FEED THE FUTURE GHANA FISHERIES RECOVERY ACTIVITY (GFRA)

Marine Protected Area Site Selection and Stakeholder Engagement Report

July 31, 2024

Feed the Future Ghana Fisheries Recovery Activity

MARINE PROTECTED AREA FINAL SELECTION AND STAKEHOLDER ENGAGEMENT REPORT

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This report was prepared by:

Dr. Steve Lindfield, Stephen Kankam and Justice Camilla Mensah

And:

Tetra Tech
Burlington, Vermont USA
Telephone: +1 (802) 495-0282
Email: international.development@tetratech.com

Tetra Tech Contact:

Heather D'Agnes, Chief of Party
Telephone: +233 (0) 599034200
Email: heather.dagnes@tetratech.com

Jason Girard, Project Manager
Telephone: +1 (802) 495-0591
Email: jason.girard@tetratech.com

Cover Photo: Video screen shot from BRUV taken from Cape Three Points Area. *Lindfield, 2024.*

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ACRONYMS AND ABBREVIATIONS

BRUV	Bait with Remote Underwater Video
CaFGOAG	Canoe and Fishing Gear Association of Ghana
CAOPA	Confederation of Professional Organizations in the Artisanal Maritime & Continental Fisheries of Africa
CEMLAWS	Center for Maritime Law and Security
COMADRIP	Coastal and Marine Conservation Drive Project
CPUE	Catch Per Unit Effort
CREMA	Community Resources Management Area
CSO	Civil Society Organization
EBSAs	Ecologically or Biologically Significant Marine Areas
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FC	Fisheries Commission
FCWC	Fisheries Committee of the West Central Gulf of Guinea
FMOC	Fisheries Management Operational Committee
FSSD	Fisheries Scientific Survey Division
GCTPA	Greater Cape Three Points Area
GEBCO	General Bathymetric Chart of the Oceans
GFRA	Ghana Fisheries Recovery Activity
GITA	Ghana Industrial Trawlers Association
GNCFC	Ghana National Canoe Fishermen Council
GPS	Global Positioning System
ICFG	Integrated Coastal and Fisheries Governance Project
IEZ	Inshore Exclusion Zone
IUCN	International Union for the Conservation of Nature
IUU	Illegal, Unreported, and Unregulated
KM	Kilometer(s)
LaBECs	Landing Beach Enforcement Committees
LEK	Local Ecological Knowledge
LUSPA	Land Use and Spatial Planning Authority
M	Meter(s)
MESTI	Ministry of Environment, Science, Technology and Innovation
MFMP	Marine Fisheries Management Plan (2022 – 2026)
MOFAD	Ministry of Fisheries and Aquaculture Development
MPA	Marine Protected Areas
MPA TAC	Marine Protected Area Technical Advisory Committee
NAFAG	National Fisheries Association of Ghana
NAFPTA	National Fish Processors and Traders Association
NM	Nautical mile(s)
OCPP	Ocean Country Partnership Programme
SDG	Sustainable Development Goals
UCC-CCM	University of Cape Coast- Center for Coastal Management
USAID	United States Agency for International Development
WASOP	West Africa Sustainable Oceans Program

1. OVERVIEW

The Feed the Future Ghana Fisheries Recovery Activity (GFRA) is a United States Agency for International Development (USAID) funded project that is supporting Government of Ghana, through the Ministry of Fisheries and Aquaculture Development (MOFAD) and the Fisheries Commission (FC), to build a durable basis for the recovery of small pelagic fisheries in Ghana. Many actions supported the Commission's planned fisheries management measures outlined in the gazetted 2022 – 2026 Marine Fisheries Management Plan (MFMP 2022-2026). One key measure is the establishment of a Marine Protected Area as an area-based fisheries management measure for the recovery of small pelagic fisheries.

The Greater Cape Three Points Area (GCTPA) has been identified as an ecologically important area, especially for small pelagic fisheries, and prioritized for protection under a proposed Marine Protected Area (MPA). GRFA and partner Hen Mpoano have been supporting MOFAD/FC to develop a strategy for the establishment of MPAs which puts stakeholder involvement as a major priority. Over the past year, Hen Mpoano has been conducting extensive stakeholder engagements at the local and regional level to ensure that communities understand what an MPA is, why it is important in their area, and most importantly are involved in the design of the MPA. Through a local ecological knowledge (LEK) participatory mapping approach, Hen Mpoano engaged with 15 communities in the GCTPA to identify specific sites that are biologically significant from the perspective of the key stakeholders and fishers from the communities and solicit their input in the design of the marine protected area.

Through the LEK participatory mapping, fishermen identified the presence of five major rocky outcrops within the GCTPA within the 6 nm inshore exclusion zone, which are regarded as important areas for feeding, spawning, and habitat for small pelagic and other predatory fish species. GFRA and Hen Mpoano collect primary data to validate these sites as needing protection based on the fish populations found in these areas, their significance as spawning or aggregation sites, or as important fish habitat. Of secondary significance is other marine biodiversity or marine habitat characteristics that make the area unique.

This report presents the rationale for the GCTPA MPA area and the research results for the key areas for protection. It also summarizes the stakeholder engagements conducted by Hen Mpoano over the past year to document the results of the extensive consultations that have taken place with communities, fishers, traditional leaders, and government stakeholders across the MPA area.

2. INTRODUCTION

2.1 Background

In 1994, Ghana ratified the United Nations Convention on Biological Diversity and in 2022, negotiations of the parties culminated in the adoption of the Kunming-Montreal Global Biodiversity Framework. Known as the '30x30 target', Target 3 of the Global Biodiversity Framework contains an ambitious commitment to conserve 30% of terrestrial, inland water, coastal and marine areas by 2030. Although Ghana has established 313 protected areas covering an area of approximately 15% of the terrestrial and inland waters (Protected Planet, 2023), there are not yet any Marine Protected Areas (MPAs) established.

There has long been interest in the establishment of marine protected areas in Ghana. In 2009 USAID, through the Coastal Resources Center at the University of Rhode Island, supported the Integrated Coastal and Fisheries Governance (ICFG) initiative for the Western Region of Ghana which aimed to establish Ghana's first marine protected area (Ateweberhan et al., 2012). This initiative was also called Hen Mpoano and at the closure of the ICFG project in 2012, Hen Mpoano became a registered CSO with a mission towards continuing many of the initiatives related to coastal and marine governance.

In 2018, FC and MOFAD produced a report on Marine Protected Areas in Ghana: Strategies, Action Plan and Implementation Framework (Nunoo, 2018). This report stated the goal of establishing and managing marine protected areas in Ghana shall be to "protect and conserve the coastal & marine ecosystems of the nation and its associated biological diversity and fisheries for the benefit of humanity". This report identified 20 sites that were proposed as potential MPAs using a 4-point criterion for site selection (socio-economic, educational, ecological, and feasibility). The GCTPA was identified in this report as an ecologically and biologically significant marine area of Ghana worthy of protection.

In 2023, GFRA in conjunction with Hen Mpoano, produced an MPA site selection report for the GCTPA (GFRA, 2023). This report analyzed and synthesized all existing scientific data about the Cape Three Points area to identify the area for protection and conducted participatory mapping to gather local ecological knowledge (LEK) from fishers and community members to identify suitable sites for the establishment of an MPA to aid the recovery of small pelagic fisheries. The accumulation of knowledge resulted in a proposed Greater Cape Three Points MPA area of 700 km2, including five potential areas for protection due to their characteristics as major rocky outcrops or muddy substrates where fishing is predominant.

Although the GCTPA is a strong candidate for the establishment of the nation's first MPA, there is a lack of scientific data on the distribution, biodiversity and abundance of marine life and benthic habitats found within the coastal Inshore Exclusion Zone (IEZ). GFRA and Hen Mpoano subsequently collected additional primary data to validate these sites as needing protection based on the fish populations, the significance of spawning or aggregation sites and important fish habitats. It is also of significance to understand the distribution of other marine biodiversity and habitat characteristics that make the area unique.

2.2 Marine Protected Area Definitions and Criteria

Marine Protected Areas (MPAs) are well established globally as conservation tools intended to protect biodiversity, promote healthy and resilient marine ecosystems, and provide societal benefits (Grorud-Colvert et al., 2021). The most widely accepted definition for a protected area is from the International Union for Conservation of Nature (IUCN). They define a protected area as: "A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values". However, the details of what does and does not "count" as a protected area can be determined by national policy and laws (Dudley and Stolton, 2022). The IUCN definition is backed by several principles, including "Only those areas where the main objective is conserving nature can be considered protected areas; this can include many areas with other goals as well, at the same level, but in the case of conflict, nature conservation will be the priority" (Stolton et al., 2013).

There are various other area-based measures, such as fishery management areas, that can be confused with MPAs. The key difference between MPAs and other area-based measures is that, whatever form the MPAs take, the primary focus is the conservation of biodiversity (Day et al., 2019). Area-based measures where the primary goals are something else, such as sustainable fishing, do not qualify as an MPA. If fishing or other extractive activities are compatible with an MPA's objective(s) and are permitted within the MPA, they must have a low ecological impact, be sustainable, be well managed as part of an integrated approach to management and fit within the definition and category of an IUCN protected area. Any industrial activities and infrastructural developments (e.g. mining, industrial fishing, oil and gas extraction) are not compatible with MPAs and should be excluded from such areas if they are to be considered as MPAs (Day et al., 2019). Therefore, for a fishery management area to meet the definition of an MPA, it would need to have nature conservation as a primary objective and be managed in accordance with that objective (e.g., contributing to the maintenance of ecologically appropriate metrics, such as population structures).

2.3 Greater Cape Three Points Marine Protected Area

Ghana's western coast supports some of the most biodiverse areas in the country. It is also densely populated with major industrial, agricultural, mining, subsistence farming and fisheries activities. The beaches, cliffs, lagoons, wildlife, cultural and historical sites and coastal landscape provide great potential for tourism development. Yet this rich coastal area is also facing several environmental challenges including overfishing, coastal deforestation, coastal erosion, pollution and rapid population growth (Ateweberhan et al., 2012; CRC and Friends of the Nation, 2011; EPA, 2021, 2020).

Various studies and reports have identified the GCTPA as a priority area for establishing the nation's first MPA. In 2009, this area was the focus for an Integrated Coastal and Fisheries Governance initiative which aimed to establish Ghana's first MPA (Ateweberhan et al., 2012). As part of this initiative, a survey was completed on the near shore rocky habitats between Axim and Busua/Butre, as they are an important but poorly known and previously unstudied part of the coastal environment. In 2011, The Coastal Resources Centre at the University of Rhode Island, also mapped out and analysed key critical coastal habitats in the Western Region of Ghana (CRC and Friends of the Nation, 2011). In 2016, the Mami Wata pilot project, led by Ghana's Environmental Protection Agency (EPA), identified ecologically or biologically significant marine areas in Côte d'Ivoire and Ghana and produced a State of the Marine Environment report for the four western coastal districts in Ghana, including the GCTPA (EPA, 2021, 2020). In 2018, the FC and MOFAD produced a report on Marine Protected Areas in Ghana: Strategies, Action Plan and Implementation Framework, which was completed by Nunoo (2018). This report identified five sites in this area out of twenty sites across the country as priority sites for MPA protection. These proposed sites are the Miemia Bay, Gross Friedrichsburg, Cape Three Points, Akwidaa Bay and Butre estuary and were all categorised as proposed biodiversity protected areas. The Centre for Coastal Management at University of Cape Coast (UCC-CCM) implemented the Coastal and Marine Conservation Drive Project (COMADRIP), a science-based initiative to create a pilot site for the design and development of an MPA management strategy for the GCTPA. Related to this project, Sagoe et al. (2021) published on the community participation in assessing fisheries related ecosystem services towards the establishment of marine protected area in the GCTPA. Finally, there have also been a series of fisheries surveys in the economic zone of Ghana, including specific sites in the Cape Three Points area, by the research vessel Dr. Fridjoft Nansen through a collaboration between the FAO and the Institute of Marine Research of Norway. Results from 2000 and 2004 show that sardinella species and anchovies were reported in some of the highest densities in the Cape Three Points area (Aziable et al., 2012).

Ecologically or Biologically Significant Marine Areas (EBSAs) are areas of the ocean that have special importance in terms of its ecological and/or biological characteristics. The GCTPA was identified by the EPA as meeting the criteria for an EBSA for which it has been proposed for consideration to the Convention on Biological Diversity (EPA, 2020). With this submission it was envisaged that the declaration of the Greater Cape Three Points Area would serve as the basis for the creation of marine protected areas in the country.

The GCTPA spans 60 kilometres of coastline in the Ahanta West and Nzema East municipalities with its adjoining mangrove swamps, sandy beaches, coastal estuaries, and lagoons (GFRA, 2023). The area includes the entire stretch of coastal ecosystems from Domunli in the west to Ampatano in the east and extends to the inshore exclusion zone 6 nm offshore, covering a total area of 700 km^2 (Figure 1). This area is important for artisanal fishing, for which it is estimated that there are a total of 1682 canoes and 9281 fishers in Ahanta West and Nzema East municipalities (GFRA, 2023). The vast majority of these fishers do not fish outside of the GCTPA, and their fishing activities are concentrated within the stretch from Achonwa in Ahanta West Municipal to the Agyan area in the Nzema East Municipal.

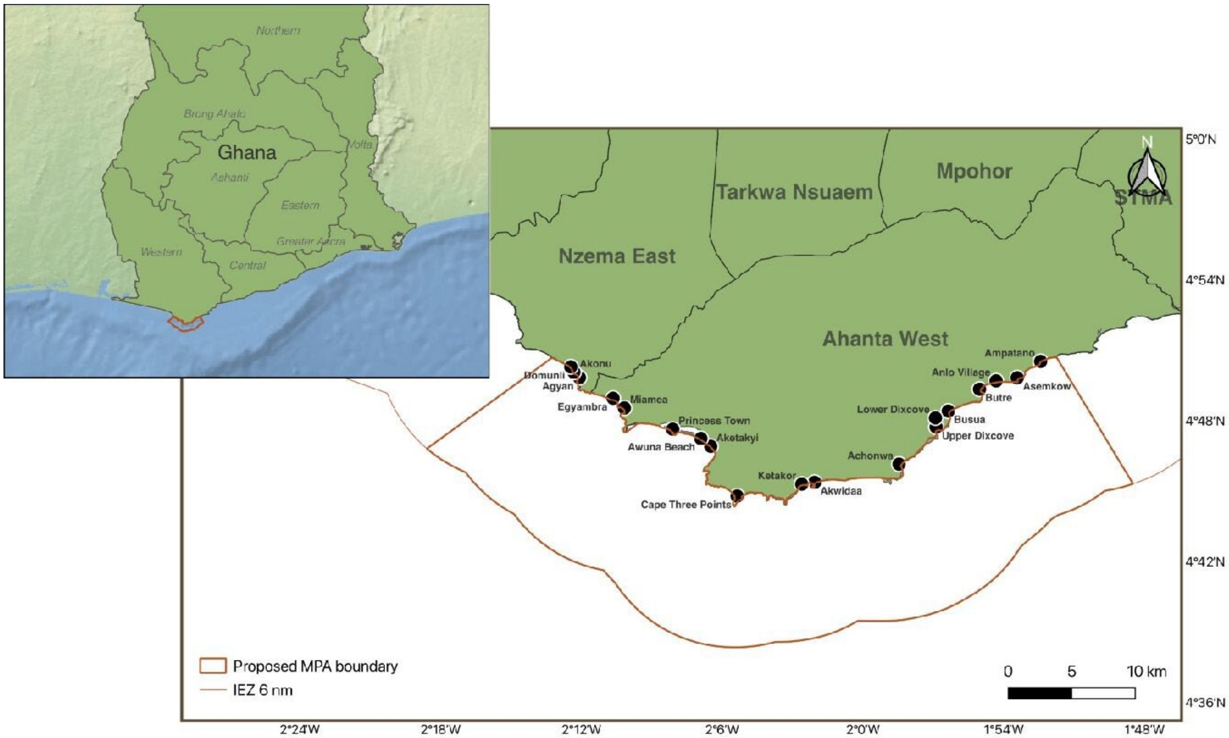


Figure 1: The location of the proposed MPA encompassing the Greater Cape Three Points Area in the Western Region of Ghana.

2.4 Habitat Distribution

Through LEK surveys and basic bathymetric data, GFRA (2023) produced maps and GIS shapefiles (Figure 2) of the main rocky outcrops in the GCTPA. The mapping revealed five areas of rocky outcrops lining up within the Inshore Exclusion Zone (IEZ) and spanning Agyan-Domunli area in the west to Pumponi-Asemkow area in the east. These rocky outcrops are reported to provide feeding grounds, spawning areas, and habitats for small pelagic and other predatory fish species and therefore regarded as important core sites for protection (GFRA, 2023). The spaces between the rocky outcrops are assumed to be soft sediment (mud and sand) and the LEK documented that these are major fishing grounds for fishers targeting small pelagics, with the area between the Princess Town and Cape Three Points rocky outcrops being the main fishing area with reportedly huge stocks of fish (GFRA, 2023).

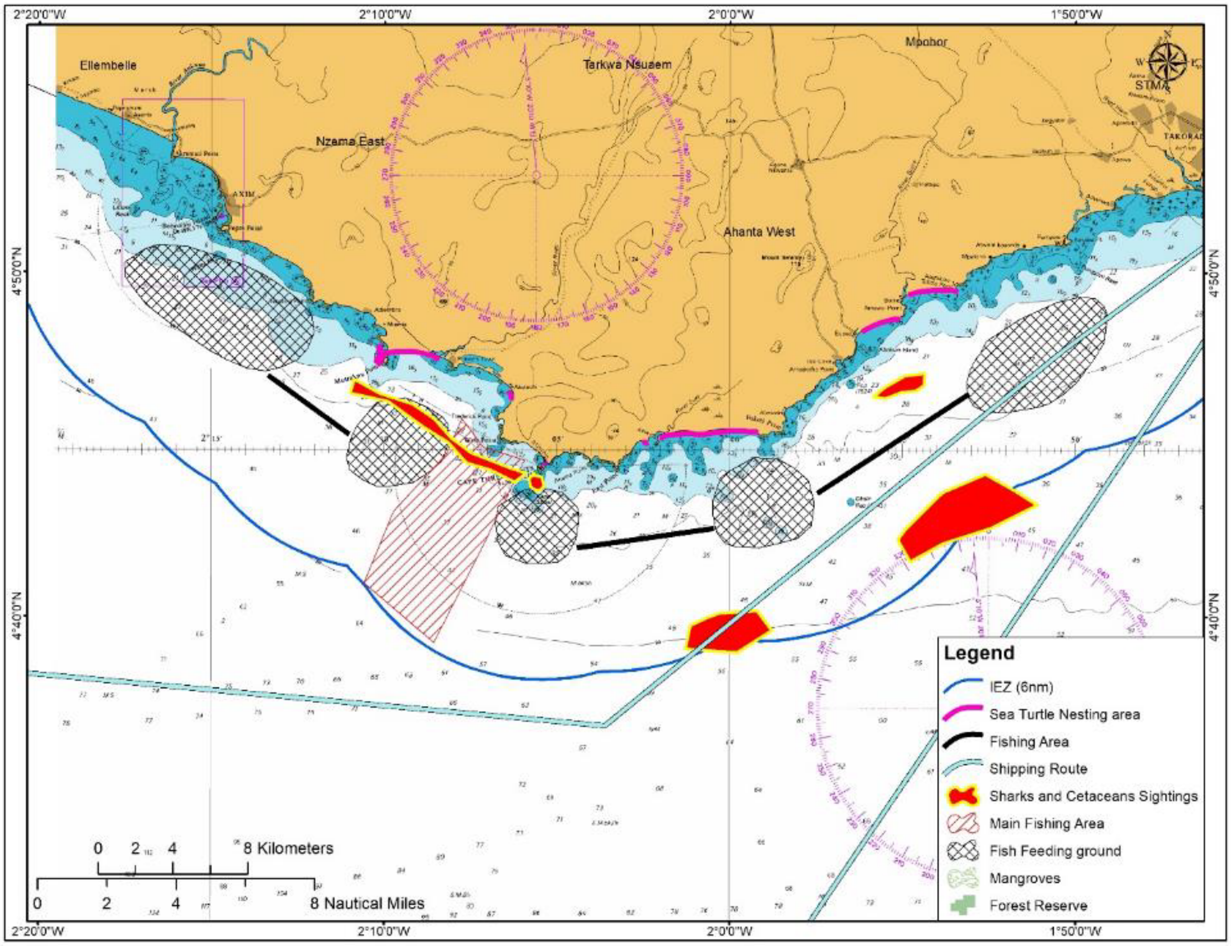


Figure 2: Composite map of local ecological knowledge and scientific data for GCTPA

Unfortunately, very little is known about these rocky outcrop areas. In 2012, the near shore rocky reef habitats in the GCTPA, typically fished by one-man unmotorised canoes deploying either hook and line or set nets at the transition between the rocky and soft bottom area, were surveyed by SCUBA diving at depths <12 m (Ateweberhan et al., 2012). Crustose coralline algae were the most dominant feature in the benthic community of these near shore rocky reef habitats, followed by turf, blue-green and fleshy algae. However, this research did not cover the deeper rocky outcrop areas identified through the LEK. GFRA supported additional research on the offshore rocky reefs to document the biodiversity and validate the distribution of the different benthic habitats within this area.

Comprehensive bathymetric surveys have also not been undertaken in Ghana and the best available data on publicly available bathymetry is from the General Bathymetric Chart of the Oceans (GEBCO) which is of low resolution, only partially based on exact measurements and relies on interpolations guided by satellite-derived gravity data (Weatherall et al., 2015). There has been recent progress on the use of satellite-derived bathymetry from wave action in West Africa, however the data is still under development and not currently available for public use (Daly et al., 2022). As it is not certain if the existing basic bathymetry is accurate, additional research conducted through GFRA also validated the precise location of the rocky reef outcrops.

2.5 Marine Biodiversity

2.5.1 Pelagic fish

The small pelagic species are the main species of interest for the proposed MPA. Small pelagics are the mainstay of the artisanal fisheries, in a good year contributes 70% of the total landings (MFRD, 2007). The Ghanaian fish market is dominated by sardinella, anchovy, and chub mackerel which are caught by the canoe and semi-industrial fishing fleets within the IEZ (Demarcq and Aman, 2002).

The two-main species of sardinella found off the coast of Ghana are the Round Sardinella, *Sardinella aurita (S. aurita)* and the Flat Sardinella, *Sardinella maderensis (S. maderensis)*. Based on landings, *S. aurita* is generally considered to be of more commercial importance than *S. maderensis* (Castro et al., 2017). It is of major concern that catches of *S. aurita* have significantly dropped from peaks of over 100,000 tonnes in the 1990's to less than 30,000 tonnes since 2015 and is now considered collapsed with catches less than 12,000 tonnes in 2019 (Lazar et al., 2020). Hydroacoustic surveys by RV Dr. Fridjoft Nansen, corroborates with the trends of severely declining landings and catch-per-unit-effort (CPUE) for which the relative biomass estimated in 2018 was the lowest ever recorded since the beginning of these surveys in mid-1980s (Lazar et al., 2020).

S. aurita are known to reside at depths from 50 to 80 m off central Ghana, between Cape Three Points and Accra (Brainerd, 1991; Castro et al., 2017). Around July and August, when the coastal upwelling begins, the fish migrate towards the coastal areas and become accessible for fishing by the artisanal fleet (Castro et al., 2017). Cape Three Points has been identified as a spawning area for *S. aurita* having favourable oceanographic conditions for larval retention and survival (Koné et al., 2017). Although eggs and larvae of Sardinellas species are found almost year-round there is higher abundance found during upwelling periods (Koranteng, 1989), this is further supported by a study done off Elmina where according to the fish gonads, the proportion of spawning capable females were highest between July and September (Osei, 2015). The proportion of spawning capable females for the flat sardinella *S. maderensis* also peaked in September.

In comparison to the decline of *S. aurita*, the stocks of *S. maderensis* have remained relatively constant with a few historical highs and lows, but this species is still currently at is lowest historical levels of catch (Castro et al., 2017). *S. maderensis* is considered more of a coastal species and relatively sedentary with limited seasonal migrations along the coast in Ghana and are caught year-round (Cury and Fontana, 1988). Whereas *S. aurita* are mostly caught during the major (June-September) and minor (December-March) upwelling periods (Castro et al., 2017).

Anchovy *Engraulis encrasicolus*, is also a vitally important part of the small pelagic fishery in Ghana. Biomass of anchovy in Ghana's coastal waters in reportedly higher than sardinella in recent years from fishery independent surveys of the R/V Dr. Fridtjof Nansen (MOFAD, 2022). However previous assessments have shown this species is currently overfished (Amponsah et al., 2016). Anchovy does not only have a substantial role in the economy of fishing industries but also plays a paramount role in the marine ecosystem. For instance, this species serves as zooplankton predators as well as preys of many other marine organisms including large pelagic fishes and cetaceans (Arneri et al., 2011). It is harvested by small scale fishermen who deploy small mesh sized purse seine and beach seine fishing gears. However, pole and line tuna vessels also harvest anchovy as bait for tuna fishing (Koranteng, 1993).

Details on the distribution and spawning of this species is not well documented, but peak catches occur during the major upwelling season between July to September each year (Amponsah et al., 2016). In May-June 2004 the highest recorded biomass from surveys by the R/V Dr. Fridtjof Nansen were found within the planned MPA area east of Cape Three Points near Egyamba and Princess Town (Aziable et al., 2012) where they are commonly detected in shallow waters, mostly at depths between 20 and 30 m (Toresen et al., 2016).

The Atlantic chub mackerel *Scomber colias* along with other small pelagic fishes, are caught with purse-seine nets in shallow inshore waters up to the 30-m depth contour. This species has its main spawning period in June – August which largely coincides with the major upwelling season and another minor spawning period between March–April, soon after the minor upwelling season (Kassah et al., 2022). As upwelling events are characterised by increased biological production, spawning at this time would be expected to present juveniles of *S. colias* with abundant food sources for rapid growth and, ultimately, enhanced recruitment to the fishery.

There are also large bodied pelagic fish such as carangids (jacks) and scombrids (mackerel and tuna) that are also found in greater abundance during periods of upwellings. These species along with other larger predators such as sharks and billfish are also found within this area.

The artisanal purse seine, encircling gillnets, and beach seines are the main fishing gear used for the exploitation of small pelagics (Lazar et al., 2020). These fishing operations avoid areas of rocky reefs as to not snag and damage the nets. However it was generally noted among the fishers and fish processors during the LEK that the sardinella and anchovies often move to rocky substrate in search of food, and eventually, become prey for other fish and marine mammals (GFRA, 2023).

2.5.2 Demersal fish

Fishery resource surveys in Ghana by the Dr. Fridtjof Nansen research vessel showed the most important demersal species caught from the 0-30 m depth range are the Carangids, Bigeye grunt, Seabreams, Barracudas, Grunts, Croakers and Cephalopods (EPA, 2021; Toresen et al., 2016). However, there are no known fine-scale surveys of demersal fish diversity from different offshore habitats in the GCTPA.

Previous surveys on near shore rocky reefs in the area (Ateweberhan et al., 2012) indicate that the near shore rocky reefs of Ghana are characterised by communities typical of marine areas experiencing high levels of overfishing and associated cascading trophic effects. These surveys, conducted by SCUBA, indicate near complete removal of top predatory fish by overfishing which was assumed to result in the release of prey species and a shift to a lower diversity ecosystem (Ateweberhan et al., 2012). It is not certain if the same patterns will be found on the offshore rocky reefs. As many predatory species are shy of SCUBA divers, the results of diving surveys can be biased, especially in areas of reduced visibility where fish can sense the divers and stay at a distance away and not be recorded (Lindfield et al., 2014).

2.5.3 Mobile benthic invertebrates

Surveys of the near shore rocky reef habitats in the GCTPA at depths of 2-11 m found the slate pencil urchin *Eucidaris tribuloides var. africana* to be the most abundant and most widely distributed mobile invertebrate species observed (Ateweberhan et al., 2012). Its extremely high abundance was suggested to likely be a result of trophic cascades related to overfishing of predatory fish. Very low densities of commercially important macro-invertebrate groups, such as lobsters, shrimps and octopus were observed. In conjunction with the reduced predation by fish related to overfishing, overharvesting of these important predatory invertebrate species could have resulted in the release and dominance of their prey (Ateweberhan et al., 2012). This baseline information on the nearshore reefs provides a useful reference point, but no comparative surveys have been done on the offshore rocky reef habitats and therefore knowledge on the diversity and abundance of mobile invertebrates is limited.

2.5.4 Sessile invertebrates

There is little knowledge on the biodiversity of sessile invertebrates such as corals and sponges. There is a deepwater Lophelia-dominated reef that was discovered at 400 m depth on the continental shelf in the far western part of Ghana in 2012 (Buhl-Mortensen et al., 2017), but there does not appear to be any surveys of reef habitat and biodiversity at depths of 10-40 m where the offshore rocky reefs are located.

2.5.5 Marine mammals

The offshore waters from Cape Three Points area have been identified as calving areas for whales and dolphins (EPA, 2021). Although limited information exists on the distribution and abundance of whales for the inshore waters (< 6nm within the IEZ), the offshore waters support a diverse assemblage of cetaceans, predominantly in shelf and slope waters (<1000 m depth contour) (de Boer et al., 2016). These species are occasionally caught as bycatch from artisanal fisheries, for which there are at least 18 species confirmed from Ghana's waters (Van Waerebeek et al., 2010). During community surveys in the Cape Three Points Area (GFRA, 2023), all the communities confirmed the presence of sea turtles, and marine mammals (whales) in the area. Marine mammals are usually sighted between August and November.

3. GCTPA RESEARCH

3.1 Research Objective

The objective is to conduct primary research that will inform the selection of specific sites within the GCTPA for protection under an MPA. Local ecological knowledge gained during participatory mapping sessions led by Hen Mpoano with 11 fishing communities in the area identified several rocky outcrop sites as being important for fish habitat or fish spawning sites. However, the exact location and extent of these sites were not known and existing bathymetry datasets for the area do not identify these reefs. Therefore, the location and extent of these rocky reefs also needs to be validated if MPA zoning is to protect representative areas of habitat. The research survey aims to validate these sites as needing protection based on the distribution of fish populations, importance of habitats, and the significance of these sites for spawning or supporting aggregations of fish. As it is important that MPAs are designed according to biodiversity objectives, these surveys will also focus on assessing the other marine biodiversity and habitat characteristics that make the area unique.

Therefore, the two main objectives for this research are:

- To quantify the relative abundance and distribution of fishery targeted fish species across the different marine habitats within this area, with a particular focus on the submerged rocky outcrop areas, to determine if these areas form important fish habitat or spawning areas that can help sustain local fisheries.
- Mapping the benthic habitat to determine the location of different habitat types for representative protection, particularly the location and extent of submerged rocky reefs. For these habitat types, document the associated biodiversity such as non-targeted fish species, mobile benthic invertebrates, and sessile habitat forming invertebrates and algae.ds

3.2 Research Methodology

The research took place between 12th February and 5th March 2024. This time of year, between December and March is typically the driest and relatively calm ocean conditions with the clearest water clarity in the Western Region. During this time of year, there can also be a minor upwelling period for a few weeks between January and March that corresponds with abundance of small pelagics such as Sardinella in Ghana (Konan, 1996; Mensah, 1991; Mensah and Koranteng, 1988). However, interestingly through extensive LEK surveys, respondents knowledgeable about Sardinella in Ghana did not mention Sardinella being caught at this time period between January and March (Castro et al., 2017).

3.2.1 Study sites

There are 21 prospective MPA communities in the Greater Cape Three Points Area. Based on optimal logistics and spreading the surveys across the area of coastline, the GCTPA was divided into three parts: West, Central and East (Figure 2). For the western part between Domunli and Aketakyi, the surveys were based out from Miemia. For the central part of the MPA area between Aketakyi and Achonwa, the surveys were based out from Akwidaa. For the western part between Achonwa and Ampatano, the surveys were based out from Butre. For each of the three parts of the GCTPA, four days of surveys were done collecting underwater video footage. In addition, on the day when the boat was moved from

Akwidaa to Butre, a reef system offshore from Achonwa was investigated using the drop camera system and bathymetric mapping. In total, 13 days of collecting underwater video were completed.

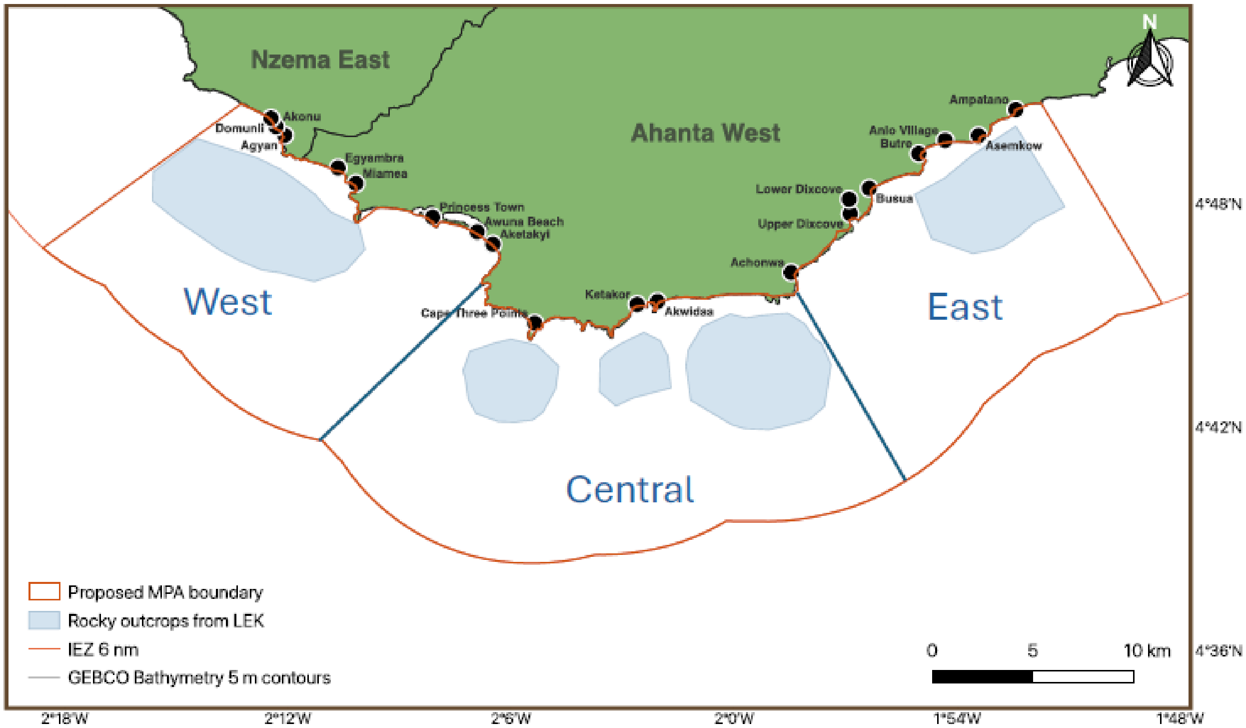


Figure 3. The proposed MPA in the Greater Cape Three Points area. The areas of rocky outcrops identified from LEK participatory mapping are shaded in blue.

3.2.2 Bathymetric mapping

As accurate bathymetric data is lacking for this area, a portable global position system (GPS) depth sounder/plotter system (Lowrance Hook Reveal 2) was developed and used to gather data on the depth contours and to mark locations of BRUVs and drop camera deployments. This depth sounder is portable as it is stored in a waterproof hard case with a 12V 7ah battery. The depth sonar transducer mount was designed by modifying an adjustable fishing rod holder and a telescopic mop handle so the transducer can be mounted on the side of the local vessels used in this survey (Figure 3).

The Lowrance Hook Reveal sounder and chart plotter can actively produce depth contours in real time during boating operations (known as Genesis Live). It also logs all data collected which can be imported into the specialized mapping software, Reefmaster 2.0, to create bathymetric maps (Figure 3c)

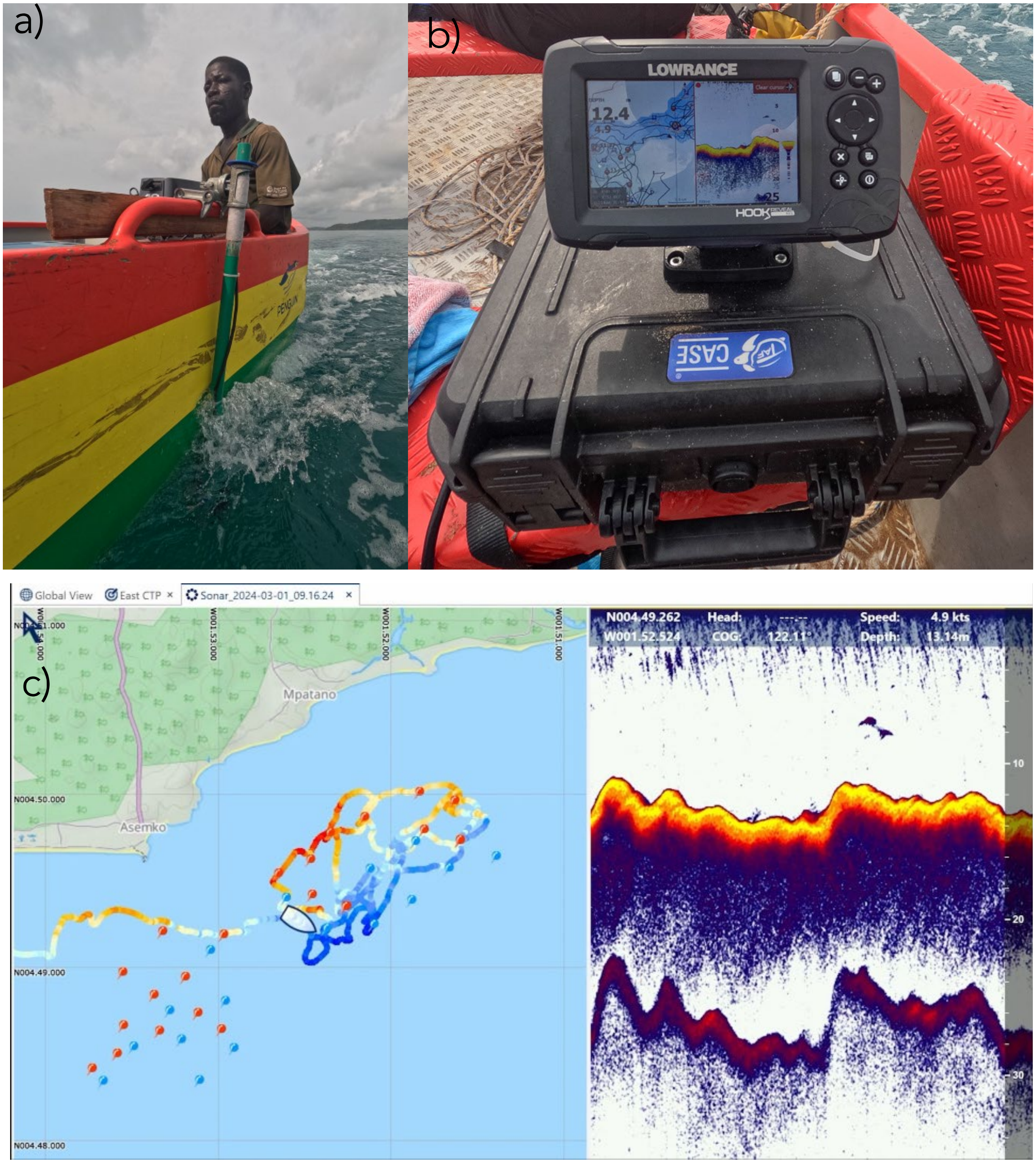


Figure 4. a) The sonar system attached to the side of the boat. b) The Lowrance Hook Reveal screen showing the boat track and creation of Genesis Live bathymetry from the sonar. c) Screenshot from the ReefMaster software showing the recorded GPS track and sonar image that can be used to make a bathymetric map.

3.2.3 Survey techniques

This research utilised fishery-independent surveys of the marine biodiversity and fishery resources. Unlike fishery-dependent surveys that utilise data collection from fishing activities, such as fish landing surveys or catch surveys on-board vessels, fishery-independent surveys can be easily stratified to cover representative areas of habitat and follow an experimental design which can reduce biases associated with opportunistic data collection from fishing operations.

With advancements and reduced costs associated with underwater video cameras, they have become a crucial tool for scientists studying marine ecosystems. Various underwater camera systems have been developed for remote surveys which reduce the need for divers to operate the cameras in-situ, which can be difficult in areas of reduced visibility, rough seas, remote locations and at deep depths. Remote video-based sampling methods are increasingly being adopted due to their range of benefits including: (a) their non-destructive nature, (b) ability to sample rare species over broad depth ranges (c) provision of a permanent record that can be reviewed to reduce interobserver variability compared to in-situ data collection (d) ability to collect coexisting data on habitat (e.g. epibenthic cover and substrate and (e) provision of images for science communication (Langlois et al., 2020). Multiple remote systems can also be deployed in the field consecutively to make efficient use of field time and enable spatially extensive sampling.

The use of bait with remote underwater video (BRUV) surveys increases the relative abundance and diversity of fishes observed, particularly species targeted by fisheries, without precluding the sampling of fishes not attracted to bait. BRUVs have been shown to provide relative measures of species richness and abundance for a range of species in a diverse array of conditions and habitats (Langlois et al., 2020). There are two main types of BRUVs that have been developed for studying fish communities in coastal marine ecosystems: benthic and pelagic (or mid-water) BRUVs. These BRUVs can be rigged with two cameras to allow stereo-video measurements of fish size and position in three-dimensional space (Langlois et al., 2020; Shortis et al., 2009). This provides accurate information on the length of fish and allows the standardisation of the sampling area (Harvey et al., 2010), however these systems are larger and more costly due to need for multiple cameras and calibration equipment and software. For this research, single camera systems were used as they are more compact and easier to deploy from basic vessels.

3.2.4 Benthic BRUVs

Benthic BRUVs are deployed on the seabed, they work equally well on rocky reef habitats and soft sediment and can provide comparable data on different habitats to investigate differences in diversity and abundance of fish species. These systems require some weight to keep them stable on the seabed and a rope and float to mark them on the surface and allow retrieval, like a fish trap. A schematic and images of a benthic BRUVs is provided in Figure 4. Rather than a large camera housing pictured in the diagram, a single GoPro Hero 10 camera in waterproof housing was mounted to the frame. Frames were built in Takoradi using galvanized steel.

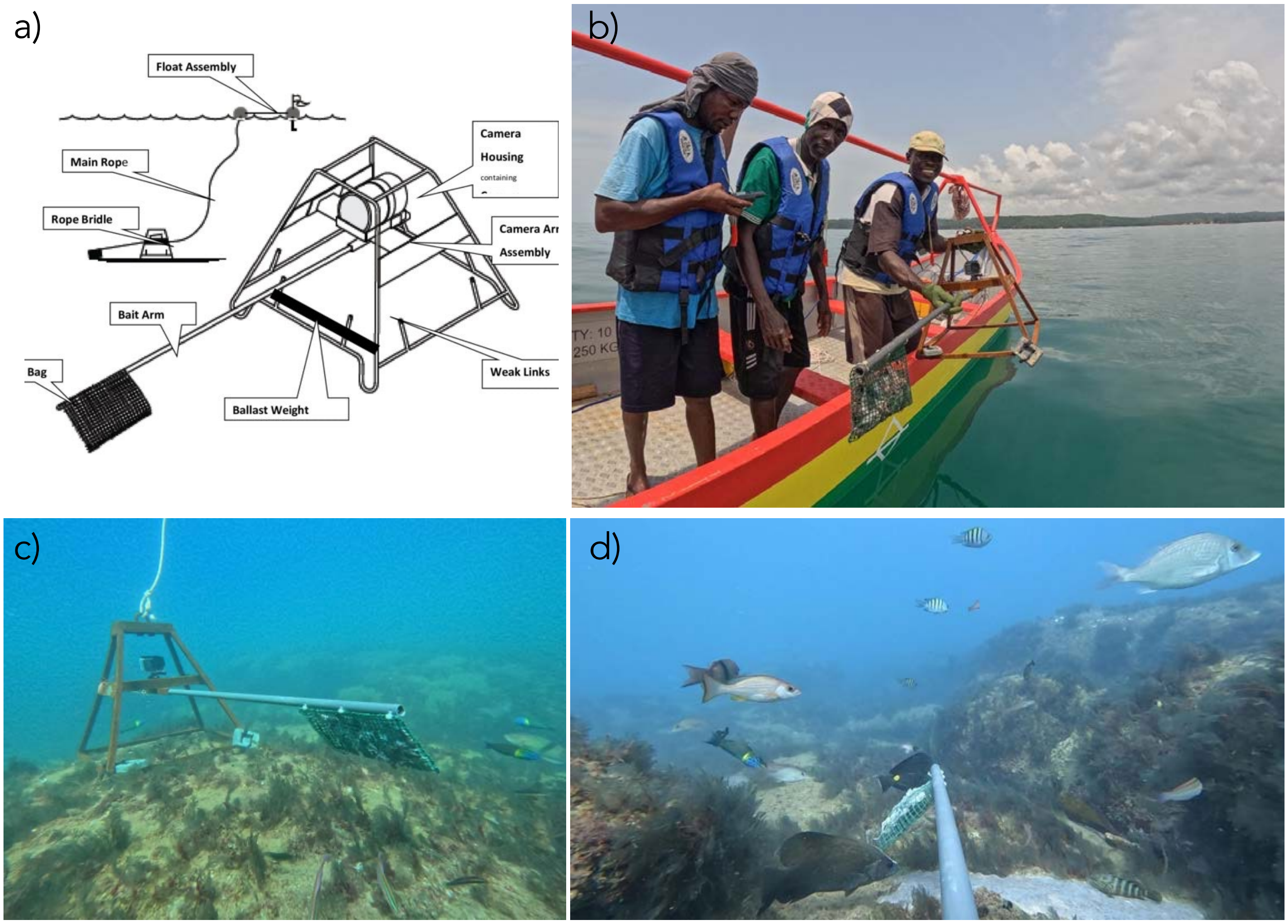


Figure 5. a) Major components of a single BRUVS system (Harvey et al., 2013), b) The benthic BRUVS deployed from the boat during the study. c) Image of the BRUVS deployed on the reef at Butre at 8 m depth d) Frame grab from the BRUVS on the rocky outcrop at Butre.

3.2.5 Pelagic BRUVS

Pelagic BRUVS (also known as mid-water BRUVS) can be deployed as either drifting systems or anchored to the seafloor. This depends on the depths where the surveys take place. The anchored or moored Pelagic BRUVS were used in this study at these shallow depths (<40 m) as they are easier to relocate after deployment and do not drift vast distances in the current. A diagram for a pelagic BRUV is provided in Figure 5, although this shows a stereo-camera system, only a single camera (GoPro Hero 10) was used for this research.

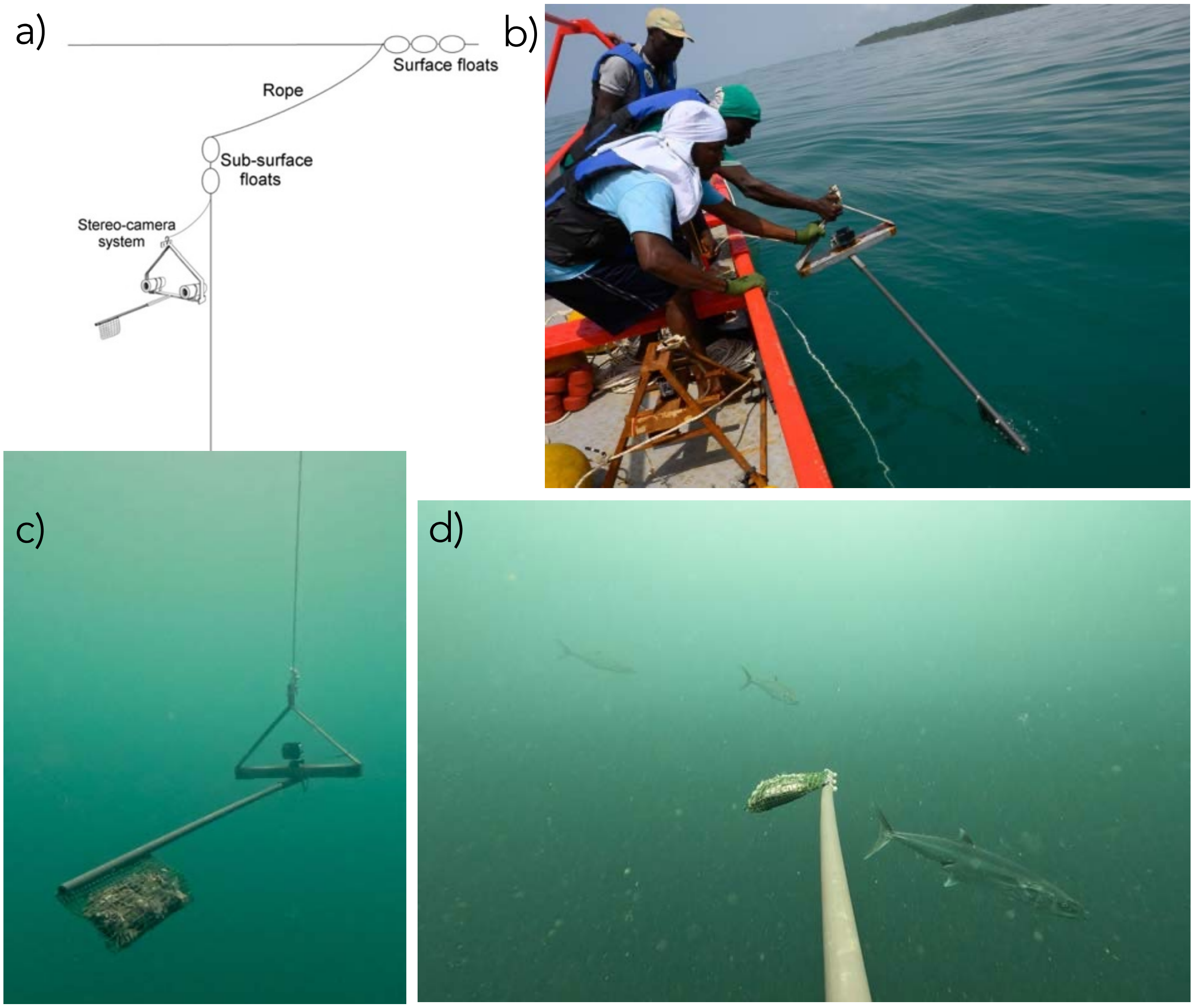


Figure 6. a) A schematic for a stereo-video pelagic BRUV that is anchored to the seabed (Santana-Garcon et al., 2014). b) The pelagic BRUVS deployed from the boat during the study. c) Image of the BRUVS hanging at a depth of 7m. d) Frame grab from the Pelagic BRUVS showing three West African Spanish mackerel.

3.2.6 Drop Camera

A drop camera system was developed to assess the habitat within the proposed MPA area. This method and its application for MPA assessments is less established than BRUVs surveys, but it is advantageous as it can be done quickly, only needing to be deployed for at least 5 seconds and therefore suited to ground-truthing habitat at relatively large spatial areas such as MPAs.

This system collected useful data when the water visibility was clean, especially at an offshore reef out from Achonwa where there was lots of fishing activity and not possible to deploy the BRUVs which need to be deployed for at least 1 hr. Unfortunately, for most of the surveys the water visibility was too poor to gather useful data. Especially on the deeper portions of the reef (>20 m) and on the soft sediment habitats where visibility was less than over the shallow reefs.

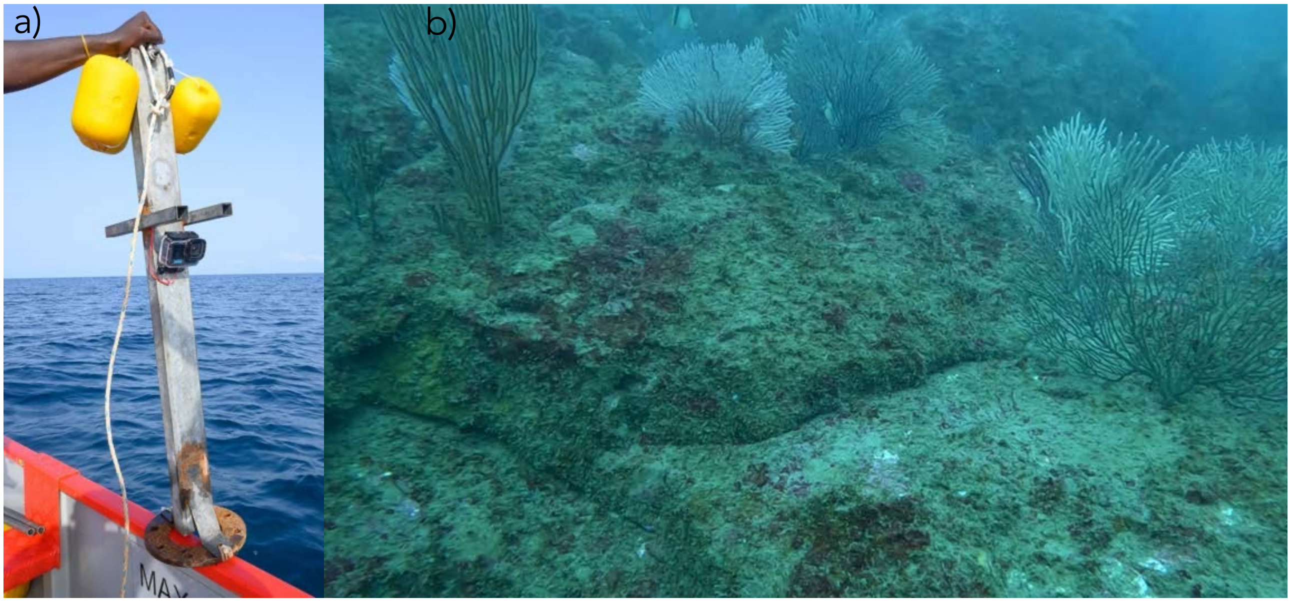


Figure 7. a) The drop camera systems developed for these surveys with a single GoPro Hero10. b) Frame grab from the drop camera deployed on the reef offshore from Miemia at a depth of 21 m

3.2.7 Sampling operations and experimental design

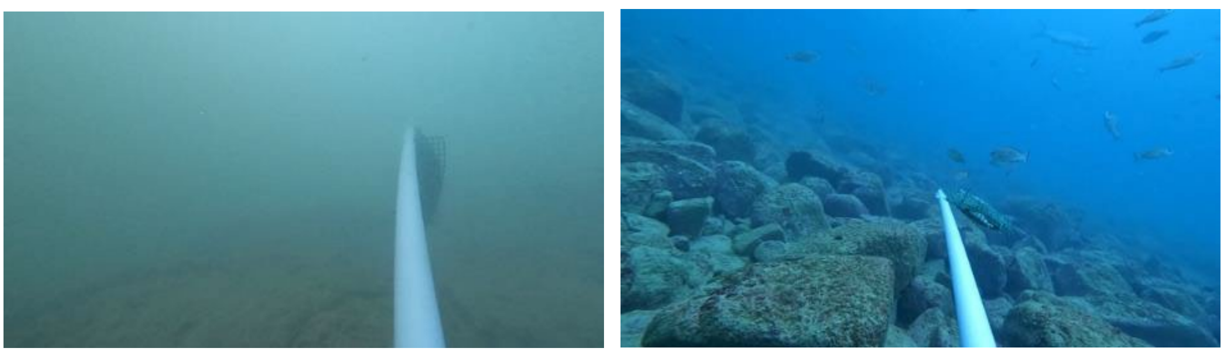
Globally accepted protocols for the use of BRUVs were followed which can allow future comparisons to data collected in other locations and provide a robust baseline for future surveys in the area to track changes over time.

Distance between BRUVS samples: Replicate benthic BRUVs were separated by at least 400 m distance as recommended by Langlois et al. (2020). Such separation between camera deployments aim to increase the independence of replicates, as mobile fish can be attracted to the bait from an unknown distance and could move between cameras and be counted twice. Pelagic BRUVs are suggested to require larger distances between replicates for which 500 m is recommended by Santana-Garcon (2014), although 250 m is used by other studies when deploying drifting systems tethered together (Bouchet and Meeuwig, 2015). Here we followed the protocol of separating the pelagic BRUVS by at least 500 m.

Length of BRUVS deployments: Standard procedures for benthic BRUVS is that they are deployed for at least 60 min (Langlois et al. 2020), whereas pelagic BRUVS are recommended to be deployed for 120 min due to the mobile nature of pelagic fish and often sparse numbers of fish encountered on video (Bouchet et al., 2018). This project used these standard soak times so the data collected is comparable to surveys in other parts of the world.

Number of BRUVS deployments: It was originally planned that 3 days would be focused on BRUVS at each of the 3 parts of the MPA (with one day reserved for bathymetric mapping), for which at least 6 benthic BRUVS and 4 pelagic BRUVS would be deployed each day using three benthic BRUVs frames and two pelagic BRUVs frames that can be deployed simultaneously. This level of BRUVS sampling effort was achieved each day and exceeded the planned number of replicates as four full days of surveys were done in each part of the MPA, with 74 benthic BRUVS and 48 pelagic BRUVs deployed over 12 days. In total 122 BRUVS were deployed, and 170 hours of video footage collected.

Distribution of sampling effort: Benthic BRUVs replicates are typically grouped into sites where 3-5 BRUVS are grouped together within certain habitats which aids in the statistical analysis of the data and comparing areas such as zones within an MPA. This study aimed to sample six different reef systems (two reefs in each of the three parts of the MPA – East, Central and West). Surveys were also going to take place on the soft sediment areas between reefs, but it was apparent that the water visibility was too poor with most replicates deployed deeper than 20 m being too dark to observe the fish. This also limited the ability to survey the reefs and although on most reefs, 12 deployments were made, only half of them captured useful video footage (Figure 7). Therefore, 6 replicate benthic BRUVS were analysed for the final study on five of the six reefs – the reef close to Agyan was too murky with only one benthic BRUV collecting useful data, as such this reef was not included for the final study of benthic fishes. For pelagic BRUVs surveys, is has been recommended that a sample size of at least 8 replicates per treatment (for example, a particular habitat or protected zone) would be optimal for sampling using pelagic stereo-BRUVs in tropical or warm-temperate areas (Santana-Garcon et al., 2014), as such 8 replicates were used to study pelagic fish around the 6 different reefs.



a) b)

Figure 8. a) Example of a benthic BRUVS were water visibility to too poor to analyse the video. b) Frame grab from the BRUVS on the rocky outcrop offshore from Miemia when the water was clearer.

Drop camera surveys: Drop camera sampling locations are typically predefined using a grid of GPS positions that are created either with a random distribution or using an equally spaced grid. However, as the bathymetry of the proposed MPA area is not known, sampling was done more opportunistically to quickly validate the areas of interest based on local ecological knowledge and bathymetric mapping operations. Deployments were made when waiting for the BRUVS to soak for their pre-defined times of 1 hr for benthic BRUVs and 2 hrs for pelagic systems. This was not done as much as planned due to the water visibility limiting the data collected in the deeper waters and any waiting time was spent focusing on bathymetric mapping.

Bathymetric mapping: It became clear from the scoping trip that the existing bathymetry for this area is not accurate. Therefore, a priority of this study was to map the location and extent of the rocky outcrop areas that were identified from LEK participatory mapping (GFRA, 2023). To create detailed bathymetric maps, vessel tracks recording sonar was done in a grid pattern with a maximum separation of 250 m between tracks, but a smaller distance of ~50-100 m was aimed for when surveying over the reefs. Given the depths are relatively shallow in this area (~30 m), the 200 KHz sonar used provides a survey swath of approximately 10 m wide (less in shallower water). Therefore, if there are features of the seabed that are smaller than the distance between survey swaths they can be missed. Typically, the shallowest potions of reef were where the surveys were focused and had many overlapping tracks when deploying the BRUVs.

3.2.8 Analysis of video data

Specialised software, EventMeasure from SeaGIS (www.seagis.com.au) was used to annotate the BRUVS footage, where fish species are identified and counted. The standard metric of abundance used is MaxN, the maximum number of individuals of a given species present in a single video frame (Langlois et al., 2020). MaxN is widely used for BRUVS as it is conservative and ensures that no individual is counted more than once. Data was formatted to global standards and can be uploaded to Global Archive, an online centralised repository of fish image annotation and ecological data to facilitate future data sharing and worldwide comparisons (https://globalarchive.org/).

3.2.9 Location of survey sites and BRUVS samples

Six different reef sites were sampled with BRUVS where bathymetric surveys were done. There were two reef sites in each of the three parts of the proposed MPA area, West, Central and East. The site names used here were used to distinguish between sites for the use of the fieldwork, but do not reflect the local names of the reef and where communities go fishing. For example, the reef site called Miemia is closer to the communities of Egyambra, Agyan, Akonu and Domunli, but it was the first reef sampled when based at Miemia.

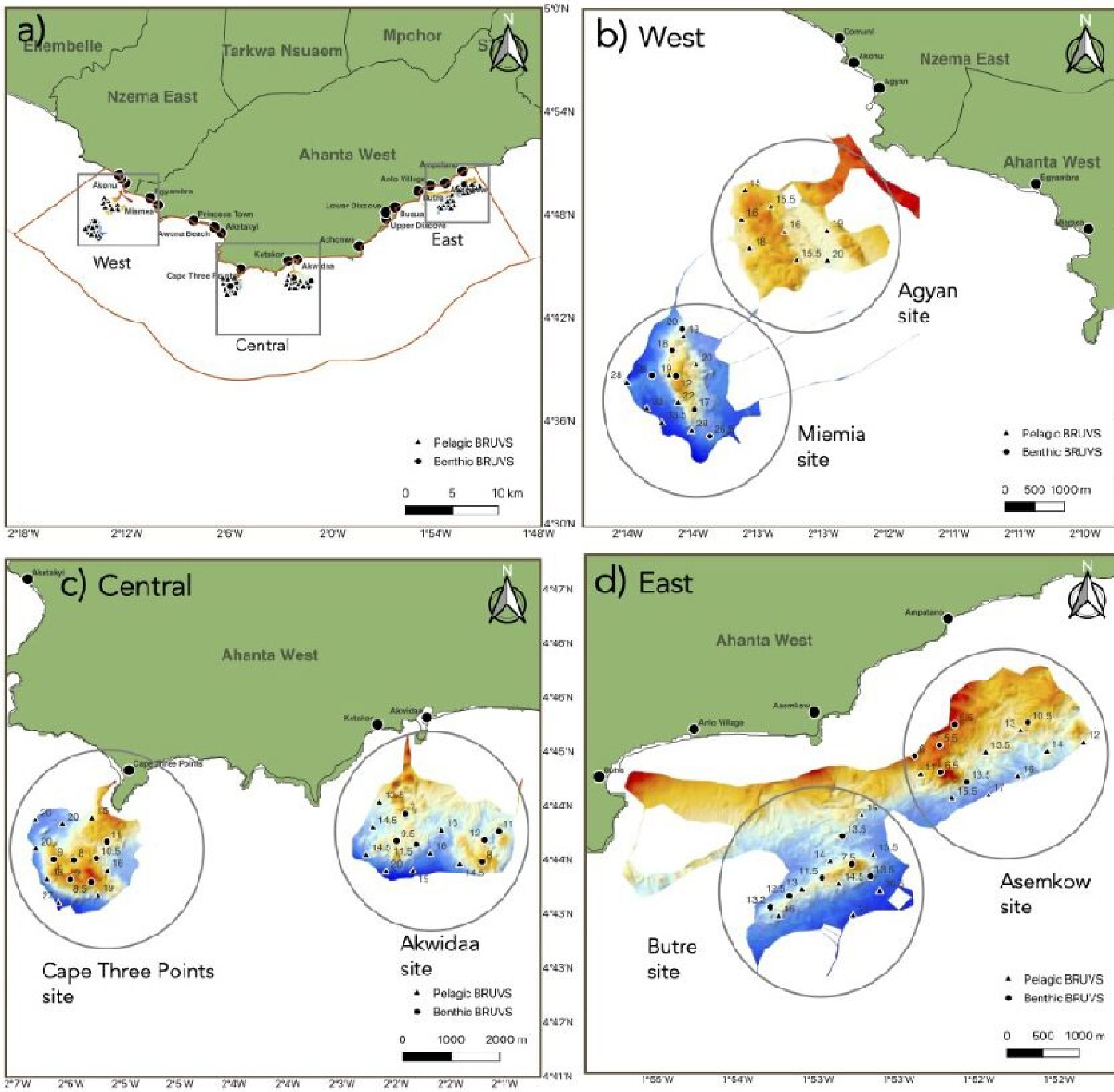


Figure 9. The six reef sites that were sampled during the study, the location of the benthic BRUVS (circles) and Pelagic BRUVS (triangles) are provided and the associated seabed depth where the cameras were deployed. For the pelagic BRUVS the cameras were positioned 7-10 meters below the surface. The areas of bathymetric surveys are overlayed in a blue-red colour gradient with red showing the shallowest depths.

4. RESULTS

4.1 Distribution of rocky reefs

The LEK participatory mapping from Hen Mpoano (GRFA, 2023) identified five main areas of rocky reefs in the GCTPA (Figure 8). These sites were confirmed from community fishermen that accompanied and guided the fieldwork to the shallowest points of the reef (the 'rocks' as they are known). When validating these reef areas through bathymetric mapping and video surveys, the extent of these reefs was not as large as the areas identified during the LEK mapping, with each of the reefs that were fully mapped having areas of ~ 1 km². The reef offshore to the SW of Miemia and east of Agyan had an area of 1 km², the reef closer to shore from Agyan had an area of at least 1.25 km², the reef out from Cape Three Points covered an area of 1.25 km², offshore from Akwidaa there are two reefs close together each with an area of 0.5 km² each. The reef SE of Butre had an area of 0.3 km². There were also more extensive reef systems closer to shore and extending past Ampatano to the east, but the full extent of this reef system could not be mapped in the four days of surveys. Overall, there was approximately 4 km² of offshore reefs (separated from the coastline by a deeper sand channel) that were mapped as part of the research. In addition, there is a small reef coming from 35 m depth to a shallow point of 18 m located 4.5 km offshore from Achonwa. Basic mapping was done on one day, but the data file became corrupted, nonetheless the position and depth of the reef was marked from drop camera deployments along with another shallow inshore reef close to the coastline (Figure 9). There is also another small reef 9 km offshore from Dixcove, at a depth of 36 m. This reef appeared to only cover a small area ~ 200 m in length and did not rise more than 2 m from the surrounding sand area. These are the main reef systems in the GCTPA according to local fishers and are important areas for fishing activities.

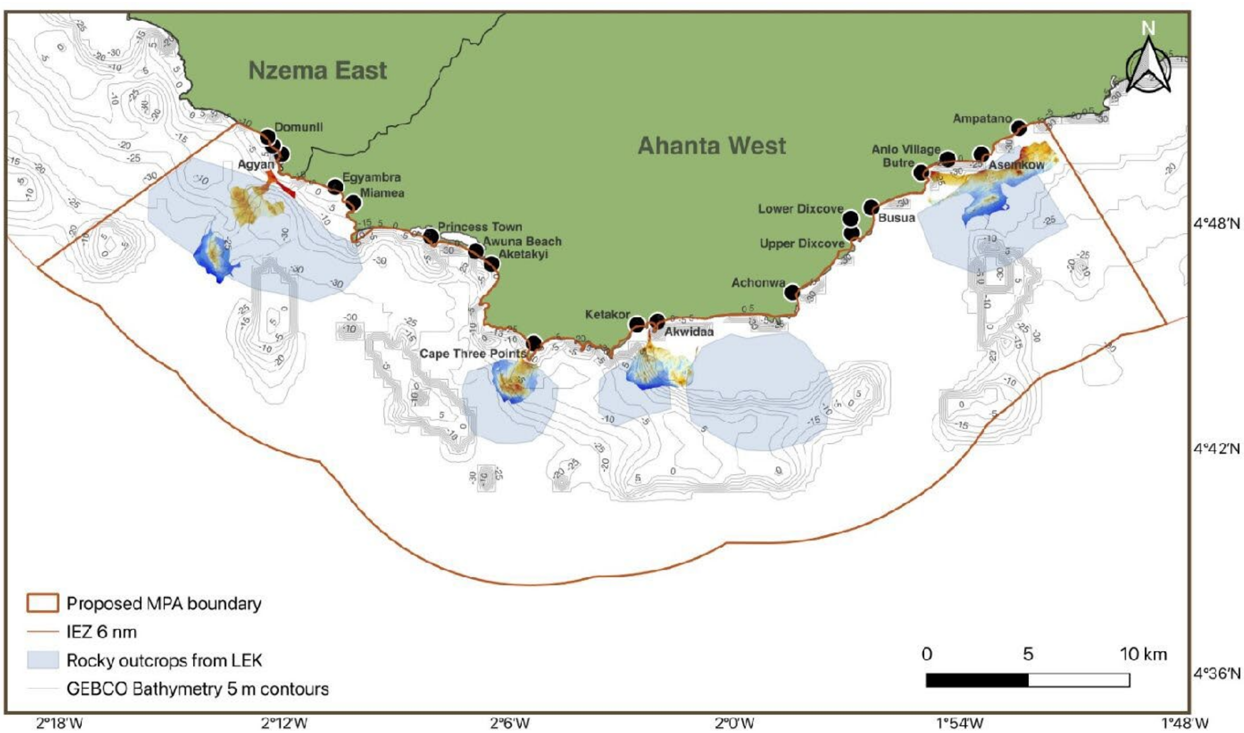


Figure 10. The location of rocky reefs in the Greater Cape Three Points area. The location and extent of the rocky outcrops identified from LEK participatory mapping are shown in blue. The publicly available GEBCO bathymetry is shown as contour lines and the areas mapped during this project are overlayed in a blue-red colour gradient, with the warmer colours showing where the depth is shallowest where the reef was present.

It was evident from this bathymetric mapping that the publicly available GEBCO bathymetry data is not accurate and identifies the offshore reef as having a depth of 25-30 meters, when it comes to a shallow point of 10 m depth (Figure 9). It also shows an area coming up to 0 m depth to the east of the reef system. This area was validated with the depth sounder and drop camera where the depth was shown to be 35 m and was an area of sand/mud.

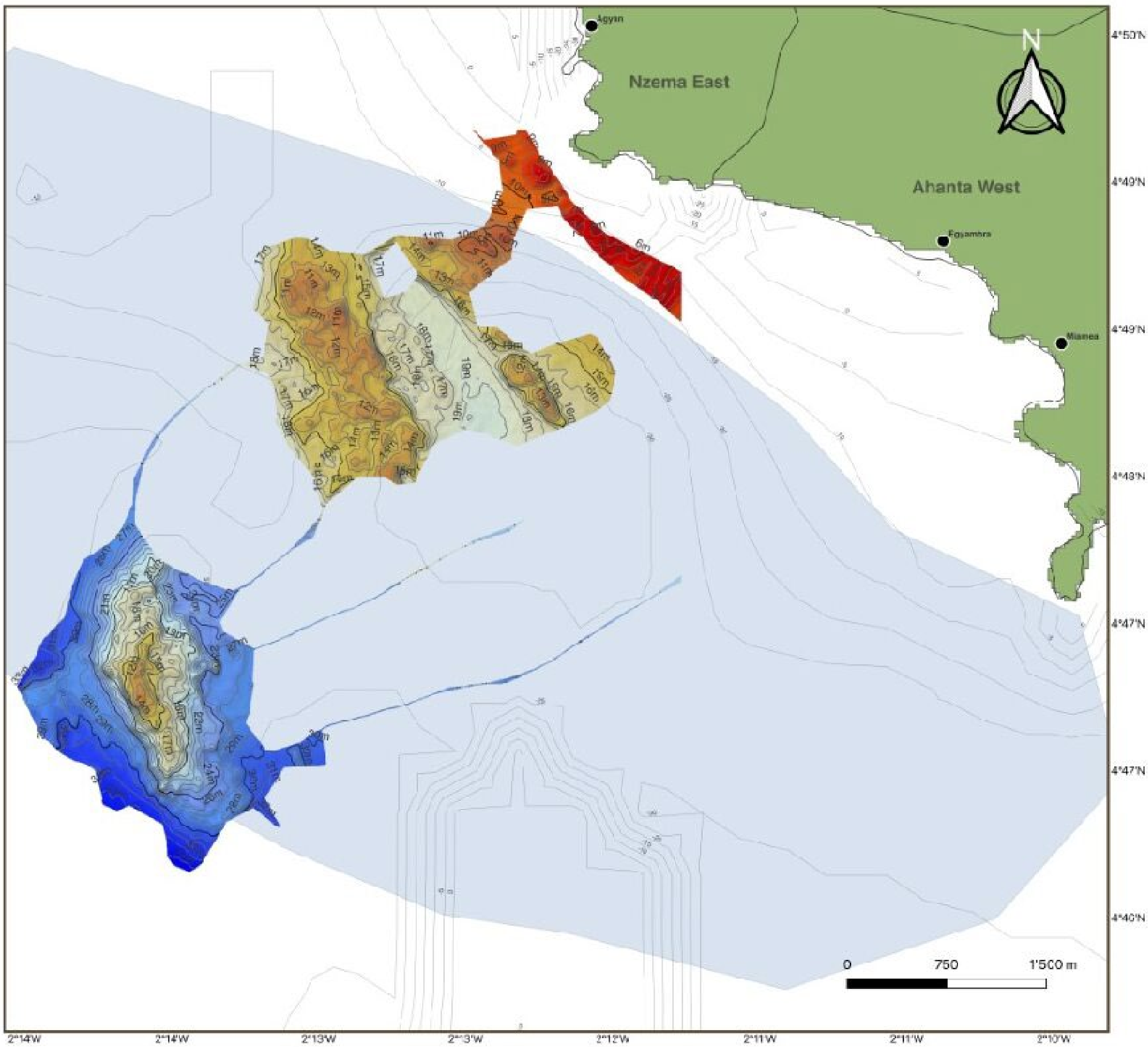


Figure 11. A detailed view of the reef systems mapped in the western part of the GCTPA. The light blue shading showed the general area of reefs identified from LEK participatory mapping. The publicly available GEBCO bathymetry is shown as contour lines and the areas mapped during this project are overlayed in a blue-red colour gradient with the contour lines showing the depths.

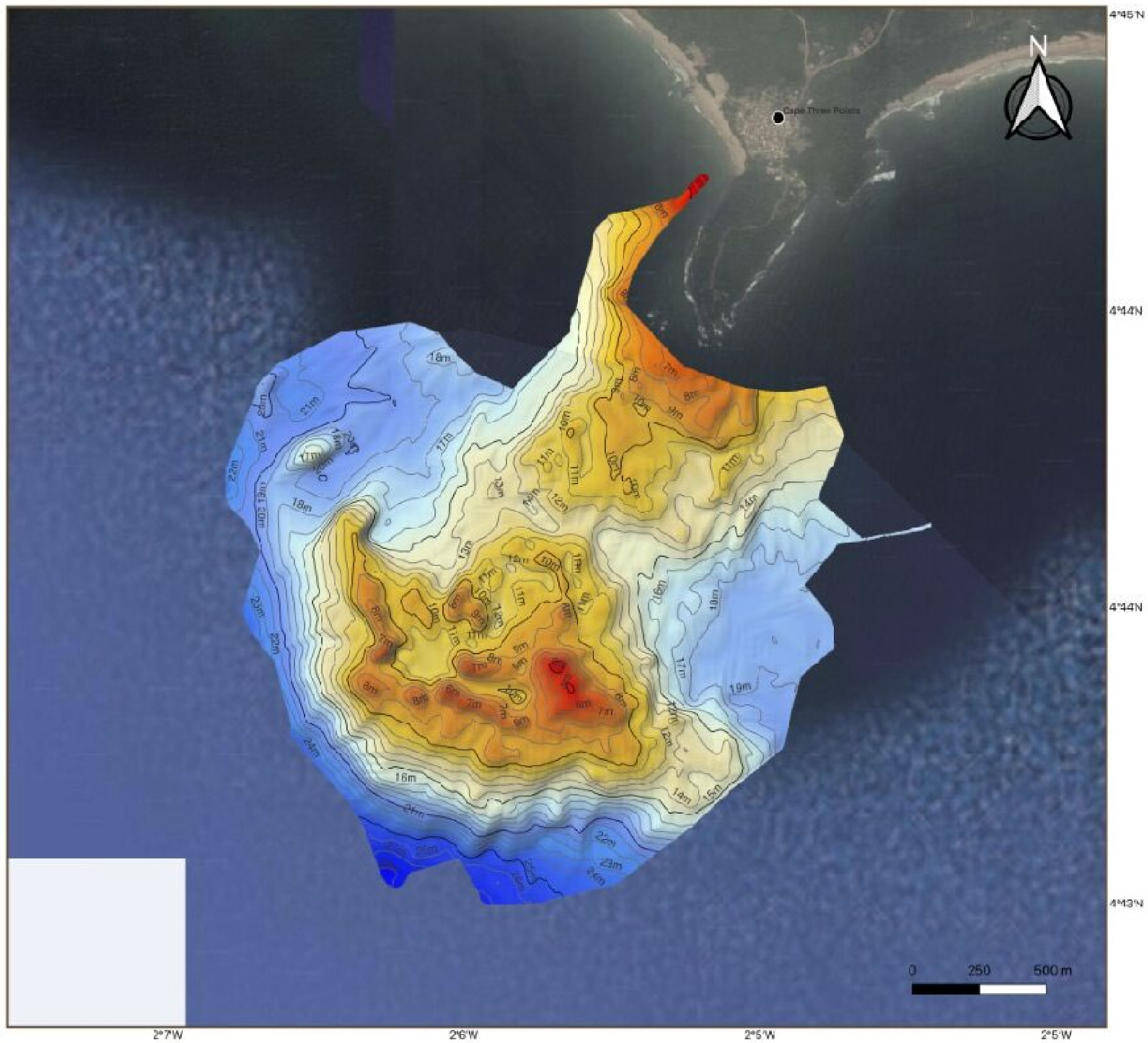


Figure 12. A zoomed in view showing the rocky reef offshore from Cape Three Points. Typically, at depths greater than 16 m the reef is covered by sand and a shallower sand channel separates the inshore and offshore reefs at a depth of 14 m. The shallowest part of the reef comes up to 5 m depth.

4.2 Fish Abundance and Diversity

From the 78 BRUVS that were analysed during the study, 1,758 fish were counted from 65 species representing 32 families. The vast majority of these species were observed from the benthic BRUVS with 6 species being observed from both sampling methods. The most abundant species were the scads (*Decapterus* spp). These scads are difficult to identify to species level from underwater observations and could be either *Decapterus macarellus* or *Decapterus punctatus*. The next most abundant species was the small planktivorous damselfish (*Azurina multilineata*) followed by the surgeonfish (*Acanthurus monroviae*), the Golden African snapper (*Lutjanus fulgens*) and the Atlantic emperor (Lethrinus atlanticus).

The highest diversity of species was observed at the Miemia site with 49 species, followed by 38 species at Akwidaa, and the lowest diversity was found at Asemkow. The greatest abundance was found at Akwidaa, which was driven by the schools of scad (*Decapterus spp*). The next highest abundance was followed by Miemia which had large numbers of damselfish observed on the benthic BRUVS, but also large schools of the of the longfin crevalle jack (*Caranx fischeri*) observed on the pelagic BRUVS.

Table 1: List of fish species observed from the pelagic and benthic BRUVS surveys. The numbers are the total of the MaxN observed from the video footage. Note that there were no benthic BRUVS surveys at the Agyan site due to reduced visibility at this site.

Family common name	Family	Taxa	BRUVS	Site						
				Agyan	Miemia	CTP	Akwidaa	Butre	Asemkow	Total
Surgeonfishes	Acanthuridae	*Acanthurus monroviae*	Benthic		28	36	47	40	13	**164**
			Pelagic		17					**17**
Triggerfishes	Balistidae	*Balistes punctatus*	Benthic		1	1	1	1	5	**9**
Blennies	Blenniidae	*Ophioblennius atlanticus*	Benthic		2	3	1	1		**7**
Jacks and Scads	Carangidae	*Caranx crysos*	Benthic	32	17					**49**
			Pelagic					9	3	**12**
		Caranx fischeri	Pelagic		42		1		5	**48**
		Caranx hippos	Benthic	2	1	2	3			**8**
			Pelagic		2					**2**
		Caranx latus	Pelagic		1					**1**
		Caranx spp	Pelagic				14			**14**
		Chloroscombrus chrysurus	Pelagic			2	17			**19**
		Decapterus spp	Benthic		3	44	49	26	94	**216**
			Pelagic				52			**52**
		Elagatis bipinnulata	Pelagic		4					**4**
		Scyris alexandrina	Benthic						1	**1**
		Scyris ciliaris	Pelagic		8					**8**
		Trachinotus goreensis	Pelagic		6		2			**8**
Butterflyfishes	Chaetodontidae	*Chaetodon robustus*	Benthic		1			2		**3**
		Prognathodes marcellae	Benthic		2					**2**
Hawkfishes	Cirrhitidae	*Cirrhitus atlanticus*	Benthic		1			1	1	**3**
Pufferfishes	Diodontidae	*Unknown spp*	Benthic			1				**1**
Remoras	Echeneidae	*Echeneis naucrates*	Pelagic	1			2			**3**
Ladyfishes	Elopidae	*Elops senegalensis*	Pelagic				2			**2**
Spadefishes	Ephippidae	*Ephippus goreensis*	Benthic		6	1	35	7	3	**52**
Groupers	Epinephelidae	*Cephalopholis nigri*	Benthic		8	15	16	17	15	**71**
		Cephalopholis taeniops	Benthic		7	2				**9**
Soapfishes	Grammistidae	*Rypticus saponaceus*	Benthic					1	1	**2**
Grunts	Haemulidae	*Parakuhlia macrophthalma*	Benthic			1	2	1	11	**15**
		Plectorhinchus macrolepis	Benthic		2				1	**3**
		Pomadasys incisus	Benthic				1			**1**
Soldierfish and Squirrelfish	Holocentridae	*Myripristis jacobus*	Benthic		1					**1**
		Sargocentron hastatum	Benthic		1					**1**
Sea chubs	Kyphosidae	*Kyphosus sectatrix*	Benthic					2		**2**
Wrasses	Labridae	*Bodianus speciosus*	Benthic		11	5	9	12	9	**46**
		Coris atlantica	Benthic		12	15	8	28	9	**72**
		Thalassoma newtonii	Benthic		12	14	10	11	6	**53**
Blennies	Labrisomidae	*Labrisomus nuchipinnis*	Benthic					1	1	**2**
Emperorfishes	Lethrinidae	*Lethrinus atlanticus*	Benthic		13	9	7	31	17	**77**
Snappers	Lutjanidae	*Apsilus fuscus*	Benthic		5	1		5		**11**
		Lutjanus agennes	Benthic		1	3	3	10	4	**21**
			Pelagic		8					**8**
		Lutjanus endecacanthus	Benthic		1					**1**

		Lutjanus fulgens	Benthic		31	29	8	12	11	**91**
		Lutjanus goreensis	Benthic		1			2	1	**4**
		Lutjanus spp	Benthic			1				**1**
Filefishes	Monacanthidae	*Cantherhines pullus*	Benthic		2	2	1	2	1	**8**
Goatfishes	Mullidae	*Pseudupeneus prayensis*	Benthic		2	2		3	4	**11**
Moray eels	Muraenidae	*Enchelycore nigricans*	Benthic		4	6	3	1		**14**
		Gymnothorax afer	Benthic		5	4	3	1	1	**14**
		Muraena melanotis	Benthic		2	1				**3**
		Muraena robusta	Benthic			1				**1**
Boxfishes	Ostraciidae	*Acanthostracion spp*	Benthic			1				**1**
Angelfishes	Pomacanthidae	*Holacanthus africanus*	Benthic		6	3	2	3		**14**
Damselfishes	Pomacentridae	*Abudefduf saxatilis*	Benthic		9	16	21	12	5	**63**
		Azurina multilineata	Benthic		48	26	102	7		**183**
		Chromis limbata	Benthic		47	3		17		**67**
		Microspathodon frontatus	Benthic			3				**3**
		Stegastes imbricatus	Benthic		1	7	2	2	1	**13**
Cobias	Rachycentridae	*Rachycentron canadum*	Pelagic		1	1				**2**
Parrotfishes	Scaridae	*Scarus hoefleri*	Benthic		10	7	6	16	17	**56**
		Sparisoma choati	Benthic		2	3		7	9	**21**
Mackerels and tunas	Scombridae	*Sarda sarda*	Pelagic		1		1			**2**
		Scomberomorus tritor	Benthic		27		3			**30**
			Pelagic				1			**1**
Combers	Serranidae	*Serranus inexpectatus*	Benthic		3			3		**6**
Porgies and pickarels	Sparidae	*Dentex gibbosus*	Benthic		3		2			**5**
		Pagrus caeruleostictus	Benthic				1			**1**
		Spicara melanurus	Benthic				4	1	9	**14**
Barracudas	Sphyraenidae	*Sphyraena afra*	Pelagic		1					**1**
		Sphyraena sphyraena	Pelagic				4			**4**
		Sphyraena spp	Benthic				4			**4**
Puffers	Tetraodontidae	*Canthigaster supramacula*	Benthic		4	4	2	3	2	**15**
		Lagocephalus laevigatus	Benthic		2		2			**4**
		Total number		**35**	**436**	**275**	**454**	**298**	**260**	**1758**
		Species richness		**3**	**49**	**36**	**38**	**35**	**29**	**65**

4.2.1 Demersal fish abundance and diversity

The benthic BRUVS were used to sample the demersal fish communities found on the rocky reefs. From the 30 BRUVS that were analysed during the study (six at each of the five sites), 1,478 fish were counted from 54 species representing 29 families (Table 2). The highest number of fish was observed at the Miemia site, with 293 followed by Cape Three Points and similar numbers (~250) at the other three sites. The highest diversity of species was also found at Miemia with 39 species, followed by Butre with 35 species, Cape Three Points with 33 species and 28-29 at the other two sites.

Table 2: List of fish species observed from the benthic BRUVS surveys. The numbers are the total of the MaxN observed from the video footage

			Site					
Common family name	**Family**	**Taxa**	**Miemia**	**CTP**	**Akwidaa**	**Butre**	**Asemkow**	**Total**
Surgeonfishes	Acanthuridae	*Acanthurus monroviae*	28	36	47	40	13	**164**
Triggerfishes	Balistidae	*Balistes punctatus*	1	1	1	1	5	**9**
Blennies	Blenniidae	*Ophioblennius atlanticus*	2	3	1	1		**7**
Jacks and Scads	Carangidae	*Caranx crysos*				9	3	**12**
	Carangidae	*Caranx hippos*	2					**2**
	Carangidae	*Decapterus spp*	3	44	49	26	94	**216**
	Carangidae	*Scyris alexandrina*					1	**1**
Buterflyfishes	Chaetodontidae	*Chaetodon robustus*	1			2		**3**
	Chaetodontidae	*Prognathodes marcellae*	2					**2**
Hawkfishes	Cirrhitidae	*Cirrhitus atlanticus*	1			1	1	**3**
Pufferfishes	Diodontidae	*Unknown spp*		1				**1**
Spadefishes	Ephippidae	*Ephippus goreensis*	6	1	35	7	3	**52**
Groupers	Epinephelidae	*Cephalopholis nigri*	8	15	16	17	15	**71**
	Epinephelidae	*Cephalopholis taeniops*	7	2				**9**
Soapfishes	Grammistidae	*Rypticus saponaceus*				1	1	**2**
Grunts	Haemulidae	*Parakuhlia macrophthalma*		1	2	1	11	**15**
	Haemulidae	*Plectorhinchus macrolepis*	2				1	**3**
	Haemulidae	*Pomadasys incisus*			1			**1**
Soldierfish and Squirrelfish	Holocentridae	*Myripristis jacobus*	1					**1**
	Holocentridae	*Sargocentron hastatum*	1					**1**
Sea chubs	Kyphosidae	*Kyphosus sectatrix*				2		**2**
Wrasses	Labridae	*Bodianus speciosus*	11	5	9	12	9	**46**
	Labridae	*Coris atlantica*	12	15	8	28	9	**72**
	Labridae	*Thalassoma newtonii*	12	14	10	11	6	**53**
Blennies	Labrisomidae	*Labrisomus nuchipinnis*				1	1	**2**
Emperorfishes	Lethrinidae	*Lethrinus atlanticus*	13	9	7	31	17	**77**
Snappers	Lutjanidae	*Apsilus fuscus*	5	1		5		**11**
	Lutjanidae	*Lutjanus agennes*	1	3	3	10	4	**21**
	Lutjanidae	*Lutjanus endecacanthus*	1					**1**
	Lutjanidae	*Lutjanus fulgens*	31	29	8	12	11	**91**
	Lutjanidae	*Lutjanus goreensis*	1			2	1	**4**
	Lutjanidae	*Lutjanus spp*		1				**1**
Filefishes	Monacanthidae	*Cantherhines pullus*	2	2	1	2	1	**8**
Goatfishes	Mullidae	*Pseudupeneus prayensis*	2	2		3	4	**11**
Moray eels	Muraenidae	*Enchelycore nigricans*	4	6	3	1		**14**
	Muraenidae	*Gymnothorax afer*	5	4	3	1	1	**14**
	Muraenidae	*Muraena melanotis*	2	1				**3**
	Muraenidae	*Muraena robusta*		1				**1**
Boxfishes	Ostraciidae	*Acanthostracion spp*		1				**1**
Angelfishes	Pomacanthidae	*Holacanthus africanus*	6	3	2	3		**14**
Damselfishes	Pomacentridae	*Abudefduf saxatilis*	9	16	21	12	5	**63**
	Pomacentridae	*Azurina multilineata*	48	26	102	7		**183**

	Pomacentridae	*Chromis limbata*	47	3		17		**67**
	Pomacentridae	*Microspathodon frontatus*		3				**3**
	Pomacentridae	*Stegastes imbricatus*	1	7	2	2	1	**13**
Parrotfishes	Scaridae	*Scarus hoefleri*	10	7	6	16	17	**56**
	Scaridae	*Sparisoma choati*	2	3		7	9	**21**
Mackerels and tunas	Scombridae	*Scomberomorus tritor*			1			**1**
Combers	Serranidae	*Serranus inexpectatus*	3			3		**6**
Porgies and pickarels	Sparidae	*Dentex gibbosus*	3		2			**5**
	Sparidae	*Pagrus caeruleostictus*			1			**1**
	Sparidae	*Spicara melanurus*			4	1	9	**14**
Barracudas	Sphyraenidae	*Sphyraena spp*			4			**4**
Puffers	Tetraodontidae	*Canthigaster supramacula*	4	4	2	3	2	**15**
	Tetraodontidae	*Lagocephalus laevigatus*	2		2			**4**
		Total number	**302**	**270**	**353**	**298**	**255**	**1478**
		Species richness	**39**	**33**	**29**	**35**	**28**	**54**

To compare the species assemblages between the five sites, the most abundant species were ranked, and their abundances plotted between each of the sites (Figure 11). This showed that the most abundant species were small schooling species, for which Miemia had large numbers of small planktivorous damselfish *Azurina multilineata* and *Chromis limbata,* whereas the highest abundances at the other sites were mainly from the mid-water schooling scad (*Decapterus* spp). The third most abundant species, the West African surgeonfish (*Acanthurus monroviae*) was regularly observed on 86% of surveys. Although in lower abundances, the most consistently observed species were the Niger hind (*Cephalopholis nigri*) and the blackbar hogfish (*Bodianus speciosus*) which were both found on 93% of samples.

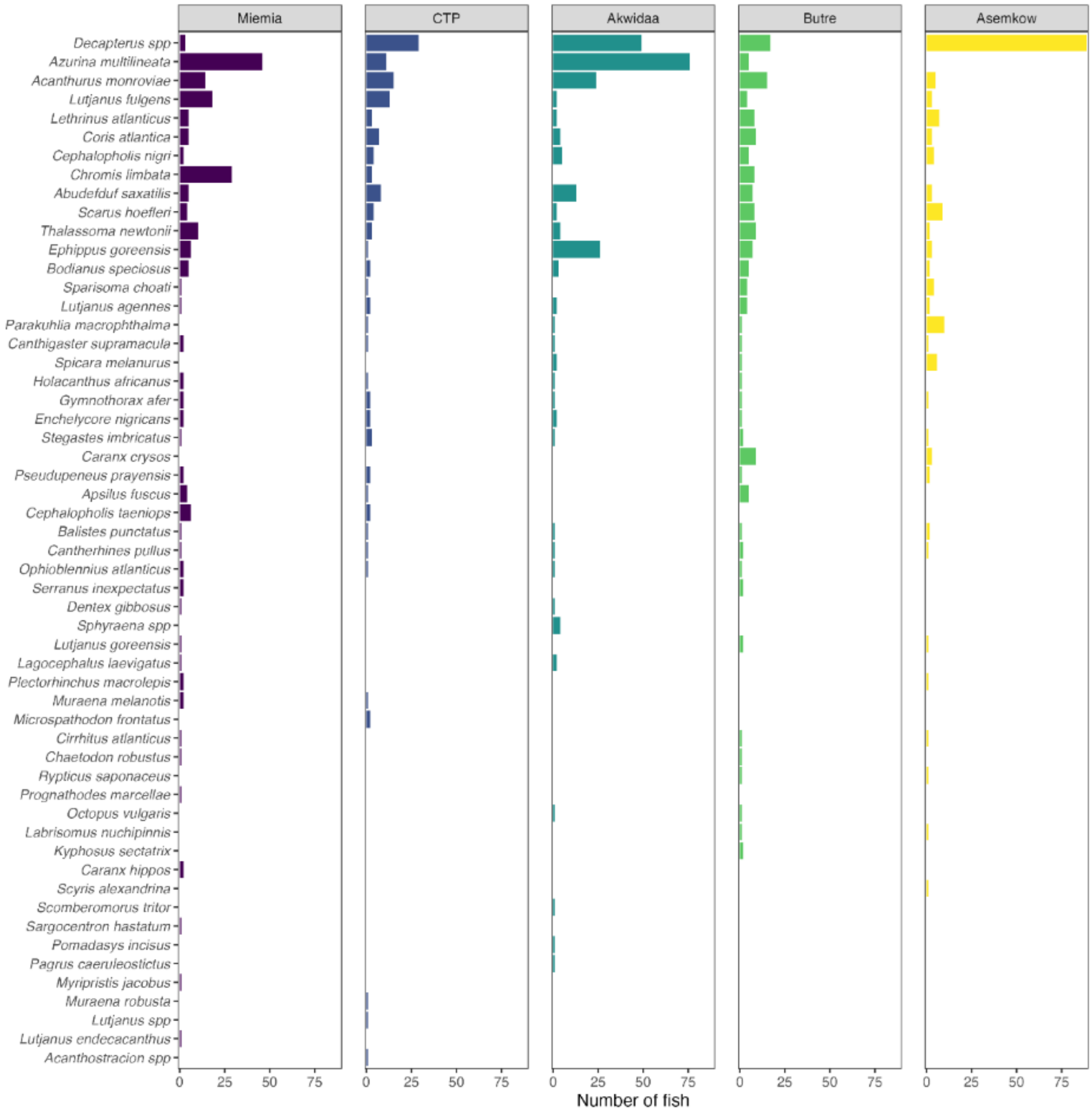


Figure 13. Ranked abundance of all species observed from the benthic BRUVS between each of the sampling sites.

In terms of the average number of fish per site (average of the six BRUVS replicates), Akwidaa had the highest number, with Miemia and Butre having similar abundance (Figure 12). No sites were significantly different from one another. The average species richness was highest at Cape Three Points, very close to Miemia with 15 species. Asemkow had the lowest diversity and abundance across these five sites.

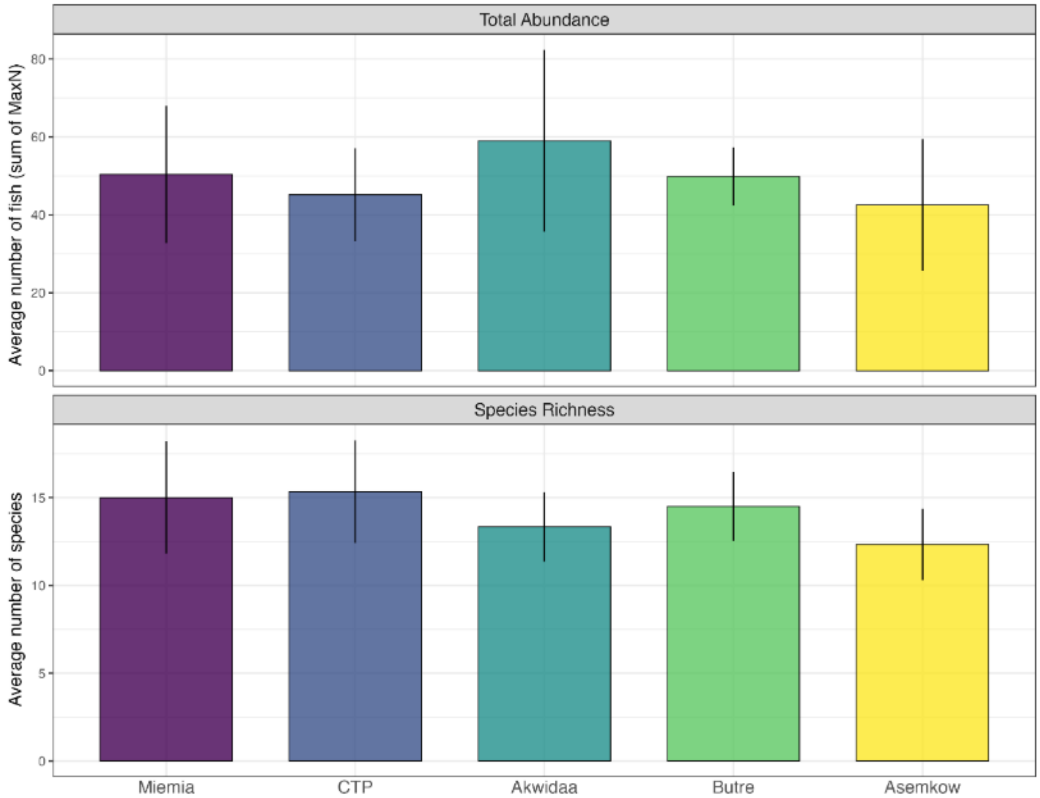


Figure 14. Average abundance and species richness of demersal fish species across the five sites surveyed. Note that demersal fish were not surveyed at the reef close to Agyan.

To investigate the abundance of fisheries targeted demersal species at the different reefs, the list of species was reduced to include the main larger bodied reef resident species that would be targeted by line fishers. This included the families Lutjanidae, Lethrinidae and Sparidae, but excluded the smaller schooling species found in these families. This analysis showed that the highest number of demersal fishery targeted species were recorded in Butre, which was significantly greater than the nearby adjoining reef offshore from Asemkow. The next greatest abundance was at the Miemia site, with Cape Three Points and Akwidaa having similarly low abundance with an average only two fish observed from each sample.

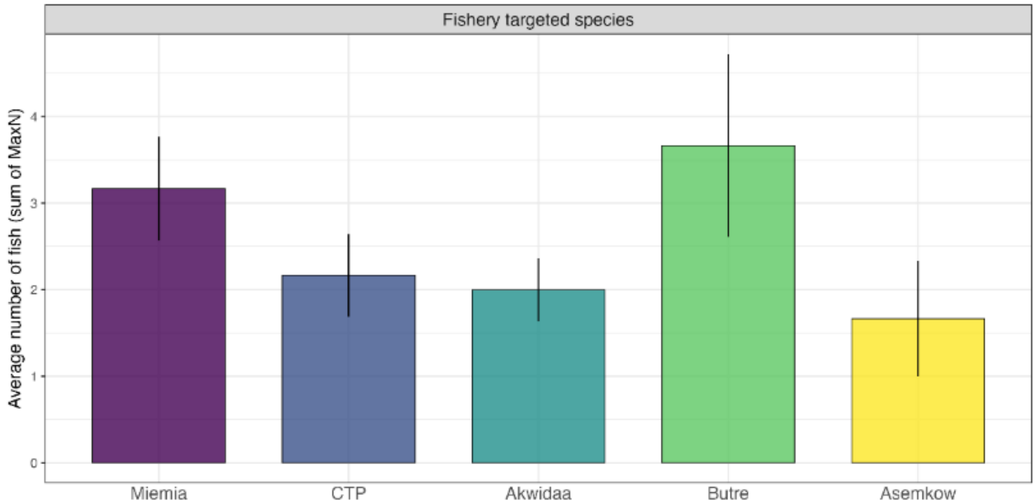


Figure 15. Average abundance of fishery targeted demersal species across the five sites surveyed.

4.2.2 Pelagic fish abundance and diversity

The pelagic BRUVS were used to sample the pelagic fish found in the midwater and were stationed at depth of 7-10 m. From the 48 BRUVS that were analysed during the study (eight at each of the six sites), 281 fish were counted from 18 species representing 8 families (Table 3). The highest number of fish was observed at the Miemia site, with 134 followed by Akwidaa with very low numbers at the other sites and no pelagic fish observed around reef close to Butre. The highest diversity of species was also found at Miemia with 13 species, followed by Akwidaa with 11 species.

Table 3. List of fish species observed from the pelagic BRUVS surveys. The numbers are the total of the MaxN observed from the video footage.

Common family name	Family	Taxa	Site						
			Agyan	Miemia	CTP	Akwidaa	Butre	Asemkow	Total
Surgeonfishes	Acanthuridae	*Acanthurus monroviae*		17					**17**
Jacks and Scads	Carangidae	*Caranx crysos*	32	17					**49**
		Caranx fischeri		42		1		5	**48**
		Caranx hippos	2	1	2	3			**8**
		Caranx latus		1					**1**
		Caranx spp				14			**14**
		Chloroscombrus chrysurus			2	17			**19**
		Decapterus spp				52			**52**
		Elagatis bipinnulata		4					**4**
		Scyris ciliaris		8					**8**
		Trachinotus goreensis		6		2			**8**
Remoras	Echeneidae	*Echeneis naucrates*	1			2			**3**
Ladyfishes	Elopidae	*Elops senegalensis*				2			**2**
Snappers	Lutjanidae	*Lutjanus agennes*		8					**8**
Cobias	Rachycentridae	*Rachycentron canadum*		1	1				**2**
Mackerels and tunas	Scombridae	*Sarda sarda*		1		1			**2**
		Scomberomorus tritor		27		3			**30**
Barracudas	Sphyraenidae	*Sphyraena afra*		1					**1**
		Sphyraena sphyraena				4			**4**
		Total number	**35**	**134**	**5**	**101**	**0**	**5**	**280**
		Species richness	**3**	**13**	**3**	**11**	**0**	**1**	**18**

To compare the species assemblages between the six sites, the most abundant species were ranked, and their abundances plotted between each of the sites (Figure 14). This showed that the most abundant species were scad (*Decapterus* spp), followed by the blue runner (*Caranx crysos*). The next most abundant species were the longfin crevalle jack (*Caranx fischeri*) and the West African Spanish mackerel (*Scomberomorus tritor*) both of which are important fishery species and only found in high abundance at the Miemia site.

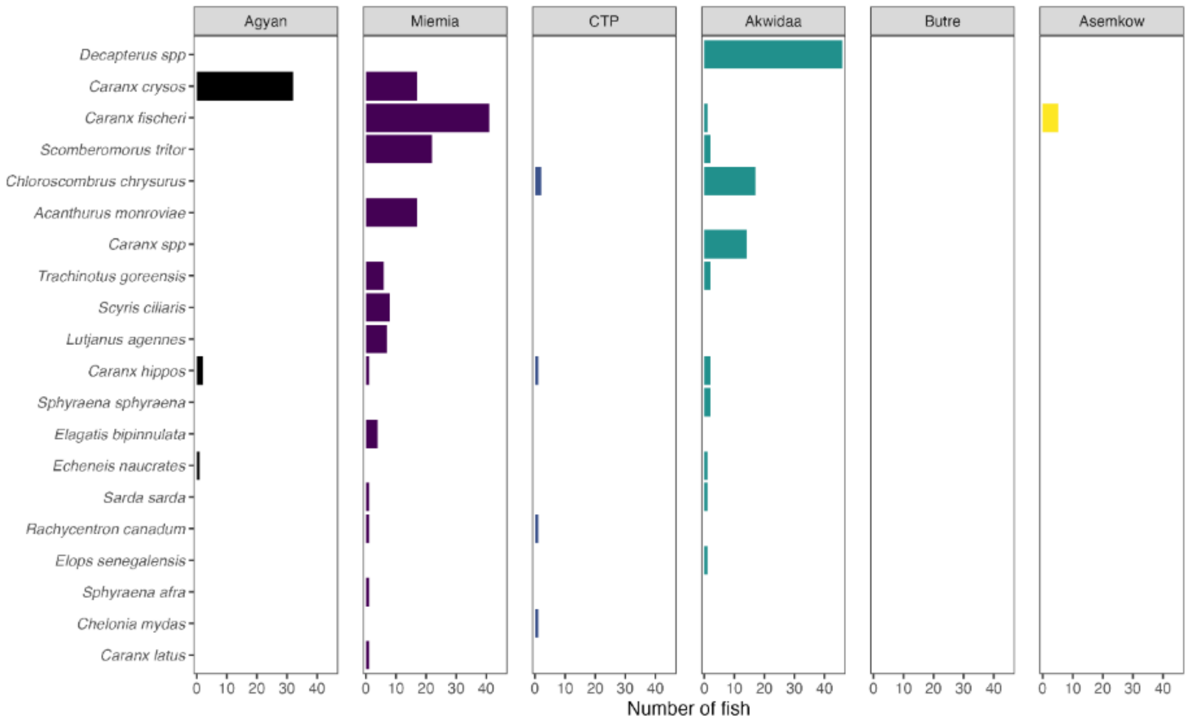


Figure 16. Ranked abundance of all species observed from the pelagic BRUVS between each of the sampling sites.

The average number of fish and species per site (average of the eight BRUVS replicates), showed that Miemia had the highest abundance and diversity followed by Akwidaa (Figure 15). Both these sites had significantly more fish and different species than were observed at Cape Three Points, Butre and Asemkow.

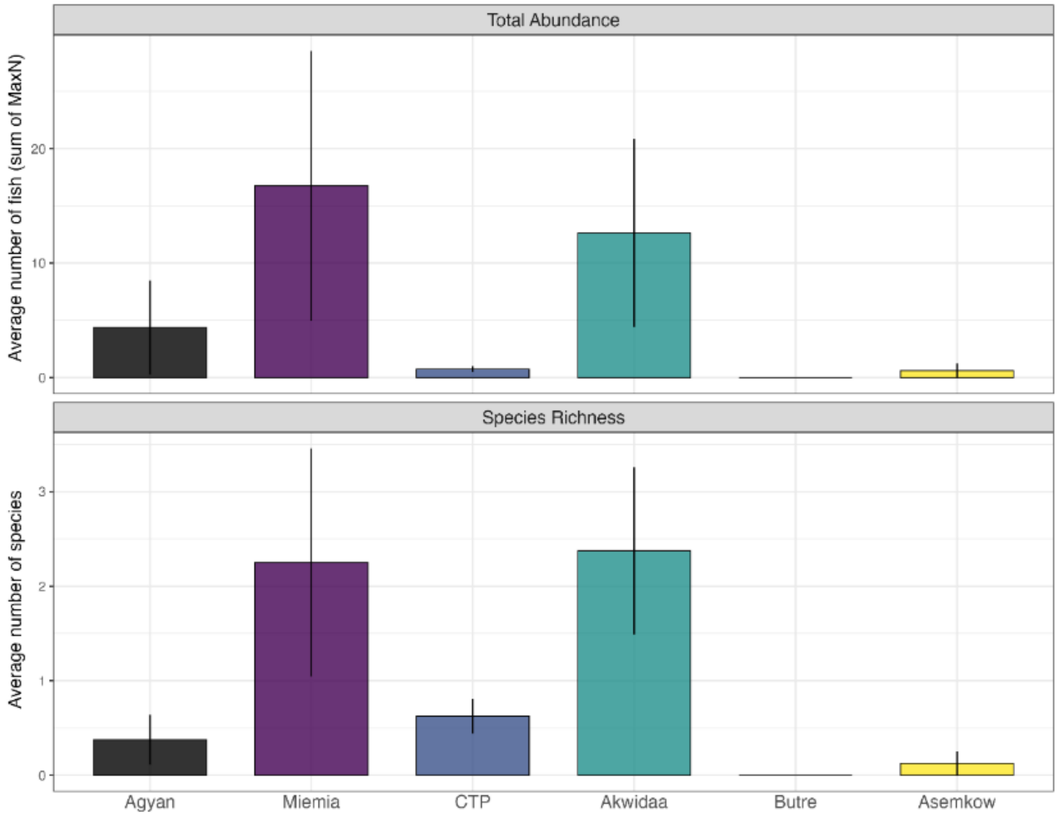


Figure 17. Average abundance of pelagic fish observed across the six sites surveyed.

To focus the analysis on pelagic fishery species, the list of species was reduced to exclude some of the reef associated species (surgeonfish and snappers) that were captured on the deployments close to the reef (*Acanthurus monroviae* and *Lutjanus agennes*) and also the remora *Echeneis naucrates* which is not targeted as a fishery species. The other species are all likely retained by fishing activities, however none of the main small pelagic fish species important to Ghana's artisanal fisheries were recorded in this study likely because these surveys were done outside of the main upwelling season when fishing activities for these species are most productive. This analysis mirrored the total abundance of all species and showed that the highest number of pelagic fishery species were recorded at the Miemia site followed by Akwidaa (Figure 16).

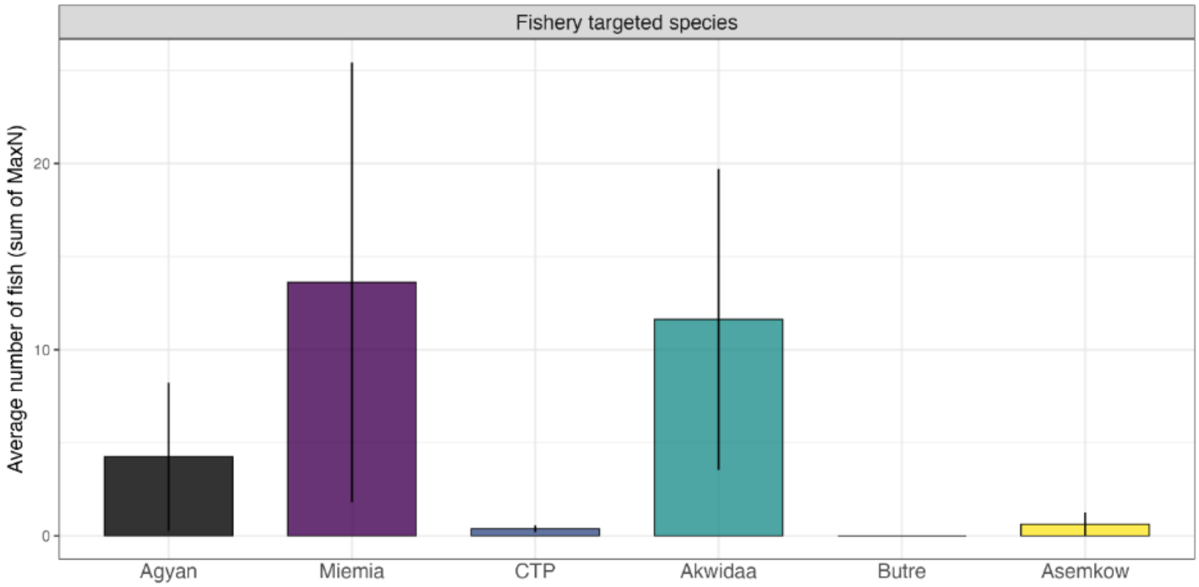


Figure 18. Average abundance of pelagic fishery species observed across the six sites surveyed.

4.3 Benthic Habitat

Through the deployment of the drop camera system and the benthic BRUVS, video footage was collected to characterise the benthic habitat found on the rocky reefs. Unfortunately, the water clarity during this sampling period reduced the ability to survey extensive areas, especially at depths greater than 15 m. Some useful information was collected to compare the habitat structure between the reefs and at different depths, especially at some of the offshore sites that were investigated when the water was clear.

Depths greater than ~20 m on these rocky reefs typically had a diverse assemblage of octocorals, such as gorgonians that colonised the benthos (Figure 18). The taxonomy of these corals is poorly known, and species level identification is not possible without specimen sampling. These areas likely serve as important habitats for fish.

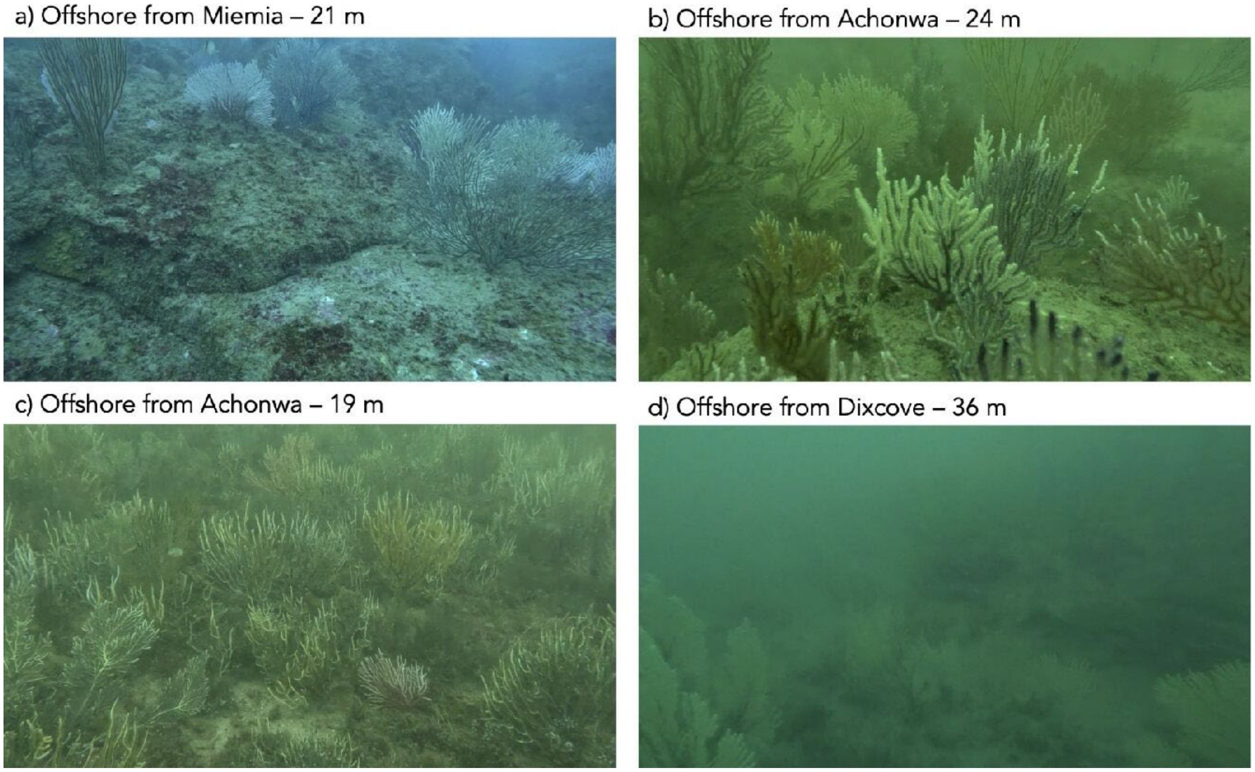


Figure 19. Images from drop camera footage showing octocoral habitat on the rocky reefs in the GCTPA.

The rocky reefs at depths of ~8-15m were mainly boulder habitat with large cracks. There was little benthic cover with some turfing algae, small amounts of foliose algae and sponges, crustose coralline algae and in some cases cyanobacteria, such as pictured in Agyan, where the water was murky (Figure 19a). Turfing red algae and crustose corraline algae is pictured Figure 19b at Miemia. Only few observations of sea urchins were present as pictured in Asemkow at 10 m depth (Figure 19c). Crustose coralline algae, turf algae and hydroids were also observed on the same reef in Asemkow (Figure 19d).

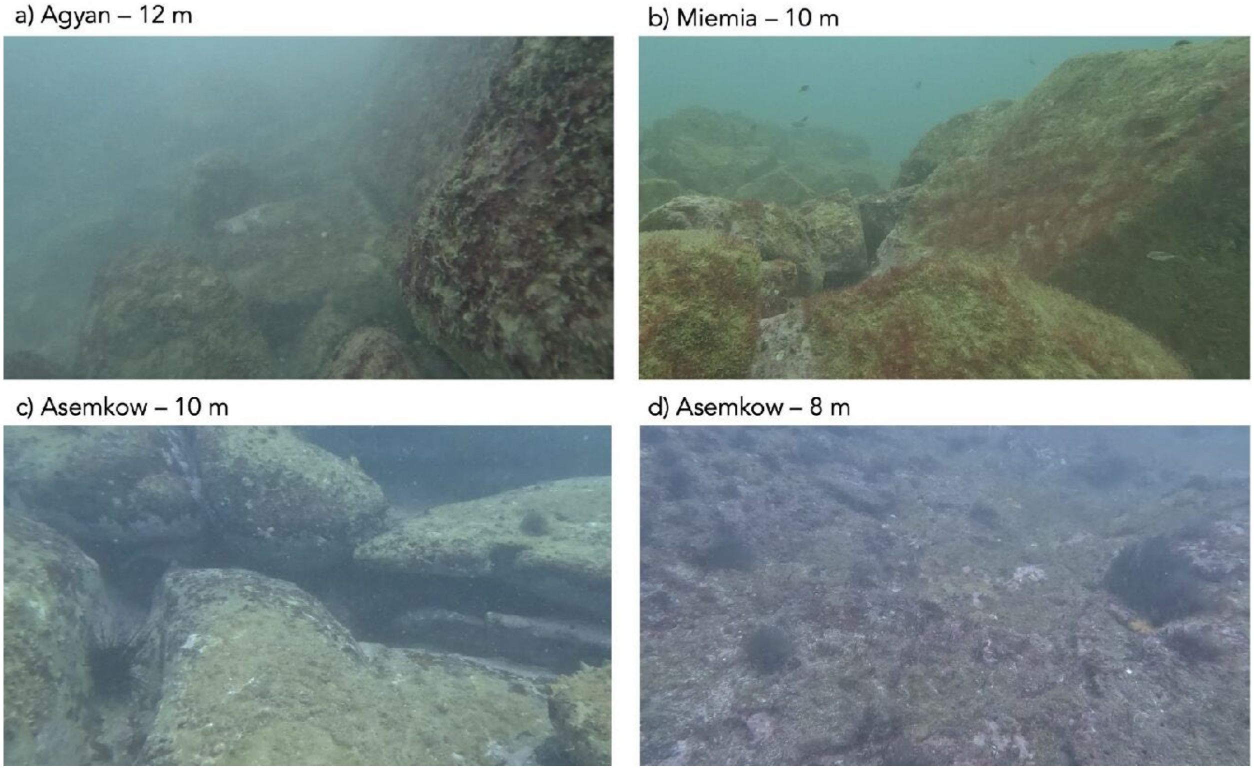


Figure 20. Images from drop camera footage showing shallow reef habitat on the rocky reefs in the GCTPA.

4.4 Other Marine Biodiversity

Two sea turtles were captured on video, one green turtle (*Chelonia mydas*) was observed on the pelagic BRUVS and one unidentified turtle was observed on the benthic BRUVS, both at the Cape Three Points site. Two common octopus (*Octopus vulgaris*) were observed at Akwidaa (9 m depth) and Butre (8.5 m depth). Two slipper lobsters (*Scyllarides herklotsii*) were observed at Cape Three Points at 8 m depth (Figure 20).

Humpback whales were also observed in this area between in October and November 2023, for which two observations were reported with photographic evidence – one on the 15th October 2023 of a small calf, without any adults observed nearby. On the 12 November 2023, 1 mother and one calf were observed. Both observations were approximately 4-6 km WSW from Miemia on the way to the reef.

Figure 21. Other marine fauna observed in the study area. a) Green sea turtle, b) Common octopus c) Slipper lobsters d) Humpback whale (photo by Florian Dezwaene).

At the shallowest part of the reef at 7 m depth on the reef out from Butre there were some encrusting hard corals, *Schizoculina fissipara,* these are photosynthetic scleractinian corals as found on tropical coral reefs and although this species is more often observed as a branching form in the Gulf of Guinea, it was observed here in its encrusting form (Figure 21). There is low diversity of scleratinian corals in the Eastern Atlantic with only 11 species confirmed in the Gulf of Guinea, most of which are poorly known (http://www.coralsoftheworld.org/). This reef also had a high coverage of hydroids and some encrusting sponges.

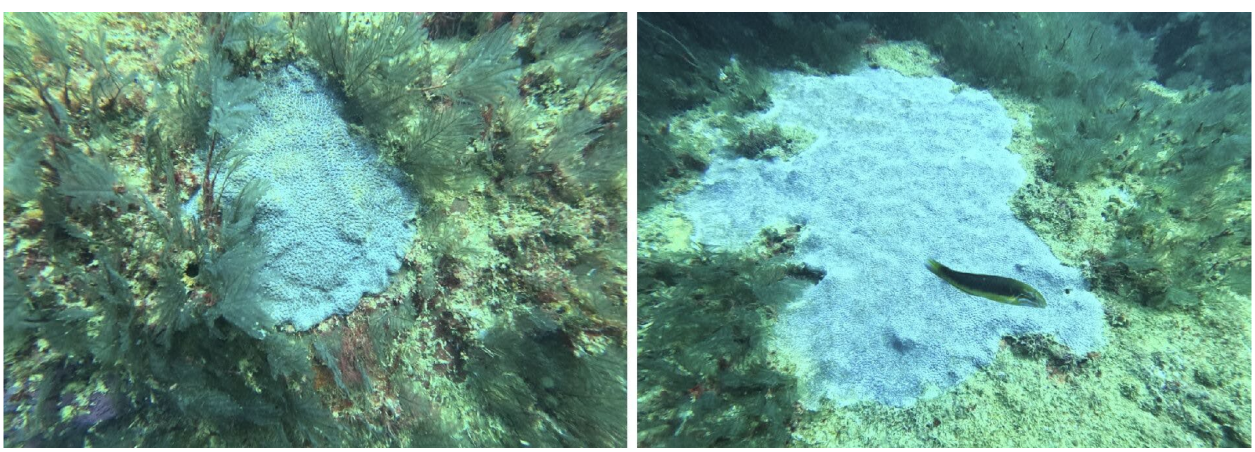


Figure 22. Schizoculina fissipara an encrusting scleratinian coral. 7 m depth Butre.

5. DISCUSSION

This study has provided important knowledge on the distribution of rocky reefs in the Greater Cape Three Points Area and their associated biodiversity. These areas are important habitats for a diversity of fish species, with 54 fish species observed on the reefs studied here, in addition to another 11 pelagic species observed around these reefs in the mid-water.

Through analysing existing data and local ecological knowledge mapping, the MPA site selection report from GRFA (2023) proposed the MPA boundaries used for this study. This area includes the entire stretch of coastal ecosystems from Domunli in the Nzema East Municipal to Ampatano in the Ahanta West Municipal out to the 6 nm inshore exclusion zone and covering an area of 700 km^2. It was identified that the five major rocky outcrops should be explored as potential core sites for the MPA and formed the focus for the current study.

5.1 Importance of rocky reef sites for fish abundance and diversity

The six different reef sites sampled here varied in the number of species and abundance of fish which is expected given variations in the size of the reefs, the distance offshore, depths of surrounding water and the shallowest depths of the reefs. Water visibility unfortunately precluded the sampling of demersal fish on the reef site close to Agyan. Overall, the sampling identified the reef site offshore from Miemia to have the highest abundance and diversity of fishes in the GCTPA for demersal and pelagic species, this site also had some of the highest numbers of fishery targeted species. This rocky reef covering an area of ~ 1 km^2 stood out as an important and unique site within the area, its position further offshore than the other reefs (~ 5 km from the nearest shoreline) also typically had clearer water and less impacted by sedimentation from river runoff. Its shallowest depth of 8 m is surrounded by depths of ~30 m, where the rocky reefs had a diversity of colonising organisms from barren boulder habitat with coralline algae on the shallow parts to a diverse assemblage of octocorals at depth >20 m.

The next most important sites in terms of fish abundance and diversity were Cape Three Points, Akwidaa and Butre, but their relative rank of importance depended on the metrics presented here. For example, Butre had the next highest diversity of demersal species and similarly high average abundance species compared to Miemia and the highest of all demersal fishery targeted species. However, there were no pelagic species recorded at this site and therefore total diversity of all species was less than these other two sites. Akwdiaa had the next highest total diversity after Miemia and on average the highest abundance of demersal species, although the average species richness was less (although not significantly different). The number of demersal fishery targeted species at Akwidaa was only slightly less than Cape Three Points, but the abundance and diversity of pelagic species, including fishery targets was much higher than the other two sites and similar to that observed at Miemia. The Cape Three Points site was somewhere between these other two sites with intermediate total diversity, but the highest on average demersal fish diversity and similar levels of demersal fishery species than Akwidaa, but the abundance and diversity of pelagic species was significantly less than Akwidaa.

Overall, if looking at demersal fish biodiversity and numbers of fishery targeted species, Butre would be ranked as the next most important site after Miemia, but for the importance of pelagic species aggregating around these reefs, then Akwidaa is regarded more important than Butre. The lowest diversity and abundance of fish species at the five sites surveyed was at Asemkow, possibly as this site was closer to shore, but it does adjoin part of a larger reef system sampled at Butre. This reef extends further inshore and fish communities may be more spread out rather than concentrated on some of the other reefs, or it is possible this area could be more heavily fished than the other sites.

5.2 Pelagic fish surveys

The most important fish species for artisanal fishers in Ghana are the small pelagics – sardinella, anchovy and mackerel (MFRD, 2007). Historical overfishing for these species, particularly the round Sardinella (*Sardinella aurita*) has resulted in the fishery now considered as collapsed (Lazar et al., 2020) and therefore it would be highly beneficial for the proposed MPA to help recover stocks of this species. Fishery-independent surveys for small pelagics are challenging and are typically done by hydroacoustic surveys from large research vessels, for which it can also be difficult to accurately determine the species surveyed without complimentary video or fishing methods (Letessier et al., 2022). As the proposed MPA is for inshore coastal waters, the depths preclude the use of large research vessels, let alone the costs and logistical difficulties of these surveys also make it impractical. Therefore, the use of pelagic BRUVS was proposed as a potential simple method for quantifying the presence of these small pelagics around the coastal waters in Ghana.

Pelagic BRUVS have been effectively used around the world, typically to assess the effectiveness of large-scale MPAs in remote ocean locations (Meeuwig et al., 2021). They have also been used to determine the degree to which pelagic fish responded to the establishment of MPAs in Australia for which most abundant taxa recorded were anchovies (*Clupeidae*) and scads (*Decapterus* spp) (Magne, 2023). The lack of small pelagics detected from the pelagic BRUVS in this study (besides one small school of scads), may be due to seasonal movements of the species, as these surveys were done outside of the main upwelling season when fishing activities for these species are most productive. It is recorded in the GFRA report (2023) from the participatory mapping exercise that these small pelagics most frequently harvested between July and September. These species are highly mobile and likely not attracted to the fish bait used in the cameras, since they are planktivorous species, so they may have also been in the area, but simply not at the times and locations when the cameras were deployed. However, when asking fishers about catching Sardinella, they suggested they are most caught further offshore at night using light fishing (which is illegal). It was concluded that these inshore reefs are currently less important for Sardinella at the time of surveys, although these reefs are apparently an area where anchovies can aggregate at certain times. Fishers from Butre mentioned having the best catches of small pelagic in August, but also good catches of anchovies were made in December before this survey, but they were reported to be further offshore from Feb through April where they are caught with light fishing.

Unfortunately, the pelagic BRUVS used in this study proved not to be an effective method for surveying small pelagics around coastal waters of Ghana. Alternative low-cost surveys would need to be fishery-dependent surveys of fishing catches where an observer/researcher may accompany fishing trips, or cameras and GPS trackers are used on vessels with community participation from fishers to record the location of captures, CPUE, and the size and species composition of the fish caught. Alternatively, there have been recent advancements in electronic monitoring techniques that can be applied to small-scale fishing activities, such as a system from Shellcatch (https://web.shellcatch.com/). Local fishers have the best knowledge on the areas and times when these species are caught and participatory data collection from fishers will be important to further investigate the particular areas and times where these species are caught to inform the zoning and management of the proposed MPA for the recovery of these species.

Pelagic species targeted by fishers also include large bodied species such jacks (Carangidae) and mackerel (Scombridae). The West African Spanish mackerel (*Scomberomorus tritor*) and several species of jacks, such as the longfin crevalle jack (*Caranx fischeri*) where observed in reasonable numbers from the pelagic BRUVS. These species are caught by fishers using purse seines and it appears these rocky outcrops are important sites for aggregations of these species. Although needing validation, these sites might also be important sites for spawning of these species, as they are defined locations that fish can navigate to at important times during their life stages. To validate the importance of these rocky reefs as spawning aggregation sites, it is best to first assess LEK on fish spawning and community participation from fishers to help record fish that may be aggregating to spawn and if needed, basic training to inspect fish gonads especially when large catches of certain species are caught at certain times. Often fish will spawn seasonally and associated with particular moon phases, and research data collection would best take place in collaboration with fishers, this could be a meaningful student project and help answer the question if these rocky outcrops are indeed important spawning areas.

5.3 Demersal fish surveys

The diversity of reef fish fauna in Ghana is poorly known with the exception of fishery targeted species, with one of the species observed in this study not previously reported from Ghana, the comber *Serranus inexpectatus* which was described in 2018 (Iwamoto and Wirtz, 2018). But its distribution is not unexpected (despite its name) since it is found in Senegal, Gabon and Angola. There are also other species that are found in the Western Atlantic which are thought to be, or recently confirmed as, divergent species in West Africa. Besides the baseline ecological research survey report on the nearshore rocky reefs of Western Ghana by Ateweberhan et al. (2012), there is a lack of in-situ surveys of marine biodiversity on the rocky reefs.

The study by Ateweberhan et al. (2012) performed underwater visual census by SCUBA diving in the area between Miemia and Cape Three Points. However, these surveys took place very close to shore at depths typically shallower than the current survey (2-11 m depth). They surveyed 14 sites with a total of 55 fish transects (50 m in length) for which they recorded over 7800 fish from 46 species representing 25 fish families. The abundances recorded in the current survey are not comparable due to the differences in baited video surveys only recording the maximum number that can be seen at one time, which underestimates the true abundance, but is a robust measure of relative abundance that can be compared to the same method over time and space. Species richness between surveys, indicated ~12 species found on the inshore reefs per survey, compared to ~14 species found on the reefs in the current survey. Although not directly comparable due to differences in survey methods, it can be concluded and expected that these reefs further offshore hosted more fish species than the shallow inshore reefs, as was also implied by the current study recording a total of 56 species, ten more than recorded on the shallow inshore reefs, although the current study did cover a wider area of coastline and larger depth gradient.

The abundance of larger bodied fishery targeted species was relatively low compared to what would be expected from baited video surveys in other locations. But given there are no other baited video surveys in coastal West Africa, comparisons to other locations in other parts of the world are not directly comparable due to different assemblages of species. These surveys provide a strong baseline to detect changes over time if the MPA is established in the future. There are many examples of increasing fish abundance after the establishment of MPAs, especially in no-take zones, for example, a 3-fold increase in snapper catches over a period of 8 years was found in an MPA in Australia (Harasti et al., 2018). These surveys found the Atlantic emperor (*Lethrinus atlanticus*) a potential indicator species for these surveys, as they were recorded on 90% of the benthic BRUVS. The majority of which were small, presumably immature fish with only 5 individuals from the 77 observed which appeared to be a large size >35 cm. Other large bodied predatory species included the African red snapper (*Lutjanus agennes*) and although only 12 individuals recorded, they do achieve a large size of 140 cm. The size of fish was not able to be recorded during this study, but it is possible for BRUVS to be deployed with stereo-video cameras were it allows accurate measurements of fish size and standardisation on the area surveyed which can vary with different levels of water clarity (Langlois et al., 2020; Shortis et al., 2009). Although this is more costly for equipment, stereo-video is an option for future surveys to monitor responses of protection over time, especially as increases in fish length and biomass of larger sized species are more reliable indicators of MPA effectiveness than abundance alone (Belackova et al., 2023; Jaco and Steele, 2020).

As relatively few large bodied species were surveyed in this study, it does suggest that fishing pressure plays a prominent role in structuring the fish community in the Greater Cape Three Points Area, as was suggested by Ateweberhan et al. (2012). The previous study also recorded the rock hind (*Cephalopholis nigri*) to be the most abundant predatory species, it was hypothesised that dominance of this smaller species may be the product of a decline in other larger-bodied groupers through competitive release. Without historical information it is difficult to tell how the fish community has been impacted by fishing pressure, but either way, the main patterns observed were consistent between these studies which indicated relatively low numbers of large sized fish. Another notable finding during these surveys was a complete lack of sharks recorded. The use of BRUVS is recognised as an effective method for surveying sharks, and these surveys suggest these reefs are one of the 20% in the world where sharks were not recorded using this survey method (MacNeil et al., 2020). There is an active shark fishery in Ghana where sharks are targeted and caught as bycatch. Amongst shark fishers in Ghana, there is a strong consensus that shark populations are declining and it has been recommended that these species should be closely monitored to prevent the extinction of vulnerable populations (Sekey et al., 2022).

This study recorded 65 different species of fish, but this is only a small proportion of the estimated 347 fish species belonging to 82 families that exist in Ghana (Nunoo 2018). Although this survey was useful for recording the fish that are resident on these rocky offshore reefs, there are many other species that are present within the proposed MPA boundaries that are found on different habitats. With only 30 successful BRUVS replicates, an increased sample size, especially on the deeper portions of the rocky reefs would have recorded some more species. This could have been possible if the water clarity was better, as during this period a total of 78 deployments were made, which would have provided a much more comprehensive survey of the reefs. If surveys were to be repeated again at times with better water quality, then a more comprehensive survey could be completed which would also focus on areas adjacent to the reefs which are the preferred fishing grounds for demersal set nets (Toga). One of the main fishery targeted species is the Cassavafish (*Pseudotolithus senegalensis*) which on one day during the surveys was caught by local fishers in high abundance close to the survey site in Butre. However, the murky water inshore precluded us from sampling on sandy or muddy substrates, as the water was cleanest on the shallowest parts of the rocky reefs. The study by Ateweberhan et al. (2012) recorded fish species caught by experimental fishing using gillnets close to the area of our surveys. These surveys recorded a different assemblage of species to what were found on the reefs and therefore future monitoring of the MPA and more comprehensive fish biodiversity surveys may consider fishery-dependent methods though community fisher participation. Training fishers in data collection protocols can also achieve a greater sense of ownership on management interventions. In addition, recent advancements in data-poor stock assessments, can provide robust information for management based on simple data collection methods (Prince and Hordyk, 2019; Prince, 2018).

5.4 Considerations for Marine Protected Area Establishment

This survey expands on the MPA site selection report from Ghana Fisheries Recovery Activity and Hen Mpoano (GRFA, 2023) and compliments previous reports that have documented biodiversity in this area to build a case for the establishment of an MPA (Ateweberhan et al., 2012; CRC and Friends of the Nation, 2011; EPA, 2021, 2020; Sagoe et al., 2021). Through analysing existing data and local ecological knowledge mapping, the MPA site selection report from GRFA (2023) proposed the MPA boundaries used for this study and identified these rocky reef areas as potential core sites for protection.

An extensive report on MPAs in Ghana: Strategies, Action Plan and Implementation Framework, was produced by the FC and MOFAD (Nunoo, 2018). This report goes into more detail on the establishment and criterion used to determine priority sites for protection within Ghana. Through this process, there was strong consensus among stakeholders that there is need to establish a network of MPAs to help arrest, restore and rebuild the marine fisheries and ecological habitats within Ghana. From the 20 candidate MPA sites identified in this report, five are located in the GCTPA. These are Miemia Bay, Gross Friedrichsburg, Cape Three Points, Akwidaa Bay and Butre Estuary and it was suggested that establishment of an MPA around Cape Three Points is highly favoured. It was identified that a network of small interconnected MPAs geographically well distributed along the coast, complementing each other and their variety of ecosystems would be recommended. The proposed MPA in the GCTPA notably connects five of these important biodiversity sites.

As this proposed marine area is highly important for local coastal communities and their livelihoods that are based around fishing, having this entire area as no-take marine reserve would not be culturally appropriate. Although strictly enforced no-take areas have the highest level of conservation gain, their use needs to be balanced with areas that still allow some sustainable human use and extractive activities. There is no hard rule on what proportion of an MPA should include no-take-zones, however, it is generally accepted that 30% of the area should be zoned as no-take. This would likely be socially difficult for the GCTPA, as the use of these coastal waters as fishing areas is widespread and unlike some other locations around the world where there is strong traditional tenure to certain fishing areas, the Greater Cape Three Points Area is utilised by fishers from many different communities along Ghana's coastline. These fishing grounds are known to be some of the most productive in Ghana and fishers will travel from other municipalities and regions to fish here. This shared open access also likely reduces the willingness for one community to conserve fish stocks if they will be fished by another. Also known as the tragedy of the commons, if there is unrestricted access to a finite and valuable resource then it tends to be over-used, or over-fished in this case. One potential way to foster greater ownership of the fishery resources is to restrict fishing access only to the local communities within the boundaries of the MPA.

In April 2024, soon after the completion of these surveys, the Minister of Fisheries and Aquaculture Development, Honourable Mavis Hawa Koomson, announced the intention to establishing the proposed MPA in the Greater Cape Three Points Area by 2026. (https://www.myjoyonline.com/fisheries-ministry-announces-ghanas-first-marine-protected-areas/) The establishment of the MPA was announced to be done through a community-based approach where local communities will be driving the development and implementation of management plans and protective measures.

Because the proposed MPA objectives, as articulated by the Minister, focus on fisheries management and biodiversity conservation, the proposed MPA should protect representative areas of critical habitat. The primary data collection in this study has identified that these rocky reefs host high levels of biodiversity supporting the local ecological knowledge from the coastal communities in this area. The presence of rocky reefs separated from the coastline are uncommon along the coast of Ghana. Recognizing the lack of data on the distribution of subtidal marine habitats and the lack of accurate bathymetric charts, the GCTPA likely has a significant proportion of rocky reefs compared to other locations in Ghana. Therefore, the protection of these rocky reefs is of high priority for conserving marine biodiversity in Ghana. Aside the rocky reefs, other habitats in this area are also important for protection if to conserve representative samples of biodiversity and ecosystem services. The sandy or muddy substrates between reefs, for example, are important habitats for fishing and local ecological knowledge suggests that the area between reefs offshore between Princess Town and Cape Three Points are the most productive fishing grounds (GRFA 2023).

Although this study focused data collection on the fish species found around subtidal rocky reefs, there is also distinct and unsampled biodiversity found in other offshore habitats. It has been suggested that within the continental shelf of Ghana, there is extremely high benthic biodiversity with about 60% of the soft bottom benthic macro-fauna encountered are believed to be new and unrecorded (Nunoo 2018). There is virtually no information on meio-fauna (dominated by worms, and crustaceans) and micro-fauna (such as ciliates, amoebas and foraminiferans) organisms in these benthic waters. In addition, there is a diversity of fish species known from the coastal waters of Ghana that were not sampled during these surveys as they prefer other habitats such as the widely distributed soft sediment and gravel areas between reefs. Hence, for effective biodiversity conservation, and also the conservation of fishery resources, representative areas of all habitats in the MPA should be zoned to have strong restrictions on use, not just the rocky reefs.

The connectivity of habitats should also be considered when zoning a marine protected areas for multiple uses. As many species of fish and other marine biodiversity are found in different habitats and move between habitats during their different life stages and for activities such as feeding, having connected habitats equally protected is important if to conserve the range of biodiversity and ecosystem functioning. There are large areas of mangrove in the rivers at Butre and Princess Town and smaller rivers at some other sites such as Akwidaa and Busua. A study by Sagoe et al. (2021) documented community perception of fisheries related ecosystem services at Cape Three Points and Princess Town, with a focus on inshore coastal habitats such as lagoons/estuaries, mangroves and beaches. These communities ranked food provisioning (finfish and shellfish) as the most important ecosystem service, followed by nursery grounds for fish. They concluded that conservation plans in the area would be efficient if prioritising the protection of fish nursery grounds. Therefore, zoning of the proposed MPA will benefit by protecting these inshore fish nursery grounds such as mangroves and estuaries and linking these habitats to the coastal waters and offshore reefs. This effort is currently underway, with Hen Mpoano conducting participatory data collection of local ecological knowledge paired with analysis of existing land cover data to identify key mangrove areas for protection in the GCTPA (Figure 22).

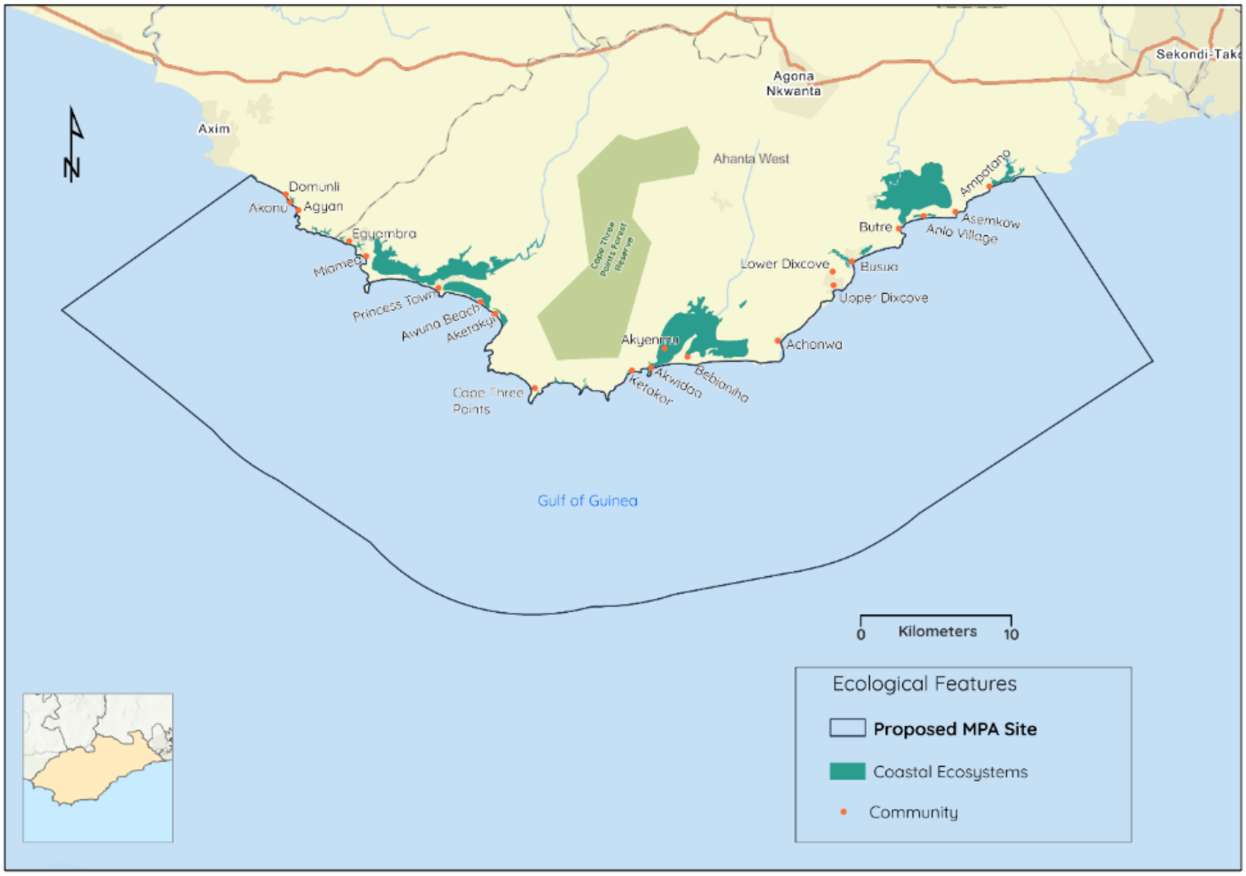


Figure 23: Map of proposed MPA area including the mangrove coastal ecosystems identified for protection.

Different coastal communities in this area appeared to have varying levels of compliance with current fishery regulations which include a ban on the use of explosives and chemicals when fishing, light fishing and the use of monofilament nets. Although the use of explosives is well known to be illegal and unsustainable, regulations on light fishing and that of monofilament nets do not appear to be as well-known and their use is widespread in the area. The establishment of the MPA should be seen as an opportunity for better enforcement on current laws, and although any changes in fishing activities will be difficult to gain widespread support in the short term, there may be opportunity for support with community-based management. For example, for the past 20 years the community in Agyan has enforced a small fishing ground close to the community where they restrict the use of demersal set nets in favour of line fishing to protect an area where they can easily access these fishery resources when needed. This community provides a key example of community-based management and enforcement in the region. It was a pity that water quality in this area was too poor at the time of surveys to assess fish populations in their managed area. This should be a priority for future research.

6. RECOMMENDATIONS

The recent announcement by the Government of Ghana that they are committed to establishing the proposed MPA in the Greater Cape Three Points Area is commendable. Involvement of local communities and community-based management will be important factor in the success of the proposed MPA as it was evident that with limited community sensitisation and co-development of fishery management regulations, such as that of illegal fishing gears, any management plans will likely not be respected. Based on the MPA site selection report by Hen Mpoano (GRFA 2023), there is strong community support for the marine protected area to conserve the rocky reef habitats and associated biodiversity and fishery resources found in the area. The current study reinforces this by documenting a diversity of fish and other habitat forming organisms associated with these reefs and how the different reefs in the area have different levels of fish abundance and diversity.

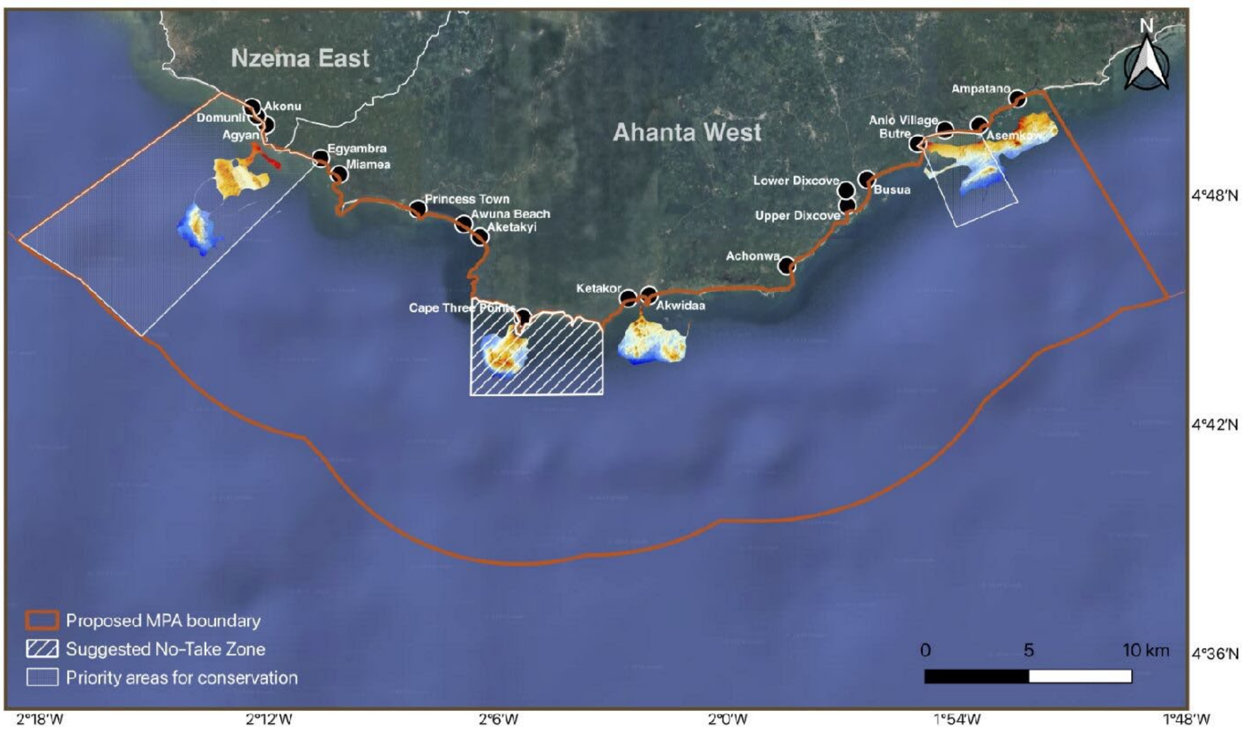


Figure 24. Suggested priority areas for conservation within the proposed marine MPA area. It is suggested that areas including the reefs in the western part of the proposed MPA and the reefs and habitats between Bure and Asemkow have higher levels of protection that other areas in the MPA. Cape Three Points area is suggested as a priority area if no-take zones are to be implemented in the MPA.

From the six rocky reef sites sampled in this study, it was clear that one particular reef had the highest diversity and abundance of fish species. This reef 5 km offshore from the communities of Miemia, Egyambra, Agyan, Akonu and Domunli also had a diversity of habitat forming soft corals on the deeper parts of the reef. This reef appears to be fairly unique in the region and would be a key area to conserve. However also due to these attributes, it is a popular area for fishing and therefore giving this area high level protection such as through a no-take zone will likely not gather widespread community acceptance. Therefore, it is suggested that some fishing could take place in this area that has limited impact on the reef habitat. This includes shallow purse seine fishing for pelagic species and line fishing. The use of bottom set nets (Tenga) may not be appropriate around the edges or on the reef as it can impact the habitat and is less selective than line fishing. This reef system is offshore from shallower yet also complex reef system closer to the community of Agyan and having a continuous boundary extending from the shore out past the reef to the offshore IEZ boundary that encompasses these reef systems would help protect a diversity of reef habitats over a depth gradient and also some sandy/muddy substrate between and further offshore.

The next most important reef site from a demersal fish biodiversity perspective was the reef offshore from Butre. Although this site lacked the observations of pelagic species, the proposed MPA has a primary goal priority on biodiversity conservation followed by that of habitat protection for small pelagics and demersal fish species. The small pelagic species that are important for artisanal fishing were also not observed at other sites during this study, therefore this site ranks higher than Cape Three Points and Akwidaa according to these objectives. This site did have the highest numbers of demersal targeted species (snapper, emperors and seabreams), some of which were a large size and therefore this site is a good area to protect to if to help replenish other nearby reef systems through spillover, such as that to the east between Asemkow and Ampatano. This area is also good to protect with the extensive estuary and mangrove communities adjacent for which there is the potential to create protected corridors that connect habitats and ecosystems. However, again this area is important for fishing and on one morning we observed 19 fishing boats between the offshore reef and Butre river mouth, and therefore it may be socially difficult for widespread support limiting fishing activities in this area.

Two other reef sites that are similarly important for fish diversity and abundance were the reefs offshore from Cape Three Points and Akwidaa. However, given that there were widespread reports that the reef at Cape Three Points is often targeted by dynamite fishing and there are known sea turtle nesting beaches to the east of the Cape Three Points lighthouse (and only two sea turtles observed during this study were at this site), then it is suggested that this area would be the next highest priority for protection. An area that encompasses the rocky reef, the headlands and beaches to the east could be a valuable area for a no-take zone. The rocky reef offshore from the lighthouse is prominent reef which appears to have been overfished and would likely respond quicky with an increase in fish stocks if there was a cessation of fishing at this site. Although it was not able to be confirmed with this survey, it seems likely that this reef could be an important fish spawning site since it is a prominent feature on the coastline, the most southern point on Ghana's coastline where currents can mix from both directions. If so, this would also likely be a good source reef for potential spillover of recruits that could replenish other locations. However, again this reef is also an important area for fishing, especially for the community at Cape Three Points, and having their support for such protection would be highly important. But if the community may be supportive and see the benefits for future fishery sustainability, then it also makes for a practical area for enforcement as the reef can be easily observed from the rocky shoreline and lighthouse.

7. STAKEHOLDER ENGAGEMENTS IN THE GCTPA

Establishing Ghana's first MPA requires collaborative efforts and the support of various stakeholders, necessitating consistent engagement at all levels, including community members, fishers, processors, traditional leaders, and local officials. Thus, under GFRA, Hen Mpoano undertook various forms of stakeholder engagement – participatory local ecological knowledge gathering, community-level engagements, educational campaigns, and consultations - across the GCTPA, at the Nzema East and Ahanta West District level, and at the level of the Western Regional government. Since March 2023, GFRA through Hen Mpoano has engaged stakeholders across all 21 prospective MPA communities (Figure 21), reaching 3,371 (1,739 men and 1,632 women) through multiple touchpoints, to ensure that all relevant parties are included in the decision-making process, leading to a well-managed and sustainable MPA. Hen Mpoano has also conducted three regional level stakeholder engagements to ensure that key members from district and regional government and agencies alongside regional fisheries associations such as Ghana National Canoe Fisherman's Council (GNCFC), National Association of Fish Processors and Traders (NAFPTA), and Canoe Fishers and Gear Owners Association of Ghana (CaFGOAG) were fully informed and consulted about the prospective GCTPA MPA.

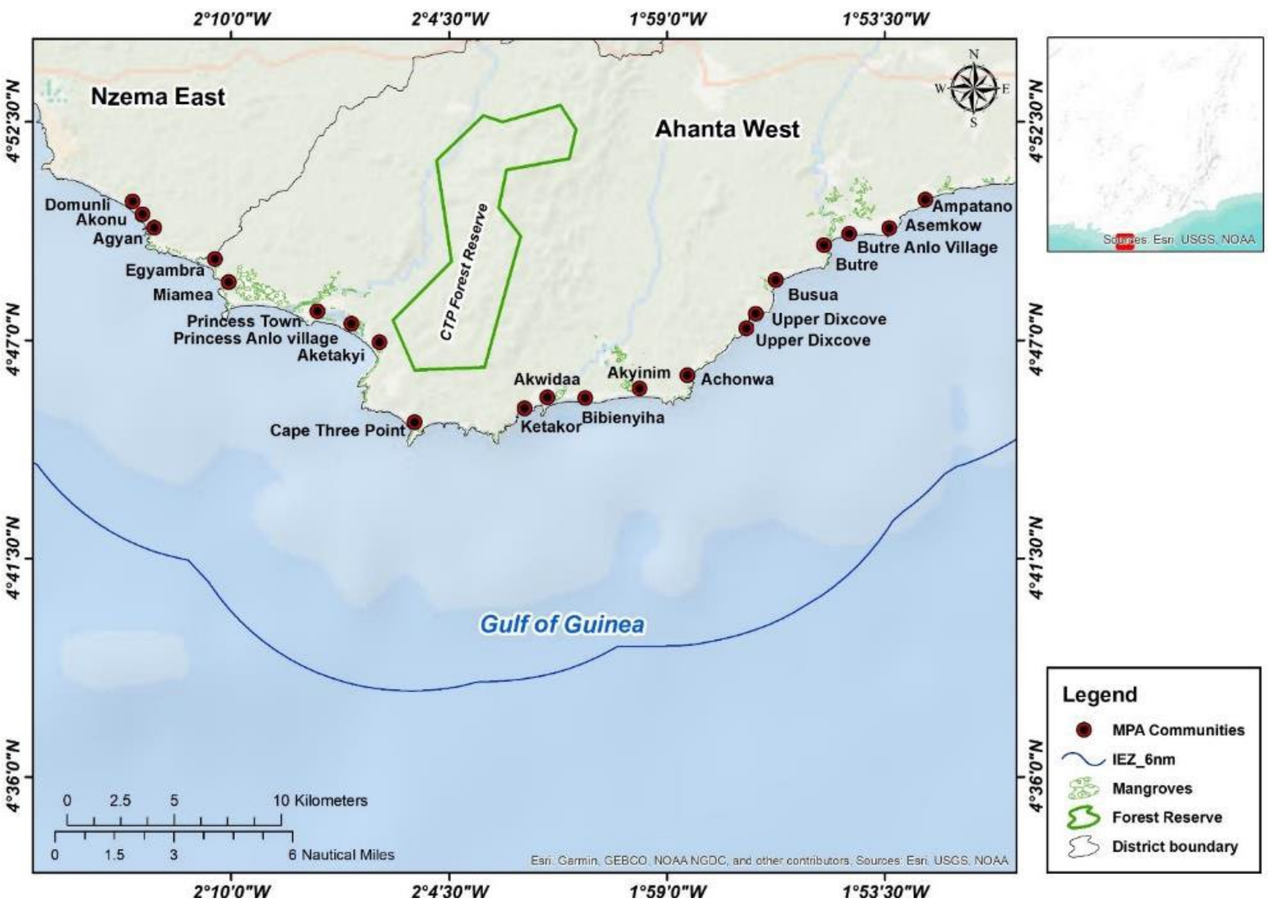


Figure 25: Map of the 21 MPA Communities in the GCTPA

As a result of these stakeholder engagements, there is widespread support for establishing a marine protected area to safeguard marine and coastal ecosystems and promote the recovery of fisheries and biodiversity. Stakeholders are eager to see the MPA implementation realized and are anticipating its official designation soon. However, concerns have been raised about current lapses in fisheries law enforcement and the government's commitment to the MPA process. To address these issues, it is crucial to ensure that, once established, MPA policies are effectively implemented and free from political interference. Stakeholders advocate for a co-management structure that allows for community-based management with legal backing. Additionally, community stakeholders have expressed concerns about the potential impacts of the MPA on their livelihoods and have requested diversified support.

7.1 Approach to Stakeholder Engagement

The bottom-up stakeholder engagement approach to establishing a Marine Protected Area (MPA) ensures active local community involvement from the outset. This strategy includes community members, fishers, processors, traditional leaders, and local officials in decision-making, fostering genuine partnerships and inclusive dialogue. This approach has been complemented by a series of regional and national level dialogues on the prospective GCTPA MPA, to engage all the relevant national and regional government, civil society, fisheries association, development partner, and academic stakeholders. This comprehensive approach to stakeholder engagement is presented in detail in the following sections.

7.2 Stakeholder Mapping and Analysis

The project conducted a stakeholder analysis to assess the interests, influence, and roles of key stakeholders and actors in the establishment of an MPA in the Cape Three Points area. The analysis was conducted at 2 levels - community and regional/district. The community-level stakeholder mapping exercise involved 14 coastal communities abutting the prospective MPA. The communities are Asemkow, Butre Anlo Village, Butre, Busua, Dixcove, Achonwa, Akwidaa, Ketakor, Cape Three Points, Akatekyi, Princess Anlo Village, Princess Town, Miemia, and Egyambra. The regional/district level stakeholder mapping, on the other hand, focused on the government institutions, industries, and CSOs.

The stakeholder analysis employed focus group discussions and key informant interviews in all 14 communities. While the focus group discussions targeted a mix of fishers, fish traders, fish processors, canoe owners, Chief Fishermen, Konkohemaas, and elders of the communities, the key informant interviews involved community leaders, chief fishermen, Community Resources Management Area (CREMA) members, and government officials. This stakeholder mapping served as the basis for all subsequent engagements in 21 prospective MPA communities because it provided an understanding of the concerns and expectations of stakeholders, ensuring that engagement strategies are tailored to address specific needs

Over 30 stakeholders and actors were identified and consulted as part of the exercise to understand their potential roles and existing traditional fisheries governance systems in the target communities. The stakeholder analysis revealed the existence of a wide range of stakeholders at the community, district and regional levels with different levels of influence and power to accelerate or hinder the establishment of the Greater Cape Three Points MPA. Consequently, it was concluded that some stakeholder groups needed to be engaged more extensively through dialogue and information sharing by virtue of their strong influence. Other stakeholders would be less prioritized for active engagement because of their minimal influence on the MPA establishment process.

Table 4: Communities and institutions visited for the stakeholder mapping

Date	Communities/Institutions Visited
1st March 2023	Ketakor
	Cape Three Points
	Akatekyie
	Miemia
	Egyambra
2nd March 2023	Princess Town
	Princess Anlo Village
	Akwidaa
	Achonwa
3rd March 2023	Dixcove
	Busua
	Butre
8th March 2023	Asemkow
	Butre Anlo Village
16th March 2023	Western Regional Coordinating Council
17th March 2023	Ahanta West Municipal Assembly

Figure 26: Pictures from the community stakeholder mapping exercise

7.3 Community-Level Engagements

Hen Mpoano developed a comprehensive community engagement plan that placed local and regional stakeholders at its core guided subsequent community engagements. This plan aimed to integrate local communities into the MPA development process, fostering a comprehensive bottom-up and inclusive approach that ensures that community participation is not just a part of the process but a driving force at every stage. The plan's key principles include information exchange, dialogue, and shared decision-making. Community members are seen as stakeholders and co-creators in discussions, planning, and decision-making, aligning the MPA with their unique needs and perspectives. This fosters ownership and responsibility for sustainable marine resource management.

Over the past year, Hen Mpoano has facilitated multiple forms of stakeholder consultations in all 21 prospective MPA communities and at the regional level through participatory mapping or marine and coastal ecosystems, community consultative meetings, workshops, and community educational campaigns, ensuring continuous dialogue and community contributions. These activities were designed to gather feedback, understand stakeholder perspectives, and make each stakeholder feel that their input is crucial and valued and that their voice is an integral part of the decision-making process. These community-level engagements have been facilitated jointly with Officers from FC and in some few instances, MOFAD.

7.3.1 Local Ecological Knowledge Mapping of the MPA Area

Despite the general knowledge of the Greater Cape Three Points area as a refuge for biodiversity and a critical fisheries habitat, there is no data on the ideal location for a nearshore marine protected area with a small pelagic fisheries recovery focus. Hen Mpoano conducted participatory mapping in 15 communities within the GCTPA to gather local ecological knowledge from fishers and community members and solicit their input in designing the marine protected area. The LEK mapping exercise, a testament to the community's expertise and vital role, helped to identify suitable sites within the GCTPA to designate as MPAs for managing and recovering fisheries and biodiversity.

The participatory mapping exercise was conducted over four weeks (from 14 April to 3 May 2023). It involved 354 people (male: 235; female: 119), including chief fishermen, the *Konkohemaa*, crew captains, crew members, fishermen, fish processors, and opinion leaders.

Table 5: Communities visited for the participatory mapping exercise.

Date	Community	Male	Female	Total
14th April 2023	Ketakor	19	12	31
	Princess Anlo Village	14	3	17
15th April 2023	Princess Town	14	10	24
18th April 2023	Egyambra	16	1	17
	Miamea	19	3	22
26th April 2023	Achonwa	21	12	33
27th April 2023	Akwidaa	10	22	32
	Cape Three Points	12	10	22
	Busua	14	10	24
28th April 2023	Butre	15	7	22
	Butre Anlo Village	9	11	20
2nd May 2023	Asemkow	15	5	20
	Akatekyie	19	6	25
3rd May 2023	Lower Dixcove	22	2	24
	Upper Dixcove	16	5	21
TOTAL		**235**	**119**	**354**

The results of the LEK were consolidated into a report and a map highlighting the key areas identified by the GCTPA communities. Hen Mpoano then held four community cluster meetings in Princess Town, Akwidaa, Achonwa, and Butre with 75 community members selected from the 15 communities to present and validate the results of the participatory mapping exercise. The communities were clustered based on proximity, accessibility, and historical relations (Table 5). Five people were selected to represent each community, including the chief fisherman, konkohemaa, and selected fishermen with over 20 years of experience in fishing.

Figure 27: Scenes from the four community cluster stakeholder validation meetings.

7.3.2 Participatory Mapping of Mangrove Ecosystems

The Greater Cape Three Points mangrove ecosystem was also assessed through a participatory mapping process engaging local fishers, traditional leaders, and community members in 19 GCTPA communities. A total of 574 people were involved in this assessment, including 346 men and 228 women. The process used maps of existing orthophotos and Google Earth images that were digitized and verified with GPS surveys, highlighting mangrove extent, biodiversity, and threats. Using these maps, Hen Mpoano then facilitated a process to gathered local ecological knowledge to select mangrove focused MPA sites.

Table 6: Communities visited for the mangrove participatory mapping exercise

Date	Communities Visited	Male	Female	Total
9th April 2024	Ampatano	30	1	31
	Asemkow	28	13	41
	Butre Anlo Village	22	5	27
10th April 2024	Butre	22	10	32
	Busua	24	7	31
	Dixcove (Lower & Upper)	24	1	25
11th April 2024	Achonwa	19	16	35
	Akwidaa	11	22	33
	Bibienyiha	9	11	20
	Akyenim	10	24	34

12th April 2024	Ketakor	16	27	43
	Cape Three Points	18	9	27
16th April 2024	Akatekyie	19	4	23
	Princess Town	16	4	20
17th April 2024	Domunli/ Akonu	16	15	31
	Agyan	21	21	42
	Princess Anlo Village	21	9	30
18th April 2024	Miemia	20	29	49
TOTAL		**346**	**228**	**574**

Figure 28: Scenes from the mangrove participatory mapping exercises

7.3.3 Community and Cluster Consultative Meetings

With the participatory mapping completed and validated, Hen Mpoano then facilitated 18 community consultation meetings and four community cluster meetings across the GCTPA communities. These consultations aimed to garner community support and input for the MPA establishment process. The consultations comprised two stages: community-level and community cluster meetings. The community meetings initiated discussions on MPAs through games and scenario modelling, while the latter aimed to consolidate community decisions and engage community leaders in discussions about MPA establishment.

The community consultations emphasized cultivating a new understanding of MPAs without imposition. The approach involved posing questions to guide discussions to uncover ideas, needs, and concerns specific to each community using a range of exercises, such as role-playing, storytelling, and ocean games. The meeting was open to all community members, including fishermen, fish processors, fisherfolk leaders, local assembly members, and the public. The community consultative meetings and training involved one thousand (1,000) members of the 17 prospective MPA communities (Table 7). More than 52% of the total participants were women.

The cluster meetings, on the other hand, were restricted to 5 to 9 people per community. The quota used was based on the level of participation in the community-level training sessions. The meetings involved 117 selected representatives, including 78 men and 39 women (Table 8). The cluster meetings created the platform for fishers from adjacent communities to develop a common understanding of the opportunities to work beyond their individual communities while harnessing their collective knowledge and engaging in synergistic actions towards achieving the common goal of MPA establishment.

Table 7: Community participation in the consultative meetings

Date	**Community**	**Male**	**Female**	**Total**
10th November 2023	Upper Dixcove	24	0	24
13th November 2023	Busua	17	27	44
12th January 2024	Asemkow	29	24	53
15th January 2024	Lower Dixcove	36	61	97
16th January 2024	Princess Town	27	21	48
	Akatekyi	20	10	30
22nd January 2024	Butre Anlo Village	21	12	33
23rd January 2024	Miemia	26	38	64
	Egyambra	17	21	38
24th January 2024	Agyan	36	28	64
	Akonu & Domunli	19	18	37
25th January 2024	Butre	61	36	97
	Achonwa	27	33	60
	Akwidaa	62	87	149
26th January 2024	Ketakor	16	28	44
	Cape Three Points	11	69	80
	Princess Anlo Village	23	15	38
TOTAL		**472**	**528**	**1000**

Table 8: Community participation in the Cluster Meetings

Date	**Cluster communities**	**Meeting Point**	**Male**	**Female**	**Total**
2nd February 2024	Busua	Busua	24	17	41
	Upper Dixcove				
	Lower Dixcove				
	Asemkow				
	Butre				
	Butre Anlo beach				
5th February 2024	Agyan	Agyan	25	3	28
	Akonu				
	Domunli				
	Egyambra				
6th February 2024	Akwidaa	Akwidaa	12	14	26
	Cape Three Points				
	Ketakor				
	Achonwa				
6th February 2024	Princess Town	Princess Town	17	5	22

	Akatekyi Princess Anlo Village				
TOTAL			78	39	117

Figure 29: Pictures from the community cluster meetings.

7.3.4 Educational Campaigns on the benefits of MPAs

After the community and cluster meetings, an educational campaign was designed and rolled out in the 20 prospective MPA communities as a follow-up to. The campaigns aimed to educate stakeholders on MPAs and their categories, develop a co-management strategy for establishing and implementing the MPA, and map critical areas for creating an MPA in Greater Cape Three Points. The campaign utilized a multi-faceted approach, including MPA literacy sessions, video documentaries showcasing critical habitats, and interactive mapping exercises using categories of MPA restriction stickers. The campaigns attracted 1,368 participants, comprising 611 males and 757 females (Table 9). This included fishermen, fish processors, fisherfolk leaders, local assembly members, and opinion leaders.

Key outcomes of the campaign included increased awareness among community members on the importance of MPAs, identification of critical areas for MPA designation, and the formulation of suggestions and solutions by fisherfolk to address challenges in various habitats. Concerns raised by community members ranged from illegal fishing practices to the need for alternative livelihood options and transparent enforcement of MPA regulations.

Table 9: Communities and number of participants engaged in the educational campaigns

Date	Community	Male	Female	Total
17th May 2024	Asemkow	25	54	79
14th May 2024	Butre	68	69	137
16th May 2024	Ketakor	21	17	38
13th May 2024	Akwidaa	47	58	105
14th May 2024	Busua	45	34	79
22nd May 2024	Akonu/ Domunli	28	46	74
24th May 2024	Bebianyiha	5	13	18
23rd May 2024	Princess Anlo Village	18	8	26
20th May 2024	Akatekyi	28	14	42
24th May 2024	Ampatano	38	29	67
23rd May 2024	Princess town	21	17	38

17th May 2024	Butre Anlo village	21	18	40
7th May 2024	Achonwa	27	36	63
15th May 2024	Lower Dixcove	40	65	105
15th May 2024	Upper Dixcove	40	100	140
21st May 2024	Egyambra	36	53	89
21st May 2024	Miemia	27	55	82
16th May 2024	Cape Three Points	29	26	55
22nd May 2024	Agyan	47	45	92
TOTAL		**611**	**757**	**1368**

Figure 30: Scenes from the community outreach campaigns

7.4 Regional and National Level Engagements

Five regional-level engagements, held between February 2023 and June 2024, provided a platform for regional stakeholders to be engaged in the MPA establishment process while also bringing together the MPA community leaders to dialogue with district and regional stakeholders. These were complemented by one national level dialogue on MPAs in Ghana held in December 2023 to bring all the national level government agencies, development partners, and other important national level stakeholders together to review progress to date towards establishing MPAs in Ghana, priorities, and align around the GCTPA MPA as a national priority.

7.4.1 Regional Stakeholder Engagement and Consultation Inception Workshop

The regional inception workshop for the MPA was held on 30th March 2023 in Busua. The workshop aimed to engage GCTPA Traditional Council members, community leaders, community members, chief fishermen, fishers, fish processors, Western Regional government officials, Ahanta West Municipal Assembly officials, and Western Regional Fisheries Commission officials. The objective was to introduce the GFRA MPA development process and solicit their support for establishing MPAs in the Cape Three Points area.

The workshop was well-attended by stakeholders who were introduced to the MPA concept and its importance to fisheries. This multi-stakeholder meeting, which attracted 47 people (male: 28; female: 19), provided a platform to share the developed MPA strategy, including the community engagement plan. Stakeholders appreciated the concept and committed to supporting the MPA establishment in the Cape Three Points area. Notably, the Municipal Assembly pledged full support and promised to provide relevant data regarding the MPA catchment area to facilitate the process.

Figure 31: Group photograph of participants at the stakeholder Inception Workshop

7.4.2 Regional Consultative Workshop on MPA Establishment in the Greater Cape Three Points Area

The regional stakeholder consultative workshop occurred on 22nd August 2023 at the WERBA House in Agona Nkwanta, Ahanta West Municipal. The workshop aimed to update Traditional Council members, assembly members, chief fishermen, Konkohemas, fishers, and fish processors from the 15 prospective MPA communities alongside regional and district officials on the MPA development and to solicit their support and input for site selection in the Cape Three Points Area. Regional-level stakeholders from the Land Use and Spatial Planning Authority (LUSPA), FC, and EPA were well represented. Additionally, officers from the Ahanta West Municipal Assembly, regional executives of GNCFC, NAFPTA, and the African Confederation of Professional Organizations of Artisanal Fisheries (CAOPA) attended. A member of the MPA Technical Advisory Committee (TAC) and the current president of the GNCFC also graced the event. In all, 63 stakeholders (47 men and 16 women) participated in the consultative workshop.

While stakeholders were generally supportive of a Cape Three Points MPA, the consultations provided opportunities to openly discuss stakeholder concerns. Many felt that an MPA is not likely to achieve expected outcomes if fishers continue to engage in illegal fishing practices, in particular light fishing. This highlights the need for continuous enforcement of existing rules against illegal fishing during MPA establishment. Stakeholders' greatest concern was the potential impact of MPAs on the livelihoods of fishers and other community people in the area. Despite these concerns, participants appreciated the fact that their views and suggestions contributed to the site selection process and advocated for their continuous involvement in the whole MPA development process. Traditional leadership authorities expressed their gratitude and support and asked for active engagements with the local people throughout the MPA development process. Finally, the Ahanta West Municipal Assembly stressed the need for the conservation of fisheries and coastal resources and pledged the full support of the Assembly in the MPA development process.

Figure 32: A cross-section of participants at the regional consultative workshop

7.4.3 MPA Technical Advisory Committee Field Visit

From September 26th to 29th, 2023, the MPA TAC conducted a field visit and study tour in the Greater Cape Three Points area. The MPA TAC is a multi-stakeholder institutional committee with representatives from FC, EPA, LUSPA, GNCFC, civil society, and academia. The TAC was formed as an advisory body that has recently been formalized under the leadership of MOFAD. This visit aimed to allow the TAC to directly observe potential MPA sites and engage with community stakeholders, enhancing their knowledge and understanding of critical issues to inform decision-making about establishing MPAs in the Cape Three Points area.

During the visit, the TAC had the opportunity to interact with Ahanta West Municipal Assembly officials. The discussions focused on the social and economic impacts of the proposed MPA in the municipality and what mitigation measures could be envisaged. The TAC also had 2 separate engagements with the chief fishermen, fishers, and fish processors in Dixcove and Cape Three Points. These engagements also discussed the potential social and economic impacts of the MPA.

Figure 33: MPA TAC members interacting with officers of Ahanta West Municipal Assembly

7.4.4 Regional Stakeholder Dialogue on Marine Protected Area Establishment Processes

The workshop held on November 14, 2023, at the WERBA House in the Ahanta West Municipal served as a crucial platform for continued engagement of district and regional stakeholders to update them on the progress of the Marine Protected Area (MPA) establishment processes in the GCTPA and to continue to seek their inputs. The workshop targeted chief fishermen, Konkohemas, assembly members, and traditional authorities from the twenty prospective MPA communities. The workshop continued to attract strong representation from the key regional-level stakeholders, including the FC, EPA, and LUSPA. Officers from the Ahanta West Municipal Assembly, NAFPTA, GNCFC, and CAOPA were also present. This workshop also included stakeholders from the newly added Nzema East Municipal Assembly. 66 stakeholders participated in the consultation workshop, with 42 men and 24 women.

The workshop provided updates on the MPA establishment processes, reviewed planned activities for the year, and presented a comprehensive community engagement plan for the MPA. The interactive activities, including marine biodiversity identification, food web analysis, and MPA scenario modelling, provided a practical understanding of the fishing industry's challenges and underscored the necessity of MPA implementation for sustainable fisheries management. Workshop participants continued to show an active interest in the establishment of the GCTPA MPA and continued to pledge their support.

7.4.5 Regional Stakeholder Workshop on MPA Establishment Processes

In keeping with the tradition of holding quarterly regional stakeholder engagements, GFRA and Hen Mpoano held the fourth regional workshop in the GCTPA MPA on June 25, 2024. This workshop brought together 92 participants (27 females and 65 males) comprised of chief fisherman, Konkohemaa, assembly members, and traditional authorities from the twenty-one prospective MPA communities alongside regional-level stakeholders including the FC, EPA, LUSPA, Wildlife Division of the Forestry Commission, and officers from the Ahanta West and Nzema East Municipal assemblies. During this workshop, particular attention was given to all the fishing associations including NAFPTA, GNCFC, CaFGOAG, CAOPA, National Fisheries Association of Ghana (NAFAG), and Ghana Industrial Trawlers Association (GITA). Representatives from the MoFAD were also in attendance.

The workshop presented the progress to date towards MPA establishment including a summary of all the consultations undertaken to date along with a summary of the various research efforts which concluded with the presentation of the proposed MPA area. The meeting concluded with the presentation of an

MPA co-design process for stakeholder comments. During the meeting, participants welcomed the MPA and continued to voice concerns with illegal practices such as light fishing, echo sounders, and galamsey which indicates a strong community desire to enforce sustainable fishing practices. They welcomed the introduction of GFRA's livelihood training program in the 21 GCTPA communities, worried about its sustainability and complained that the focus on youth 18-35 years of age limited participation. They suggested that the community engagement process engage chiefs and opinion leaders separately to ensure their support and understanding of the MPA initiative. Questions were raised about the legal framework for MPA establishment, suggesting the need to ensure MPA establishment has clear legislation. Finally, there was a suggestion to construct roads in the proposed area to enhance tourism, demonstrating a forward-thinking approach to community development. Overall, participants appreciated the bottom-up approach and encouraged the co-design process with the recommendation that trained community members can educate others in the communities about the benefits of the MPA, fostering understanding and unity in decision making.

7.4.6 National MPA Multistakeholder Workshop

Recognizing the fact that establishment of MPAs is a national priority, GFRA held a workshop in December 5-6, 2023 that brought together key government stakeholders that drive Ghana's MPAs vision and the MPA TAC members alongside various district and regional stakeholders from the GCTPA to strengthen stakeholder collaboration in support of a unified vision for the establishment of MPAs. Workshop participants included MOFAD, FC, Ministry of Environment, Science, Technology and Innovation (MESTI), EPA, WD, LUSPA, Members of Parliament from Nzema East and Ahanta West, District Assemblies, Sustainable Development Goals (SDGs) Advisory Unit of Office of the President, University of Ghana, University of Cape Coast, Hen Mpoano, Fisheries Committee of the West Central Gulf of Guinea (FCWC), IUCN, UK Ocean Country Partnership Program (OCPP), the European Union, and GNCFC. The workshop was a forum for all stakeholders to discuss the status of implementation of MPA activities and identify priorities and needed capacity and resources for the establishment of MPAs in Ghana. The SDGs Advisory Unit highlighted Ghana's high-level vision and commitment for MPAs in the context the country's Sustainable Oceans Plan, which will be developed within the framework of the High-Level Panel for the Sustainable Ocean Economy. The FC confirmed that MPA establishment is a priority under the MFMP 2022-2026 and a GFRA supported legal expert shared his recommendations for the pathways toward MPA establishment based on the GFRA supported legal and policy review. The recommendation of following the path towards Gazette Notification in the short-term was well received by participants.

The workshop was also a good platform for ensuring cross agency and cross-donor information sharing and collaboration. MESTI, EPA and Wildlife Division shared their current environment and biodiversity priorities and how they relate to MPA establishment. Wildlife Division will be a key stakeholder given the Wildlife Resources Management Bill (2022) gives them the legal backing to establish protected areas including MPAs. The Bill will become law after Presidential ascent and will be relevant to the MPA establishment process. Three key development partners, the European Union, the OCCP, and IUCN, presented their interest and upcoming funding priorities related to MPAs. The European Union's West Africa Sustainable Oceans Program (WASOP) will include a biodiversity conservation component that will focus on identifying sites for protection. The OCPP has an improved marine biodiversity and livelihoods component in their Ghana program that includes establishing, fully implementing, and effectively managing and enforcing MPAs. IUCN shared experiences from collaborations with the WD to develop a revised management plan for the Anlo-Keta RAMSAR site.

The workshop resulted in a common vision for MPAs and priorities for action in 2024. Stakeholders rallied around the Cape Three Points Area as the priority for the first MPA to be designated in Ghana. Participants also suggested that a communications strategy must be developed for information sharing, education and awareness creation and supplementary livelihood programs must be implemented for communities impacted by MPAs.

Figure 34: Group photo showing participants of the MPA Policy, Planning, and Political Support Workshop

7.4.7 World Ocean Day Celebration

To commemorate World Ocean Day and raise national visibility of the prospective GTCPA MPA, GFRA partnered with MOFAD to host a celebratory event in June 2024 at the Busua Beach Resort in the Western Region. The event was attended by the USAID/Ghana Director for Economic Research, the Director for Research at MoFAD, the Western Regional Minister, the Western Region Fisheries Commission Director, representatives from the Ahanta West and Nzema East municipalities, Ghana National Canoe Fishermen Council, traditional authorities from the Greater Cape Three Points area, and community members living near the proposed Marine Protected Areas in the region.

Over 250 stakeholders, including 10 representatives from each of the 21 communities abutting the proposed MPA participated in the celebration. These community representatives were carefully selected to include chief Fishermen, Konkohemaas (fish mothers), assembly members, traditional leaders, and CREMA executives. Also in attendance were the MPA TAC members, Government Officials from MoFAD/FC, the Wildlife Division, the EPA, and the media.

The purpose was to raise awareness about GFRA's partnership with the Ministry of Fisheries and Aquaculture to create Ghana's inaugural network of Marine Protected Areas. Festivities included a regatta competition, cultural performances, the introduction and outdooring of Marine Protected Area champions, and solidarity messages from the diverse stakeholder groups present.

Figure 35: Scenes from the 2024 World Ocean Day Celebration

8. CONCLUSION

Over the past year GFRA, in partnership with MOFAD, FC, and partner Hen Mpoano, have taken active steps to advance the establishment of an MPA in the GCTPA, in alignment with the Government of Ghana's National Marine Fisheries Management Plan (2022-2026). The MPA area has been well delineated based on the best available scientific data, extensive consultation with local fishers and communities to gather their local ecological knowledge on fishing grounds and fish behaviours, and additional research commissioned directly by GFRA. The results of this research project have been detailed in this report and resulted in the identification of four prioritized areas for additional protection within the marine MPA (Figure 37) as well as the identification of priority mangrove ecosystems for protection in the coastal areas abutting the MPA (Figure 38).

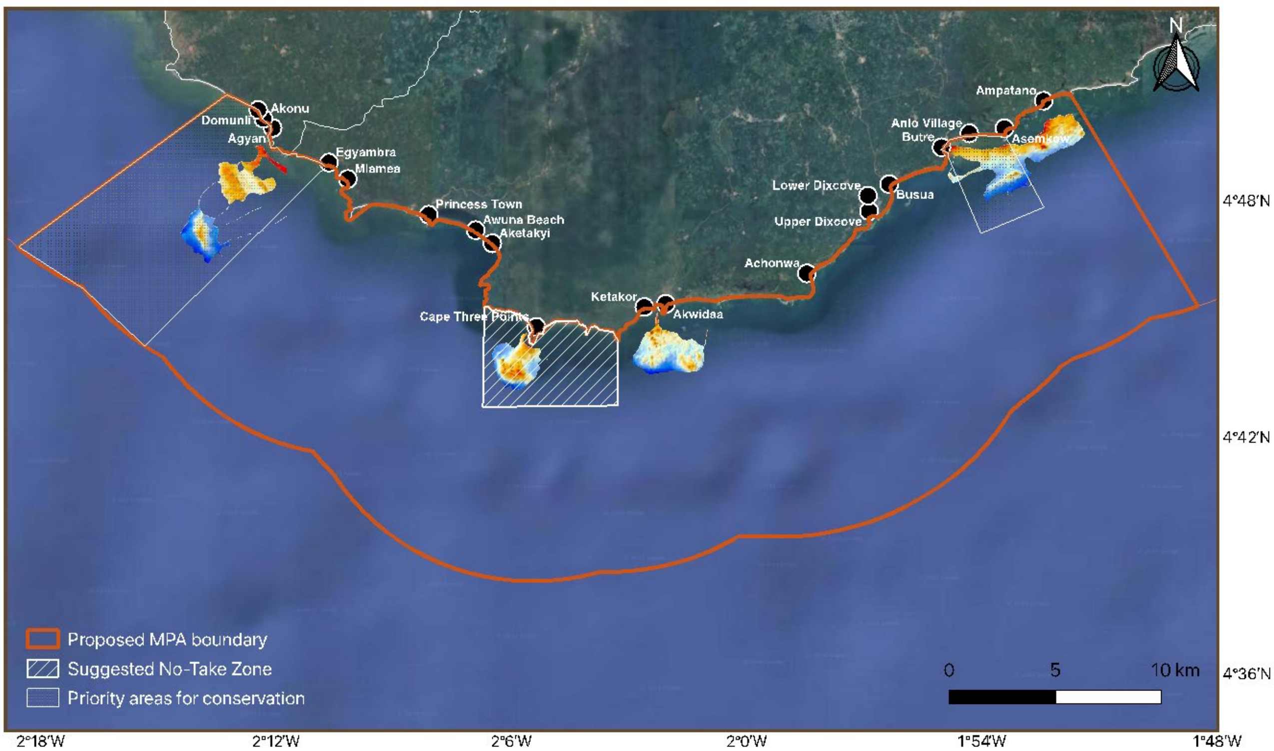


Figure 36: Proposed marine MPA area including three rocky reef areas for additional protection

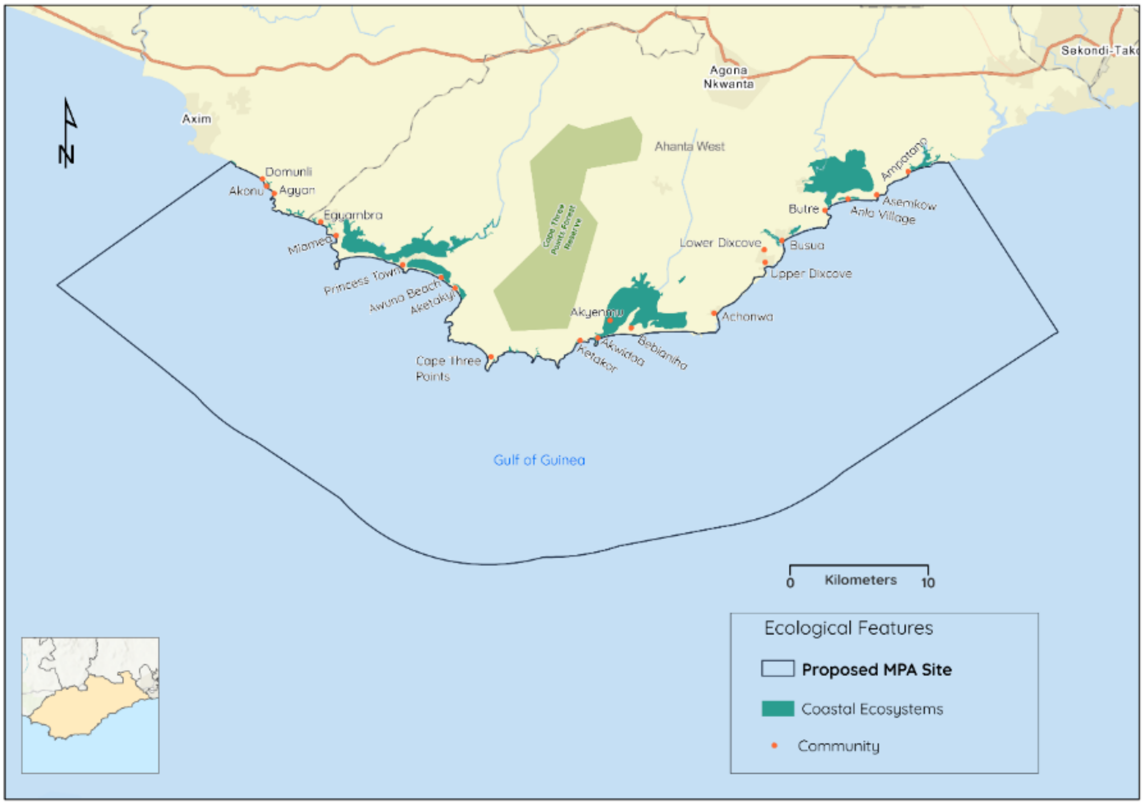


Figure 37: Proposed MPA area with key mangrove areas identified for additional protection.

The year-long bottom-up stakeholder engagement approach across local, district, regional, and national levels ensured that all key stakeholders were aware of the idea of an MPA and able to provide inputs during its evolution. The emphasis was on frequent community engagements among the 21 prospective MPA communities, culminating in the active involvement of community members, including fishers, traditional leaders, and local officials, as co-creators in establishing the MPA. The regional-level engagements, on the other hand, provided a platform for engaging key decision makers and for community leaders to dialogue with the district and regional stakeholders. Overall, 3,639 people have been reached through various stakeholder engagement approaches (Table 10) although it should be noted that many of the same individuals participated in these various engagements.

Table 10: Summary of community, regional, and national stakeholder engagements.

Name	Dates	Male	Female	Total
Regional Inception Workshop	30th March 2023	28	19	47
Local Ecological Knowledge Mapping of the MPA Area	14 April 2023	235	119	354
Review and Validation of the LEK Mapping Report	22 – 25 May 2023	75	0	75
Regional Stakeholder Consultative Workshop	22nd August 2023	47	16	63
MPA Technical Advisory Committee Field Visit and Study Tour to Cape Three Points	26-29 Sept 2023	-	-	-
Community Consultative Meetings	10 Nov 2023 – Jan 26 2024	472	528	1000
Regional Stakeholder Consultative Workshop	14 Nov 2023	42	24	66

National MPA Stakeholder Consultation	5-6 Dec 2023			
Participatory Mapping of Mangrove Ecosystems	9 -18 April 2024	346	228	574
Educational Campaigns on the benefits of MPAs	7 - 24 May 2024	611	757	1368
Regional Stakeholder Consultative Workshop	25 June 2024	65	27	92
World Ocean Day Celebration	5th June 2024	-	-	-
TOTAL		**1921**	**1718**	**3639**

Stakeholders have expressed strong interest in seeing the MPA implementation become a reality. They are anticipating the official designation of the MPA soon. However, concerns about lapses in the current fisheries law enforcement and the government's commitment to the MPA process were raised. It is essential to take the necessary measures to ensure that, once established, MPA policies are effectively implemented and remain free from political interference. The stakeholders insist on a co-management structure that allows for community-based management with legal backing. Community stakeholders also expressed concerns about the potential impacts of the MPA on their livelihoods and requested diversified support.

ANNEX 1: REFERENCES

Amponsah, S.K., Ofori-Danson, P.K., Nunoo, F.K., 2016. Population dynamics of Engraulis encrasicolus (Linnaeus, 1758) within Ghana's coastal waters. International Journal of Fisheries and Aquatic Studies 4, 258–263.

Arneri, E., Carpi, P., Donato, F., Santojanni, A., 2011. Growth in Small Pelagic Fishes and Its Implications in Their Population Dynamics. Biologia Marina Mediterranea 18, 106–113.

Ateweberhan, M., Gough, C., Fennelly, L., Frejaville, Y., 2012. The Nearshore Rocky Reefs of Western Ghana, West Africa: Baseline ecological research surveys. Blue Ventures Conservation, London.

Aziable et al., 2012. Distribution and abundance of the main pelagic fish stocks in the Western Gulf of Guinea (Benin, Togo, Ghana and Côte d'Ivoire).

Belackova, A., Willenbrink, N., Gonçalves, J., Horta E Costa, B., 2023. Potential protection effects in a small marine reserve: a demersal community analysis from stereo baited remote underwater video. Mar. Ecol. Prog. Ser. 708, 79–100. https://doi.org/10.3354/meps14259

Bouchet, P., Meeuwig, J., Huveneers, C., Langlois, T., Letessier, T., Lowry, M., Rees, M., Santana-Garcon, J., Scott, M., Taylor, M., 2018. Marine Sampling Field Manual for Pelagic Stereo BRUVS (Baited Remote Underwater Videos). National Environmental Science Programme (NESP).

Bouchet, P.J., Meeuwig, J.J., 2015. Drifting baited stereo-videography: a novel sampling tool for surveying pelagic wildlife in offshore marine reserves. Ecosphere 6, art137. https://doi.org/10.1890/ES14-00380.1

Brainerd, T.R., 1991. Sardinella fishery off the coast of West Africa: the case of a common property resource.

Buhl-Mortensen, L., Serigstad, B., Buhl-Mortensen, P., Olsen, M.N., Ostrowski, M., Błażewicz-Paszkowycz, M., Appoh, E., 2017. First observations of the structure and megafaunal community of a large Lophelia reef on the Ghanaian shelf (the Gulf of Guinea). Deep Sea Research Part II: Topical Studies in Oceanography 137, 148–156. https://doi.org/10.1016/j.dsr2.2016.06.007

Castro, K., Skrobe, L., Asare, C., Kankam, S., 2017. Synthesis of scientific and local knowledge on Sardinella species in Ghana. Takoradi, Ghana. The USAID/Ghana Sustainable Fisheries Management Project (SFMP).

CRC, Friends of the Nation, 2011. Assessment of Critical Coastal Habitats of the Western Region, Ghana. Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI.

Cury, P., Fontana, A., 1988. Compétition et stratégies démographiques comparées de deux espèces de sardinelles (Sardinella aurita et Sardinella maderensis) des côtes ouest-africaines. Aquatic living resources 1, 165–180.

Daly, C., Baba, W., Bergsma, E., Thoumyre, G., Almar, R., Garlan, T., 2022. The new era of regional coastal bathymetry from space: A showcase for West Africa using optical Sentinel-2 imagery. Remote sensing of environment 278, 113084.

Day, J., Dudley, N., Hockings, M., Holmes, G., Laffoley, D., Stolton, S., Wells, S., Wenzel, L., 2019. Guidelines for applying the IUCN protected area management categories to marine protected areas.

de Boer, M.N., Saulino, J.T., Van Waerebeek, K., Aarts, G., 2016. Under Pressure: Cetaceans and Fisheries Co-occurrence off the Coasts of Ghana and Côte d'Ivoire (Gulf of Guinea). Frontiers in Marine Science 3.

Djakouré, S., Penven, P., Bourlès, B., Koné, V., Veitch, J., 2017. Respective roles of the Guinea Current and local winds on the coastal upwelling in the northern Gulf of Guinea. Journal of Physical Oceanography 47, 1367–1387.

Dudley, N., Stolton, S., 2022. Best Practice in Delivering the 30x30 Target (No. (2nd Edition)). The Nature Conservancy and Equilibrium Research Bristol.

EPA, 2021. State of the marine environment report for Ahanta west. Ellembelle, Jomoro and Nzema east districts in the western region of Ghana. Environmental Protection Agency, Accra.

EPA, 2020. Potential Ecologically or Biologically Significant Marine Areas of Ghana: Marine Area Off Cape Three Points Ghana, West Africa. Environmental Protection Agency, Accra.

GFRA, 2023. Marine Protected Area Site Selection Report. Feed the Future Ghana Fisheries Recovery Agency.

Grorud-Colvert, K., Sullivan-Stack, J., Roberts, C., Constant, V., Horta e Costa, B., Pike, E.P., Kingston, N., Laffoley, D., Sala, E., Claudet, J., Friedlander, A.M., Gill, D.A., Lester, S.E., Day, J.C., Gonçalves, E.J., Ahmadia, G.N., Rand, M., Villagomez, A., Ban, N.C., Gurney, G.G., Spalding, A.K., Bennett, N.J., Briggs, J., Morgan, L.E., Moffitt, R., Deguignet, M., Pikitch, E.K., Darling, E.S., Jessen, S., Hameed, S.O., Di Carlo, G., Guidetti, P., Harris, J.M., Torre, J., Kizilkaya, Z., Agardy, T., Cury, P., Shah, N.J., Sack, K., Cao, L., Fernandez, M., Lubchenco, J., 2021. The MPA Guide: A framework to achieve global goals for the ocean. Science 373, eabf0861. https://doi.org/10.1126/science.abf0861

Harasti, D., Williams, J., Mitchell, E., Lindfield, S., Jordan, A., 2018. Increase in Relative Abundance and Size of Snapper Chrysophrys auratus Within Partially-Protected and No-Take Areas in a Temperate Marine Protected Area. Front. Mar. Sci. 5. https://doi.org/10.3389/fmars.2018.00208

Harvey, E., Goetze, J., McLaren, B., Langlois, T., Shortis, M., 2010. Influence of range, angle of view, image resolution and image compression on underwater stereo-video measurements: high-definition and broadcast-resolution video cameras compared. Marine Technology Society Journal 44, 75–85.

Harvey, E., McLean, D., Frusher, S., Haywood, M., Newman, S.J., Williams, A., 2013. The use of BRUVs as a tool for assessing marine fisheries and ecosystems: a review of the hurdles and potential. University of Western Australia 20.

IUCN-WCPA Task Force on OECMs, 2019. Recognising and reporting other effective area-based conservation measures. IUCN, Gland Switzerland.

Iwamoto, T., Wirtz, P., 2018. A Synopsis of the Eastern and Central Atlantic Combers of the Genus Serranus (Teleostei: Scorpaeniformes: Serranidae). PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES 65.

Jaco, E., Steele, M., 2020. Early indicators of MPA effects are detected by stereo-video. Mar. Ecol. Prog. Ser. 647, 161–177. https://doi.org/10.3354/meps13388

Kassah, J., Blay, J., Okyere, I., Lazar, N., 2022. Maturity length, fecundity and spawning season of Atlantic chub mackerel *Scomber colias* in the coastal waters of Ghana (west-central Gulf of Guinea). African Journal of Marine Science 44, 291–298. https://doi.org/10.2989/1814232X.2022.2113140

Konan, N.D.A., 1996. Upwelling Off the Cote D'ivoifte-Ghana and Sardinellas Fisheries in the Western Gulf of Guinea, in: Summaries of Contributions Presented at the Workshop on West African Fisheries Organized During the Advanced Course on Upwelling Systems (Atlantic Ocean Eastern Boundary). Presented at the Intergovernmental Oceanographic Commission (of UNESCO), Las Palmas.

Koné, V., Lett, C., Penven, P., Bourlès, B., Djakouré, S., 2017. A biophysical model of S. aurita early life history in the northern Gulf of Guinea. Progress in oceanography 151, 83–96.

Koranteng, K., 1989. The sardinella (herring) fishery in Ghana: The past, recent developments, and the years ahead. Fisheries Research and Utilization Branch, Tema.

Koranteng, K.A., 1995. The western Gulf of Guinea coastal upwelling-peculiarities changes, and fisheries implications: a review, in: Summaries of Contributions Presented at the Workshop on West African Fisheries Organized During the Advanced Course on Upwelling Systems (Atlantic Ocean Eastern Boundary). Presented at the Intergovernmental Oceanographic Commission (of UNESCO), Las Palmas.

Koranteng, K.A., 1993. Size at first maturity of the anchovy (Engraulis encrasicolus) in Ghanaian waters and suggestions for appropriate mesh size in its fishery.

Langlois, T., Goetze, J., Bond, T., Monk, J., Abesamis, R.A., Asher, J., Barrett, N., Bernard, A.T.F., Bouchet, P.J., Birt, M.J., Cappo, M., Currey-Randall, L.M., Driessen, D., Fairclough, D.V., Fullwood, L.A.F., Gibbons, B.A., Harasti, D., Heupel, M.R., Hicks, J., Holmes, T.H., Huveneers, C., Ierodiaconou, D., Jordan, A., Knott, N.A., Lindfield, S., Malcolm, H.A., McLean, D., Meekan, M., Miller, D., Mitchell, P.J., Newman, S.J., Radford, B., Rolim, F.A., Saunders, B.J., Stowar, M., Smith, A.N.H., Travers, M.J., Wakefield, C.B., Whitmarsh, S.K., Williams, J., Harvey, E.S., 2020. A field and video annotation guide for baited remote underwater stereo-video surveys of demersal fish assemblages. Methods in Ecology and Evolution 11, 1401–1409. https://doi.org/10.1111/2041-210X.13470

Lazar, N., Yankson, K., Blay, J., Ofori-Danson, P., Markwei, P., Agbogah, K., Bannerman, P., Sotor, M., Yamoah, K.K., Bilisini, W.B., 2020. Status of the small pelagic stocks in Ghana in 2019. Scientific and Technical Working Group. USAID/Ghana Sustainable Fisheries Management Project (SFMP). Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island. GH2014_SCI083_CRC 17.

Letessier, T.B., Proud, R., Meeuwig, J.J., Cox, M.J., Hosegood, P.J., Brierley, A.S., 2022. Estimating Pelagic Fish Biomass in a Tropical Seascape Using Echosounding and Baited Stereo-Videography. Ecosystems 25, 1400–1417. https://doi.org/10.1007/s10021-021-00723-8

Lindfield, S.J., Harvey, E.S., McIlwain, J.L., Halford, A.R., 2014. Silent fish surveys: bubble-free diving highlights inaccuracies associated with SCUBA-based surveys in heavily fished areas. Methods in Ecology and Evolution 5, 1061–1069.

MacNeil, M.A., Chapman, D.D., Heupel, M., Simpfendorfer, C.A., Heithaus, M., Meekan, M., Harvey, E., Goetze, J., Kiszka, J., Bond, M.E., Currey-Randall, L.M., Speed, C.W., Sherman, C.S., Rees, M.J., Udyawer, V., Flowers, K.I., Clementi, G., Valentin-Albanese, J., Gorham, T., Adam, M.S., Ali, K., Pina-Amargós, F., Angulo-Valdés, J.A., Asher, J., Barcia, L.G., Beaufort, O., Benjamin, C., Bernard, A.T.F., Berumen, M.L., Bierwagen, S., Bonnema, E., Bown, R.M.K., Bradley, D., Brooks, E., Brown, J.J., Buddo, D., Burke, P., Cáceres, C., Cardeñosa, D., Carrier, J.C., Caselle, J.E., Charloo, V., Claverie, T., Clua, E., Cochran, J.E.M., Cook, N., Cramp, J., D'Alberto, B., de Graaf, M., Dornhege, M., Estep, A., Fanovich, L., Farabaugh, N.F., Fernando, D., Flam, A.L., Floros, C., Fourqurean, V., Garla, R., Gastrich, K., George, L., Graham, R., Guttridge, T., Hardenstine, R.S., Heck, S., Henderson, A.C., Hertler, H., Hueter, R., Johnson, M., Jupiter, S., Kasana, D., Kessel, S.T., Kiilu, B., Kirata, T., Kuguru, B., Kyne, F., Langlois, T., Lédée, E.J.I., Lindfield, S., Luna-Acosta, A., Maggs, J., Manjaji-Matsumoto, B.M., Marshall, A., Matich, P., McCombs, E., McLean, D., Meggs, L., Moore, S., Mukherji, S., Murray, R., Kaimuddin, M., Newman, S.J., Nogués, J., Obota, C., O'Shea, O., Osuka, K., Papastamatiou, Y.P., Perera, N., Peterson, B., Ponzo, A., Prasetyo, A., Quamar, L.M.S., Quinlan, J., Ruiz-Abierno, A., Sala, E., Samoilys, M., Schärer-Umpierre, M., Schlaff, A., Simpson, N., Smith, A.N.H., Sparks, L., Tanna, A., Torres, R., Travers, M.J., van Zinnicq Bergmann, M., Vigliola, L., Ward, J., Watts, A.M., Wen, C., Whitman, E., Wirsing, A.J., Wothke, A., Zarza-Gonzâlez, E., Cinner, J.E., 2020. Global status and conservation potential of reef sharks. Nature 583, 801–806. https://doi.org/10.1038/s41586-020-2519-y

Magne, J., 2023. A temporal analysis of the pelagic fish assemblages in two marine protected areas, South-western Australia.

Meeuwig, J.J., Thompson, C.D.H., Forrest, J.A., Christ, H.J., Letessier, T.B., Meeuwig, D.J., 2021. Pulling Back the Blue Curtain: A Pelagic Monitoring Program for the Blue Belt. Front. Mar. Sci. 8, 649123. https://doi.org/10.3389/fmars.2021.649123

Mensah, M.A., 1991. The influence of climatic changes on the coastal oceanography of Ghana.

Mensah, M.A., Koranteng, K.A., 1988. A Review of the Oceanography and Fisheries resources in the coastal waters of Ghana, 1981-1986. Report-Marine Fishery Research (Ghana).

MOFAD, 2022. National Fisheries Management Plan, Government of Ghana 2022-2026. Ministry of Fisheries and Aquaculture Development, Government of Ghana.

Nunoo, F.K., 2018. Marine Protected Areas in Ghana: Strategies, action plan and implementation framework. Accra.

Osei, I., 2015. Aspects of the biology of Sardinella aurita and Sardinella maderensis (Clupeidae) in the coastal waters of the central region, Ghana. Unpublished. Master's Thesis, University of Cape Coast, Cape Coast, Ghana.

Prince, J., Hordyk, A., 2019. What to do when you have almost nothing: A simple quantitative prescription for managing extremely data-poor fisheries. Fish Fish 20, 224–238. https://doi.org/10.1111/faf.12335

Prince, J.D., 2018. Informing community-based fisheries management with spawning potential surveys. Pacific Community Newsletter 154, 43–52.

Protected Planet, 2023. Protected Planet | Ghana [WWW Document]. Protected Planet. URL https://www.protectedplanet.net/country/GHA (accessed 8.24.23).

Sagoe, A.A., Aheto, D.W., Okyere, I., Adade, R., Odoi, J., 2021. Community participation in assessment of fisheries related ecosystem services towards the establishment of marine protected area in the Greater Cape Three Points area in Ghana. Marine Policy 124, 104336. https://doi.org/10.1016/j.marpol.2020.104336

Santana-Garcon, J., Newman, S.J., Harvey, E.S., 2014. Development and validation of a mid-water baited stereo-video technique for investigating pelagic fish assemblages. Journal of Experimental Marine Biology and Ecology 452, 82–90. https://doi.org/10.1016/j.jembe.2013.12.009

Sekey, W., Obirikorang, K.A., Alimo, T.A., Soku, M., Acquah, B., Gyampoh, B.A., Adjei-Boateng, D., Asare-Ansah, O., Ashiagbor, G., Kassah, J.E., 2022. Evaluation of the shark fisheries along the Coastline of Ghana, West Africa. Regional Studies in Marine Science 53, 102434. https://doi.org/10.1016/j.rsma.2022.102434

Shortis, M., Harvey, E., Abdo, D., 2009. A review of underwater stereo-image measurement for marine biology and ecology applications. Oceanography and Marine Biology: An Annual Review 47, 257–292.

Stolton, S., Shadie, P., Dudley, N., 2013. Guidelines for applying protected area management categories including IUCN WCPA best practice guidance on recognising protected areas and assigning management categories and governance types. IUCN.

Toresen, R., Olsen, M., Asante, A.S., Carocci, F., Psomadkis, P., 2016. Surveys of the fish resources and ecology of Ghana (Benin, Togo, Ghana, Côte d'Ivoire). Survey of the pelagic and demersal resources, plankton and hydrography 1 - 20 April 2016 (No. NORAD – FAO project GCP/INT/003/NOR. Cruise reports Dr. Fridtjof Nansen). Institute of Marine Research, Bergen, Norway.

Van Waerebeek, K., Ofori-Danson, P., Debrah, J., 2010. The Cetaceans of Ghana, a Validated Faunal Checklist. West African Journal of Applied Ecology 15. https://doi.org/10.4314/wajae.v15i1.49428

Weatherall, P., Marks, K.M., Jakobsson, M., Schmitt, T., Tani, S., Arndt, J.E., Rovere, M., Chayes, D., Ferrini, V., Wigley, R., 2015. A new digital bathymetric model of the world's oceans. Earth and space Science 2, 331–345.

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