Honduras marine research report 2024

Alex O’Brien, Operation Wallacea

Executive summary

Staff

James Bell, Abi Bellamy, Antal Borcsok, Manon Broadribb, Korrie Brown, Sophie Carolan, Imogen Clark, Laurie Dalton, Luke Dance, Rebecca Engel, Catheline Froehlich, Miranda Gibson, Patrycja Glaz, Rachel Gunn, Toby Haddon, Emily Hammond, Catherine Hay, Jenny Hickman, Niamh Kelly, Damaris Landers, Monica McCard, Alex O'Brien, Eugenie Ollenberger, Naomi Slator, Dom Thompson.

Acknowledgements

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We have worked with countless great collaborators over the years. Our main collaborative partners this year were:

- Professor James Bell – Victoria University of Wellington, New Zealand
- Professor Michael Bonsall – University of Oxford, UK
- Dr Holly East – Northumbria University, UK
- Dr James Guest – University of Newcastle, UK
- Dr Rachel Gunn – University of Tübingen, Germany
- Dr Monica McCard – Liverpool John Moores University, UK
- Dr Benjamin Titus – University of Alabama, USA

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1. Introduction

Operation Wallacea has been conducting marine research in Honduras since 2003. The program, which started in the Cayos Cochinos archipelago is now based across the mainland site of Tela and the Westerly Island of the Bay Island chain, Utila (Figure 1) in addition to various associations with local and national groups within Honduras. The marine research is part of a holistic effort by Operation Wallacea within Honduras, as the program also incorporates a large terrestrial research site in the cloud forests of the Cusuco National Park.

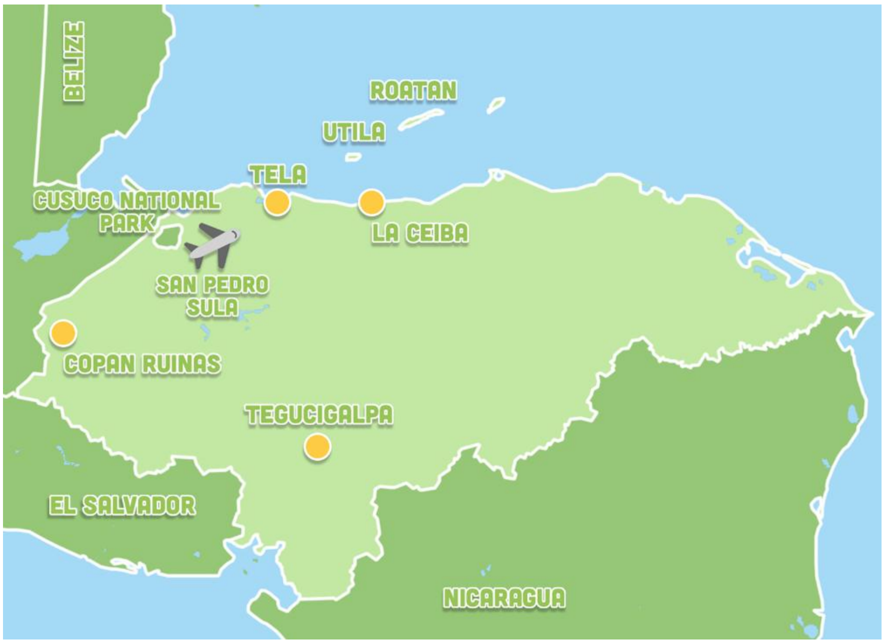

Figure 1: Map of Honduras showing the Operation Wallacea research sites: (1) Cusuco National Park terrestrial research site, (2) Utila marine research site located at the Bay Islands College of Diving, and (3) Tela Bay marine research site located at the Tela Marine Research Centre.

Operation Wallacea is a network of academics from universities across the globe, who design and implement biodiversity and conservation management research programmes. Research is supported by students who join the programme, to develop their resume, or collect data for a dissertation or thesis. Partnering academics benefit from funding for high quality fieldwork, enabling them to publish papers in peer reviewed journals. The model enables large temporal and spatial datasets to be collected, which can then be used for assessing the effectiveness of conservation management interventions.

The overall structure of these projects is to bring academics and world leaders into the field to run specialist research groups within the overall project framework. These groups consist of principle researchers, PhD students, dissertation and thesis students alongside research assistant volunteers. The projects run each summer for a number of weeks between June - August. This format gives many advantages to field research, such as bringing together a variety of multidisciplinary field scientists into the field with a central organisation coordinating the research. Funding for the research is entirely based on volunteers, which ensures that projects can be run over prolonged periods of time and the datasets can be built up over many years without the reliance on grant funding. The research is based on collecting data on the local ecosystems that can be channelled into high quality research publications and grant applications to establish examples of best practice conservation in the local communities.

The marine research and conservation objectives of Operation Wallacea in Honduras often require a multidisciplinary approach, utilising expertise from a variety of research backgrounds or data collection from a variety of locations. To achieve this, Operation Wallacea has established two independent research operations within the marine program. They are based at permanent research centres and concentrate on studying the biodiversity and ecology of the local marine and terrestrial ecosystems, which in turn facilitates high level scientific research conducted by internationally renowned academics that form an integral part of the Operation Wallacea research model. The first marine research site in Honduras is run from the Bay Islands College of Diving (who house the Whale Shark and Oceanic Research Centre (WSORC) year-round) on the island of Utila and the second at the mainland site of Tela, in partnership with the well-developed Tela Marine Research Centre.

1.1 Standardised methodologies

To address the aim of assessing coral reef ecosystem health and function on both Utila and Tela, a set of standardised methodologies have been developed and used to collect data on the benthic, fish and invertebrate communities since 2012. These methods were developed with the aim of increasing the accuracy and level of scientific detail obtained. Survey teams were made up of university-level volunteers led by a member of the Operation Wallacea science team, comprising experienced scientists trained in the data collection methods outlined below.

1.1.1. Benthic habitat surveys

Quantifying the benthic community structure is a useful indicator of overall ecosystem health and function. Particularly useful parameters in coral reef monitoring include the percentage benthic cover of key functional groups such as hard (Scleractinian) corals, algae, other living benthic components and substrate. These data can then be used to help explain trends in other monitoring data sets such as patterns in the abundance and diversity of fish and invertebrates, as well as identify major threats to a particular reef. Benthic habitat surveys were performed using 50m line intercept transects (English et al 1997). These transects were replicated in triplicate at a pair of chosen depths (5m, 10m, 15m) depending on the available depths and suitability of the reef area for this survey technique. Transects were completed with a 10m separation between each transect. Members of the in-water benthic survey team filmed video footage of the transect in-situ which was then later analysed to extract a datapoint every 0.25m along the transect, recording data on the benthic classification under the transect tape at that exact point. In the case of hard corals and macroalgae, species level identification was performed, or genus level identification where species level was not possible or was more appropriate. Sponges and soft corals were identified to growth form (e.g. encrusting, rope, vase etc. in the case of sponges). See table 1 for benthic classifications used for this technique. For analysis of data for this report, the full list was consolidated into four key groups as follows:

1. Hard coral – Live hard coral cover (category HCO)
2. Algae – Live algal cover (categories DCA, MAA, TAL)
3. Other – Other living benthic categories or unknowns (ANE, ASC, BRY, CCA, CYA, INV, MIL, OTH, PEY, SCO, SGR, SPO, UNK, WAT, ZOA)
4. Substrate – Non-living substrate (DCO, RBB, RCK, SAN, SIL)

These consolidated categories were determined for their functional

Table 1: Benthic classifications utilised for Point-intercept benthic transects

Benthic code	Benthic category
ANE	Anemone
ASC	Ascidian
BRY	Bryozoan
CCA	Coraline Crustose Algae
CYA	Cyanobacteria
DCA	Dead Coral with Algae
DCO	Dead Coral
HCO	Hard Coral
INV	Other Invertebrate
MAA	Macroalgae
MIL	Millepora
OTH	Other
PEY	Peysonnellia
RBB	Rubble
RCK	Rock
SAN	Sand
SCO	Soft Coral
SGR	Seagrass
SIL	Silt
SPO	Sponge
TAL	Turf Algae
UNK	Unknown
WAT	Water
ZOA	Zooanthid

1.1.2. Fish abundance, diversity and biomass estimation

Fish perform vital ecosystem services to coral reefs, but their abundance in many areas has been significantly impacted by fishing pressures. Monitoring their abundance and diversity provides an indication of the relative success of fisheries management efforts, whilst assessing the trophic structure of fish communities gives an indication of the ecosystem services which may be lacking. Understanding the biomass present in an ecosystem is a significant improvement on simple population estimates. The ecological service provided by an individual, as well as its value to the overall fishery, is determined by its biomass. A fishery with fewer individuals is not necessarily a less valuable or ecologically healthy community, but instead it is the overall biomass of fish, and specifically of key trophic groups such as herbivores, which provide the most accurate indicator of ecosystem value to both ecologists and fisheries scientists.

Surveys were performed using Stereo-Video Surveys (SVS) which consists of two GoPro cameras in waterproof housings and mounted on an aluminium bar. Before any surveys were conducted the cameras were calibrated in water using footage of a specially designed calibration cube at different orientations. Calibration of the stereo-video cameras is essential to obtain and maintain accurate length measurements of the fish from the stereo-video footage.

The SVS monitoring team consisted of at least three SCUBA divers: one operating the SVS system, one measuring the length of transects using a transect line, and one to provide additional support to help the team operate safely. The SVS operator swims slowly along each transect with the cameras angled slightly downwards toward the reef, as instructed in the SVS system user manual. To provide a consistent survey effort, a standard survey speed was used to aim for surveys to be completed in around six minutes. Six 50m transects were conducted at each site, separated from one another by 10m, were conducted at two of the following depths: 5m, 10m or 15m. This was determined depending on the available depths of the site and suitability of the reef area for this survey technique. The depths are consistent between areas as follows:

- Utila: 5m, 15m
- Banco Capiro, Tela: 10m, 15m
- La Ensenada, Tela: 5m, 10m

SVS footage was analysed using the specialised software EventMeasure. Fish were only recorded if they were within the 5m width of the transect (i.e. 2.5m to the left and 2.5m to the right of the cameras). Individual fish were identified by family, genus, and species with care taken to record individuals only once, and to incorporate both benthic and pelagic species into census data. Total length measurements were computed using EventMeasure, measuring from the tip of the snout to the tip of the tail, and biomass calculated using published ratios from Fishbase online database.

2. Utila Marine Research

Utila is one of the three main islands, along with Roatan and Guanaja, which make up the Bay Islands on the northern coast of Honduras. It is located approximately 30km from the Honduran mainland and comprises a single main island 13km in length and 5km wide (~41 km^2), with a total of 11 small offshore Cays. The island is characterised by extensive mangrove forests with a large lagoon system towards the centre of the island, combined with areas of lowland tropical forest. Much of the coast is surrounded by fringing coral reef, with a more extensive reef system off the west coast of the main island surrounding the Cays. Operation Wallacea began working in Utila in 2006 and as of 2024 work alongside the research base at the Bay Islands College of Diving.

2.1. Utila Marine Protected Areas

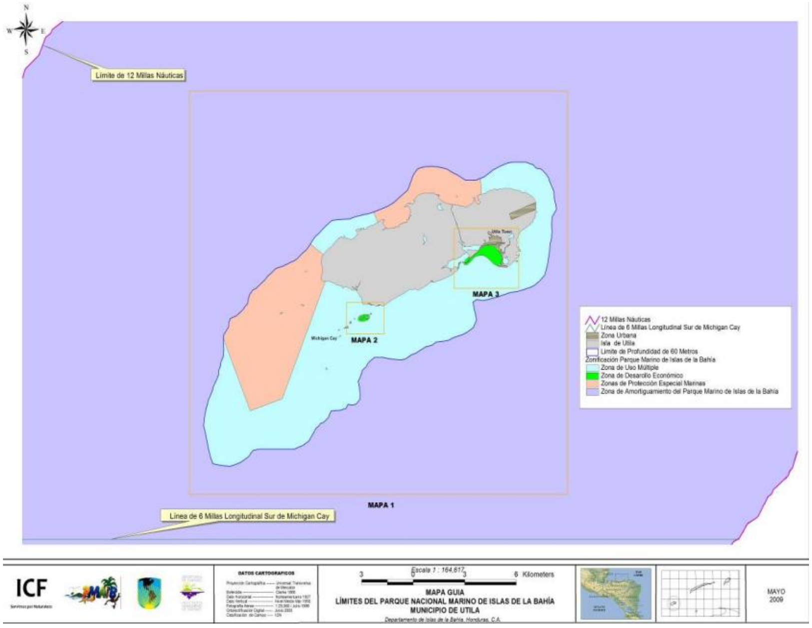

Figure 2: Map of Utila, Honduras highlighting the Marine Protected Areas and zones with restricted usage.

The Bay Islands Conservation Association (BICA) coordinate the conservation efforts of the island. BICA was formed in 1991 as a non-profit and non-governmental organisation aimed at designing and implementing efforts to protect the natural ecosystems throughout the Bay Islands. On Utila, marine conservation efforts are progressing, with the reefs of Utila being a part of the Bay Islands National Marine Park (BINMP), a significant marine protected area (MPA) covering 6471.5 km^2. Within this MPA, there are designated zones of special marine protection including Turtle Harbour on the north coast, and Raggedy Cay on the southwest coast.

2.2. Utila settlements and industry

The human population on Utila is concentrated around a small town in the southeast of the island. Outside of the town, human settlements are sparse and small and are often formed by tourist developments rather than permanent residences. In 2023, a census of the island indicated a permanent population of approximately 5215 residents on the main island, and up to 1,500 additional people on the nearby Cays according to a 2000 census. This shows a significant increase in population since the 2013 census which recorded 3947 residents. The main industry on the island is tourism and historically has been catering for the lower-end ‘backpacker’ market, however since the COVID-19 pandemic, there has been an increase in higher end dive tourism and has developed a reputation as not just an area to learn to dive and dive recreationally, but as a core training centre for dive professionals in the Caribbean. Tourists are estimated to add between 500 and 1,500 people to the overall population of the island, depending on the season. There are now around 10 permanent diving schools on the island, with around 10-20 more boutique or pop-up centres thought to be in operation seasonally. Most Instructors and dive staff on the island are foreigners, with notable exceptions to the staff of individual dive centres.

2.3. Utila core research objectives

The main objectives of the research on Utila are:

- Annual monitoring of the status of the reefs along the south coast of the island, to determine the health of the reef system and associated fishery.
- Conducting high quality marine research to address key questions relating to Caribbean wide ecological priorities.
- Establishing the Bay Islands College of Diving research centre WSORC as an internationally recognised centre for quality marine research.

2.4 Specialised Research Projects

2.4.1. Drivers of variation in cleaner-client interactions on coral reefs and their implications for the future

This study aims to investigate how ecological factors influence individual behavioural variation in the Caribbean sharknose goby (*Elacatinus evelynae*) and how changes at the individual level may scale up to impact cleaner-client interactions and reef community dynamics. Cleaning interactions play a vital role in maintaining coral reef fish health by reducing ectoparasite loads, enhancing recruitment, and supporting fish diversity. As environmental change continues to alter reef ecosystems, understanding how cleaner fish behaviour responds to biotic and abiotic factors is crucial for predicting broader ecological impacts.

During fieldwork, the boldness and cleaning behaviour of *E. evelynae* were quantified using cameras and mirror tests at cleaning stations. Temperature and light loggers were deployed to monitor environmental conditions, while emergence traps were used to assess ectoparasite density. Cleaning stations were filmed, and 3D models were created to analyse structural complexity. Client abundance and diversity were recorded through video analysis and underwater visual transects. To assess the influence of territorial damselfish on cleaner-client interactions, focal cleaning stations were placed within and outside damselfish territories. Additionally, goby models with varying shades of blue were used to investigate client attraction based on goby coloration, and gobies were temporarily caught for photographic comparison before being returned to their coral heads. Cryptobenthic fish diversity was further assessed using quadrat-based visual surveys with clove oil sedation, standardized photography, and Habitat Assessment Scores (HAS).

By examining the relationship between cleaner fish behaviour and ecological variables, this study will provide insights into how environmental change may affect cleaner-client dynamics, the functional role of cleaning stations, and the stability of coral reef communities. Findings will help predict the resilience of cleaning interactions under future environmental stressors, contributing to broader coral reef conservation efforts.

2.4.2. Understanding the Dynamics and Resilience of Marginal Coral Reef Ecosystems in the Central Caribbean

This year was the first data collection for this project, which aims to investigate the health and resilience of coral reefs across Tela and Utila, Given the widespread decline of Caribbean coral reefs due to climate change, disease, and overfishing, understanding the factors that contribute to reef resilience is essential for conservation efforts.

During fieldwork, 10 permanent 1x1m quadrat sites were established at 15m depths—three in Tela and six in Utila—using small metal stakes and tags for long-term monitoring. Structure-from-motion photogrammetry techniques were employed to create 2D orthomosaics of each quadrat, enabling detailed tracking of coral survivorship and community composition over time with subsequent years data collection.

By comparing the reef systems of Banco Capiro and Utila, this study will provide insights into the ecological differences between turbid and clear-water reefs, assess the recovery potential of Tela's reefs following recent mass-coral mortality, and enhance our understanding of potential refugia for coral conservation within the Mesoamerican Barrier Reef.

2.4.3. Monitoring of long-spined sea urchin (*Diadema antillarum*)

Data has been collected on the long-spined sea urchin in Tela and Utila since 2015, the research has maintained consistent data collection throughout, investigating the distribution and population dynamics of this species.

This study aims to investigate the population of the long-spined sea urchin (*Diadema antillarum*) in Tela Bay, Honduras, and their impact on reef health. As a keystone herbivore, *D. antillarum* plays a crucial role in controlling macroalgal overgrowth, but its populations have remained severely depleted across the Caribbean since a mass mortality event in the 1980s. Notably, Tela Bay shows higher urchin densities than other areas in the Caribbean, making it an important site for studying potential recovery mechanisms and reef resilience.

During fieldwork, *D. antillarum* population densities were recorded across 50m x 2m transects, with data collected on the individual's life stage and habitat complexity was assessed using the Habitat Assessment Score (HAS).

By tracking long-term trends in urchin populations and their interactions with reef ecosystems, this study will provide insights into factors driving partial *D. antillarum* recovery in Tela Bay. The findings will help inform conservation and management strategies aimed at restoring herbivore populations and improving reef resilience across the Caribbean.

2.4.4. Marine sponge abundance, biodiversity and functional role on reefs.

A new study for 2024 aims to investigate the role of sponges in shaping reef habitat complexity and biodiversity across Tela and Utila. Sponges play essential functional roles on coral reefs, contributing to nutrient recycling, bioerosion, and habitat formation. Understanding their distribution, ecological interactions, and influence on fish and invertebrate communities will provide valuable insights into reef ecosystem dynamics.

During fieldwork, photogrammetry methods used an array of GoPro cameras which were employed to create large-scale (100m^2) mosaics, mapping sponge biodiversity and benthic cover. These monitored areas will allow for long-term tracking of sponge recruitment, mortality rates, and disease prevalence. Additionally, high-resolution 3D models of reef habitats—including coral-dominated, soft coral-dominated, and sponge-dominated areas—were generated using a Sony A1 camera to assess habitat complexity. GoPro cameras were then deployed in these areas to quantify fish populations and their associations with different reef structures. Targeted surveys were also conducted to examine the relationships between sponge species, their morphological traits, and the occurrence of associated sedentary fauna, such as fish, crustaceans, and echinoderms.

By analysing how sponges contribute to reef complexity and support marine biodiversity, this study will enhance our understanding of their ecological importance. The findings will provide insight into species-specific associations, reef food web dynamics, and the role of sponges as key habitat providers, informing future conservation and management strategies for Caribbean coral reefs.

2.4.5. Advancing Stereo-Video Systems for Marine Conservation: Cost-Effective Solutions and AI Integration

This study aims to develop cost-effective stereo-video system (SVS) equipment and software to make this technology more accessible to conservation groups. SVS is a valuable tool for marine research, enabling precise measurements of fish and habitat structures, yet current systems are prohibitively expensive, limiting their widespread use in conservation efforts. By reducing hardware costs and developing new software solutions, this project seeks to enhance the affordability and efficiency of SVS technology.

During this project, various stereo-video camera setups will be designed, built, and tested, comparing their performance to existing SVS models. A new software platform for SVS footage analysis will be developed, with a focus on automation and user accessibility. Additionally, trailing new camera configurations will help refine the best cost-performance balance for conservation applications. Finally, an infrastructure will be established to integrate artificial intelligence (AI) into the analysis process, streamlining data processing and improving the accuracy of marine biodiversity assessments.

By making SVS technology more affordable and integrating AI for automated analysis, this project will empower conservation organizations with advanced tools for ecological monitoring, ultimately contributing to more effective and data-driven conservation strategies.

2.4.6. Understanding the Pederson cleaner shrimp and its relationships with it’s surroundings: from behaviour with neighbours to resource partitioning

This study aims to evaluate the effectiveness of extended camera-based observation methods for studying small, stationary marine animals, using the well-documented symbiotic relationship of Pederson’s cleaner shrimp (*Ancylomenes pedersoni*) as a model system. Underwater behavioural research presents unique challenges, including site accessibility and environmental variability, and there is little standardization for best practices in observational methodology. By refining camera-based techniques, this study seeks to improve the accuracy and consistency of behavioural data collection.

During fieldwork, cleaning stations occupied by *A. pedersoni* and the closely related *Periclimenes yucatanicus* were mapped, and cameras were deployed to record their interactions for approximately four hours. Filming took place across diverse environments to capture variations in shrimp behaviour and symbiotic dynamics. Following video documentation, shrimp, associated anemones (Bartholomea annulata), other crustaceans, benthic algae, phytoplankton, and fish tissue samples were collected—either directly from the field or via local fish markets when necessary. Stable isotope analysis will be conducted to assess resource partitioning among species living in close proximity.

By optimizing camera-based observation techniques, this study will contribute to the standardization of underwater behavioural research, reducing methodological inconsistencies and improving data quality. Additionally, insights into the ecological interactions between cleaner shrimp species and their symbiotic partners will enhance our understanding of resource use and behavioural ecology in marine ecosystems.

2.4. Utila study sites

Six sites have been chosen for detailed ecosystem monitoring along the south coast of Utila island since 2012 (Figure 3). The sites were chosen based on several criteria, in particular (1) logistical considerations such as distance and conditions to ensure data collection was completed at each site, and (2) to represent a gradient of habitat types and distances from the core human population of Utila town. These sites form the basis of our monitoring efforts across Utila, with other research sites included as needed to meet additional objectives as required.

Figure 3: Map of Utila Island showing Operation Wallacea's selected six core study sites.

Table 2: Information on the study sites for Operation Wallacea across Utila, Honduras

Dive site name	Site code	Coordinates
Little Bight	LB	N 16.07926302, W 86.92942222
Black Coral Wall	BCW	N 16.08305968, W 86.91699554
Coral View	CV	N 16.08823274, W 86.91094506
Sturch Bank	SB	N 16.089602, W 86.9035006
Stingray Point	SP	N 16.068864 W 86.955193
Lighthouse	LH	N 16.08498, W 86.90032

2.5. Utila benthic habitat quality

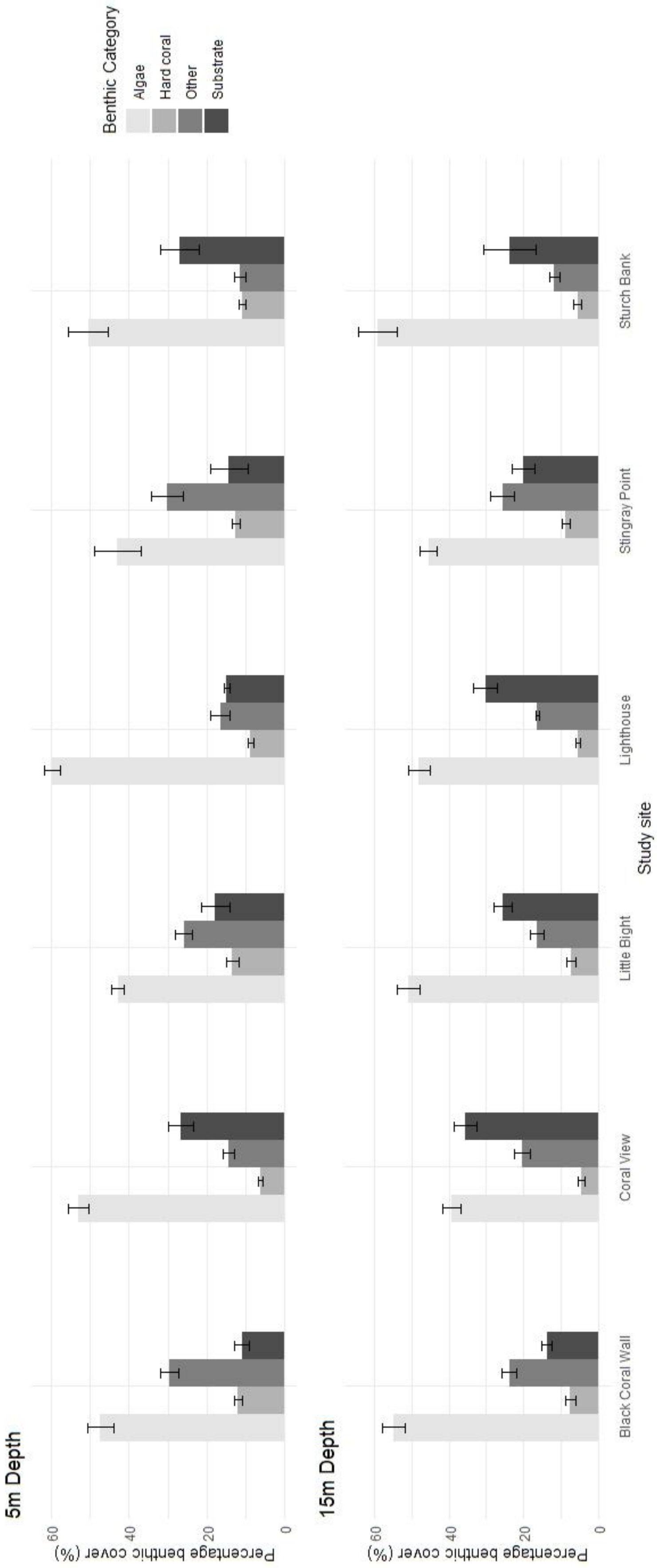

Figure 4: Benthic community structure on six coral reefs study sites around Utila in 2024. Data are mean values ±Standard error for depths 5m and 15m habitats calculated from point intercept transects (n=6).

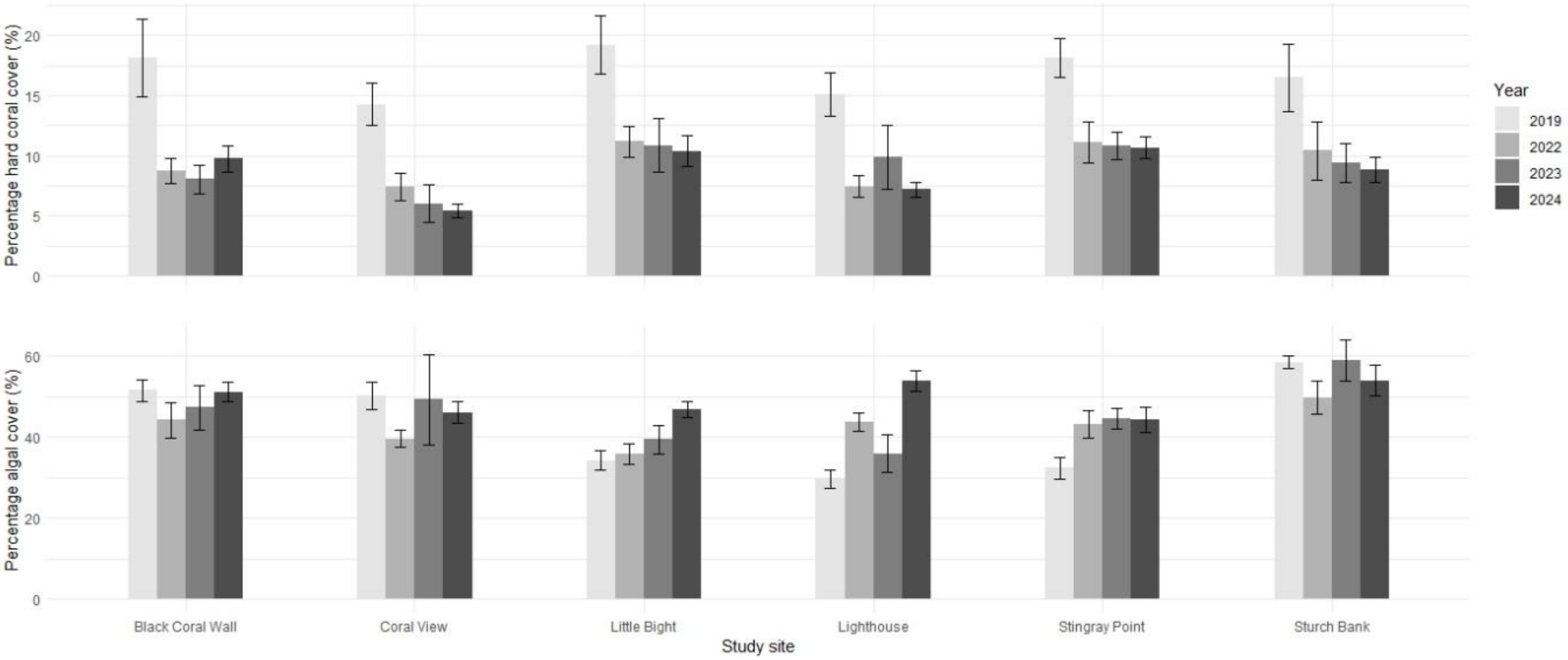

Figure 5: Temporal variation in percentage cover of hard coral and algal coverage at six study sites across Utila between 2019 and 2024. Data are mean values ±SE calculated from point intercept transects (n=6).

2.6. Utila fish community structure

2.6.1. Utila Fish abundance and diversity

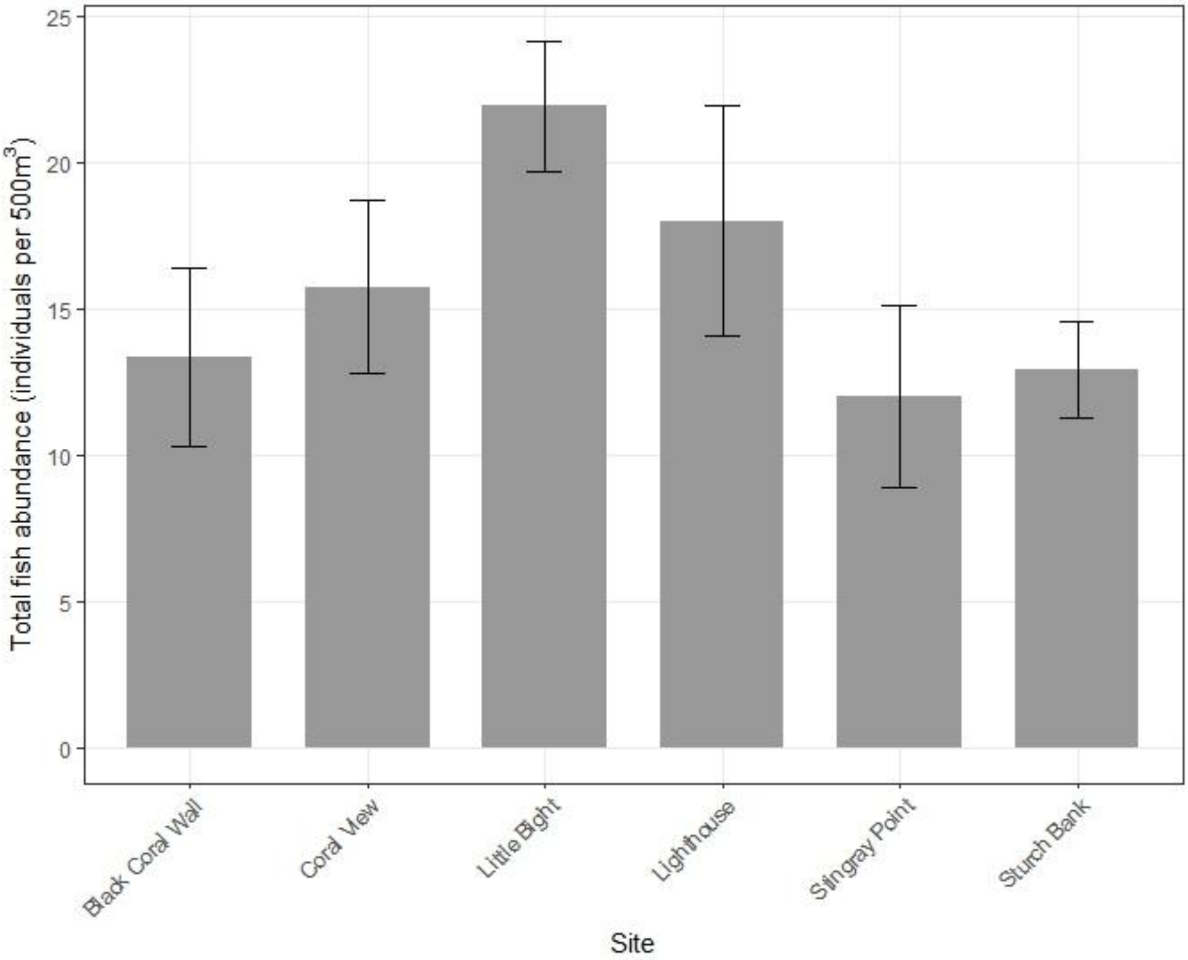

Figure 6: Total fish abundance for six coral reef study sites around Utila 2024. Data are mean values ±SE calculated from Stereo-Video surveys (n=6).

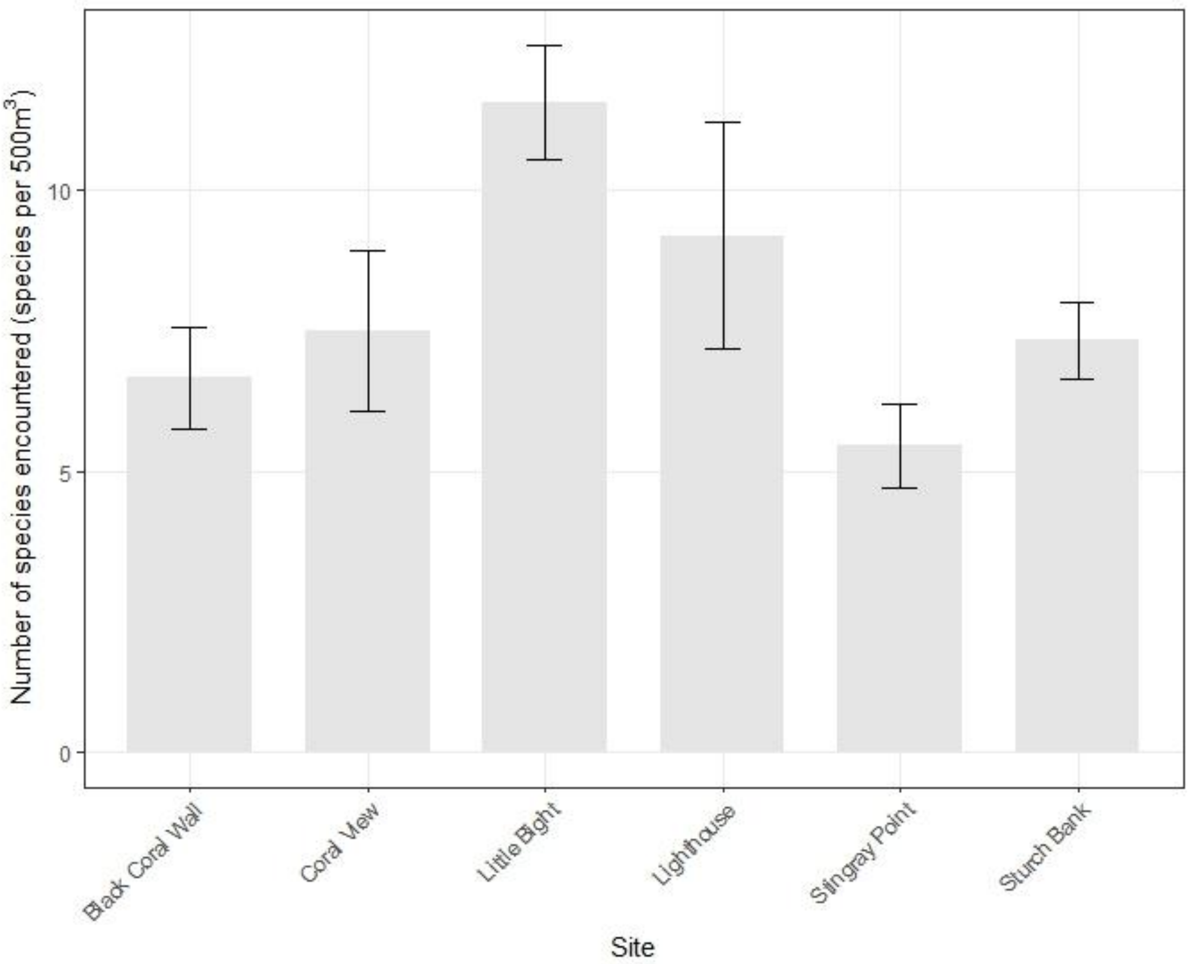

Figure 7: Total fish species diversity for six coral reef study sites around Utila 2024. Data are mean values ±SE calculated from Stereo-Video surveys (n=6).

2.6.2. Utila fish biomass and trophic structuring

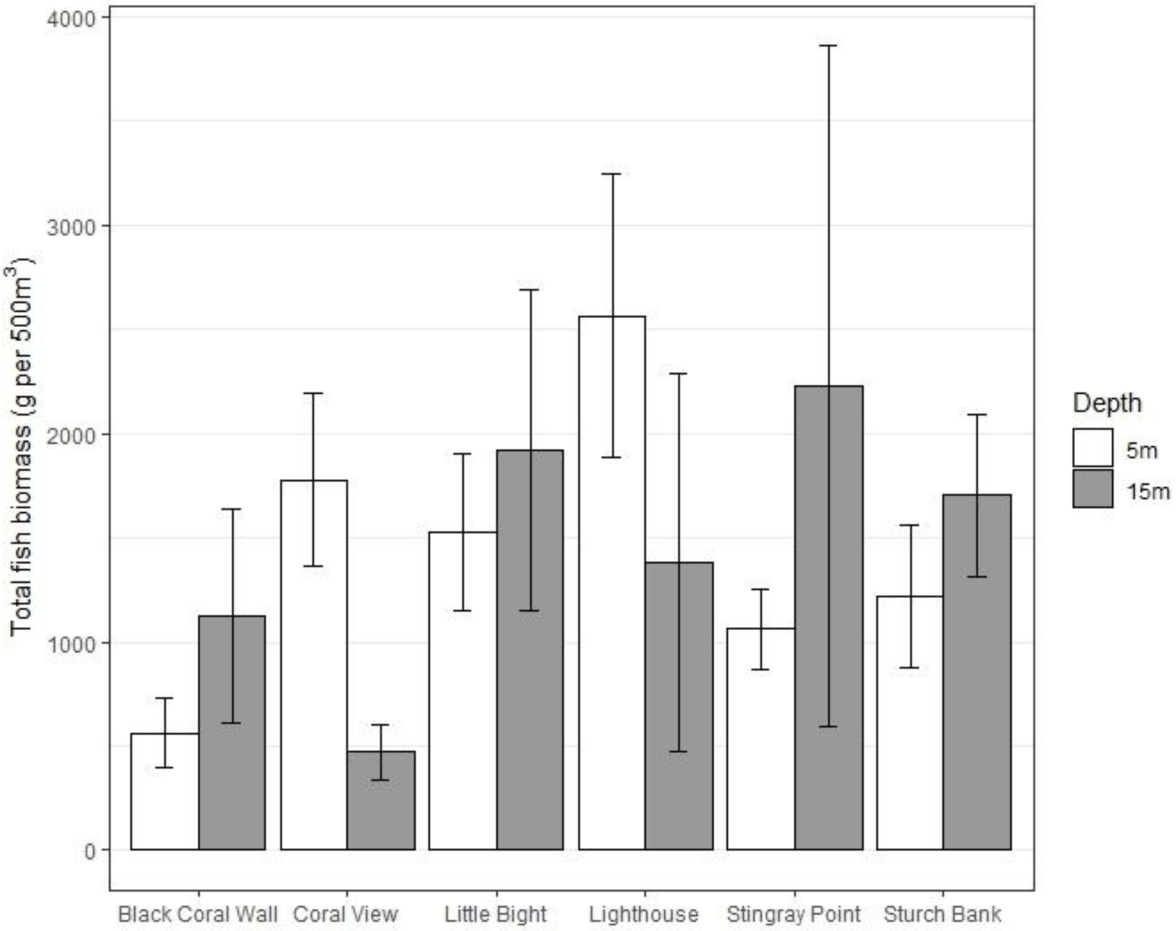

Figure 8: Total fish biomass on six coral reef study sites across Utila in 2024. Data are mean values ±SE for 5m and 15m habitats calculated from stereo-video surveys (n=6).

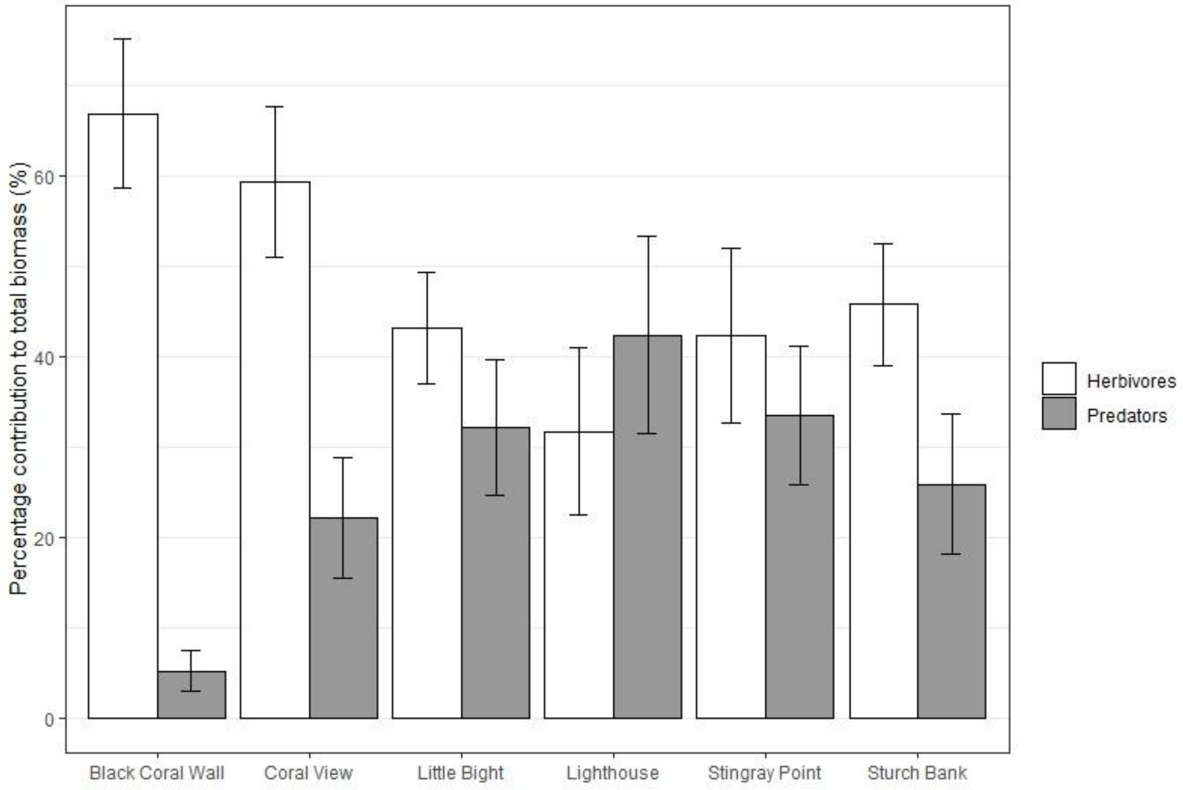

Figure 9: Percentage contribution of herbivorous fish species and predatory fish species to total biomass on six coral reefs across Utila in 2024. Data are mean values ±SE for 5m and 15m habitats calculated from stereo-video surveys (n=6).

3. Tela Marine Research

Tela is a coastal city located on the northern shores of Honduras along the Caribbean Sea. Situated approximately 90 km west of La Ceiba, Tela is known for its sandy beaches and ecotourism. The area encompasses expansive mangrove forests, wetlands, lowland tropical forests, lagoon systems, and an extensive coral reef system. Operation Wallacea began working at Tela in 2012 alongside the Tela Bay research centre.

3.1. Tela Marine Protected Areas

The Tela Bay Marine Wildlife Refuge (TBMWR), which is co-managed by the Instituto de Conservación Forestal (ICF), Programa de Manejo Sostenible de la Zona de Vida Silvestre y los Recursos Naturales de la Cuenca del Río Ulúa (PROLANSATE) for the national parks, and Asociación de Municipalidades de la Bahía de Tela (AMATELA) & Tela Marine Research Center for the wildlife refuge. Tela Bay formed a collaborative fisheries management plan between local authorities and fishing communities in 2018. The TBMWR began its operations in 2018 and was officially formalized on 30 August 2019. The TBMWR is also evaluated every 2-5 years, with adjustments made as needed based on new information regarding fishing resources (ICRI, 2024).

In 2018, the Honduran government designated an 822 km^2 area of Tela Bay as protected under the El Refugio de Vida Silvestre Marino de Tela program (Bodmer et al. 2021). Tela Bay therefore includes three Marine Protected Areas (MPAs) which are shown in Figure 10:

- Janeth Kawas National Park (Decree 154-94)
- Punta Izopo National Park (PNPI, 261-2000)
- Tela Bay Marine Wildlife Refuge (RVSBT; Decree 132-2017)

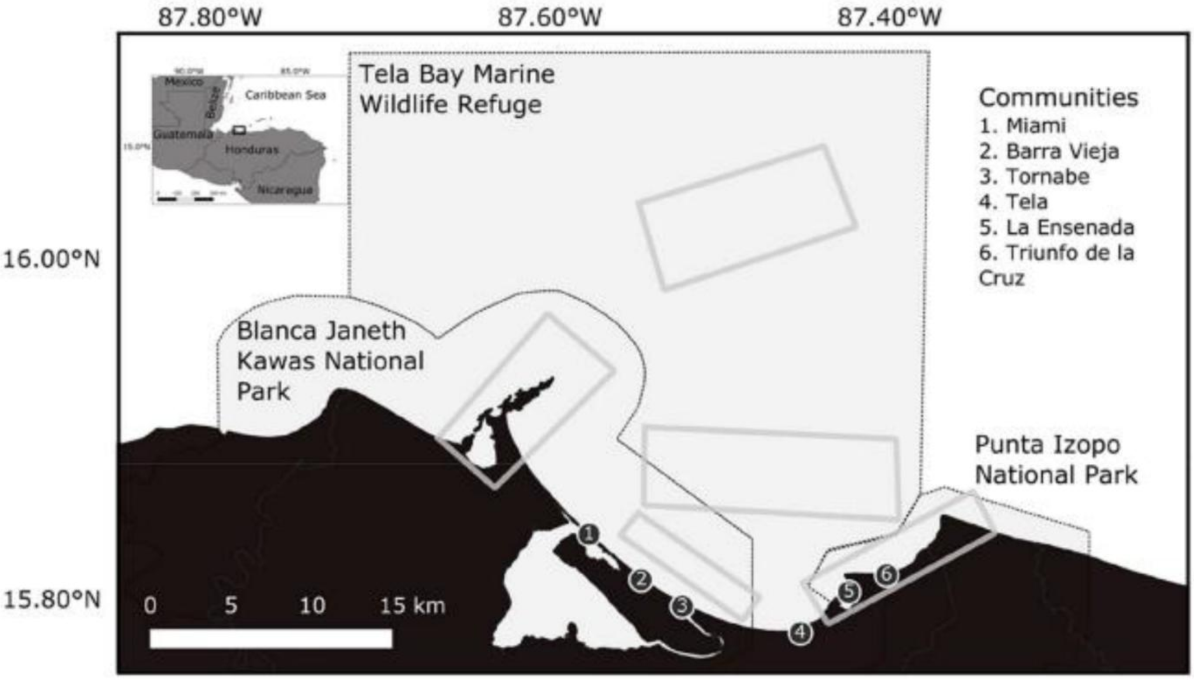

Figure 10: Map showing the protected areas around Tela Bay (taken form Rivera, 2021)

3.2. Tela settlements and industry

The human population in Tela is mainly concentrated in the central urban area along the coastline. Outside of the town, smaller, more dispersed settlements are found, typically consisting of villages and tourist accommodations rather than large residential developments. Recent estimates put the population at around 30,000, though this number fluctuates during peak tourist seasons. The city's economy is largely driven by tourism, especially ecotourism and beach-related activities. Visitors are attracted to Tela’s pristine beaches, nearby national parks, and vibrant culture. Tourism fluctuates seasonally, with a significant increase in population during peak periods, as both international and domestic travellers arrive. Moreover, the region has seen growth in eco-lodges and guided tour services catering to nature lovers and adventure enthusiasts.

3.3. Tela core research objectives

The main objectives of the research project at Tela are:

- Annual monitoring of the status of the reefs along Banco Capiro and La Ensenada, to determine the health of the reef system and associated fishery.
- To quantify the importance of the coral reef system to the ecological functioning of the area.
- Conducting high quality marine research to address key questions relating to Caribbean wide ecological priorities.
- Producing publications suitable for peer review to enhance the knowledge on Tela Bay.
- Establish the Tela Marine research centre as an internationally recognised centre for quality marine research.

3.4 Specialised Research Projects

3.4.1. Investigating possible microplastic bioaccumulation in invasive lionfish.

Data has been collected on the invasive lionfish In Tela since 2015, the research has been varied, consistently collecting data on lionfish size, morphometrics, stomach contents and even behaviour.

In 2024 the lionfish research was developed further to investigate the presence of microplastics in lionfish in the waters of Tela, Honduras. With microplastics recognized as a growing environmental and human health concern, particularly in marine ecosystems, it is crucial to assess their impact on invasive non-native species (INNS) like lionfish. As lionfish are commonly culled and sold as food across the Caribbean, understanding their ingestion of microplastics is important for evaluating potential human exposure and environmental risks.

Lionfish digestive tract samples were collected, as well as microplastic samples from sediment around the study sites for analysis by Fourier-transform infrared spectroscopy (FTIR). This will allow us to identify and quantify microplastic ingestion, providing insights into pollution levels in the region. By assessing lionfish as bioindicators, this research will contribute to understanding plastic contamination in marine food webs and inform future conservation and management strategies.

3.4.2. Understanding the Dynamics and Resilience of Marginal Coral Reef Ecosystems in the Central Caribbean

This year was the first data collection for this project, which aims to investigate the health and resilience of coral reefs across Tela and Utila, Given the widespread decline of Caribbean coral reefs due to climate change, disease, and overfishing, understanding the factors that contribute to reef resilience is essential for conservation efforts.

During fieldwork, 10 permanent 1x1m quadrat sites were established at 15m depths—three in Tela and six in Utila—using small metal stakes and tags for long-term monitoring. Structure-from-motion photogrammetry techniques were employed to create 2D orthomosaics of each quadrat, enabling detailed tracking of coral survivorship and community composition over time with subsequent years data collection.

By comparing the reef systems of Banco Capiro and Utila, this study will provide insights into the ecological differences between turbid and clear-water reefs, assess the recovery potential of Tela's reefs following recent mass-coral mortality, and enhance our understanding of potential refugia for coral conservation within the Mesoamerican Barrier Reef.

3.4.3. Monitoring of long-spined sea urchin (*Diadema antillarum*)

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During fieldwork, *D. antillarum* population densities were recorded across 50m x 2m transects, with data collected on the individual's life stage and habitat complexity was assessed using the Habitat Assessment Score (HAS).

By tracking long-term trends in urchin populations and their interactions with reef ecosystems, this study will provide insights into factors driving partial *D. antillarum* recovery in Tela Bay. The findings will help inform conservation and management strategies aimed at restoring herbivore populations and improving reef resilience across the Caribbean.

3.4.4. Marine sponge abundance, biodiversity and functional role on reefs.

A new study for 2024 aims to investigate the role of sponges in shaping reef habitat complexity and biodiversity across Tela and Utila. Sponges play essential functional roles on coral reefs, contributing to nutrient recycling, bioerosion, and habitat formation. Understanding their distribution, ecological interactions, and influence on fish and invertebrate communities will provide valuable insights into reef ecosystem dynamics.

During fieldwork, photogrammetry methods used an array of GoPro cameras which were employed to create large-scale (100m^2) mosaics, mapping sponge biodiversity and benthic cover. These monitored areas will allow for long-term tracking of sponge recruitment, mortality rates, and disease prevalence. Additionally, high-resolution 3D models of reef habitats—including coral-dominated, soft coral-dominated, and sponge-dominated areas—were generated using a Sony A1 camera to assess habitat complexity. GoPro cameras were then deployed in these areas to quantify fish populations and their associations with different reef structures. Targeted surveys were also conducted to examine the relationships between sponge species, their morphological traits, and the occurrence of associated sedentary fauna, such as fish, crustaceans, and echinoderms.

By analysing how sponges contribute to reef complexity and support marine biodiversity, this study will enhance our understanding of their ecological importance. The findings will provide insight into species-specific associations, reef food web dynamics, and the role of sponges as key habitat providers, informing future conservation and management strategies for Caribbean coral reefs.

3.5 Tela study sites

Six sites across the Banco Capiro reef were initially chosen for detailed ecosystem monitoring along Tela Bay since 2012. The sites were chosen based on several criteria, in particular (1) logistical considerations such as distance and conditions to ensure data collection was completed at each site, and (2) to study a representative range of habitat types found on the Banco Capiro reef.

However, in 2023 there was mass coral mortality across areas of the Banco Capiro reef, with all six of the chosen study sites heavily affected. A decision was made to diversify the geographical range of the study sites to encompass sites within the La Ensenada reef. Three of the original sites continue to be monitored (Butter Fingers, Canyon and Kisci's Garden), to track the progression of the reef that was subject to the mass coral mortality.

The La Ensenada reef is situated much closer to the bay's foreshore and is considerably shallower than Banco Capiro, with maximum depths of around 10–12 meters compared to Banco Capiro, where the reef extends to 30 meters. Anecdotal observations suggest that La Ensenada may serve as a nursery ground for juvenile marine species in the bay, with multiple observations of large schools of juvenile fish seen there. The shallowness of La Ensenada causes it to experience higher extremes in water temperate, necessitating individuals to be more thermally tolerant than the individuals in deeper reefs such as Banco Capiro (with the reef crest of La Ensenada as shallow as 2m, compared to 10m for Banco Capiro). These heat-resistant individuals may later migrate to other reef areas, and spawn of coral and other sessile organisms would likely migrate towards areas such as Banco Capiro. Historically, this migration may have contributed to the biodiversity and resilience of Banco Capiro's ecosystem. Additionally, in the aftermath of mass coral mortality across Banco Capiro, such a recruitment process could be essential for the recovery and persistence of Banco Capiro's reef community.

The La Ensenada reef was a relative unknown, with few permanent buoys across the reef and little known about the extent of the reef itself. Exploratory dives were conducted during the 2024 season to scope out research sites and install buoys. During these dives it was noted that the reef itself is also divided into three sections by two large sand channels which likely formed from the mouth of the Laguna Negra. It was therefore ensured that as well as the usual criteria for study sites (logistical considerations such as distance and conditions to ensure data collection was completed at each site, and to study a representative range of habitat types found across the reef). that each of the three La Ensenada sites would each be located on one of these sections with one before the first sand channel, one between the channels, and one after the second channel.

Table 3: Dive site information across Tela, Honduras for 2024

Study site name	**Location**	**Site codes**	**Coordinates**
Butter Fingers	Banco Capiro	BUT	N 15.86351 W 87.49525
Canyon	Banco Capiro	CAN	N 15.86414 W 87.50662
Kisci's Garden	Banco Capiro	KIS	N 15.86550 W 87.50017
Canary Road	La Ensenada	CNR	N 15.79714 W 87.44496
Lullaby	La Ensenada	LUL	N 15.80013 W 87.44414
Palm View	La Ensenada	PMV	N 15.80338 W 87.43922

3.6 Banco Capiro benthic habitat quality

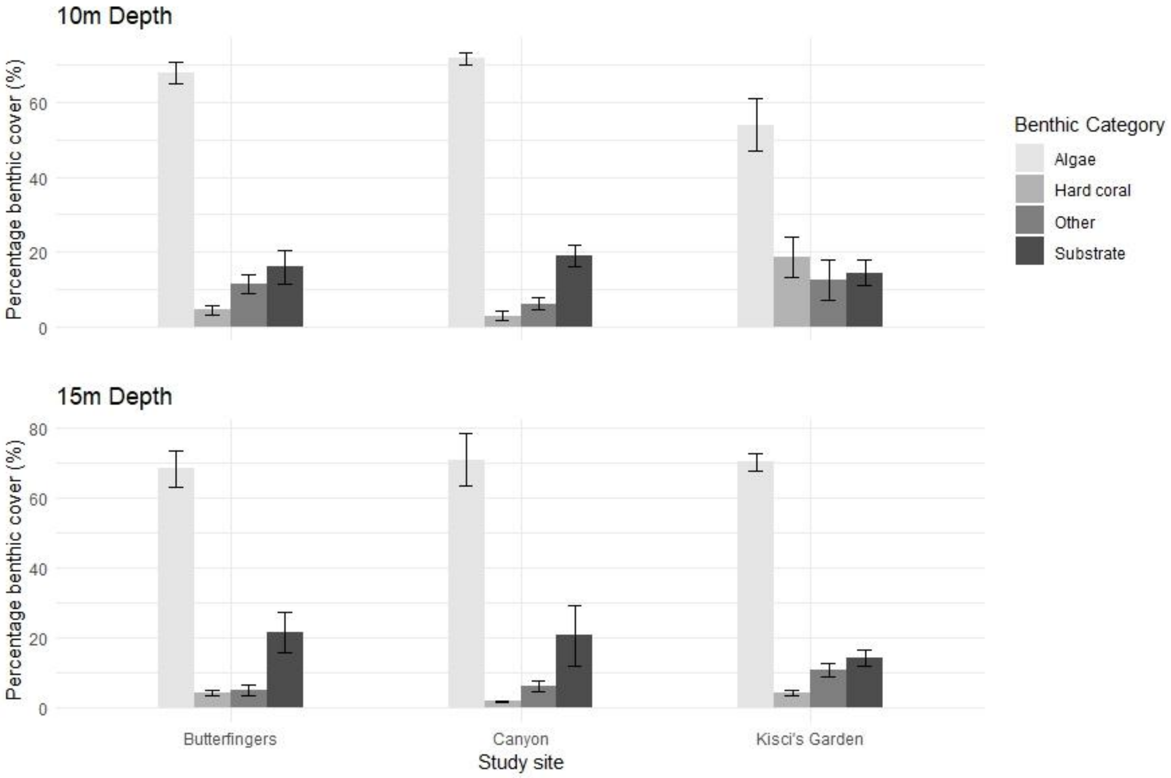

Figure 11: Benthic community structure on three coral reefs study sites around Banco Capiro, Tela in 2024. Data are mean values ±Standard error for depths 10m and 15m habitats calculated from point intercept transects (n=6).

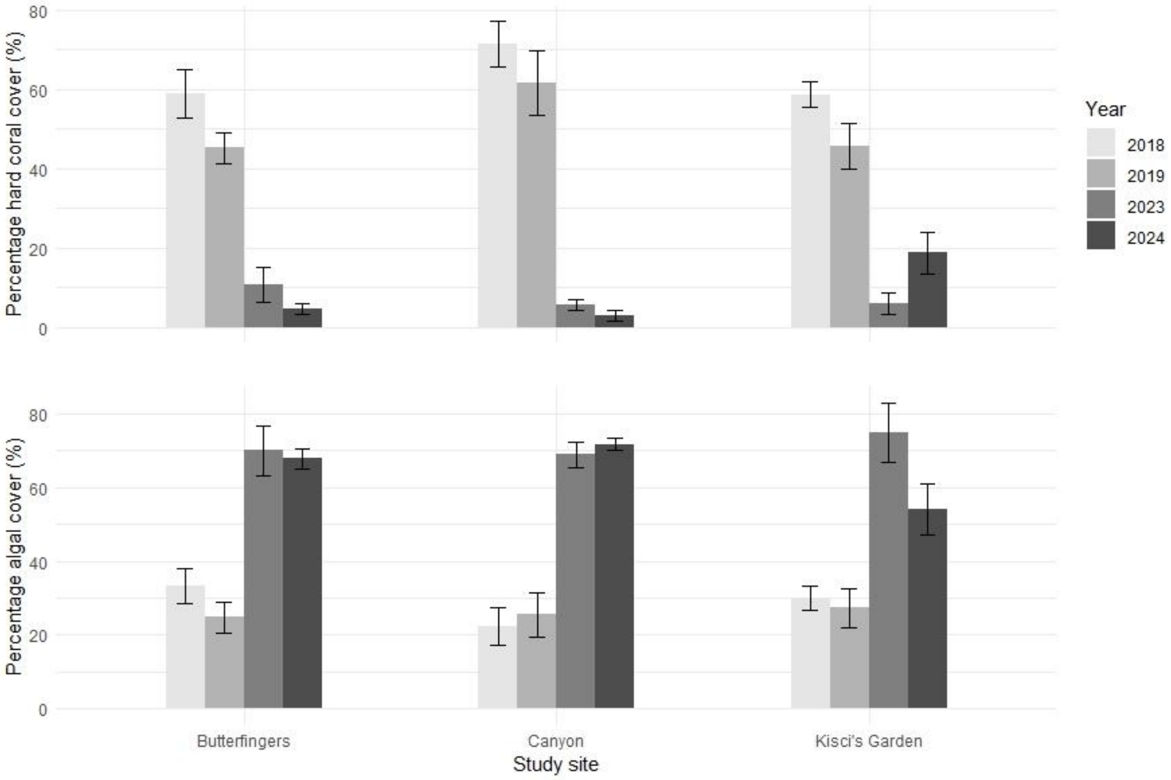

Figure 12: Temporal variation in percentage cover of hard coral and algal coverage at three study sites across Banco Capiro, Tela between 2018 and 2024. Data are mean values ±SE calculated from point intercept transects (n=6).

3.7. Banco Capiro fish community structure

3.7.1. Banco Capiro Fish abundance and diversity

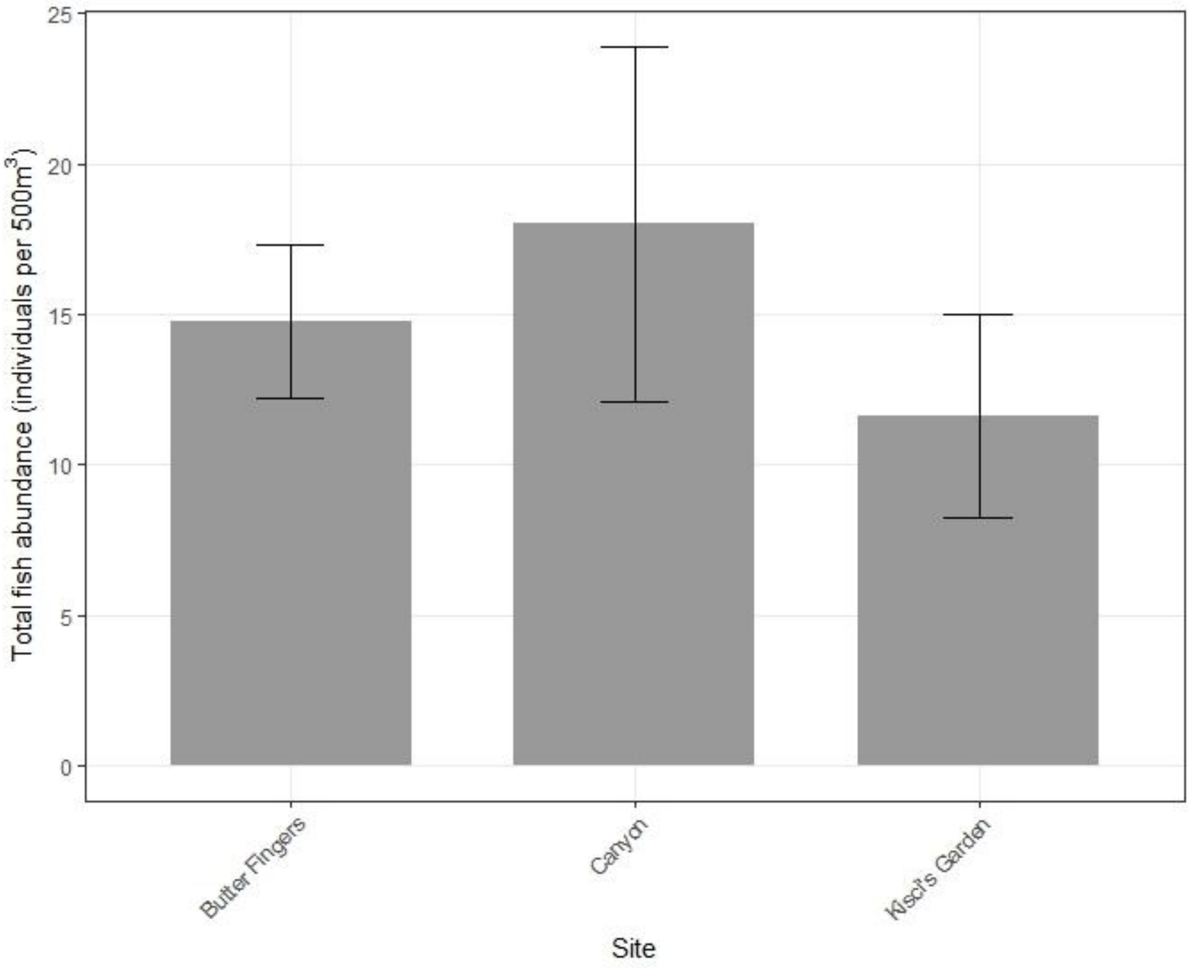

Figure 13: Total fish abundance for six coral reef sites on Banco Capiro, Tela in 2024. Data are mean values ±SE calculated from Stereo-Video surveys (n=6).

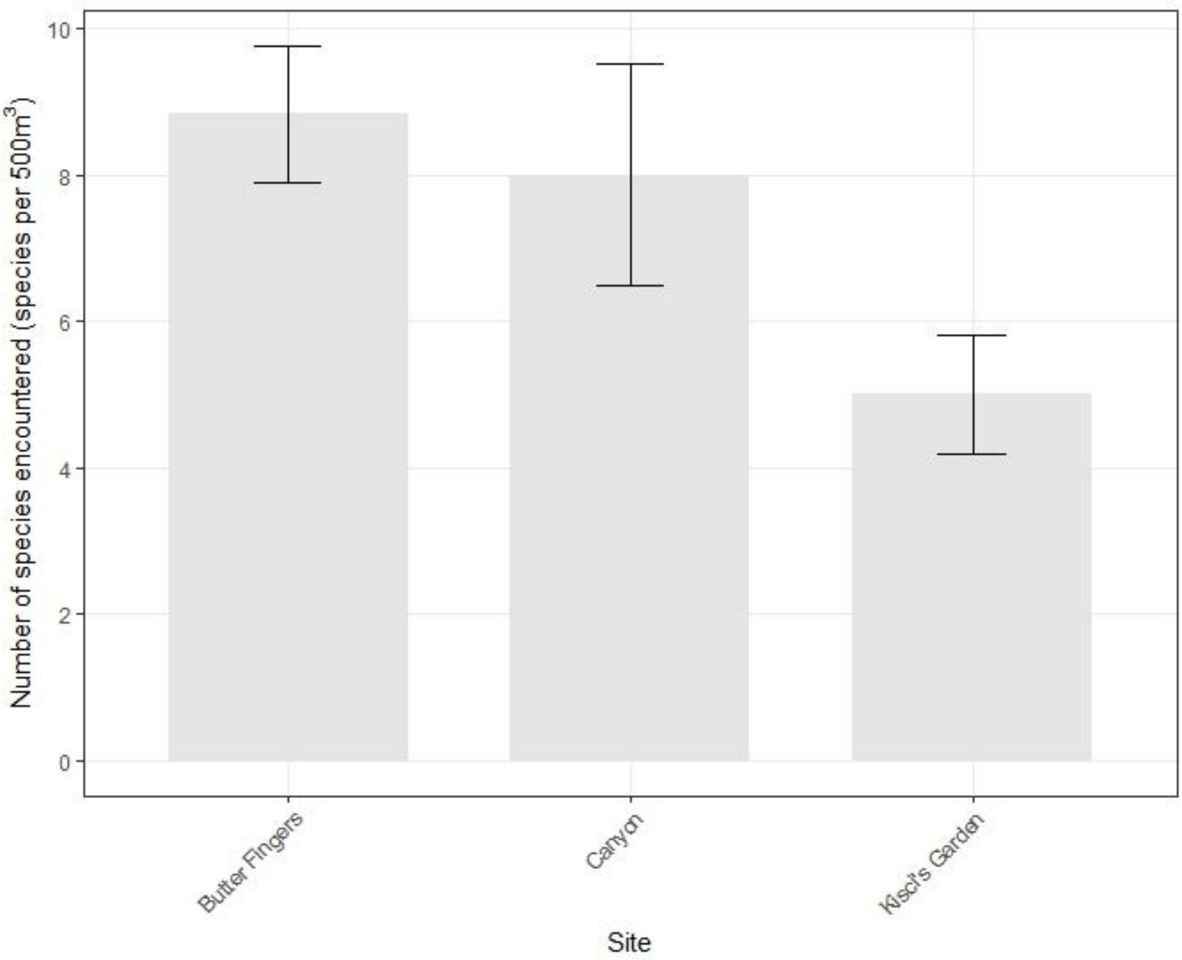

Figure 14: Total fish diversity for six coral reef sites on Banco Capiro, Tela in 2024. Data are mean values ±SE calculated from Stereo-Video surveys (n=6).

3.7.2. Banco Capiro fish biomass and trophic structuring

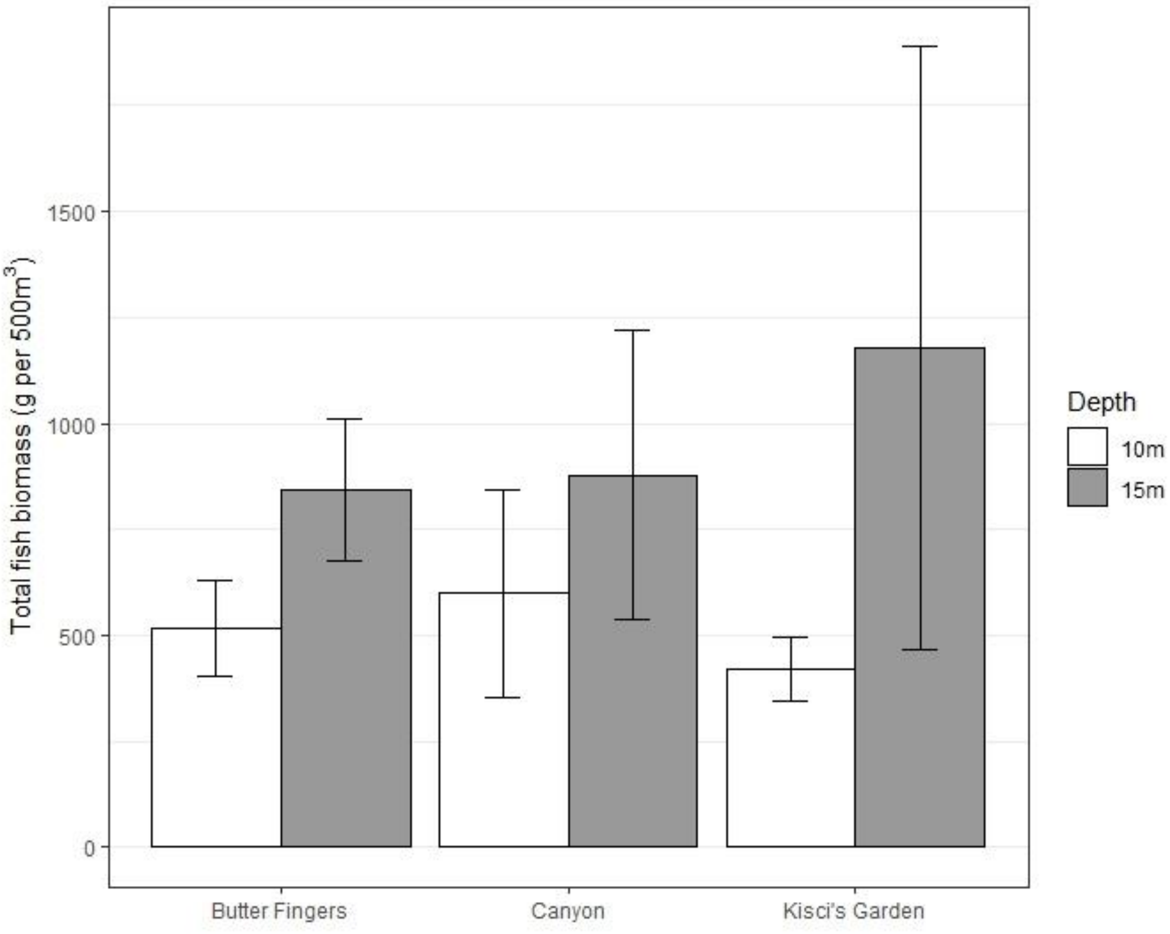

Figure 15: Total fish biomass on six coral reef sites across Banco Capiro, Tela in 2024. Data are mean values ±SE for 10m and 15m habitats calculated from stereo-video surveys (n=6).

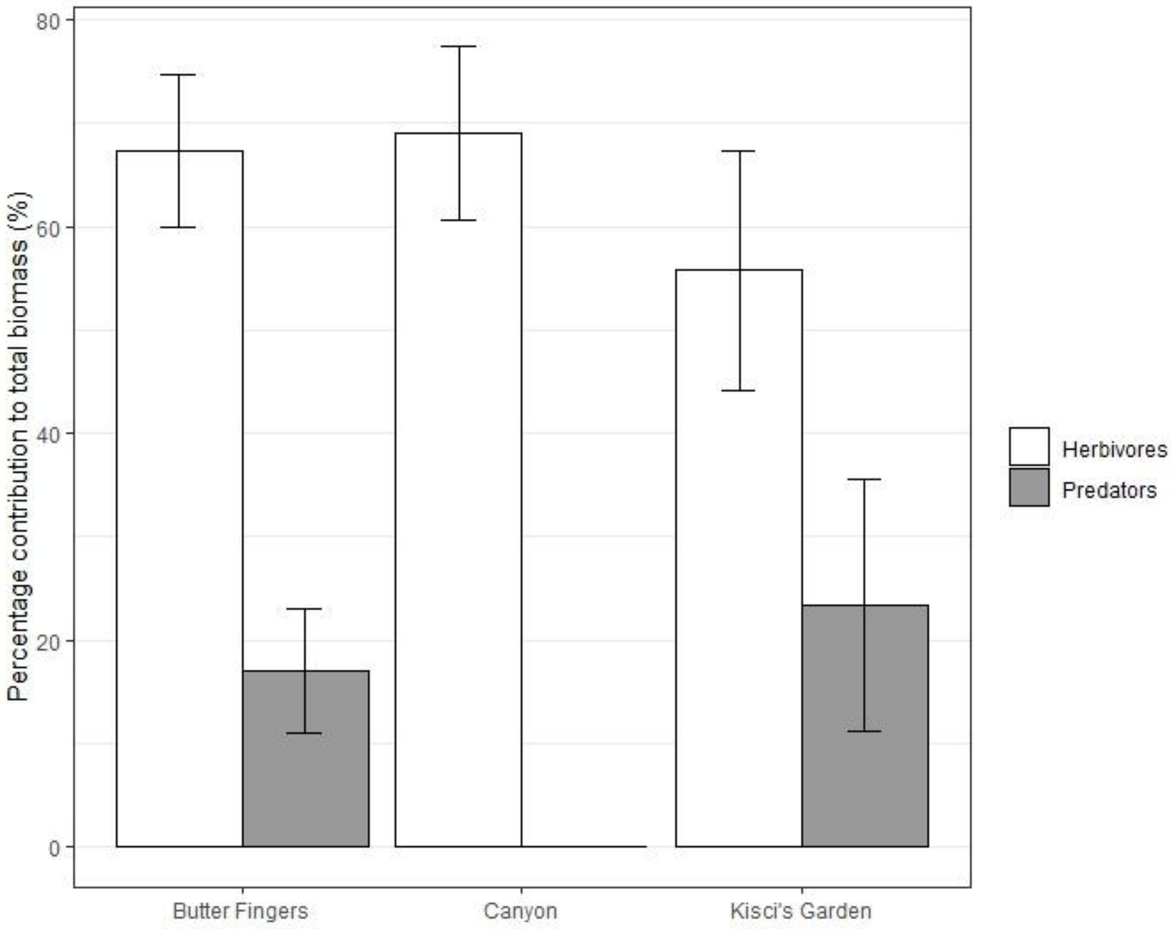

Figure 16: Percentage contribution of herbivorous fish species and predatory fish species to total biomass on six coral reefs across Banco Capiro, Tela in 2024. Data are mean values ±SE for 5m and 15m habitats calculated from stereo-video surveys (n=6).

3.8. La Ensenada benthic habitat quality

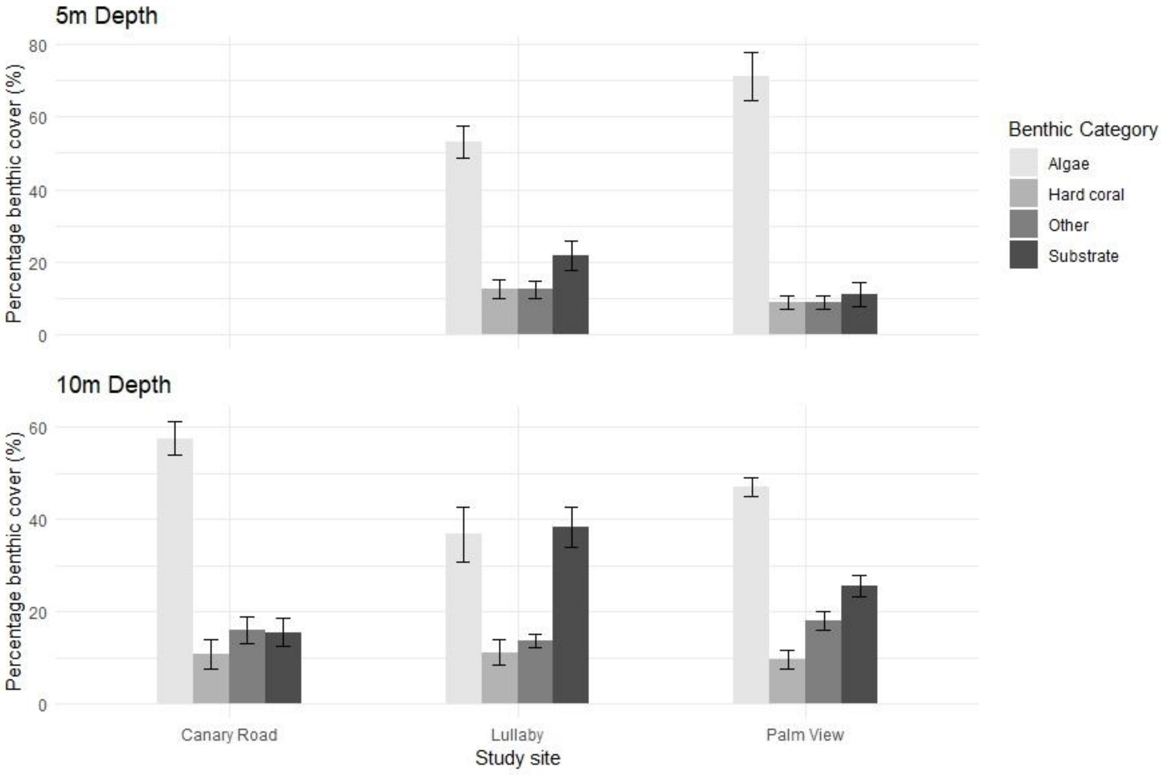

Figure 17: Benthic community structure on three coral reefs study sites around Banco Capiro, Tela in 2024. Data are mean values ±Standard error for depths 10m and 15m habitats calculated from point intercept transects (n=6).

3.9. La Ensenada fish community structure

3.9.1. La Ensenada Fish abundance and diversity

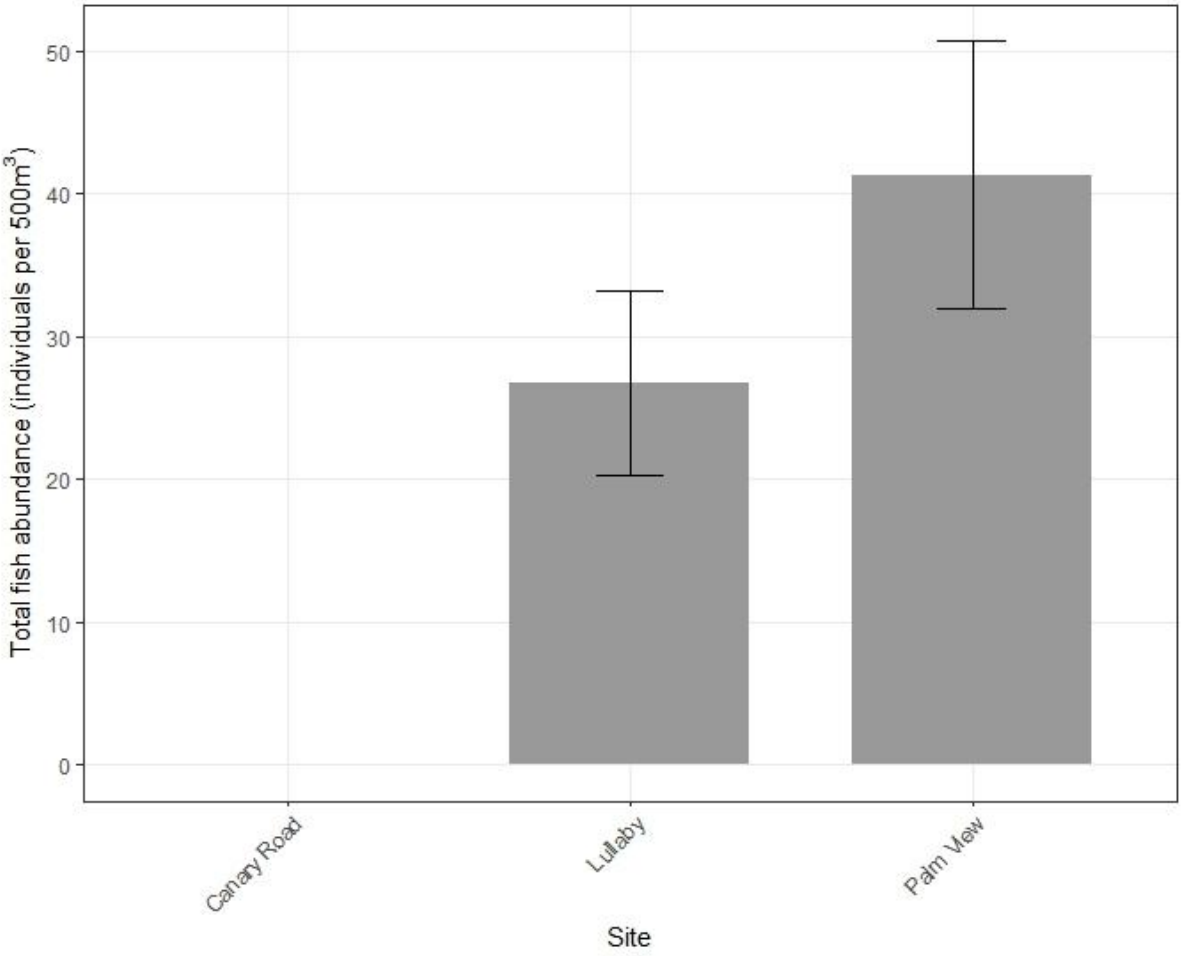

Figure 18: Total fish abundance for six coral reefs around La Ensenada, Tela in 2024. Data are mean values ±SE calculated from Stereo-Video surveys (n=6).

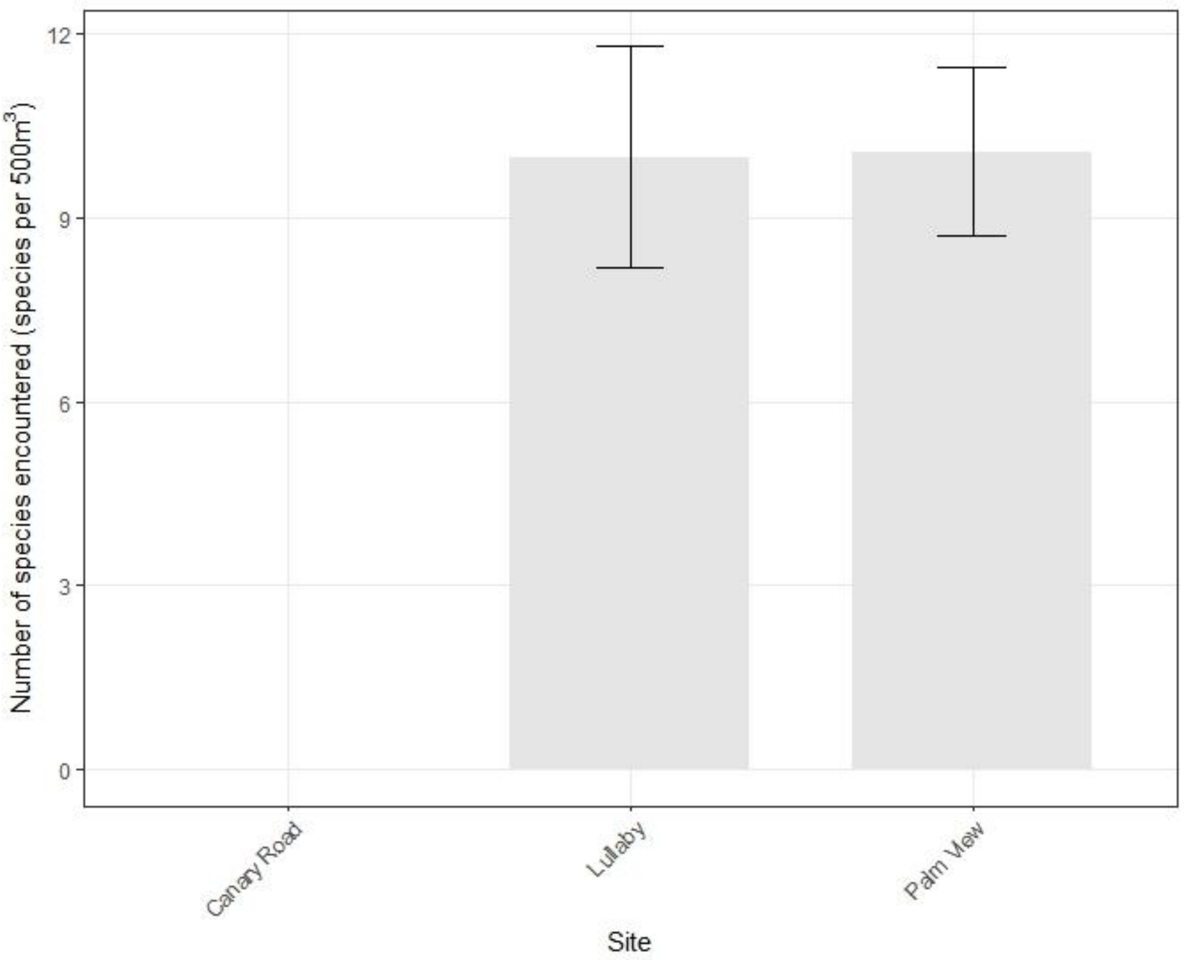

Figure 19: Total fish species diversity for six coral reefs around La Ensenada, Tela in 2024. Data are mean values ±SE calculated from Stereo-Video surveys (n=6).

3.9.2. La Ensenada fish biomass and trophic structuring

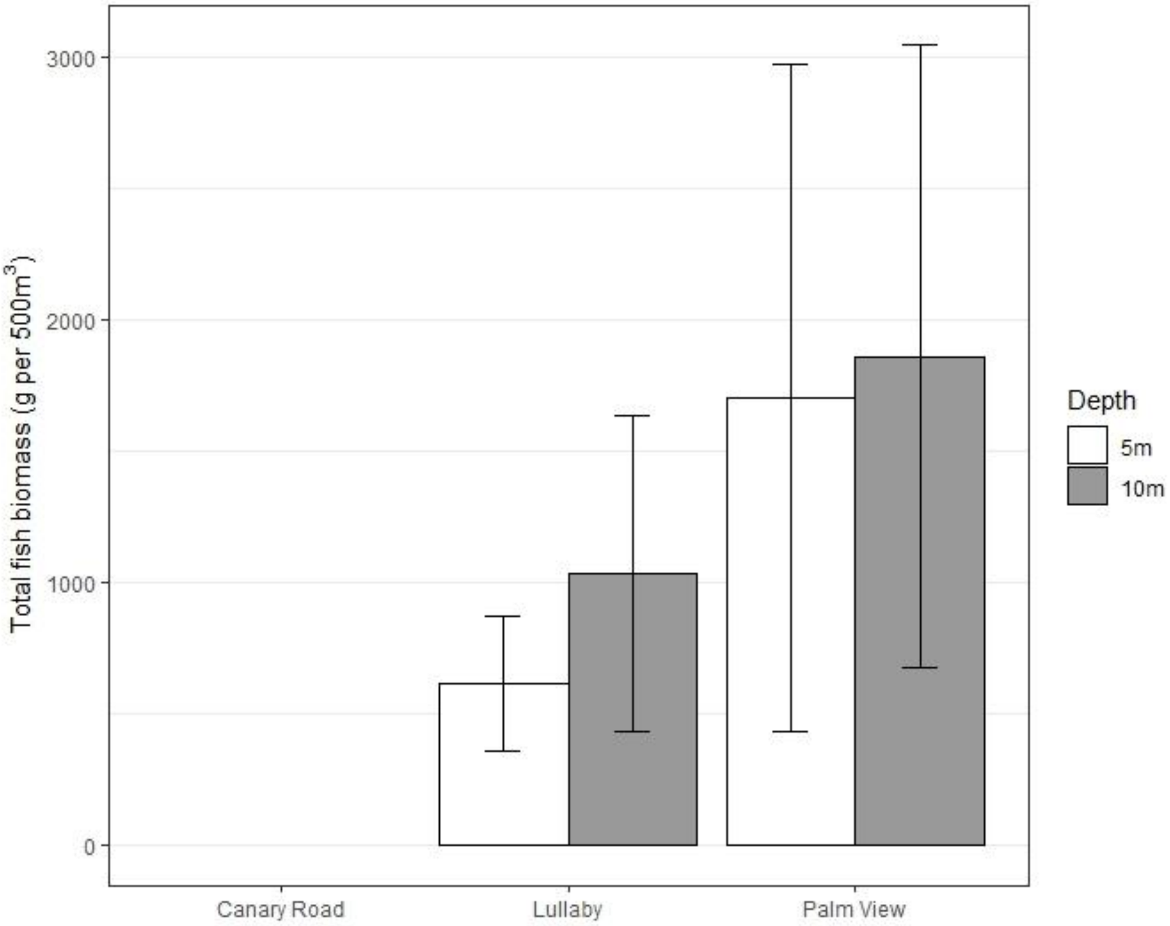

Figure 20: Total fish biomass on six coral reef sites across La Ensenada, Tela in 2024. Data are mean values ±SE for 10m and 15m habitats calculated from stereo-video surveys (n=6).

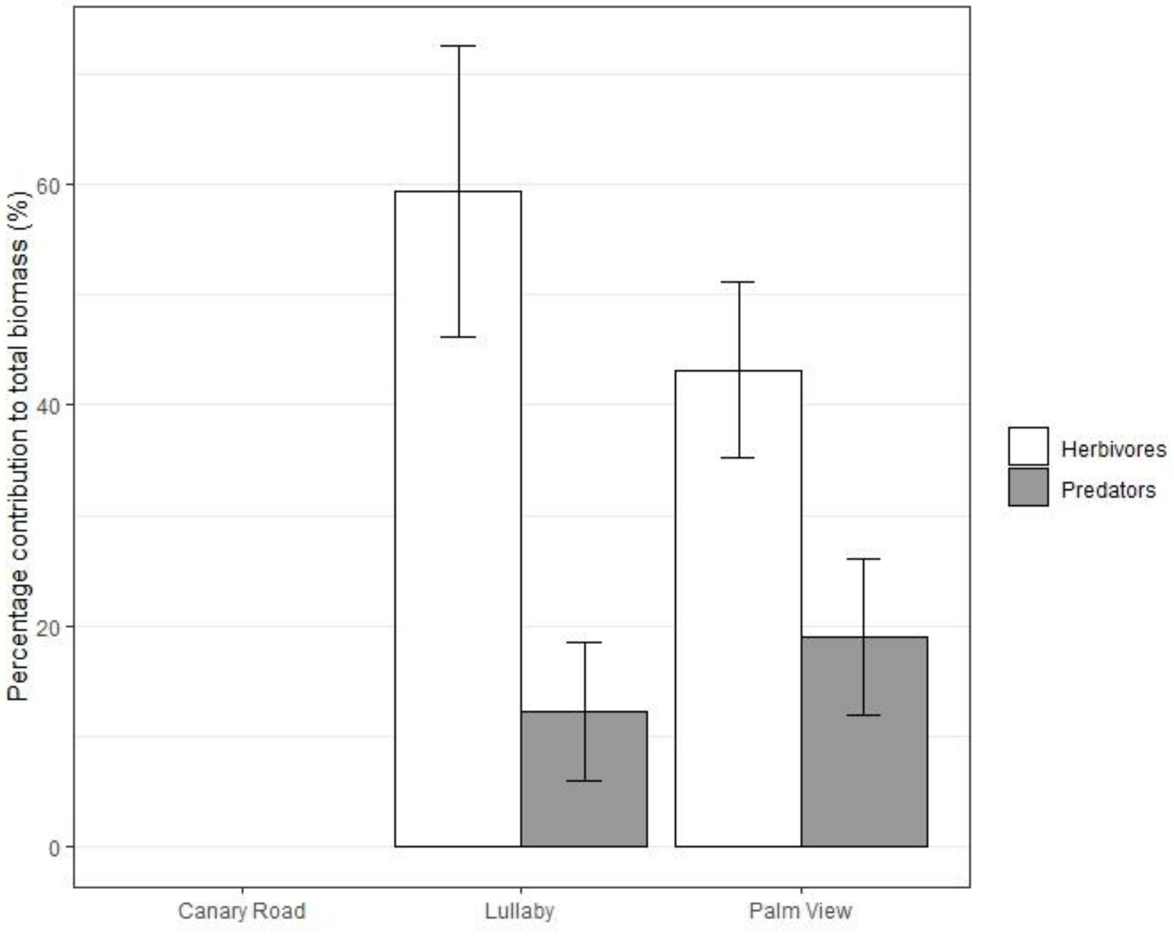

Figure 21: Percentage contribution of herbivorous fish species and predatory fish species to total biomass on six coral reefs across La Ensenada, Tela in 2024. Data are mean values ±SE for 5m and 15m habitats calculated from stereo-video surveys (n=6).

4. Future research directions

The Operation Wallacea marine expeditions in Honduras are well established, having consistently been collecting data and producing scientific outputs for a number of years. The aim of Operation Wallacea and its partners in Honduras is to continue to produce high quality internationally recognised research, characterised by publication in peer reviewed journals, to inform marine management and conservation in the area and wider Caribbean. Having just began several new research projects in 2024, the focus will be to progress these projects for the following years, facilitating robust research for our academic partners to produce scientific outputs and inform conservation. In the near future, our research will also be addressing the following key areas where we will look to continue.

4.1. Environmental profiling

Understanding the environmental conditions present at a study site is vital at explaining patterns in data investigating biodiversity and ecology. It is therefore extremely important that we characterise the environmental conditions present at each of our reef study sites in as much detail as possible. Spatial comparisons between sites will be conducted using an oceanographic probe fitted with sensors to measure (1) full spectrum photosynthetically active radiation (PAR, wavelength range 400-700nm), (2) ultra-violet B radiation (UV-B, wavelength range 280-400nm), (3) temperature, (4) depth, (5) soundscape (via a highly sensitive hydrophone). This will allow detailed and accurate measurements to be taken on light attenuation, temperature fluctuations and noise pollution, amongst others. This probe will be positioned on the benthos at a range of depths at each site, and at standardised times of day, and will remain constantly connected to a buoy housing solar panels for power. Temporal data on light and temperature will be obtained using HOBO pendant loggers placed on the reef for pre-determined time periods, allowing both diurnal and seasonal environmental fluctuations to be measured. The data from this project will be used to support the more specific research projects taking place.

4.2. The Role of Free-Living coralites in establishing new coral reefs and their potential use in restoration

With the success of the research conducted by Dr Nadia Jogee with us in Honduras in 2019 for her PhD, we will be developing a new research program investigating the free-living stony corals, corallites. It has been shown that they assist in the recovery and expansion of coral reefs in the Maldives. There is a knowledge gap regarding how these coralites respond to disturbances and whether they also have the potential to aid recovery. To fill this gap, we intend to collect coralites that were non-invasively tagged in 2019 to investigate their survival, growth, and range expansion. Further studies will also be conducted using SCUBA and snorkelling around to build a picture of whether the coralite community has changed in this period. Coral mucus samples will be collected to observe the strains of symbiotic algae they harbour. This will help assess whether they contain more resilient strains than non-coralite corals. These samples will be collected using non-invasive FTA cards. Further data collection will focus on the potential use of corallites in reef restoration and the potential for them to be utilised by restoration efforts in the Caribbean or further afield.

Appendix

Publication outputs to date: Honduras Marine

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