55, P=0.003)

Discussion

238 Here, we provide the first characterization of mesophotic reefs in the Cayman Islands that
239 combines benthic habitat and fish assemblages. Our results show that fish populations are
240 primarily composed of basslet (*Grammidae*) and damselfish (*Pomacentridae>Stegastinae*)
241 species, with species of wrasse (*Labridae*) and chromis (*Pomacentridae>Chrominae*) also
242 present in high relative abundance. Although present in lower relative densities, species of
243 snapper (*Lutjanidae*) and parrotfish (*Scaridae*) represent the highest contribution to community
244 biomass on the mesophotic reefs surveyed. The benthos at 45m is dominated by macroalgae and
245 sand/rubble, which can be generally described as algae-covered hard substrate dispersed among
246 patches of sand and rubble. Sponges, seafans, and crustose coralline algae are also found in high
247 frequency however, hard coral cover represents one of the lowest percent covers. Among the
248 corals present, the dominant contributing species belong to the genera *Agaricia, Siderastrea,* and
249 *Orbicella.*

251 Among all the mesophotic sites surveyed, *Gramma melacara* (blackcap basslet) and *Chromis*
252 *insolata* (sunshinefish) are the most abundant in terms of number of fish. These species,
253 however, are absent on shallow reefs in the same region of Grand Cayman (Johnson et al. 2023).
254 Previous surveys of Caribbean fish communities also note high densities of *C. insolata* on
255 mesophotic reefs with their presence generally lacking on shallow reefs, suggesting this species
256 is a mesophotic specialist (Baldwin et al. 2018; Garcia-Hernandez et al. 2018; Gress et al. 2018;
257 Pinheiro et al. 2016). Likewise, *G. melacara* is also a mesophotic specialist and is considered
258 common on MCEs in the Western/Central Caribbean (Chasqui et al. 2020; Dustan and Lang
259 2019), however it is not present on MCE species lists from Cozumel (Gress et al. 2018), Curacao
260 (Baldwin et al. 2018; Pinheiro et al. 2016), or Bermuda (Pinheiro et al. 2016; Goodbody-
261 Gringley et al. 2019), and thus its geographic distribution may be limited to the Central
262 Caribbean. Although species of snapper (*Lutjanidae*) are the most abundant by biomass across
263 all sites, this is not consistent among the 4 sites surveyed, with these species being generally
264 absent from Ghost Mountain. Rather, parrotfish are the dominant group at this site, where the
265 most abundant species by biomass is *Scarus taenopterus.* Within the other three sites, variation
266 also exists among the dominant species of snapper with *Lutjanus analis* being the highest
267 contributor to biomass at La Mesa and Roundabout, while *Lutjanus mahogoni*, is the highest
268 contributor at Lighthouse Point. As macrocarnivores, such as snappers, are often transient it is
269 likely that variations in species contributions of these groups and the absence of snappers from
270 surveys at Ghost Mountain and may be an artifact of the visual survey method, which is limited
271 to a short period of time and may miss transient species

273 The overall benthic cover of MCEs in Grand Cayman is similar to mesophotic reefs at other
274 Central Caribbean locations (Dustan and Lang 2019; Reed et al. 2019; Carpenter et al. 2022). For
275 example, sponges are the highest contributing benthic invertebrate to percent cover on MCEs in
276 Grand Cayman, constituting an average of $10.587 \pm 0.560\%$ of the benthos, which conforms to
277 previous reports from Lesser et al. (2018) who described an increase in sponge abundance and
278 diversity with increasing depth. However, while macroalgae cover in Grand Cayman is similar to
279 that on MCEs at Pulley Ridge (Florida, United States of America) and in Puerto Rico (Reed et al.
280 2019; Apeldoorn et al. 2019) is higher than that reported for several other Caribbean MCEs
281 (Gress et al. 2019; Dustan and Lang 2019), including Little Cayman (Carpenter et al, 2022).

282 Differences in macroalgae cover between these neighbouring islands may be related to
283 differences in levels of marine protection, as roughly 57% of the nearshore environment in Little
284 Cayman is classified as no-take marine protected areas compared to less than 20% in Grand
285 Cayman. While comparable fish data for mesophotic reefs in Little Cayman is not available,
286 protection of ecologically important reef fish populations, such as herbivores, is expected to lead
287 to reduced algal cover (Jackson et al. 2014).
288
289 While coral cover at 45m depth in Grand Cayman is low, at an average of 2.6%, similar percent
290 coral cover is noted on MCEs in Honduras, Mexico, and at Pulley Ridge, yet is lower than the
291 8% cover documented in Bonaire and substantially lower than in Puerto Rico and the US Virgin
292 Islands, where percent cover reaches nearly 30% on upper mesophotic sites (Reed et al. 2019;
293 Gress et al. 2019; Appeldoorn et al. 2019; Smith et al. 2019; Frade et al. 2019). Despite regional
294 differences in percent cover of scleractinian corals, species presence on MCEs appears relatively
295 homogenous across the Caribbean, with species in the genus *Agaricia* being predominant (Reed
296 et al. 2019; Gress et al. 2019; Appeldoorn et al. 2019; Smith et al. 2019; Frade et al. 2019). In
297 Grand Cayman, coral species assemblages closely resemble those of nearby Little Cayman,
298 where species in the genera *Agaricia, Siderastraea* and *Orbicella* have the highest contribution
299 to percent cover at 45m depth (Carpenter et al. 2022). However, *Madracis spp.* occur in
300 relatively high frequency in Little Cayman yet are absent from the surveys in Grand Cayman.
301 Conversely, the genus *Mycetophylia* is a top contributor to MCEs in Grand Cayman but not in
302 Little Cayman. Variations in percent coral cover and species contributions among locations are
303 likely driven by the availability of incident light as a function of reef topography. For example,
304 on the *Orbicella* reefs in the US Virgin Islands, the reef slope is gradual with extensive flat
305 regions in the upper mesophotic zone (Smith et al. 2019). However, the Cayman Islands are
306 surrounded by deep trenches, with near vertical walls beyond the shallow fore reef leading to
307 limited light availability beyond 30m (Lesser et al. 2018; Slattery and Lesser 2019).
308
309 Alternatively, differences in benthic composition, such as the dominance of *Agaricia spp* on Grand Cayman
310 MCEs, may be related to disturbance history. The proximity of these MCEs to the Island of
311 Grand Cayman exposes these sites to heavy levels of tourism and overfishing, impacting both
312 coral and fish communities (Stallings 2009; Johnson et al. 2023; Rocha et al., 2023). In fact,
313 benthic composition of MCEs is documented to affect the fish community, with high coral cover
314 being linked to high fish density and richness (Garcia-Sais 2010). Thus, MCEs likely do not
315 provide a refuge from disturbance for coral and fish communities in regions with high
316 disturbance frequency or severity, and will likely be composed of weedy, fast-growing coral
317 species that can tolerate high disturbance conditions, associated with less dense and diverse fish
318 populations.
319

Conclusion

321
322 In conclusion, this study provides an overview of the fish and benthic assemblage at mesophotic
323 depth off the coast of Grand Cayman. Our study showed that the benthic composition is highly
324 variable across a small geographical scale with the exception of macroalgae, being the dominant
325 benthic component across all sites. Fish assemblages were also distinct, with differences for
326 biomass and density between trophic guilds across sites. Our study highlights the unique benthic

327   and fish communities of Grand Cayman's mesophotic reefs at 45m, which qualitatively appear
328   different to other regions within the Caribbean (Scott 2019; Garcia-Hernandez 2018; Smith
329   2010). Whether the unique composition of benthic and fish communities is a result of geological
330   and biological processes, or the influence of local scale anthropogenic activity remains to be
331   seen. Future research on remote mesophotic reefs within the same ecoregion will provide further
332   insight into why Grand Caymans mesophotic reefs appear as distinct communities and will allow
333   assessments of the relative influence from local anthropogenic activity.

334 **Supplementary**

335

336 Supplementary I

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Figure 1

Context of the study and sampling techniques.

Maps of the study sites, Lighthouse Point, Ghost Mountain, La Mesa and Roundabout and the position of Grand Cayman amidst the Caribbean Sea (A). Picture of the dive team laying transect and taking pictures of the quadrat during a 15 meters practice dive (B).

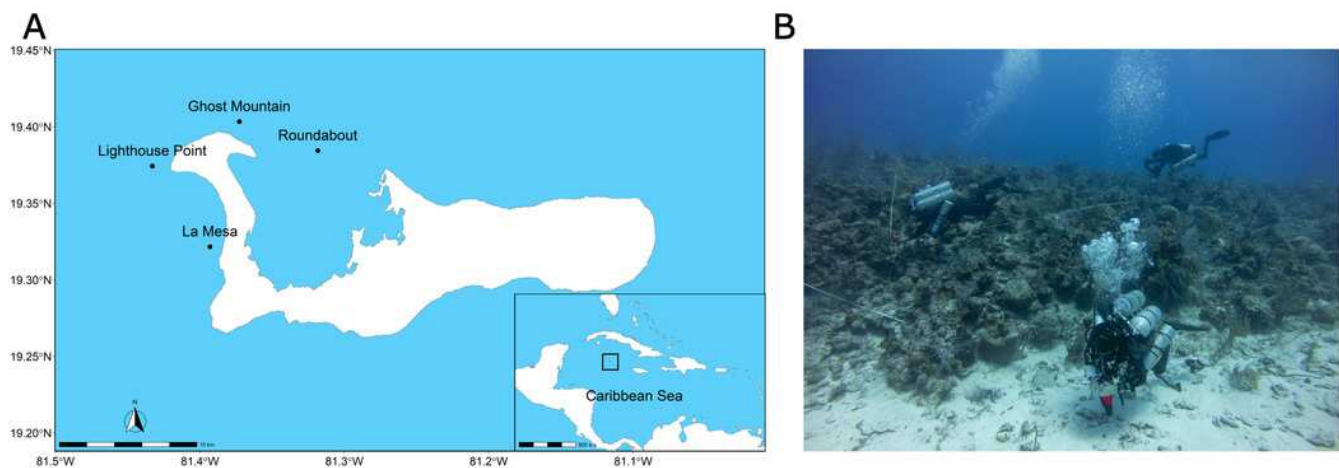



Figure 2

Comparison of Species richness (number of unique species per transect) (A), Biomass (estimated weight of fish in g per transect) (B), Density (number of fish per transect) (C) and Diversity (Shannon diversity index) (D) between Sites.

Boxplots' horizontal bars represent the sites median values, the upper and lower sections (box outlines) represent the interquartile range, the whiskers extend to 90% of the data, with dots being outliers.

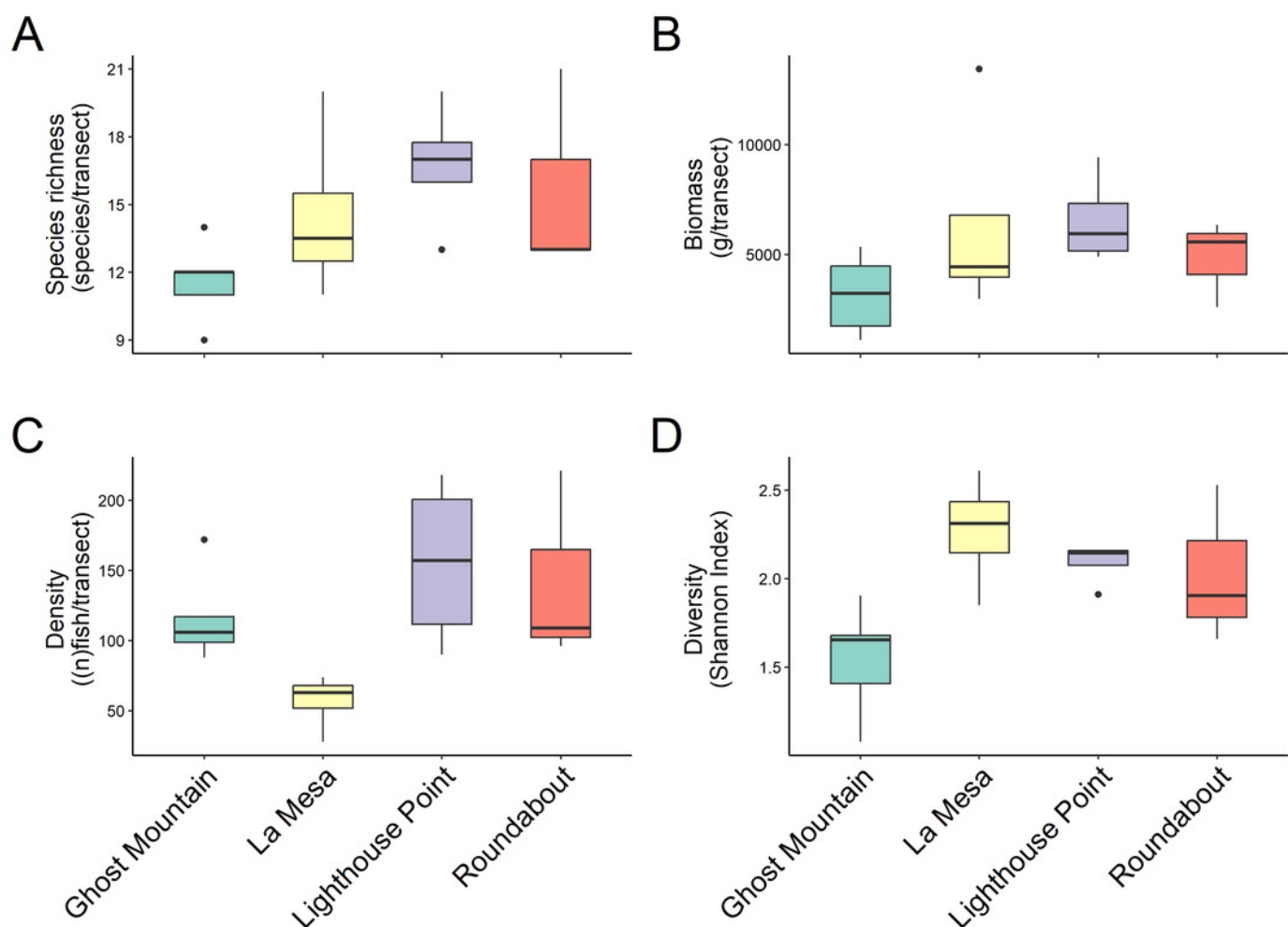



Figure 3

Comparison of Species richness (number of unique species per transect) (A), Biomass (estimated weight of fish in mg per transect) (B), Density (number of fish per transect) (C), and Diversity (Shannon diversity index) (D) between Trophic Guilds.

Boxplots' horizontal bars represent the sites median values, the upper and lower sections (box outlines) represent the interquartile range, the whiskers extend to 90% of the data, with dots being outliers.

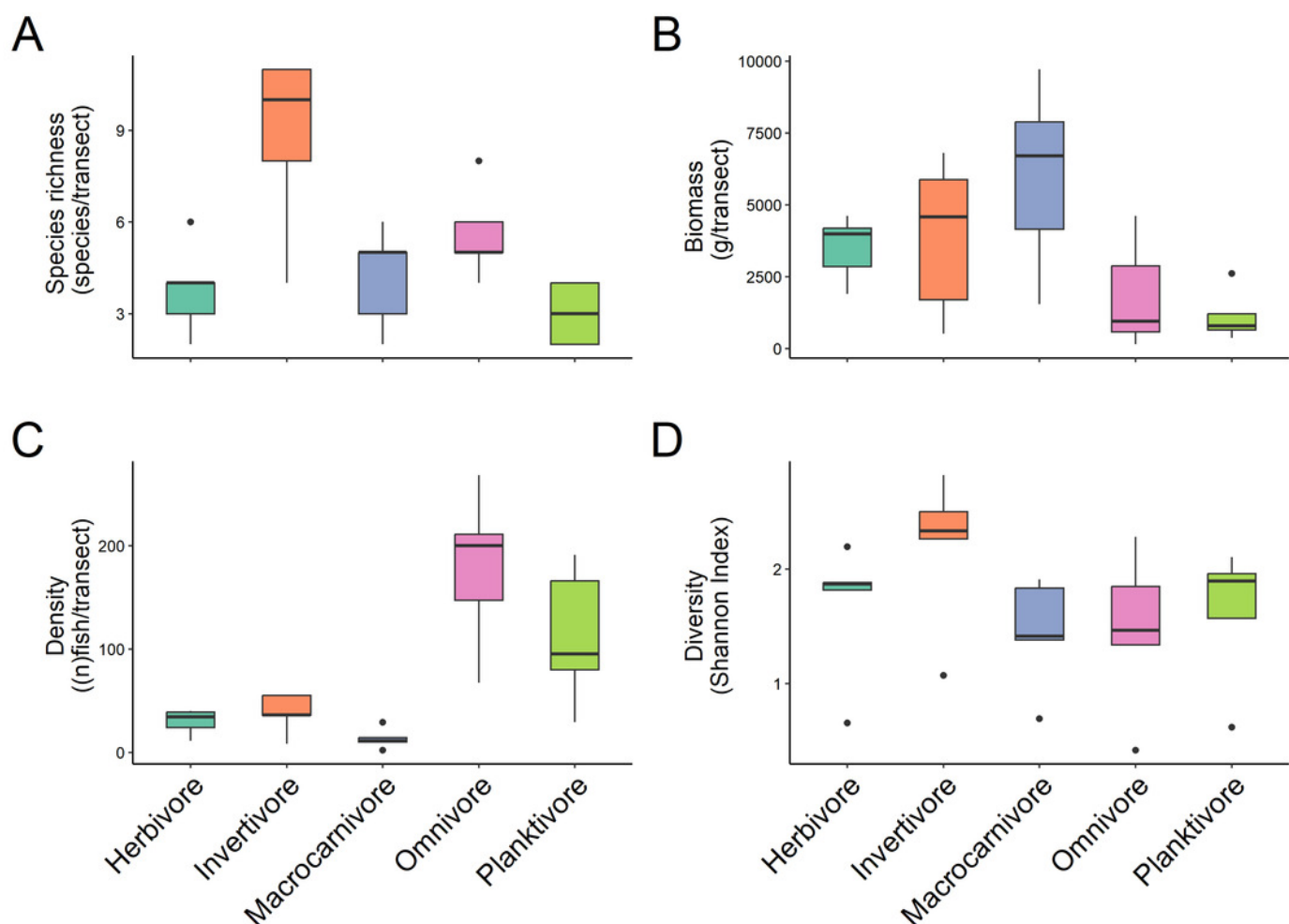



Figure 4

Biomass (A) and Density (B) of the common fish families across all sites. Biomass (C) and Density (D) of each species across all sites.

Solid lines in plots A and B are the average per common family, and the whiskers are the range of the data. Each rectangle in C ad D shows at least one occurrence of a species on one of the transects. The absence of a rectangle represents the absence of a species on a site.

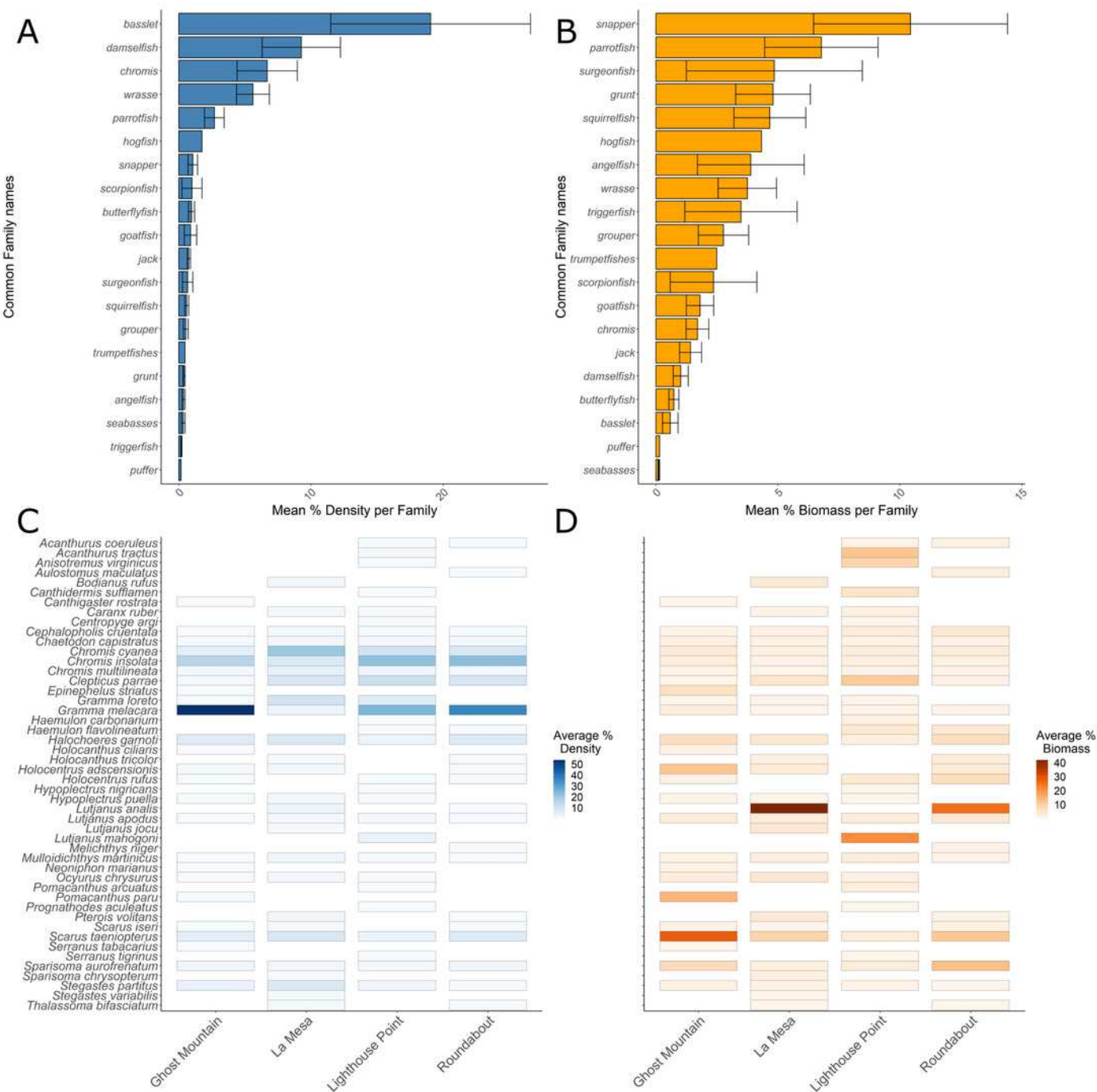



Figure 5

Comparison of the percentage cover of the different functional groups (macroalgae, sand/rubbles, sponge, CCA and hard coral).

The horizontal middle bars represent the median values, whilst the upper and lower sections (box outlines) represent the interquartile range. The whiskers extend to 90% of the data, with dots being outliers.

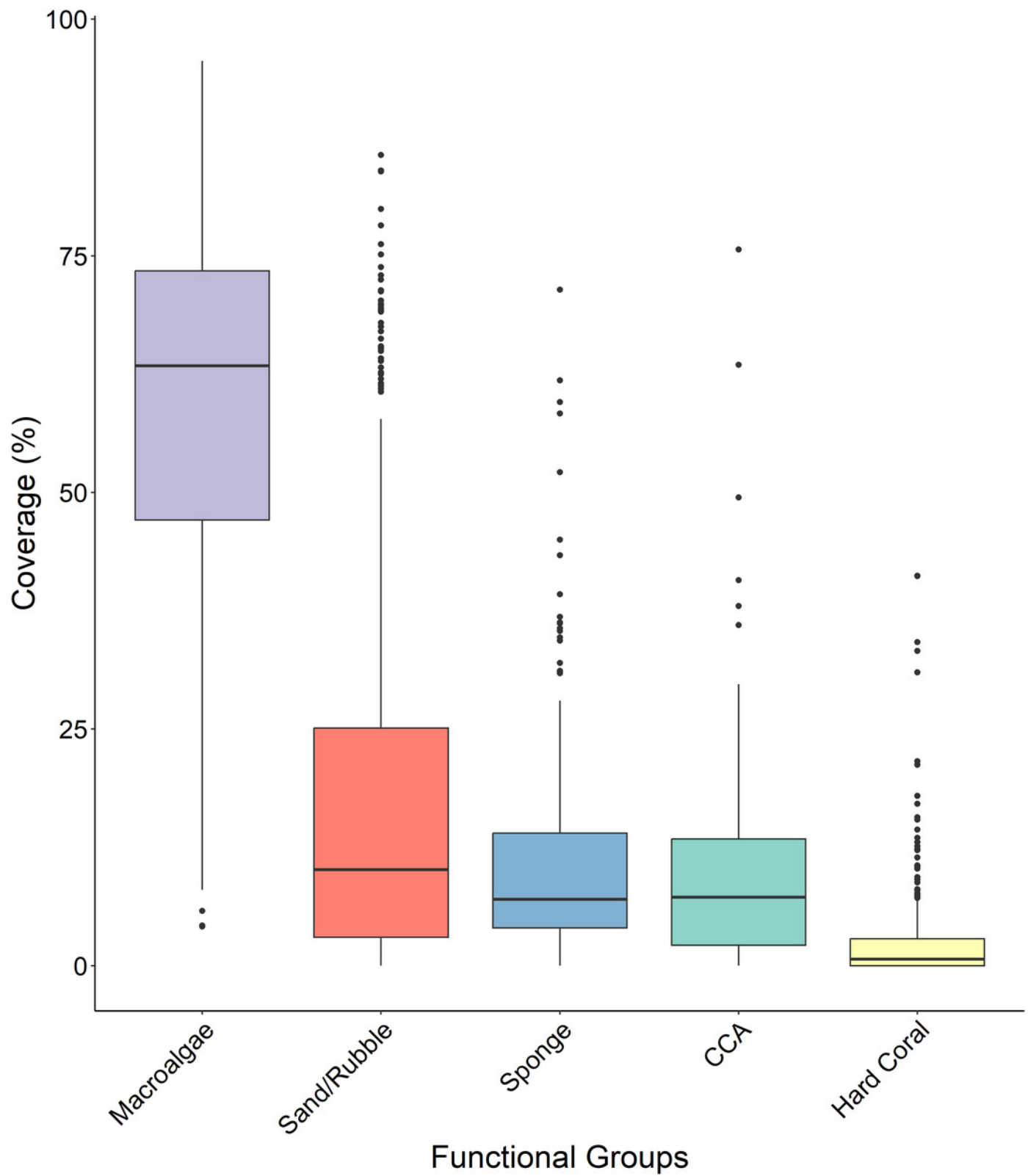



Figure 6

Comparison of the percent contribution of each Scleracctinian coral genus observed per site.

With Agaricia being the most common genus recorded across all sites.

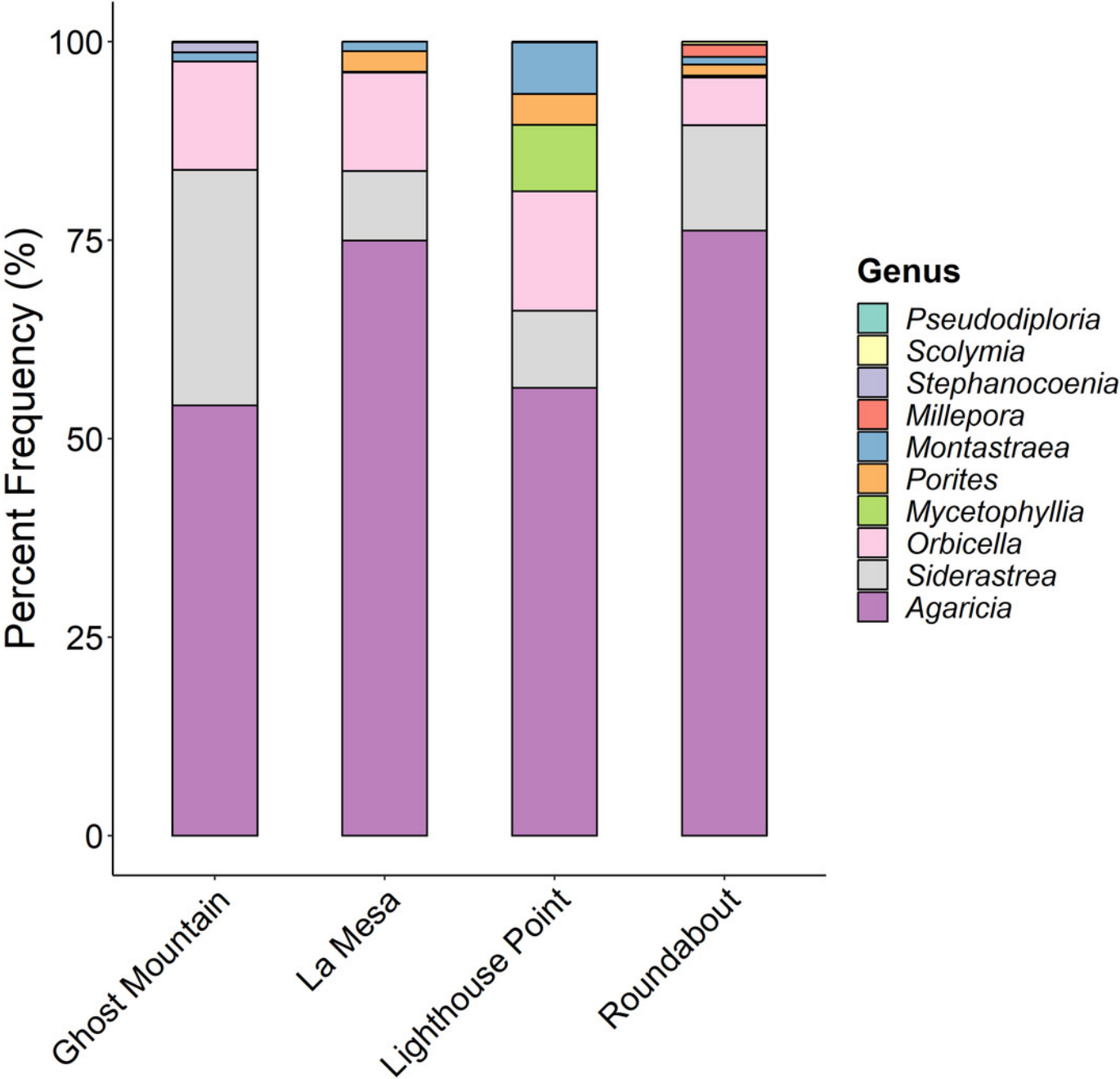
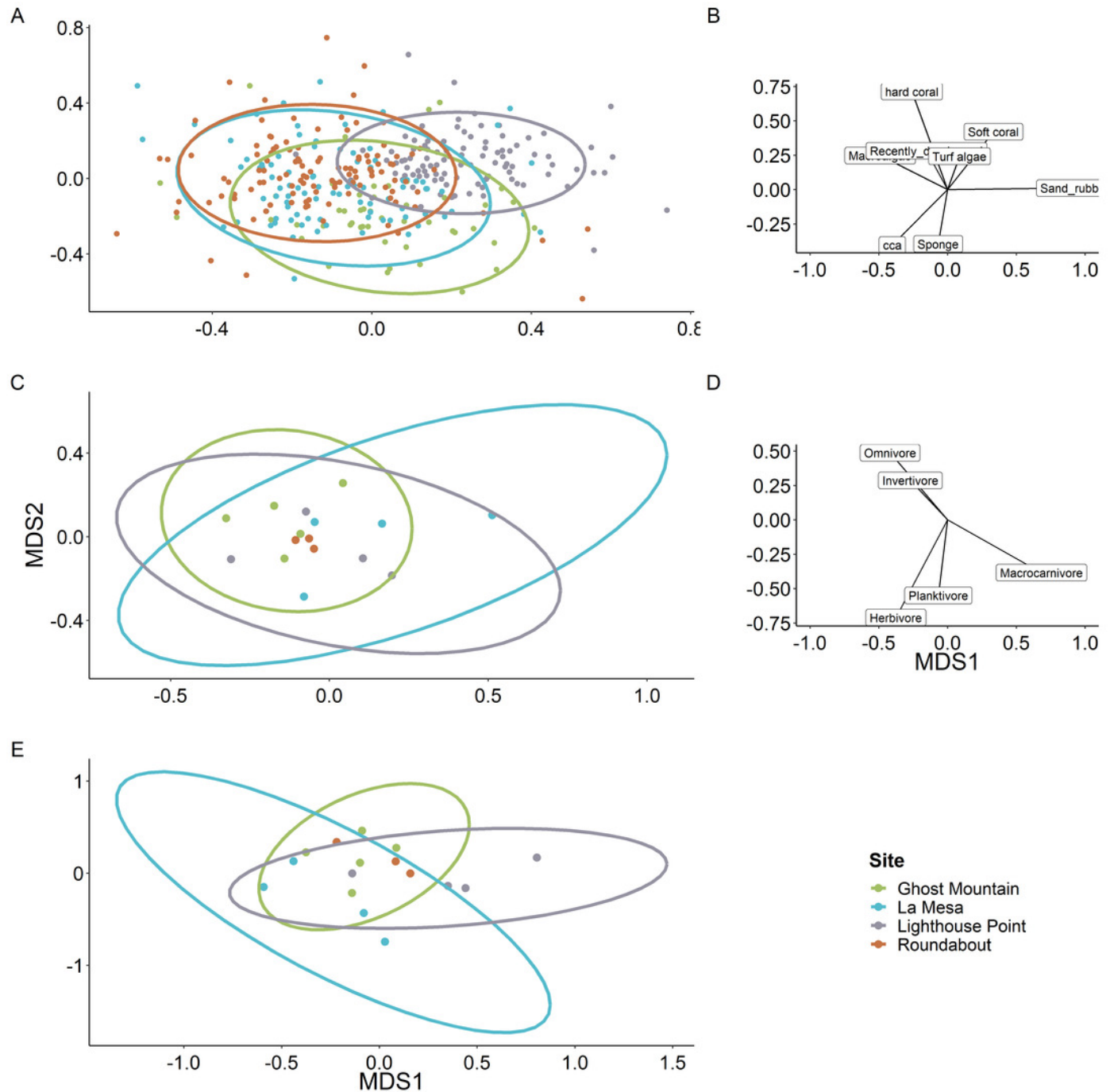



Figure 7

Ordination plots of the dissimilarity between the sites regarding benthic composition (A), fish trophic guild composition (C) and fish species (E).

Each dot represents a quadrat for the benthic ordination plot (A) and a transect for the fish trophic plots (C and E). Roundabout's ellipse is not present owing to a deficit of replicates which does not allow the projection (C and E). Each ellipse represents the tendency of a site to drift along the two axes following the vectors on the right of each ordination plot (B and D).

Benthic component's Adjusted P-values throughout sites.

	Sand/Rubble	Sponge	CCA	Hard Coral
Macroalgae	<0.001	<0.001	<0.001	<0.001
Sand/Rubble		0.067	0.001	<0.001
Sponge			0.157	<0.001
CCA				<0.001